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RESEARCH NOTES

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Physiological Analysis of Growth and Yield Variation in Summer Groundnut (*Arachis hypogaea* L.)

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Abstract

The significant differences among the genotypes for dry matter production in stem, pods, roots, total dry matter production plant^{-1}, AGR, RGR, NAR and LAR at various stages of growth played an important role in yield determining processes. The values of these growth parameters increased between 60 and 80 DAS and declined thereafter towards maturity. The plant height, number of branches and number of leaves were increased rapidly up to 100 DAS and declined thereafter. Leaf area and leaf area index (LAI) played an important role in maintaining high photosynthetic activity and ultimately productivity of the plant. The leaf area and LAI showed increasing trend up to 100 DAS and decreased thereafter. The genotypes, RHRGS-06083, RHRGS-06080 and JL-501 recorded highest pod yield which was mainly due to higher number of pods plant^{-1}, pod yield plant^{-1}, 100 kernel weight and harvest index. The genotype AK-159 recorded highest oil content while genotype JL-24 recorded highest protein content. The genotypes JL-24 and ICR-48 had maximum total chlorophyll and produced moderate pod yield.

Key words : Dry matter production, growth parameters, vegetative growth and source, generative growth and sink, physiological parameters, groundnut.

Physiological approach to assess the causes for variation in grain yield is the basic attempt towards increasing the crop productivity. Growth analysis is a physiological probe into the development of crop in chronological sequence to elucidate and account the causes for the difference in yield through the events that had occurred earlier in growth. The problem of variation in growth, development and yield involves the interaction of external factors with the physiological processes of a plant *viz*., photosynthesis, respiration, transpiration, water use efficiency etc. Higher rates of photosynthesis may lead to higher yields but this is not always true. The yielding ability of crop depends on efficient source to sink relationship. Dry matter produced is a result of net photosynthetic process. However, all the dry matter produced by the crop is not harvested, since it is distributed among various plant parts *viz*., leaves stem, root and pods. Thus, a plant type which is efficient in photosynthesis and also able to divert maximum possible dry matter towards the economically important plant parts need to be evolved.

A large variation in growth and yield is seen among the different improved cultivars of groundnut. The growth analysis techniques help in understanding the growth pattern and also contribution of various plant parts to economical yield. It also helps in finding out yield contributing characters. Thus growth analysis forms the basis for manipulation of productivity of the field crop. The yield of groundnut is largely influenced by the partitioning of assimilates between vegetative and reproductive parts, the length of pod filling period and pod setting. The most important yield determining factor in groundnut is the

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growth of the peg. Many times it remains under developed or does not reach to the soil and thus fails to produce pod. This may be because of non synchronous flowering.

Materials and Methods

Eighteen groundnut genotypes were evaluated for physiological analysis of growth and yield variation during summer 2008 at Cotton Improvement Project, M.P.K.V., Rahuri with two replications under irrigated condition on medium black soil. The sowing was done by dibbling on 24th February, 2008 by adopting 30 x 10 cm spacing. The gross and net plot size was 5.0 x 1.8 and 4.8 x 1.2 m^2, respectively. All the package of practices were adopted for good crop growth. The observations on dry matter production and its distribution in component parts of plants and vegetative growth were recorded at 20 days interval from date of sowing on randomly selected three plants from each plot. The growth parameters *viz*., AGR and LAR (Radford, 1967), RGR and NAR (Gardner *et al*., 1988) and LAI (Watson, 1947) were analyzed at various stages of growth. Yield and yield contributing characters were recorded while attaining the physiological maturity on randomly selected five plants. Protein and oil content of kernels was estimated by using Foss Infratec. 1241 Grain Analyzer instrument. Chlorophyll content of leaves was estimated at 10 days after flowering by Arnon (1949) on fresh weight basis.

Results and Discussion

The pattern of dry matter production and its distribution in plant parts has been of phenomenal interest to the research workers engaged in yield analysis. This method has been accepted as one of the standard methods of yield analysis. The data collected on dry matter at different time intervals would give the picture in quantitative terms as regards to accumulation and partitioning of the total dry matter among the plant parts throughout the growth periods of the crop. In view of this, it was envisaged to know the pattern of dry matter accumulation and its distribution in component parts of plant.

The overall functioning of the plant ultimately leads to formation and progressive accumulation of dry matter. In the present study, the dry matter accumulation in roots increased steadily whereas in stem it increased progressively at constant rate with the advancing age of the crop. After flowering, the dry matter is stored in reproductive parts. Therefore, the rate of dry matter accumulation in vegetative parts gets declined and increase in pods with the advancement of crop age. The genotype RHRGS-06083 recorded maximum

Table 1. Dry matter production and its distribution in component parts of plant influenced by groundnut genotypes.

Genotypes	Dry matter production (g plant^{-1})				
	Root	Stem	Leaves	Pods	Total
SB-XI	1.03	16.03	17.03	14.92	49.01
JL-24	1.01	15.81	17.15	18.17	52.13
JL-220	1.06	15.61	16.32	15.77	48.76
JL-286	1.05	14.55	16.90	17.62	50.12
TPG-41	1.12	15.79	16.97	20.94	54.81
TAG-24	1.02	11.21	13.18	19.39	44.78
TG-26	0.99	12.09	10.89	17.17	38.64
AK-159	1.08	13.96	16.15	16.97	48.16
ICR-48	1.09	12.16	13.77	16.39	43.40
ICGS-11	1.09	16.30	17.64	16.57	51.59
ICGS-37	1.11	12.56	13.13	16.11	42.90
ICGV-86564	1.14	15.28	16.19	22.65	55.25
JL-501	1.07	13.78	14.39	23.76	52.99
RHRGB-21	1.10	12.21	14.79	19.00	47.09
RHRGB-06030	1.09	15.67	17.38	20.77	54.91
RHRGS-06080	1.15	15.65	16.71	23.86	57.36
RHRGS-06083	1.20	16.52	18.30	24.84	60.86
RHRGS-06097	1.06	12.21	12.83	16.93	43.02
S.E.±	0.013	0.873	1.049	0.015	0.021
CD at 5 %	0.040	2.618	3.147	0.045	0.064

dry matter plant^{-1} in roots (1.20 g plant^{-1}), stem (16.51 g plant^{-1}), leaves (18.30 g plant^{-1}) and pods (24.84 g plant^{-1}) as well as highest dry matter production (60.86 g plant^{-1}). In addition to this, the genotypes, RHRGS-06080 (57.36 g plant^{-1}), ICGV-86564 (55.25 g plant^{-1}) and RHRGB-06030 (54.91 g plant^{-1}) were found to be promising for dry matter production and their distribution in component parts of plants (Table 1). Ghosh *et al.* (1997) stated negligible amount of dry matter partitioning in the roots. The rate of dry matter accumulation in leaves was low at initial stages which was rapid in between grand growth period and became steady towards maturity. The findings were in agreement with the results of Kumar and Kumar (1999). Total dry matter of the plant increased progressively with the advancing age of the crop up to harvest. Similar results were reported by Jadhav *et al*. (1993).

Computation of growth indices such as absolute growth rate, relative growth rate, leaf area index, net assimilation rate and leaf area ratio may give complete analysis of biological yield. AGR is a simple measure of rate of increase in dry weight. In the present study, the AGR was minimum during early vegetative stage and increased with the onset of reproductive phase and again declined at harvest. All the genotypes recoraed (Table 2) minimum AGR values during 20-40 DAS at vegetative stage, while AGR values of all the genotypes increased during 80-100 DAS at reproductive stage. The genotype RHRGS-06083 recorded highest AGR in between 80-100 DAS (0.855 g day^{-1}). These results are in accordance with results of Patil (1992). RGR expresses the increase of dry weight in unit time interval with relation to initial dry weight. In the present study, it is seen that there was progressively decrease in RGR up to harvest.

Table 2. Growth parameters influenced by groundnut genotypes at various stages of growth.

Genotypes	AGR		RGR		NAR		LAI		LAR	
	60-80 days	80-100 days	60-80 days	80-100 days	60-80 days	80-100 days	60-80 days	80-100 days	60-80 days	80-100 days
SB-XI	0.497	0.707	0.013	0.011	0.016	0.015	5.184	8.450	0.839	0.718
JL-24	0.570	0.728	0.014	0.010	0.017	0.015	5.624	8.854	0.838	0.676
JL-220	0.456	0.710	0.012	0.010	0.018	0.015	5.324	8.264	0.882	0.719
JL-286	0.564	0.698	0.013	0.009	0.017	0.014	5.850	8.840	0.807	0.647
TPG-41	0.610	0.741	0.016	0.010	0.018	0.015	5.810	8.870	0.865	0.676
TAG-24	0.585	0.543	0.015	0.008	0.019	0.014	4.850	7.244	0.791	0.610
TG-26	0.584	0.409	0.016	0.007	0.020	0.012	4.260	6.490	0.726	0.620
AK-159	0.487	0.738	0.012	0.011	0.018	0.016	5.217	8.560	0.810	0.696
ICR-48	0.610	0.480	0.014	0.007	0.020	0.013	4.897	7.680	0.710	0.625
ICGS-11	0.530	0.807	0.014	0.012	0.017	0.012	5.134	8.327	0.848	0.682
ICGS-37	0.682	0.433	0.016	0.008	0.019	0.016	5.500	8.930	0.796	0.694
ICGV-86564	0.653	0.778	0.015	0.010	0.018	0.016	5.964	8.647	0.829	0.653
JL-501	0.628	0.747	0.015	0.010	0.021	0.018	4.637	7.630	0.706	0.559
RHRGB-21	0.631	0.595	0.015	0.008	0.021	0.015	4.600	7.140	0.695	0.537
RHRGB-06030	0.669	0.718	0.015	0.009	0.022	0.018	4.570	7.304	0.630	0.506
RHRGS-06080	0.676	0.839	0.015	0.010	0.019	0.017	5.774	8.676	0.798	0.588
RHRGS-06083	0.745	0.855	0.016	0.010	0.020	0.018	5.817	8.697	0.792	0.581
RHRGS-06097	0.637	0.496	0,016	0.007	0.019	0.011	5.254	8.047	0.842	0.659
S.E.±	0.011	0.002	0.001	0.002	0.001	0,002	0.128	0.326	0.047	0.041
CD at 5 %	0.031	0.006	N.S.	N.S.	N.S.	N.S.	0.385	0.981	0.140	0.122

The genotype ICGS-11 (0.012 g g^{-1} day^{-1}) recorded highest RGR in between 80-100 DAS. NAR is a major source of activity and efficiency of dry matter production. The rate of increase in dry weight per unit leaf area, assuming that both dry weight and leaf area increased exponentially. The NAR was increased at vegetative stages and declined drastically towards harvest. The genotypes, RHRGB-06030, RHRGB-06083 and JL-501 recorded highest NAR in between 80-100 DAS (0.018 g dm^{-2}). The results were in accordance with Pawar (2000). LAI is the useful parameter not only for dry matter production but also for predicting the efficiency of photosynthetic system. In the present investigation, LAI of all the genotypes increased significantly up to 100 DAS and declined thereafter. The genotype TPG-41 (8.870) recorded maximum LAI at 100 DAS. Rajmane (2001) reported similar results. LAR obviates the ratio of relative increments in leaf area and dry weight of the plants and helps in understanding the growth complex of plants. It also indicated 'the assumption of linear and quadratic form of functional relationship between dry weight and leaf area. In the present investigation, the LAR declined steadily with the advancing age of the crop. The genotypes JL 220 (0.719) and SB XI (0.718) recorded highest LAR at 100 DAS.

The chlorophyll content in leaves is considered as an important index for judging the rate of photosynthesis. The higher chlorophyll content is one of the important factors responsible for better yield. The genotypic differences in respect of chlorophyll-a, chlorophyll-b and total chlorophyll (mg g^{-1}) were statistically significant. The genotype JL-24 (0.594 mg g^{-1}) and TG-26 (0.491 mg g^{-1}) recorded highest and lowest chlorophyll 'a' content, respectively (Table 3). These findings support the observations reported by George and Nair (1990). Significantly highest chlorophyll-b content was recorded by the genotype RHRGS-06083 (0.489 mg g^{-1})

Table 3. Chlorophyll a, chlorophyll b, total chlorophyll, protein content and oil content in groundnut genotypes.

Genotype	Chl 'a' (mg g^{-1})	Chl 'b' (mg g^{-1})	Total Chl (mg g^{-1})	Protein content (%)	Oil content (%)
SB-XI	0.526	0.449	0.973	22.50	49.80
JL-24	0.594	0.486	1.080	25.80	49.30
JL-220	0.518	0.441	0.961	25.30	49.80
JL-286	0.523	0.458	0.980	25.00	49.20
TPG-41	0.522	0.480	1.012	23.90	48.10
TAG-24	0.504	0.448	0.952	23.70	48.70
TG-26	0.491	0.426	0.920	22.80	48.11
AK-159	0.530	0.473	1.005	24.10	50.50
ICR-48	0.560	0.462	1.024	24.10	48.90
ICGS-11	0.565	0.471	1.037	23.50	49.60
ICGS-37	0.529	0.469	1.000	23.90	49.60
ICGV-86564	0.494	0.434	0.930	23.70	48.12
JL-501	0.504	0.442	0.949	23.40	48.40
RHRGB-21	0.533	0.460	0.995	24.70	49.10
RHRGB-06030	0.495	0.419	0.917	25.30	49.00
RHRGS-06080	0.531	0.475	1.010	23.90	50.40
RHRGS-06083	0.543	0.489	1.034	24.70	49.50
RHRGS-06097	0.545	0.467	1.015	25.20	49.40
S.E.±	0.004	0.004	0.005	0.119	0.203
CD at 5 %	0.012	0.013	0.016	0.355	0.607

among all the genotypes except JL-24 (0.486 mg g^{-1}) and TPG-41 (0.480 mg g^{-1}). However, the genotype RHRGB-06030 (0.419 mg g^{-1}) recorded lowest chlorophyll-b content than other genotype. Significantly highest total chlorophyll content was recorded by the genotype JL-24 (1.080 mg g^{-1}), whereas, the genotype RHRGB-06030 (0.917 mg g^{-1}) recorded lowest total chlorophyll content.

The genotype JL-24 (25.80%) found significantly superior for protein content, while, the genotype SB-XI (22.50%) and TG-26 (22.80%) were inferior for protein content (Table 3). The genotypes, AK-159 (50.50%) was significantly superior for oil content over other genotypes except RHRGS-06080 (50.40%). These findings are in accordance with the results of Nelson and Carlos (1993), Yadav and Mishra (1994) and Taliwal *et al*. (1993).

In the present investigation, a wide range of variation was observed for days to 50 per cent flowering and days to maturity. The genotypes RHRGS-06083 (48 days) and TG-26 (37 days) required the maximum and minimum number of days for 50 per cent flowering, respectively. The days required for physiological maturity ranged between 115 and 133 days. The genotypes TG-26 and AK-159 showed earliness, while genotypes RHRGS-06080 and RHRGS-06083 showed late maturity period. It is interesting to note that the highest yielding genotype RHRGS-06083 required maximum days to 50 per cent flowering (48 days) and physiological maturity (133 days) resulted into maximum dry matter accumulation during vegetative phase and subsequently it's efficient partitioning during reproductive phase towards the development of economic parts of the plant and ultimately increasing the yield. Similar results were reported by Brar *et al*. (1999).

Plant height is basically a genetically

Table 4. Vegetative growth and source influenced by groundnut genotypes.

Genotypes	50% flowering	Physio-logical maturity	Plant height (cm)	Branches plant^{-1}	Leaves plant^{-1}	Leaf area (dm^2) plant^{-1}
SB-XI	41	120	34.8	6.3	62.50	25.36
JL-24	43	121	34.1	6.9	70.00	26.56
JL-220	47	129	28.2	6.7	61.50	24.79
JL-286	45	120	23.8	7.4	67.50	26.49
TPG-41	45	130	21.6	9.2	69.00	26.61
TAG-24	40	119	22.8	6.7	52.25	21.73
TG-26	37	115	14.4	6.7	50.50	19.47
AK-159	44	116	26.9	6.8	67.00	25.68
ICR-48	42	120	18.5	6.7	57.50	23.04
ICGS-11	44	129	19.4	6.8	62.00	24.98
ICGS-37	45	125	21.9	6.9	66.50	26.79
ICGV-86564	47	125	26.0	8.2	67.00	25.94
JL-501	41	120	20.2	7.1	50.75	22.89
RHRGB-21	43	118	21.3	6.5	47.50	21.42
RHRGB-06030	42	125	27.4	7.1	52.00	21.91
RHRGS-06080	47	131	27.6	9.2	71.50	26.02
RHRGS-06083	48	133	24.4	9.5	72.75	26.09
RHRGS-06097	43	125	20.9	9.4	65.00	24.14
S.E.±	0.752	0.786	2.63	0.75	0.571	0.015
CD at 5 %	2.243	2.345	7.85	2.26	1.703	0.045

controlled character and is being influenced by environmental conditions and genotypes. In the present study (Table 4) the genotypes, SB XI (34.8 cm) and JL 24 (34.1 cm) for plant height; RHRGS 06083 (9.5) and RHRGS 06097 (9.4) for number of branches plant^{-1}; RHRGS 06083 (72.75) and RHRGS 06080 (71.50) for number of leaves plant^{-1}; ICGS 37 (26.79 dm^2) and TPG 41 (26.61 dm^2) for leaf area were superior for respective characters.

From yield point of view, reproductive phase assumes significance as the sink lies in the reproductive part. The number of pods plant^{-1} is one of the important yields contributing character. In the present investigation, RHRGS-06083 (20.70), RHRGS-06080 (19.70) and RHRGB-06030 (18.90) produced higher number of pods plant^{-1} (Table 5). All the genotypes under investigation exhibited two kernels pod^{-1} except RHRGB-21. The genotypes TPG-41 (59.80 g) and ICGV-86564 (57.56 g) were found to be superior in respect of 100 kernel weight. RHRGB-06083 maintained higher dry pod yield plant^{-1} (24.85 g) and plot^{-1} (2.38 kg) followed by the genotypes RHRGS-06080 (23.86 g and 2.19 kg), JL 501 (23.74 g and 2.17 kg), TPG 41 (20.94 g and 1.93 kg) and RHRGS- 06030 (20.77 g and 2.00 kg).

Dry pod yield (q) hectare^{-1} exhibited considerable amount of variation among the genotypes under study. The significantly highest dry pod yield (55,05 q ha^{-1}) was recorded by the genotype RHRGS-06083, which was mainly due to higher number of pods plant^{-1}, number of kernels pod^{-1}, dry pod yield plant^{-1}, weight of 100 kernels and harvest index. These findings are on the similar lines to those reported by Mishra *et al*. (1991), Jadhav and Sengupta (1991) and Jayalakshmi *et al*. (2000).

The harvest index is the best indicator of

Table 5. Yield and yield contributing characters influenced by groundnut genotypes.

Genotypes	Pods plant^{-1}	Kernels pod^{-1}	Wt. of 100 kernel (g)	Dry pod yield (g) plant^{-1}	Dry pod yield (kg) plot^{-1}	Dry pod yield (q) ha^{-1}	Harvest index (%)
SB-XI	12.30	2.00	30.15	14.92	1.25	28.89	30.45
JL-24	17.70	2.00	38.10	18.17	1.52	35.19	34.85
JL-220	16.20	2.00	38.20	15.77	1.32	30.56	32.35
JL-286	16.70	2.00	40.25	17.62	1.47	34.12	35.15
TPG-41	17.20	2.00	59.80	20.94	1.93	44.60	38.20
TAG-24	17.70	2.00	42.10	19.39	1.78	41.30	43.30
TG-26	17.20	2.00	35.00	17.17	1.60	37.13	44.44
AK-159	15.70	2.00	34.05	19.97	1..42	32.87	35.24
ICR-48	17.70	2.00	45.60	16.39	1.37	43.43	37.77
ICGS-11	15.50	2.00	44.00	16.57	1.38	32.08	32.12
ICGS-37	16.30	2.00	37.25	16.11	1.52	35.11	37.55
ICGV-86564	17.00	2.00	57.56	22.65	2.08	48.25	41.00
JL-501	18.70	2.00	50.60	23.74	2.17	50.61	44.81
RHRGB-21	18.70	2.00	38.00	19.00	2.03	46.85	40.35
RHRGB-06030	18.90	2.00	44.10	20.77	2.00	46.36	37.83
RHRGS-06080	19.70	2.00	45.05	23.86	2.19	50.83	41.60
RHRGS-06083	20.70	2.00	40.15	24.85	2.38	55.05	40.84
RHRGS-06097	17.00	2.00	33.75	16.93	1.74	40.32	39.35
S.E.±	0.039	0.118	0.383	0.083	0.056	0.092	0.051
CD at 5 %	0.118	N.S.	1.147	0.128	0.165	0.275	0.152

photosynthetic translocation efficiency and considered as one of the criteria for selection of high yielding genotypes. The genotype JL-501 maintained highest (44.81%) harvest index, indicating the better translocation efficiency. These results are in accordance with Uddin *et al*. (1999) and Jayalakshmi *et al*. (2000).

From the results obtained in the present investigation, it was concluded that the morphological characters *viz*., plant height, number of branches, number of leaves and leaf area mainly responsible for growth in groundnut. The genotypes with the highest efficiency of dry matter partitioning towards pods resulted into the highest pod yield. Thus, the dry matter production, partitioning and its diversion towards reproductive organ are the main dominating yield contributing characters in groundnut. Total dry matter plant^{-1}, number of pods plant^{-1}, dry pod yield plant^{-1}, 100 kernel weight and harvest index are main yield contributing characters in groundnut.

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Genetic Diversity Studies in Jatropha (*Jatropha curcas* L.)

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Abstract

The D^2 values in 30 genotypes of jatropha ranged between 3.41 to 93.45 indicating, the presence of considerable amount of genetic diversity. All the 30 genotypes evaluated were grouped into 6 clusters in which cluster I and II were largest with 12 genotypes each followed by cluster III with 3 genotypes and cluster IV, V, and VI were solitary in nature. The maximum intra-cluster distance were exhibited by genotypes of cluster II suggesting that genotypes present in these cluster possessing varied genetic architecture. The maximum inter-cluster distance was observed between clusters I and II suggesting that the genetic architecture of the genotypes in one cluster differ entirely from genotypes including in other clusters. Based on variance of cluster mean the character seed yield plant^{-1} contributed maximum divergence followed by oil content, number of secondary branches plant^{-1} and number of clusters plant^{-1}. On the basis of intra-cluster distance, cluster mean and *per se* performance, genotypes *viz*.; RY-117, TNMC-22, Bilaspur-1 and Kalyanpur can be used in future breeding programme.

Key words : Divergence, intra and inter cluster, solitary, jatropha.

The genus Jatropha belongs to tribe Joannesieae of Crotonidae in the Euphorbiaceae family and contains approximately 170 known spp. Plant species which can be used to provide diesel fuel substitute have captured the interest of scientists more in arid and semi-arid regions than in temperate zone. It adapts well to semiarid marginal sites and oil can be processed for use as a diesel fuel substitute. Diverse parents in jatropha are expected to yield higher frequency of heterotic hybrids. D^2 statistic is useful multivariate statistical tool for effective discrimination among various genotypes (Murty and Arunachalam, 1966). The present investigation were carried out to study the nature of extent and pattern of variation existing in different populations of jatropha cultivars.

Materials and Methods

In the present investigation, 30 diverse genotypes of jatropha collected from different locations at All India Co-ordinated Research Project, MPKV, Rahuri, were evaluated to assess the amount of genetic variability. The experiment was laid out in a randomized block design with three replications during *kharif*, 2010. The trees were planted at the distance of 3 x 3 m. The plot size was 12 x 9 m for gross and 6 x 3 m for net. Randomly selected five plants from each plot were utilized to record observations on plant height (cm), collar diameter of the plant (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, Number of clusters plant^{-1}, number of fruits plant^{-1}, 100-seed weight (g), shelling percentage, oil content (%), seed yield plant^{-1} (g). D^2 analysis as described by Mahalanobis (1936) was utilized to assess the genetic diversity among thirty genotypes and Tochers' method was employed for grouping

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the genotypes into different clusters as described by Rao (1952).

Results and Discussion

Analysis of variance revealed that the genotypes varied significantly for all the characters studied, indicating the wide range of variability available in the germplasm. On the basis of D^2 values, 30 genotypes were grouped into 6 clusters (Table 1). Clusters I and II had the largest number of genotypes (12) followed by cluster III with 3 genotypes, while remaining all clusters possessed one genotype in each, cluster I and II with 12 genotypes indicated that majority of genotypes under study had narrow genetic diversity among them. The similarity in the base population from which they had been evolved might be the cause of genetic uniformity. However, the unidirectional selection potential for one particular trait or a group of linked traits in several places may produce similar phenotypes which can be aggregated into one cluster irrespective of their geographic origin. Das *et al*., (2008) also reported clustering in jatropha. Anjani *et al*., (2002) studied 89 accessions and grouped them into six clusters.

The maximum intra cluster distance was observed in cluster II (D^2 = 11.47) followed by cluster I (D^2 = 9.79), suggesting that genotypes included in these clusters might have different genetical architecture (Table 2). However, the lowest intra cluster value was observed in cluster III (D^2 = 2.62) indicating that the strains of these clusters resembled one another genetically and from common gene pool.

The inter-cluster distance between the V and VI (D^2 = 13.02), cluster I and III (D^2 = 14.89) and cluster II and IV (D^2 = 16.16) was comparatively low suggesting that the genetic constitution of the genotypes in one cluster were in close proximity with the genotypes in other cluster of the pair (Table 2). The highest inter-cluster distance was observed between genotypes of cluster cluster I and II (D^2 = 51.98) followed by cluster I and VI (D^2 = 51.69), cluster I and IV (D^2 = 45.96) and cluster IV and VI (D^2 = 45.15). These clusters are quite divergent from each other and the genotypes belonging to them can be used for hybridization programme because crosses between genotypes belonging to the clusters having maximum inter cluster distance, will give

Table 1. Distribution of 30 Jatropha genotypes into different clusters.

Cluster no.	No. of genotype	Genotypes
I	12	Raipur-1, Raipur-2, TFRI-2, Baramunda, RJ-117, Indore-1, Indore-2, Chandua, Mancheshwar, TFRI-4, TFRI-3, TFRI- 1 ,
II	12	Bilaspur-1, Bilaspur-2, PKVJ-AKT-1, PKVJ-DHW-1, Sagar, TNMC-5, TNMC-7, RJ-124, TNMC-2, TNMC-3, PJ-Sel-1, NOVODB
III	3	Kalyanpur, PKVJ-Sel-1, PKVJ-MKU-1
IV	1	PJ-Sel-2
V	1	TNMC-22
VI	1	Ambikapur

Table 2. Average intra and inter cluster D^2 values from 30 genotypes of Jatropha.

Clusters	C_1	C_2	C_3	C_4	C_5	C_6
C1	9.79 (3.13)	51.98 (7.21)	14.89 (3.86)	45.96 (6.78)	36.48 (6.04)	51.69 (7.19)
C2		11.42 (3.38)	32.49 (5.70)	16.16 (4.02)	22.46 (4.74)	21.25 (4.61)
C3			6.86 (2.62)	41.47 (6.44)	21.99 (4.69)	23.04 (4.80)
C4				0.00 (0.00)	25.70 (5.07)	45.15 (6.72)
C5					0.00 (0.00)	13.02 (3.61)
C6						0.00 (0.00)

Figures in brackets indicates D value

Table 3. Cluster mean performance for 10 characters in Jatropha.

Cluster no.	Plant height (cm)	Collar diameter (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Clusters plant^{-1}	Fruits plant^{-1}	100 seed weight (g)	Shelling per-centage	Oil content (%)	Seed yield plant^{-1} (g)
I	238.92	9.73	11.44	64.11	14.83	30.03	56.30	36.14	28.60	81.35
II	213.17	9.24	11.22	39.11	12.31	24.06	56.27	36.14	25.12	76.94
III	228.33	9.47	11.00	56.67	13.33	27.44	53.90	35.52	20.01	81.04
IV	218.33	9.73	11.67	38.83	10.67	24.67	55.57	32.38	37.00	73.71
V	186.33	8.60	15.33	43.67	13.00	25.00	53.33	31.87	23.43	68.30
VI	205.33	7.85	13.33	42.00	13.33	26.00	55.60	38.21	13.37	71.00

high heterotic response and yield better recombinants (Bhatt, 1970).

Cluster means for different characters indicated that none of the clusters contained genotype with all the desirable characters and so recombinant breeding between genotypes of different clusters is needed (Table 3). Cluster I with 12 genotypes recorded highest seed yield plant^{-1}, plant height, collar diameter, number of secondary branches plant^{-1}, number of fruits plant^{-1} and number of clusters plant^{-1}. All these characters appeared to have played an important role in determining the seed yield per plant in jatropha. Cluster II with maximum number of genotypes recorded more plant height, 100-seed weight and shelling percentage. Clusters IV, V and VI being monogenotypic recorded lower seed yield plant^{-1}, plant height, collar diameter, number of clusters plant^{-1} and number of fruits plant^{-1}. The results on the contribution of individual traits towards total divergence (Table-4) suggested that the character seed yield plant^{-1} (45.29%) contributed the highest for divergence, followed by oil content (24.60%), number of secondary branches plant^{-1} (22.76%) and number of clusters per plant (3.45%). However, the contribution of shelling percentage, number of primary branches plant^{-1} (0.46%), number of fruits plant^{-1} (0.69%), plant height (0.92%) and 100-seed weight (1.38%) was of low magnitude. The character collar diameter contributed zero per cent for divergence. Results obtained by earlier workers and in present study varied substantially which may be due to environment and dissimilarly of material under study as suggested by Bains and Sood (1984).

The hybridization among genetically diverse parental genotypes for specific trait may be helpful in bringing the new gene pool in population and expanding the range of adaptation. Hence, from the present study, the genotypes RJ-117, TNMC-22, Bilaspur-1 and Kalyanpur were identified as best performers and suggested for hybridization in jatropha..

Table 4. Contribution of various characters to divergence.

Characters	Per cent contribution
Plant height (cm)	0.92
Collar diameter (cm)	0.00
Primary branches plant^{-1}	0.46
Secondary branches plant^{-1}	22.76
Cluster plant^{-1}	3.45
Fruits plant^{-1}	0.69
100 seed weight (g)	1.38
Shelling percentage	0.46
Oil content (%)	24.60
Seed yield plant^{-1} (g)	45.29
Total	100.00

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Heterosis and Combining Ability in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.)]

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Abstract

Among the hybrids produced from 4 x 10 line x tester crossing programme, maximum positive standard heterosis for grain yield ha^{-1} over hybrid check, Shanti was observed in DHLB-18A x S-11/775 (65.62%) followed by RJJRB-13A x S-10/222 (54.52%) and DHLB-15A x S-10/222 (51.39%). Among the hybrids with positive significant SCA effects for grain yield, the frequency of good x average combiner was more. Among the top ten hybrids both the parents of five hybrids were found to be good general combiners. Three lines *viz*., DHLB-15A, DHLB-18A and RHRB-13A and males S-11/775 and S-10/222 gave top yielding hybrid combinations. Three hybrids *viz*., DHLB-18A x S-1 1/775, RHRB-13A x S-10/222, DHLB-15A x S-10/222 exhibited significant favorable heterobeltiosis, standard heterosis, GCA and SCA effects for yield and most of the related traits.

Key words : Heterosis, combining ability, cytoplasmic sources, GCA, SCA effects.

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is a highly cross-pollinated crop with protogynous flowering and wind borne pollination mechanism, which fulfills one of the essential biological requirements for hybrid development. India is a major producer of pearl millet both in terms of area (9.43 million ha) and production (8.01 million tonn), with an average productivity of 850 kg ha^{-1} (Anonymous, 2010). The quantum jump (from 303 to 850 kg ha^{-1}) in the productivity of pearl millet was possible mainly through development of hybrids by the utilization of cytoplasmic genetic male sterility system. Burton (1958) was the first to develop cytoplasmic male sterile line Tift 23A bred at Tifton, Georgia, USA.

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The improvement in pearl millet needs attention for the characters like early flowering, grain yield plant^{-1}, grain yield ha^{-1}, earhead length and girth, protein content and number of tillers plant^{-1}. Keeping these things in view, the present study was planned, to estimate the heterosis for yield and its components and to estimate the general and specific combining ability of parents and hybrids, respectively.

Materials and Methods

Fourty crosses were made following line x tester mating design using four CMS lines and ten males by hand pollination at Bajra Research Scheme, College of Agriculture, Dhule, during summer 2011. The fourty F_1s alongwith their parents were evaluated in a randomized block design, with three replications at Dhule, in plot of two rows of 4.5 m length spaced at 50 cm apart and 15 cm distance within rows during *kharif*, 2011. All the agronomical practices and plant protection measures were followed as per recommendation. The observations were recorded on five randomly selected plants in each replications for 40 hybrids, their respective parents and two hybrids checks *viz*., Sraddha (SC-I) and Shanti (SC-II) on eleven characters *viz*., days to 50 per cent flowering, days to maturity, plant height, number of effective tillers plant^{-1}, ear head length, ear head girth, grain yield ha^{-1}, fodder yield plant^{-1}, 1000-seed weight, number of grains cm^{-2} and protein content (%). For estimation of general and specific combining ability variances the line x tester analysis as outlined by Kempthorne (1957) was followed.

Results and Discussion

The cross DHLB-15A x S-10/206 recorded maximum negative heterosis over standard check Shraddha (-8.89%) and Shanti (-14.58%) for days to 50 per cent flowering. The cross combination DHLB-14A x S-10/227 and DHLB-18A x S-10/201 also recorded negative heterosis over standard checks. The standard heterosis over checks for days to 50 per cent flowering was ranged from -14.58 (DHLB-15A x S-10/201) to 6.25 per cent (RHRB-13A x DHLBI-1008). This will be helpful to isolate early genotypes. Significant negative heterosis for days to 50 per cent flowering in hybrid have also been reported by Kulkarni *et al*., (1993),

Table 1. Range of standard heterosis for yield, its components and number of hybrids exhibiting significant heterosis in pearl millet.

Characters	Range %	SE I	No. of hybrids showing desirable significant heterosis over			
			MP	BP	Shradha	Shanti
Days to 50% flowering	-14.5 8 to 6.25	1.55	13	1	-	3
Days to maturity	-7.32 to 1.22	0.85	26	-	-	23
Plant height (cm)	-17.07 to 1.58	2.79	-	2	25	19
Effective tillers plant^{-1}	-27.78 to 33.33	0.14	13	4	20	2
Ear head length (cm)	1.49 to 23. 76	0.33	35	20	34	37
Ear head girth (cm)	-10.19to 11.11	0.27	25	13	15	2
Grain yield ha^{-1} (q)	-36.57 to 65.62	18.26	34	32	24	13
Fodder yield plant^{-1} (g)	-48.33 to 34.32	0.93	36	32	23	6
1000 grain weight	-4.55 to 23.64	0.25	31	19	16	18
Grains cm^{-2}	-15.52 to 24.83	0.74	2	1	35	6
Protein content (%)	-39.24 to 50. 11	0.320	24	14	25	19

MP-Mid parent, BP-Better parent.

Chavan and Nerkar (1994), Patil *et al*., (1994) and Pachade (2006).

The standard heterosis over checks for days to maturity was ranged from -7.32 to 1.22 (Table 1) for days to maturity. The hybrids showing higher magnitude of heterosis in desirable direction for this trait were DHLB-14A x S-10/227, DHLB-15A x DHLBI-1008 and DHLB-15A x S-10/230. Similar results were observed by Kulkarni *et al.*, (1993), Dass (1994) and Chavan and Nerkar (1994). Among 40 hybrids three hybrids *viz*., RHRB-13A x DHLBI-1008, RHRB-13A x S-10/219 and

Table 2. Three best performing cross combinations, their GCA, SCA effects, heterobeltiosis and standard heterosis for various traits in pearl millet.

Characters	Best performing hybrids	GCA effects	SCA effects	Hetero-beltiosis (%)	Standard heterosis over checks	
					Shraddha	Shanti
		P_1 P_2				
Days to 50 % flowering	DHLB-15AxS-10/206	A x G	-2.30	-14.58**	-8.89	-14.58**
	DHLB-14A x S- 10/227	A x A	-2.35	-8.51	-4.44	-10.42*
	DHLB-18AxS-10/201	A x G	-2.00	-8.33	-2.22	-8.33
Days to maturity	DHLB-14AxS-l 0/227	A x A	-1.35	-3.80	-1.30	-7.32**
	DHLB-15A x DHLBI-1008	A x A	-1.85*	-3.75	0.00	-6.10**
	DHLB-15AxS-10/230	A x A	-1.10	-2.50	1.30	-4.88*
Plant height (cm)	RHRB-13A x DHLBI-1008	G x A	-9.06*	10.63*	-18.44**	-16.41**
	RHRB-13A x S-10/219	G x A	-6.64	14.26**	-15.77**	-13.67**
	DHLB-15AxS-10/216	A x A	-11.73*	17.98**	-11.50**	-9.30**
Effective tillers plant^{-1}	DHLB-15AxS-10/216	A x A	0.28	50.00**	71.43**	33.33*
	DHLB-15Ax S-10/219	A x A	0.23	37.50*	57.14**	22.22
	DHLB-18AxS-l 1/775	A x A	0.39	40.00*	50.00*	16.67
Ear head length (cm)	RHRB-13AxS- 10/201	A x A	1.48**	8.77**	16.98**	22.77**
	DHLB-18AxS-l 1/775	A x A	1.12*	11.71**	16.98**	22.77**
	DHLB-14AxS- 10/230	A x P	1.56**	15.09**	15.09**	20.79**
Ear head girth (cm)	DHLB-14A x DHLBI-967	P x A	0.27	1.79	11.76*	5.56
	DHLB-15Ax S-10/219	A x A	0.25	18.95**	10.78*	4.63
	DHLB-18AxS-l 1/775	A x A	0.41	7.84	7.84	1.85
Grain yield ha^{-1} (q)	DHLB-18AxS-l 1/775	G x A	17.05**	144.62**	113.17**	65.62**
	DHLB-13AxS-10/222	A x G	5.84*	134.73**	98.88**	54.52**
	DHLB-15AxS-10/222	Gx G	2.73*	130.03**	94.85**	51.39**
Fodder yield plant^{-1} (g)	DHLB-18AxS-l 1/775	G x A	24.85**	128.51**	94.69**	31.88**
	DHLB-lSAx S-10/219	G x G	15.97**	163.69**	84.63**	25.06**
	RHRB-13AxS-10/201	A x P	22.87**	114.08**	41.37**	-4.24
1000 grain weight	RHRB-13AxS-10/216	P x A	1.22**	34.69**	17.86**	20.00**
	DHLB-14AxS- 10/230	A x A	0.90*	20.95**	13.39**	15.45**
	RHRB-13AxS-10/201	P x P	0.77	11.11*	7.14	9.09
Grains cm^{-2}	DHLB-18AxS-10/222	G x G	1.33	11.73*	49.59**	24.83**
	DHLB-14AxS-10/216	P x A	1.60*	-4.69	26.03**	5.17
	RHRB-13A x DHLBI-1008	A x P	1.52*	1.69	24.38**	3.79
Protein content (%)	DHLB-lSAx S-10/219	G x G	3.07**	14.69**	69.51**	50.11**
	DHLB-14AxS-l 1/775	G x G	2.66**	22.63**	57.69**	39.64**
	DHLB-15AxS-10/201	G x P	3.13**	1.08	49.39**	32.29**

*,** Significant at 5 and 1 per cent probability levels, respectively, G = Good parent having significant GCA effect in desired direction, A = Average parent having either positive or negative but non-significant GCA effect, P = Poor parent having significant GCA effects in undesired direction, P_1 = First parent and P_2 = Second parent.

DHLB-15A x S-10/216 exhibited significantly positive standard heterosis in desirable direction for plant height. The cross DHLB-13A x DHLBI-1008 recorded maximum negative heterosis for plant height over standard check Shraddha (-18.44%) and Shanti (-16.41%). These results are in agreement with those of Chavan and Nerkar (1994), Patil *et al.* (1994) and Patel *et al.* (2008).

Effective tillers plant^{-1} is one of the important yield attributes and positive heterosis is desirable for it. The hybrids DHLB-15A x S-10/216, DHLB-15A x S-10/219 and DHLB-18A x S-11/775 were the significantly high heterotic combinations for number of effective tillers plant^{-1}. Similar results were reported by Kulkarni *et al.* (1993), Pachade (2006) and Davda *et al.* (2008).

For earhead length standard heterosis was ranged from 1.49 to 23.76 per cent. The maximum significant standard heterosis for earhead length was recorded by RHRB- 13A x S-10/201 over standard check Shraddha (16.98%) and Shanti (22.77%), followed by DHLB-18A x S-11/775 and DHLB-14A x S-10/230. These results are in agreement with

Table 3. Performance of the hybrids in relation to *per se* values, heterosis and combining ability for grain yield ha^{-1} (q) and other characters.

Hybrids	*Per se* values for grain yield (q ha^{-1})	Desirable heterosis for grain yield (q ha^{-1})		SCA effects for grain yield (q ha^{-1})	GCA combination for grain yield (q ha^{-1})	Useful and significant for components traits hetrobeltiosis
		SC (%) (Shanti)	BP (%)			
DHLS-18A x S-11/775	58.59	65.62**	144.62**	17.05**	GxA	ET.EHL, GY/ha, FY/P, 1000 GW
RHRB-13A x S-10/222	54.67	54.52**	134.73**	5.84*	AxG	EHL,GY/ha, FY/P, 1000 GW
DHLB-15A x S-10/222	53.56	51.39**	130.03**	2.73	GxG	EHL, EHG, GY/ha, FY/P, 1000 GW
DHLB-18A x S-10/219	49.89	41.02**	131.98**	7.69**	GxA	EHL, EHG, GY/ha, FY/P, 1000 GW, PC%
DHLB-15A x DHLBI-967	49.33	39.45**	95.61**	2.78	GxG	EHL, GY/ha, FY/P, 1000GW
DHLB-15A x S-10/227	48.22	36.31**	112.53**	2.50	GxG	EHL, EHG, GY/ha, FY/P, 1000 GW
DHLB-18A x S-10/216	48.00	35.68**	125.96**	5.21*	GxG	ET, EHL, EHG, GY/ha, FY/P, 1000 GW, PC %
DHLB-15A x S-10/219	47.78	35.06**	110.59**	5.42**	GxA	ET, EHL, EHG, GY/ha, FY/P, 1000 GW, PC %
DHLB-14A x DHLBI-967	45.78	29.40**	81.52**	7.49**	PxG	GY/ha, FY/P, PC %
RHRB-13A x S-10/227	45.33	28.14**	105.66**	1.62	AxG	EHL, EHG, GY/ha, FY/P

*,** Significant at 5 and 1 per cent probability levels, respectively, G = Good parent having significant GCA effect in desired direction, A = Average parent having either positive or negative but non-significant GCA effect, P = Poor parent having significant GCA effects in undesired direction.

DAF : Days to 50 per cent flowering
PLH : Plant height (cm)
ELH : Earhead length (cm)
GY/ha : Grain yield ha^{-1} (q)
1000 GW : 1000 grain weight (g)
PC % : Protein content (%)
DAM : Days to maturity
ET : Number of effective tillers plant^{-1}
EHG : Earhead girth (cm)
FY/P : Fodder yield plant^{-1} (g)
No. G/CM^2 : Number of grains cm^{-2}

those of Hapse *et al*. (1986) and Chavan and Nerkar (1994).

The maximum positive standard heterosis for earhead girth over hybrid check Shraddha was observed in DHLB-14A x DHLBI-967 (11.76%) followed by DHLB-15A x S-10/219 (10.78%). Bhamre (1986) and Chavan and Nerkar (1994) also found varied range of heterosis for earhead girth.

The hybrids having significant heterosis for grain yield ha^{-1} also had significant heterosis for one or more other characters. The hybrid DHLB-18A x S-11/775 (65.62%) and RHRB-13A x S-10/222 (54.52% over hybrid check Shanti) showed high percentage of heterosis. These, results are in agreement with those of Patil *et al*. (1994), Vaghashiya *et al*. (2009) and Vagadiya *et al*. (2010).

The range of standard heterosis for fodder yield $plant^{-1}$ (g) was -48.33 (DHLB-14A x S-10/201) to 34.32 (DHLB-15A x S-10/201) over check Shanti. The maximum positive standard heterosis for fodder yield $plant^{-1}$ (g) recorded by DHLB-18A x S-11/775 over standard check Shraddha (94.69%) and Shanti (31.88%). The maximum positive standard heterosis was recorded for 1000-grain weight by the hybrid RHRB-13A x S-10/216 over hybrid check Shraddha (17.86%) and Shanti (20.00%) followed by DHLB-14A x S-10/230.

The range of standard heterosis for number of grains cm^{-2} was ranged from -15.52 (DHLB-14A x DHLBI-1008) to 24.83 (DHLB-18A x S-10/222) over hybrid Shanti. The maximum heterosis for number of grains cm^{-2} was recorded by DHLB-18A x S-10/222 over standard check Shraddha (49.59 %) and Shanti (24.83%). For protein content the maximum positive significant standard heterosis was recorded in hybrids DHLB-15A x S-10/219, DHLB-14-A x S-11/775 and DHLB-15A x S-10/201 over standard check Shraddha and Shanti. Pachade (2006) reported similar results for crude protein content.

Hybrids with positive and significant SCA effects (Table 2) for grain yield were produced by almost all type of parental combinations (good x good, good x average, good x poor, average x good, average x average, poor x poor). The crosses with high SCA effects were in general combinations of parents with good x good, good x poor and good x average or average x poor GCA effects. This was represented in best three hybrids for grain yield ha^{-1} *viz*., DHLB-18A x S-11/775 (good x average) and DHLB-13A x S-10/222 (average x good) and RHRB-15A x S-10/222 (good x good) had significant desired SCA effects and significant heterotic response over better parent as well as the two standard checks. The frequency of good x average was more. Among top 10 hybrids in five hybrids *viz*., DHLB-18A x S-11/775, RHRB-13A X S-10/222, DHLB-15A x S-10/222, DHLB-18A x S-l0/219 and DHLB-15A x DHLBI-967 one of their parent found to be good general combiner (Table 3). Hapse (1989) and Rasal (1992) reported presence of at least one or average general combiner for high SCA effects in most of the traits.

The high yield potential in cross combination (high x low) might be attributed due to good combiner while heterosis involved in high x high combiners involved interaction between positive x positive effects. In the present study, low x low combinations also produced by hybrids with high SCA and this can be attributed due to over dominance or epistasis. In present investigation the performance of hybrids *viz*., DHLB-18A x S-11/775, RHRB-13A x S-10/222 and DHLB-15A x S-10/222 recorded more than 50 per cent heterosis over both hybrids standard checks Shraddha and Shanti and showed positive significant SCA effects for grain yield

ha^{-1}, therefore, these combinations are economically viable to exploit commercially. Similar results were reported by Unnikrishnan *et al*. (2004) and Sushir *et al*. (2005).

Among the female parents DHLB-18A, DHLB-15A and RHRB-13A and among male parents S-11/775, S-10/222 and DHLBI-967 gave top yielding hybrid combinations. In the present study, among top ten hybrid combinations three hybrids *viz*., DHLB-18A x S-11/775, RHRB-13A x S-10/222 and DHLB-15A x S-10/222 exhibited significant favorable standard heterosis, GCA and SCA effects for grain yield and most of the components and quality traits, could be utilized for commercial cultivation after extensive testing in state and national triats.

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A Late Duration Rice Hybrid Sahyadri - 5 for Maharashtra State

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Abstract

Sahyadri-5 is a high yielding rice hybrid derived through three line breeding (CMS system) from a cross between RTN-13A and RTN-5R. It matures in 140-145 days (late in duration), midtall stature (115-120 cm plant height), long slender and transluscent kernel type with average yield of 7.0 to 7.5 t ha^{-1}. It has good milling (71.8 %) and head rice recovery (62.90%). It recorded consistent increase in grain yield over the popular checks in almost all the trials conducted during the year 2006 to 2010 in varied agro-ecological conditions in the state and country indicating it's stability in yield performance. The rice hybrid Sahyadri-5 observed to have multiple resistant to major diseases and insect pests at endemic sites. In view of above characteristics, the rice hybrid Sahyadri-5 (RTNRH-10) was recommended to release for commercial cultivation in the state of Maharashtra in the year 2011.

Key words : Sahyadri-5, resistance, yield, quality.

The rice hybrids are getting popularity among the farmers, in view of it's higher yield potential over conventional rice varieties (SPV's) in the state and country (Ingale *et al*., 2004). The area under hybrid rice is increasing gradually in the state. However, nearly 20 per cent of total rice area is under late duration rice varieties in the state. It indicates the requirement of late duration rice hybrids for commercial cultivation in the state to bring more area under rice hybrids and increase rice productivity in the state. Therefore, the efforts were made to evolve suitable late duration rice hybrid along with high yielding, good milling and cooking quality, resistance to major diseases and insect pests.

Materials and Methods

The test crosses between stable CMS A lines and identified respective R lines were effected at Agricultural Research Station, Shirgaon (Ratnagiri) during the year 2004. The test crosses were evaluated for its fertility restoration during subsequent season and confirmed it's fertility restoration in retest crosses evaluation. The seed production of promising cross combination were undertaken based on its vigour, spikelet fertility and grain yields during *rabi* 2005-06. Among the various cross combinations RTN13A x RTN-5R was observed superior on the basis of vigour and grain yields and was tested in station, state and national coordinated trials in subsequent year along with the checks at various locations in a randomized block design.

The statistical analysis of yield data of all the trials were done according to Panse and Sukhatme (1978). The rice hybrid was evaluated for its cultural packages in agronomical trial at the research station during *kharif*-2008 and tested on farmers fields in adaptive trials in the state during *kharif*-2008 and 2009. Simultaneously the grain quality

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analysis was done at Directorate of Rice Research, Hyderabad for necessary quality traits. The rice hybrid was evaluated for its reaction to various insect pests and diseases at endemic sites during 2006 and 2007 at state screening nursery and during *kharif* 2010 in national screening nurseries. Based on yield performance, reaction to major insect pests and diseases and requisite kernel qualities; the rice hybrid RTNRH-10 was recommended for release as Sahydri-5 during the year 2011.

Results and Discussion

Sahyadri-5 (IET-20884) is late in duration (140-145 days), mid tall (115-120 cm), non-lodging, non-shattering rice hybrid having high yield potential (7.0 to 7.5 t ha^{-1}). It is long slender hybrid with 26.20 g test weight. It exhibited higher hulling (81.0%), milling per cent (71.8%) and head rice recovery (62.9%) with intermediate amylose content (24.18%) and alkali spreading value (4.0), having volume expansion ratio (5.0), water uptake (440 ml), elongation ratio (1.6%) and 65 mm gel consistency. It is non scented with long slender grain type (kernel length 6.34 mm, breadth 2.0 mm and LB ratio 3.17) rice hybrid suitable for cooked rice, parched rice, beaten rice, puffed rice, idly, dosa etc. preparations (Table-1). It has good milling quality, cooking quality, intermediate amylose content as compare to earlier Sahyadri rice hybrids (Anonymous 2011a).

Sahyadri-5 (7567 kg ha^{-1}) recorded 62.66 and 54.09 per cent higher grain yield over the best variety check Karjat-2 and hybrid check Sahyadri-3 in observational yield trial, respectively conducted at station during *kharif* 2006. Sahyadri-5 (6899 kg ha^{-1}) rice hybrid given 65.68 and 30.83 per cent increased in grain yield above the best variety check Karjat-2 and Sahyadri-3 hybrid check, respectively in station trial conducted during *kharif*-2007. Sahyadri-5 (5831 and 6118 kg ha^{-1}) rice hybrid recorded 49.28 and 29.06 per cent higher grain yield while it has given 17.20 and 26.85 per cent higher grain yield over best variety check Karjat-2 and hybrid check Sahyadri-3 in state co-ordinated trials conducted at 9 locations during *kharif* 2006 and 2007, respectively (Table 2).

Sahyadri-5 (RTNTH-10) was tested in All India Co ordinated Shallow Low Land Hybrid Rice Trial (AICRIP-SLHRT) as IET -20884 at

Table 1. Salient features of Sahyadri-5 rice hybrid (RTNRH-10).

Characters salient features	Particulars
Duration (Days)	140-145
Plant height (cm)	115-120
Average yield (t ha^{-1})	7.0 to 7.5
Straw yield (t ha^{-1})	7.5 to 8.0
(Potential)	
Harvest index (%)	46.66
Number of tillers $hill^{-1}$	15-20
Grains $panicle^{-1}$	200-225
Length of panicle (cm)	27.5
Plant type	Compact
Panicle exertion	Well exerted
Awns	Absent
Grain qualities- Hulling %	81.0
Milling (%)	71.8
Head rice recovery (%)	62.9
Kernel length (mm)	6.34
Kernel breath (mm)	2.0
Length and breath ratio	3.17
Alkali spreading value	4.0
Volume expansion ratio	5.0
Kernel length after cooking KLAC (mm)	10.70
Elongation ratio ER (mm)	1.6
Test weight (g)	26.20
Amylose content (%)	24.71
Gel consistency (mm)	65.0
Water uptake	440 ml
Grain type	Long slender
Grain chalkness	VOC
Aroma	Non scented
Test quality after cooking	Good (6.0)

Table 2. Average yield performance of Sahyadri-5 (RTNRH-10) rice hybrid in various trials during the year 2006 to 2010.

Particulars (Season/year)	Season and year	Average yield (kg ha^{-1})			Per cent increase over check	
		Sahyadri -5	Karjat-2 (HYV.CH)	Sahyadri-3 (HY.CH)	Karjat-2 (HYV.CH)	Sahyadri-3 (HY.CH)
Observational yield trial	*Kharif*-2006	7567**++	4652	4911	62.66	54.09
Station trial	*Kharif*-2007	6899**++	4164	5273	65.68	30.83
State co-ordinated trials	*Kharif*-2006	5831**++	3906	4518	49.28	29.06
State co-ordinated trials	*Kharif*-2007	6118**++	5220	4823	17.20	26.85
AlCRIP-Rice SLHRT trials (National trial)	*Kharif*-2067	3616@	3112 (Sashi)	-	15.45 (Sashi)	-
Agronomical trial	*Kharif*-2008	5320**	3420	5246	55.56	-
Adaptive trials in farmer's fields (19 nos.)	*Kharif*-2008	5052**	3682	-	37.21	-
Adaptive trials in farmer's fields (36 nos.)	*Kharif*-2009	5120*+	3739	4838	27.8	12.9
Demonstration	*Kharif*-2010	7589**+	4120	6665	84.20	13.86
Mean		5901.33	4001.67	5182.00	47.47	13.88

*, 5 % and **, 1 % level of Significant over best variety check Karjat-2, +, 5 % and ++, 1 % level of significant over best hybrid check Sahyadri-3 and @, 5 % and @@, 1 % level of significant over best regional check Sashi)

Table 3. Packages for large scale seed production of Sahyadri-5 (RTNRH-10) rice hybrid.

Particulars	Female parent	Male parent
Parents	RTN-13A	RTN-5R
50 % flowering at Ratnagiri location	*Kharif*- 90-100 days *Rabi*- 115-120 days	*Kharif*- 110-115 days *Rabi*- 115-120 days
Duration (days)	*Kharif*- 120-130 *Rabi*-145-150	*Kharif*- 140-145 *Rabi*- 145-150
Sowing	*Kharif* : 15 days later than 1st sowing of R line	*Kharif*: R-1 1st day sowing R_2 6th day of 1st sowing R_3 11th day of 1st sowing
	Rabi : A line sowing 3 days earlier than 1st sowing of R line	*Rabi*: 3 days later than A line (First sowing of R line and two sowing after 1st sowing with 5 days interval)
Planting	25 days old seedlings	30 days old seedlings
Rows	6	2
Spacing (cm)	15 x 15	20 x 15
Seedling hill^{-1}	One	One
Seed rate in the nursery	15 kg ha^{-1}	5 kg ha^{-1}
GA_3 dose	60 g ha^{-1} on A line only in two split doses 1. 30 ppm at 5 % heading and 2. 60 ppm at 30 to 40% heading or 2nd day after 1st spraying	

six locations in the country along with national, regional and local checks. It has recorded 15.45 per cent increased grain yield over best regional variety check Sashi.

Sahyadri-5 rice hybrid recorded highest grain yield of 5320 kg ha^{-1} with 125 kg N ha^{-1} followed by 5309 kg ha^{-1} for 100 kg N ha^{-1} and 4888 kg ha^{-1} with 75 kg N ha^{-1} in agronomical trial conducted during *kharif*-2008. It recorded on an average 37.21 per cent higher grain yield over variety check Karjat-2 in 19 adaptive trials conducted in low line areas during *kharif*-2008, while it has also given an average 27.8 and 12.9 per cent higher grain yield over best variety check Karjat-2 and hybrid check Sahyadri-3, respectively in 36 adaptive trials conducted on farmers field during *kharif* 2009 in low line areas. It has also given (7589 kg ha^{-1}) 84.20 and 13.86 per cent higher grain yield over variety check Karjat-2 and Sahydri-3 hybrid check in front line demonstration conducted at different stations on 0.40 hectare area each during *kharif* 2010 (Anonymous, 2011b).

Sahyadri-5 rice hybrid has been screened under IET- 20934 for reactions to various diseases and insects pests during the years *kharif* 2006 to 2007 in state and *kharif* 2010 in national screening nurseries trials, in which it showed resistant to leaf blast, neck blast and moderately resistant to sheath blight and bacterial leaf blight. It showed resistant reaction to plant hoppers, gall midge, leaf damaging pest, whorl maggots, blue beetles, leaf folders and stem borer. Thus, the hybrid Sahyadri-5 observed to have multiple resistant to major diseases and insect pests (Anonymous, 2010).

The seed production packages of Sahyadri-5 rice hybrid was standardized at the research station. The proper synchronization in flowering of male and female parents could be achieved through three stagger sowing of male parent at 5 days interval following by complete sowing of female parent on 15th day of 1st sowing of male line in *kharif* while in *rabi* 1st date of R line sowing may be done three days later than A line sowing and IInd and IIIrd dates R line be sown 5 days interval (Table 3). The usual cultural packages be followed for large scale multiplication of hybrid seed of Sahyadri-5 in suitable areas. The seed production of Sahyadri-5 rice hybrid is comparatively easy due to less difference in stagger flowering between parental female and male lines of the hybrid. Therefore, ample seed production could be possible on large scale in the suitable areas to meet the seed demands.

In view of the high yield potential, good milling and cooking qualities, resistance to major diseases and insects pests, the hybrid Sahyadri-5 (RTNRH-10) was recommended to release for commercial cultivation in the state of Maharashtra during the year 2011.

Sahyadri-5, a late duration new rice hybrid with high yield potential multiple resistance may meet the requirements of the farmers in the state and country. It may help to increase the rice production and productivity in the state and country through large scale adoption of this rice hybrid.

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Cropping Pattern for Osmanabad District Based on Rainfall Characterization

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Abstract

Mean annual rainfall of Osmanabad district is in the range 550-750 mm. Out of 26 years, normal years ranged from 6-11 showing the inter tahsil variation. The frequency of deficit year was higher in Kalamb and Paranda tahsils as compared to other tahsils. Normal years were more in Bhoom tahsil i.e. 11 years followed by Paranda and Osmanabad, whereas the lowest year of normal rainfall found in Omaraga. The probability of occurrence of 20mm rainfall was greater than 50 per cent from 23 MW and persists up to 40 MW. In shallow to medium soil, crops suggested are- linseed, safflower, sunflower, sorghum, gram, mustard. While in medium to deep soil type, crops suggested are Hy. sorghum, gram, safflower, sunflower, pea and wheat. Horticultural fruit crops like, ber, custard apple, guava, sapota, pomogranate, some medicinal crops like tikhadi, ritha, shikekai, ashwagandha, shatawari, sonamukhi, floriculture crops like rose, marigold, chrysanthemum, astar, vegetables like chilli, ladies finger, pea, tomato, brinjal, cucumber, bitter guard, fenugreek, spinach, radish, onion, garlic, Indian bean, pigenpea, cluster bean, french bean and carrot etc. can be grown.

Key words : Rainfall, probability, length of growing period, cropping pattern.

Crop growth and yield variation can be primarily attributed to inter seasonal climatic variability in terms of change in temperature, rainfall and input management (Agrawal, *et al*. 1994). Osmanabad district of Marathwada region of Maharashtra state is spread over 17°35' 18°40' N latitude and 75°16' to 76°40' E longitude. The altitude of Osmanabad district is 600-611 m above mean sea level. The major part of Osmanabad is situated in Balaghat plateau. The mean annual maximum and minimum temperature of Osmanabad district is 40°-15°C respectively. Mean annual rainfall of Osmanabad district is in the range at 550-750 mm. Though the mean annual rainfall of Osmanabad district comes in the category of assured rainfall zone but, the inter tahsil variation are wide so the intra seasonal behavior warrants timely management for sustainable crop production. The major crops grown in the district are sorghum, wheat, groundnut, srhar, black gram, gram, soybean and sugarcane. Soil type and rainfall varies from tahsil to tahsil. Soil of Osmanabad district is shallow to medium with average water holding capacity of 60-90 mm. However, crops are grown in both the seasons i.e. *kharif* and *rabi*. The intra seasonal distribution varies from year to year and the soil moisture after withdrawal of monsoon goes on depleting fast. Hence, utmost care should be taken in planning *rabi* crops on residual soil moisture.

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Materials and Methods

The historical daily data of rainfall at each tahsil of Osmanabad district were collected from State Department of Agriculture, Collectorate of Osmanabad, Department of Agricultural Meteorology, College of Agriculture, Parbhani and Agricultural Research

Station, Tuljapur. The rainfall data from the newly created taluka Lohara and Washi were for a very short period and hence they are not included in present study. However, daily rainfall data for Osmanabad, Tuljapur, Omarga, Kalamb, Paranda and Bhoom were available for last 26 years which were used for further analysis. The data collected for each tahsil of Osmanabad district were subjected to statistical analysis such as standard deviation, coefficient of variation, extreme lowest and highest, starting, ending and duration of rainy season, initial and conditional probability using Markov and Marshall chain probability model. Dry and wet spell probability using Markov and Marshall chain probability model, starting and ending of rainy season by frequency analysis of weekly rainfall were estimated from the computerized programmes developed by CRIDA, Hyderabad.

Results and Discussion

On the basis of variability in annual total rainfall of each tahsil from normal were categorized as deficit, moderate deficit, normal, moderate surplus and surplus year and the frequencies of the year grouped under each category are presented in Table 1. The data presented in the table indicated that out of 26 years normal years ranged from 6-11 showing the inter tahsil variation. The frequency of deficit year was higher in Kalamb and Paranda tahsils as compared to other tahsils. Out of 26 years surplus years ranged between 5-7, while deficit years ranged in 6-10.

Data on seasonal percentage distribution of rainfall recorded at each tahsil of Osmanabad district is presented in Table 2. Data indicated that the rainfall recorded during SW monsoon ranged between 80 -87 per sent of total annual rainfall in different tahsils. The data further indicated that rainfall received during post monsoon season ranged between 12.48-18.43 per cent. During winter and summer season, very short ranges were recorded and they were ranged between 0.02-0.12 per cent and 0.49-1.73 per cent respectively. The data indicated that majority of the rainfall (more than 98%) is concentrated during SW monsoon season and NE monsoon seasons.

However, from agricultural management point of view a week is to be considered as an ideal period. The major rains were concentrated during MW 22 to 43. The statistics of the weekly total rainfall indicated that lovv coefficient of variance was noticed during this period indicating the surety of rainfall during this period. However, coefficient of variance in remaining weeks was higher because of low rainfall. Generally higher variability found in MW 28 to 31 and MW 34 to 36 indicating need for contingency crop planning. These results are similar to rainfall analysis in scarcity zone of Maharashtra reported by Jadhav *et al*. (1999).

Length of growing period : Patil snd Kale (1988) and Vaidya *et al.* (2008) classified this district under assured rainfall agro climate zones of Maharashtra State.Under rainfed conditions, if adequate rainfall is received which meet the evapotranspirative demand, crop can be successfully harvested with normal yield.

Under rainfed condition, length of growing period can be considered as the period during

Table 1. Frequencies distribution of annual total rainfall in different categories.

Tahasil Category	Osmanabad	Tuljapur	Omarga	Kalamb	Paranda	Bhoom
Deficit	6	7	8	10	9	7
Moderate deficit	4	3	2	0	1	2
Normal	10	9	6	9	10	11
Moderate surplus	0	2	3	1	0	1
Surplus	6	5	7	6	6	5
Total years	26	26	26	26	26	26

which water is sufficiently available for crop evapotranspiration either through rainfall or soil moisture storage. So lengths of growing period for each tahsil of Osmanabad district were estimated as sum of length of rainy season period for which soil moisture is sufficiently available for crop and post rainy season rainfall that can be sufficient for establishment of rainfed *rabi* crops.

It is assumed that daily evapotranspiration as 4 mm per day in mild winter, 3 mm per day with moderate winter. From post monsoon rainy season crop conserve the soil moisture. The water holding capacity of soil depends on soil type, its texture and structure. In this study, the water holding capacity of soil for 1m depth of soil profile considered as 100 mm for shallow soils, 150 mm for medium soils and 200 mm for deep black soils.

Length of growing period was estimated from the historical data of rainfall of each tahsil of Osmanabad district. For its conclusion forward, backward accumulation of weekly rainfall was calculated from which start and end of rainy season at each tahsil was estimated. The data presented in Table 3 indicated that the latest onset in different tahsils was MW 27 (first week of July). It means the *kharif* crops can be very safely sown in this week and yield of the crops having duration of 19 weeks can be very safely grown. However, considering the early withdrawal, the short duration crops of 90-100 days can be advocated in Omarga and Kalamb tahsil.

Osmanabad, Tuljapur and Paranda tahsil had duration or 20 weeks starting from MW 23-42, whereas for Umarga and Kalamb tahsil, the duration was 21 weeks, starting from MW

Table 2. Season wise per cent distribution of annual rainfall of each tahasil of Osmanabad district.

Tahasil	Season wise per cent distribution of rainfall				
	Mean annual rainfall	South west monsoon	North east monsoon	Winter season	Summer season
Osmanabad	705.8	86.99	12.48	0.02	0.49
Tuljapur	781.7	86.60	12.67	0.03	0.67
Omarga	693.4	83.41	15.92	0.05	0.60
Kalamb	739.6	85.53	13.45	0.12	0.97
Paranda	566.4	79.71	18.43	0.03	1.73
Bhoom	654.1	84.17	15.01	0.04	0.75

Table 3. Starting, ending and duration of rainy season at each tahasil of Osmanabad district.

Tahasil	Starting				Ending				Duration			
	Mean	Earlist	Latest	S.D. (mm)	Mean	Earlist	Latest	S.D. (mm)	Mean	Min.	Max.	S.D. (mm)
Osmanabad	23.5	22	25	1.0	42.8	38	52	3.5	19.3	14	29	3.6
Tuljapur	23.5	22	25	0.9	42.3	38	52	4.0	19.8	14	29	3.9
Omarga	23.6	22	27	1.2	41.1	35	52	3.8	19.5	12	29	3.8
Kalamb	23.5	22	27	1.2	42.8	35	52	4.1	19.3	11	30	4.5
Paranda	23.7	22	26	1.0	42.9	36	52	3.8	19.2	12	28	3.7
Bhoom	23.8	22	26	1.0	42.7	36	52	3.8	18.9	12	28	3.9

Table 4. Probability of occurrence of rainfall at tahasil level of Osmanabad district during rainy season at probability limit 20, 30, 40 mm.

MW	Osmanabad			Tuljapur			Umerga			Kalamb			Paranda			Bhoom		
	20	30	40	20	30	40	20	30	40	20	30	40	20	30	40	20	30	40
22	.1538	.1154	.1154	.1538	.0769	.0000	.1154	.0385	.0000	.0769	.0769	.0000	.1923	.1923	.0769	.1155	.0385	.0385
23	.6154	.5000	.3462	.5385	.4231	.3462	.5000	4231	.2692	.4615	.3077	.2308	.5385	.3462	.1923	.3846	.3462	.3077
24	.5385	.3462	.3077	.6538	.5000	.2692	.5769	.4231	.3077	.6154	.5385	.4231	.4231	.6846	.3462	.5769	.5385	.3846
25	.4615	.3462	.2308	.3462	.3077	.1923	.3077	.2692	.2308	.3846	.3077	.2692	.1923	.1923	.1154	.3462	.2692	.2308
26	.5385	.3462	.2308	.5769	.4615	.3462	.3846	.2308	.1923	.4615	.3077	.2308	.2692	.2308	.1538	.4615	.3462	.1923
27	.5385	.4231	.3846	.5385	.5000	.2692	.5385	.4231	.2692	.4231	.3077	.2692	.3846	.3077	.1923	.4231	.3846	.1923
28	.4231	.3462	.3077	.4231	.4231	.3462	.4231	.3077	.3077	.5385	.3462	.2308	.2692	.2308	.1923	.5385	.3462	.2308
29	.5000	.3077	.2692	.4231	.3846	.2692	.4615	.3462	.2692	.6154	.5769	.3846	.3846	.2692	.1538	.3462	.2308	.1538
30	.5769	.5000	.3846	.5385	.5000	.3846	.6154	.3846	.3846	.5385	.5000	.3846	.3462	.3077	.1923	.5385	.3846	.2308
31	.5769	.4231	.2692	.5769	.3846	.3846	.4615	.4231	.2692	.5000	.3846	.2692	.2308	.0769	.0385	.3846	.2992	.1538
32	.5385	.4615	.4231	.5385	.4231	.3462	.5000	.4231	.3077	.5769	.3462	.2692	.3462	.2692	.1538	.3077	.2308	.1538
33	.4615	.4231	.2308	.5385	.3462	.3077	.4615	.3077	.1923	.4231	.3846	.2692	.3077	.2308	.1154	.5000	.3077	.1923
34	.5385	.4231	.4231	.4615	.3462	.3077	.4231	.3846	.3462	.4615	.4231	.4231	.3077	.2308	.1923	.3846	.3462	.3462
35	.3846	.2692	.2308	.4231	.3462	.2692	.4615	.2692	.2692	.4615	.3846	.3077	.3462	.3077	.2692	.3846	.3462	.3077
36	.5385	.5000	.4615	.5000	.4615	.3846	.5000	.3846	.2692	.3154	.5000	.3846	.2308	.1923	.1923	.3077	.3077	.2308
37	.5000	.4231	.3462	.5385	.4615	.3846	.5385	.5000	.4231	.4615	.4231	.3846	.6538	.5000	.4615	.4615	.3846	.3846
38	.6154	.5000	.4615	.6538	.6538	.6154	.6154	.6154	.3846	.5769	.5000	.4221	.4231	.3846	.3846	.5769	.5769	.5000
39	.7308	.5385	.4231	.8077	.6538	.5769	.6538	.4615	.3846	.6923	.5000	.4615	.6538	.4615	.3846	.5000	.4231	.4231
40	.5000	.5000	.3846	.4615	.3846	.3077	.4231	.4231	.4231	.3846	.3462	.3462	.4615	.3846	.2308	.5000	.3462	.3077
41	.3462	1077	.2692	.3846	.3462	.3462	.4231	.3846	.3846	.3462	.3462	.3077	.3846	.3462	.3077	.4231	.2308	.2308
42	.1923	.1538	.1154	.2692	.2308	.1923	.2308	.1923	.1923	.3077	.1923	.1538	.1923	.1538	.0769	3077	.2692	.1923

23-43. Only Bhoom tahsil had duration of 19 weeks, starting from MW 24-42.

In general, length of growing period ranged between 18 and 20 weeks in different tahsils of Osmanabad district.

Onsets and withdrawal : Mean start of rainy season ranged from 23-24 MW in different tahsils early onset is at 22 MW in all tahsil. While late onset ranged between 25-27 MW. Mean termination of rainy season was in 42-43 MW. Early termination occured in 35-38 MW in all tahsils. Mean duration of rainy season ranged between 18-19 weeks. Minimum duration ranged between 11 and 14 weeks in this district, while maximum duration of 28 to 30 weeks was estimated.

Probability of rainfall occurrence : The probability analysis provides a tool for the assurance of fix quantity of rainfall in particular week for given tahsils. Probability of rainfall occurrence, at 20, 30 and 40 mm is given in Table 4. As the major amount of annual rainfall was concentrated during SW monsoon that is MW 23-41 are considered for this study indicated that the probability of occurrence of rainfall decreased as the quantum of rainfall increased in almost all tahsils and all weeks considered. Same results were obtained by Maniyar *et al.* (2008).

It is advocated that during crop life if the break in monsoon activities are observed, the farmers should apply life saving irrigations at critical growth stages. According to study of rainfall distribution and soil type, the crops and cropping pattern are suggested below. Sorghum is main crop in both the seasons that is *kharif* and *rabi*. In *kharif* season other crops grown are rice, groundnut, arhar, black gram and in *rabi* - wheat, gram, safflower linseed are to be grown. Sugarcane is irrigated crop grown in Tuljapur, Kalamb and Osmanabad tahsils only. With the help of duration of monsoon in each tahsil and length of growing season crops and cropping pattern suggested for *kharif* season are given in Table 5.

Table 5. Cropping pattern on the basis of length of growing period of Osmanabad district.

Tahasil (season duration)	**Soil type**	**Croppring pattern for *kharif* season**
Bhoom (130-135 day)	Shallow	Monocropping of sorghum, blackgram, green gram, castor, sunflower, pearlmillet and sesamum
	Medium	Sorghum, pearlmillet, maize, sunflower, sesamum groundnut as monocrop; black gram/green gram + tur; soybean
	Deep	Maize, groundnut, sorghum, pearlmillet, soybean, tur + soybean
Osmanabad, Tuljapur, Paranda. (140-145 day)	Shallow	Hybrid sorghum/pearl millet, tur, sorghum, pearl millet, as monocrop or can be mixed with black gram, green gram
	Medium	Soybean, sunflower maize, sorghum, perlmillet as monocropping or can be mixed with green gram, blackgram
	Deep	Soybean, cotton, Hy sorghum + tur, cotton + black gram/soybean, sunflower
Omarga, Kalamb (145-150 day)	Shallow	Intercropping system with base crop of short duration and with long duration sorghum + black gram/sesamum, perlmillet + green gram.
	Medium	Intercropping system with base crop of long duration and component crop of short duration cotton + tur; sorghum + tur; sorghum + soybean/black gram; cotton + soybean/green gram
	Deep	Intercropping system with base crop of long duration to be sown early and component crop to be sown later groundnut, sorghum, cotton, soybean mix with black gram, green gram, seasamum, sunflower

Study also showed that the major rainfall was received in September month which was beneficial in all tahsils of Osmanabad district. On which *rabi* crop can be grown safely like linseed, safflower, sunflower, sorghum, gram, mustard while on shallow and medium soils, Hybrid, sorghum, gram, safflower, sunflower, pea and wheat may be grown on medium to deep soil.

Plantation of trees like anola woodapple, ber, jamoon, karwanda, bibwa etc. may be beneficial for off season production, for forage purpose, as a shelter belt and wind breaks around the field.

Horticultural fruit crops like, ber, custard apple, guava, sapota, pomegranate can be taken. Some medicinal crops like tikhadi, ritha, shikekai, ashwagandha, shatawari, sonamukhi etc. can be taken. Floriculture crops like rose, marigold, chrysanthemum, astar and vegetables like chilli, ladies finger, pea, tomato, brinjal, cucumber, bitter guard, fenugreek, spinach, radish, onion, garlic, Indian bean, pigenpea, cluster bean, french bean, carrot etc.

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Character Association Studies in Rice (*Oryza sativa* L.)

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Abstract

Grain yield was significantly correlated with traits, *viz*., productive tillers plant^{-1}, number of tillers square^{-1} meter, panicle length, number of grains panicle^{-1}, 1000 grain weight, straw yield plant^{-1} and harvest index. Path coefficient analysis revealed that number of tillers square^{-1} meter, days to maturity, grains panicle^{-1}, straw yield plant^{-1} and harvest index had the highest positive direct effects on grain yield. Improvement of the grain yield can be immensely efficient via number of tillers square^{-1} meter, days to maturity, grains panicle^{-1}, straw yield plant^{-1} and harvest index based selection.

Key words : Rice, correlation, direct and indirect effects.

Path analysis has been used by plant breeders to assist for identifying useful selectable traits (Dewey and Lu, 1959). Partitioning of the correlation coefficient into its components, one component being the path coefficient that measures the direct effect of a predictor variable upon its response variable; the second component being the indirect effects of a predictor variable on the response variable through another predictor variable is the advantage of path analysis (Dewey and Lu, 1959).

In this study, an attempt was made to study the direct and indirect effects of some important yield components on grain yield of rice by correlation and path coefficient analysis. The results might be capable in the selection criteria in further studies in order to increase the selection efficiency.

Materials and Methods

The experimental material for present study comprised of 50 indigenous genotypes of rice (*Oryza sativa* L.). The field experiment was carried out in a randomized block design with 3 replications, during *kharif*-2011 at ARS, Vadgaon (Maval). Each plot consisted of two rows of 5 m length with a spacing of 20 x 15 cm. Two border rows were planted at both the sides to reduce the border effect. The recommended package of practices of crop production and protection were followed for successful crop growth. Observations were recorded on twelve characters *viz*., days for 50 per cent flowering, days to maurity, plant height, productive tillers plant^{-1}, number of tillers square^{-1} meter, panicle length, grains panicle^{-1}, length: breadth ratio of grain, 1000 grain weight, seed yield plant^{-1}, straw yield plant^{-1} and harvest index. Genotypic and phenotypic correlation coefficients were estimated by the method proposed by Singh and Chaudhari (1977). Path coefficient analysis was done according to the procedure suggested by Dewey and Lu (1959).

Results and Discussion

In the present study, various quantitative characters were investigated and their

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relationship with yield as well as among themselves was examined using correlation analysis (Table-1). The genotypic correlation among various yield and yield contributing traits revealed that seed yield plant^{-1} was significantly and positively correlated with harvest index, straw yield plant^{-1}, panicle length, grains panicle^{-1}, 1000 grain weight, number of productive tillers plant^{-1}, number of tillers square^{-1} meter and positively but non significantly correlated with plant height, length:breadth ratio of grain and days to 50 per cent flowering. Similar kind of associations were reported by Bhadru *et al*. (2011) for plant height, 1000 grain weight, panicle length, Hari *et al*. (2006) for panicle length, Vange (2008), Chakraborty *et al*. (2010) for number of tillers square^{-1} meter, panicle length, number of grains panicle^{-1} and 1000 grain weight, Sarma and Sharma (2009) and Umadevi *et al*. (2009) for productive tillers plant^{-1} and panicle length, Basavaraja *et al*. (2011) and Rajamadhan *et al*. (2011) for grain yield plant^{-1}, number of productive tillers plant^{-1}, 1000 grain weight, panicle length and number of grains panicle^{-1}, Umadevi *et al*. (2009) for straw yield plant^{-1}, Garg *et al*. (2010) for days to 50 per cent flowering, Murthy *et al*. (2011) for harvest index and straw yield plant^{-1}.

It was revealed that almost all traits were positively correlated with seed yield plant^{-1} with varying degrees except days to maturity. It gives information regarding selection index, while starting a breeding programme. Productive tillers plant^{-1} and number of tillers square^{-1} meter showed positive significant correlation with all the characters without length:breadth ratio of grain. Productive tillers plant^{-1}, number of tillers square^{-1} meter, panicle length, grains panicle^{-1}, 1000 grain weight and harvest index showed highly positive correlation among themselves indicating that simultaneous selection for these characters would result in improvement of high yielding rice genotypes.

Table 1. Genotype correlation of different characters in rice.

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Productive tillers plant^{-1}	Tillers plant^{-1}	Panicle length (cm)	Grains panicle^{-1}	L:B ratio of grain	1000 grain weight (g)	Straw yield plant^{-1} (g)	Harvest index (%)	Seed yield plant^{-1} (g)
Days to 50% flowering	1	0.9978**	0.5392**	0.0956	0.0959	0.0880	0.1106	-0.0618	0.0370	0.1833	-0.1337	0.0725
Days to maturity		1	0.5225**	-0.0125	-0.0126	0.0253	0.0537	-0.0335	0.0051	0.1681	-0.2403	-0.0218
Plant height(cm)			1	0.0440	0.0432	0.0768	0.1421	0.1568	0.1976	0.1515	-0.1007	0.0511
Productive tillers plant^{-1}				1	0.9871**	0.9144**	0.9766**	0.1317	0.7770**	0.7349**	0.5382**	0.9989**
Tillers sq^{-1} m.					1	0.9136**	0.9811**	0.1352	0.7765**	0.7363**	0.5361**	0.9981
Panicle length (cm)						1	0.9781**	0.1497	0.6746**	0.7753**	0.3790**	0.9610**
Grains panicle^{-1}							1	0.2134	0.8343**	0.8160**	0.4264**	0.9978**
L: B ratio of grain								1	0.3524*	0.1685	-0.0008	0.1616
1000 grain weight (g)									1	0.6792**	0.3183*	0.8029**
Straw yield plant^{-1} (g)										1	-0.2067	0.7485**
Harvest index (%)											1	0.4757**
Seed yield plant^{-1} (g)												1

*, ** Significant at 5 and 1 per cent level respectively.

The association of different component characters among themselves and with yield is quite important for devising an efficient selection criterion for yield. Such interdependence often affects the relationship of component characters with yield, thereby making correlation coefficient to be ineffective. So there is a need to partition the correlation into direct and indirect effects to get the information on actual contribution of each character to yield. Thus, correlation in conjunction with path analysis could give a better insight into cause and effect relationship between different pairs of characters. This will help in the simultaneous improvement of characters along with grain yield in breeding programme.

The direct and indirect contributions of each character as revealed by path coefficient analysis (Table 2) that, seed yield plant^{-1} was the result mainly of days to 50 per cent flowering, plant height, productive tillers plant^{-1}, number of tillers square^{-1} meter, panicle length, grains panicle^{-1}, 1000 grain weight, straw yield plant^{-1} and harvest index as they were significantly correlated with it. These variables were related inter se, so that each factor influenced the seed yield by a direct contribution and indirect contributions through other variables with which it was correlated.

The characters *viz*., days to maturity, number of tillers square^{-1} meter, grains panicle^{-1}, straw yield plant^{-1} and harvest index exerted positive direct effect on grain yield and correlation of these characters with seed yield was positively significant except for days to maturity. Thus, direct selection for these traits will be rewarding for yield improvement. These findings are in agreement with reports of Jayasudha and Sharma (2010) for harvest index, Bakshipour *et al*. (2001), Satyavathi *et al*. (2001) for grains panicle^{-1}, Murthy *et al*. (2011) for straw yield plant^{-1} and harvest index,

Table 2. Direct and indirect effects of different characters on seed yield in rice.

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Productive tillers plant^{-1}	Tillers plant^{-1}	Panicle length (cm)	Grains panicle^{-1}	L:B ratio of grain	1000 grain weight (g)	Straw yield plant^{-1} (g)	Harvest index (%)	Seed yield plant^{-1} (g)
Days to 50% flowering	-0.4422	0.4436	-0.0030	-1.6508	1.5797	-0.0281	0.0750	0.0036	-0.0083	0.2614	-0.1585	0.0725
Days to maturity	-0.2384	0.4370	-0.0029	0.2159	-0.2067	-0.0081	0.0364	0.0020	-0.0012	0.2397	-0.1194	-0.0218
Plant height(cm)	-0.4490	0.2283	-0.0056	-0.7601	0.7119	-0.0246	0.0964	-0.0092	-0.0442	0.2160	-0.2849	0.0511
Productive tillers plant^{-1}	-0.0423	-0.0055	-0.0002	-17.2277	16.4642	-0.2924	0.6815	-0.0078	-0.1737	1.0479	0.6381	0.9989**
Tillers sq^{-1} m.	-0.0424	-0.0055	-0.0002	-17.2277	16.4642	-0.2921	0.6817	-0.0080	-0.1735	1.0491	0.6357	0.9981**
Panicle length (cm)	-0.0389	0.0110	-0.0004	-15.7915	15.0420	-0.3198	0.6632	-0.0088	-0.1508	1.1055	0.4493	0.9610**
Grains panicle^{-1}	-0.0489	0.0235	-0.0008	-17.3484	16.5517	-0.3128	0.6781	-0.0126	-0.1865	1.1636	0.5055	0.9978**
L: B ratio of grain	0.0273	-0.0146	-0.0009	-2.2738	2.2252	-0.0479	0.1447	-0.0589	-0.0788	0.2403	0.0010	0.1616
1000 grain weight (g)	-0.0164	0.0022	-0.0011	-13.4176	12.7842	-0.2157	0.5657	-0.0207	-0.2235	0.9685	0.3773	0.8029**
Straw yield plant^{-1} (g)	-0.0811	0.0735	-0.0009	-12.6905	12.1228	-0.2479	0.5533	-0.0099	-0.1518	1.4260	-0.2450	0.7485**
Harvest index (%)	0.0591	-0.1050	0.0006	-9.2937	8.8269	-0.1212	0.2891	0.0000	-0.0711	-0.2947	1.1856	0.4757**

*, ** Significant at 5 and 1 per cent level respectively.

Satish *et al*. (2009) for grains panicle^{-1}, Garg *et al*. (2010) for days to maturity, Nandan *et al*. (2010), Chakraborty *et al*. (2010) for grains panicle^{-1} and harvest index and Basavaraja *et al*. (2011) for number of tillers square^{-1} meter.

The residual effect determines how best the causal factors account for the variability of the dependent factors, the seed yield, in this case. In the present study, residual effect was (0.2551) indicating that characters considered sufficient for the variability in seed yield of rice. From the foregoing discussion, it is evident that harvest index, number of tillers square^{-1} meter, days to maturity, grains panicle^{-1}, straw yield plant^{-1} and harvest index were emerged as major components of grain yield in rice. These characters also had their indirect contribution on grain yield via number of tillers square^{-1} meter, grains panicle^{-1}, straw yield plant^{-1} and harvest index. Hence, these characters may also be included in formulating selection criteria for improvement of grain yield in rice.

Present investigation clearly revealed that the traits *viz*., number of tillers square^{-1} meter , grains panicle^{-1}, straw yield plant^{-1} and harvest index had strong association with seed yield plant^{-1} and also showed the high positive direct contribution through indirect effects of other component traits. Therefore, improvement of the seed yield will be immensely efficient, in selection based on these traits. Based these studies are promising genotypes were KMR-1-41, KMR-1-96, Bas-370, IR-8, VDN-9410, ND-8011, Sonsali, Kalagira, IR-64 in the breeding programme for improvement of rice.

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Phule Nachani: A High Yielding Finger Millet Variety for Maharashtra State

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Abstract

Phule Nachani (KOPN 235) a finger millet variety is derived from locally collected germplasm through selection. It has erect growth habit with dark green colour, no pigmentation and semi drooping leaf angle and flag leaf angle of the variety is curved at tip. The seed is brown colour having 1000 grain of 3.02 g. The grain colour is light brown. It matures in 115-125 days (late maturity group). The genotype possesses strong culm strength, semi loose ear with easy threshability. The variety is highly resistant to neck blast and resistant to leaf blast. At various locations and state trials conducted during the year 2006 to 2010, the genotype Phule Nachani (KOPN 235) consistently recorded the best performance. It gave 25.04 q ha^{-1} seed yield which was 23.23 per cent higher than the national check PR 202 (20.83 q ha^{-1}). The genotype Phule Nachani (KOPN 235) gave 24.12 q ha^{-1} grain yield in AICRP-IVT trial. It is registered to NBPGR, New Delhi under accession number IC 588750. The variety is tested by KOPN 235 name and released in 2011 under the name 'Phule Nachani' for cultivation in finger millet growing areas of Sub montane zone and Western ghat zone of Maharashtra state.

Key words : Phule Nachani, finger millet.

Finger millet or Ragi/Nagali/Nachani (*Eleusine coracana* L.) is an important staple food for the traditional consumers and the people belonging to the lower socio-economic strata. It is small seeded minor cereal having light brown to brick red and also white coloured seed coat with minutely undulated surface. Finger millet grain is highly nutritious with good quality protein, rich in minerals, dietary fiber, phyto-chemicals and vitamins. It is comparable to rice in protein, fat content and far superior in many other constituents. Finger millet has the highest content of calcium among known food grain, it provides 8-10 times more calcium than wheat or rice. It is also rich in phosphorus and potassium. The finger millet carbohydrates have the unique property of slower digestibility and regarded as food for long sustenance. It is good source of micronutrients and phyto chemicals. Regular uses of finger millet can greatly help in addressing to the micronutrient deficiency. This hardy cereal is grown where

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other cereals fail to yield satisfactorily due to unfavorable agro-climatic conditions. Among the small millets, finger millet is the most important millet grown in Maharashtra State. However, the finger millet area, production and productivity has come down substantially in the last decade (Anonymous, 2011 a). Hence, use of high yielding variety is a most important remedy to improve the productivity of finger millet on the fields of farmers and state also.

In Maharashtra, finger millet is grown alongwith the hill sides of Sahyadri and Satpuda ranges on very poor soils. In Western Maharashtra, it is grown mainly by drilling as well as transplanting and majority of the area is under midlate to late local varieties. It indicats the need for suitable finger millet high yielding, non lodging and blast resistant variety.

Materials and Methods

The local germplasm collection was done during 1996-97 from different finger millet growing area of Maharshtra state. The collected germplasm was evaluated at Zonal Agricultural Research Station, Shenda Park, Kolhapur during *kharif* 2001-02 by following selection breeding method. Previously it was used as local check with name Chandgad local during *kharif* 2001 to *kharif* 2004. The promising progenies were isolated and studied for its yield and ancillary characteristics in station trials conducted during *kharif* 2006 to 2007. The variety Phule Nachani was evaluated in multilocation trials at six locations of sub montane and ghat zone of Maharshtra during *khraif* 2008 to 2010 in a randomized block design with three replications alongwith checks. The seeds were directly sown by dibbling with 22.5 x 10 cm. spacing. A basal dose of 50 kg N ha^{-1} and 25 kg P_2O_5 ha^{-1} was applied at the time of sowing. The observations on yield and yield contributing characters were recorded in respective season. The statistical analysis of yield data of all the trials was done according to Panse and Sukhatme (1985). The variety was evaluated in All India Coordinted Initial Varietal Trial conducted during *kharif* 2009 at 22 locations in India. The variety was also evaluated for agronomic performance and its reaction to important diseases and pests during *kharif* 2009 to 2010 at the station. The variety was evaluated on farmer's field of sub montane and ghat zone of or Maharshtra during *kharif* 2010.

Results and Discussion

The finger millet variety Phule Nachani was evaluated with national finger millet check PR

Table 1. Summary of grain yield (q ha^{-1}) performance of the genotype Phule Nachani in various trials of finger millet during *kharif* 2006 to 2010.

Name of the Trial	Yeat	No. of trials over the locations	Mean yield (q ha^{-1})		% increase over check
			KOPN 235	PR 202	
Station trial (Late group)	2006	1	16.39	9.19	78.30
Station trial (Late group)	2007	1	16.07	12.28	30.90
Station trial (Late group)	2010	1	24.99	20.02	24.83
Mean			19.15	13.83	38.47
Multilocation trial	2008	4	24.32	21.33	14.02
Multilocation trial	2009	5	28.45	23.35	21.84
Multilocation trial	2010	6	25.30	20.36	24.26
Mean			26.22	21.62	21.28
General mean			25.04	20.32	23.23

202 of various stations and multiocation trials during *kharif* 2006 to 2010. In station trials conducted during *kharif* 2006, 2007 and 20 10, the variety Phule Nachani recorded 78.30, 30.90 and 24.83 per cent respectively, higher grain yield than the check PR 202. In pooled analysis of station trials the variety Phule Nachani gave 38.47 per cent higher grain yield than the check PR 202. The state co-ordinated multiocation trials conducted during *kharif* 2008 to 2010 showed that the Phule Nachani recorded 14.02, 21.84 and 24.26 per cent respectively, higher grain yield than the check PR 202. The mean performance of all the station for three years showed that Phule Nachani gave 21.28 per cent more grain yield than the check PR 202. However, overall station and multilocation trials recorded 23.23 per cent higher grain yield than the check PR 202. (Table 1) (Anonymous 2006-2010). In the All India Coordinated Initial Varietal Trial conducted during *kharif* 2009 at 22 locations in India, variety Phule Nachani recorded 24.12 q ha^{-1} grain yield (Anonymous 2010). In the agronomic trials conducted during *kharif* 2009 and 2010 it recorded 10.40 and 13.12 per cent higher yield respectively and pooled data showed 11.76 per cent, higher grain yield of Phule Nachani than PR 202 at 90 kg ha^{-1} nitrogen level while the fertilizer levels at

Table 2. Yield performance (q ha^{-1}) of Phule Nachani in All India Coordinated Initial Varietal Trial conducted during *kharif* 2009.

State	Location	Mean yield (q ha^{-1})		SE±	CD 0.05	C.V.%
		Phule Nachani	PR 202 (c)			
A.P.	Perumallpalle	37.02	35.07	1.57	4.44	9.90
	Vizianagaram	13.56	25.83	0.95	2.68	7.72
Bihar	Dholi*	5.56	23.15	0.75	2.12	6.90
Chattisgarh	Jagadpur	18.52	30.25	1.79	5.07	14.50
Gujarath	Dahod	13.83	25.68	0.82	2.32	8.65
	Waghai	11.57	30.40	0.66	1.86	4.77
Jharkhand	Ranchi*	4.94	25.62	1.26	3.56	9.54
Madhya Pradesh	Dindori	18.52	34.07	1.30	3.68	10.27
	Rewa*	7.10	18.58	0.63	1.80	8.80
Karnataka	Bangalore	35.56	43.21	1.36	3.85	6.23
	Hanumanamati	18.08	17.99	1.02	2.90	10.00
	Mandya	36.42	28.37	2.41	6.83	10.90
M.S.	Kolhapur	26.22	25.75	0.97	2.75	8.04
T.N.	Coimbatore	38.16	38.49	1.48	4.20	7.63
	Paiyur	37.04	37.68	2.19	6.19	10.05
Pondichery	Karaikal	37.07	35.02	3.04	8.61	17.02
U.P.	Kanpur	10.62	20.35	2.06	5.82	24.83
Uttarakhand	Almora	20.62	34.51	1.18	3.35	7.86
	Gaja*	8.39	12.11	0.45	1.28	5.38
	Ranichauri*	7.62	15.04	0.73	2.08	9.34
	Pantnagar	18.22	32.40	1.70	4.83	12.63
Orissa	Berharmapur	19.11	32.84	2.0	5.65	15.10
India	Mean	24.12	31.05			

Table 3. Quality parameters of finger millet variety Phule Nachani.

Parameters	Unit	Value		Test method
		Phule Nachani	PR 202	
Calorific value	(kcal 100^{-1} g)	339	333	By calculation
Protein	(g 100^{-1} g)	7.4	7.3	AOAC 920.87
Carbohydrates	(g 100^{-1} g)	73.4	71.1	IS :2234-2205
Fat	(g 100^{-1} g)	1.8	2.1	AOAC 920.85
Dietary fiber	(g 100^{-1} g)	24.24	-	118:11062-1984
Calcium	(mg 100^{-1} g)	334.3	378.0	AOAC 984.27 & 999. 10
Iron	(mg 100^{-1} g)	4.82	3.29	AOAC 944.02, 32.0 1.09
Phosphorus	(mg 100^{-1} g)	239.2	257.8	18:14828-2000
Moisture	(%)	10.8	-	-

60:30:00 kg ha^{-1} showed 6.39 and 26.09 per cent more grain yield during *kharif* 2009 and 2010 respectively while pooled data showed 16.24 per cent higher grain yield by Phule Nachani than PR 202.

The variety Phule Nachani was also screened for reaction to major finger millet diseases and pest during the year *kharif* 2009 and 2010 at Kolhapur station. The variety showed resistance to leaf blast and neck blast diseases. No other pest was observed during *kharif* 2009 and 2010 on finger millet. The variety Phule Nachani had shown 36.51 per cent overall increase in yield over the check PR 202 in the adaptive trials conducted on farmers field during *kharif* 2010. The quality parameters of finger millet variety analysed by National Agril. Food Analysis and Research Lab., Pune during 2010 recorded 4.82, 239.2 and 334.3 (mg 100^{-1} g) iron, phosphorus and calcium respectively (Table 3). Similar type of iron and protein content range in finger millet was reported earlier by Barbeau and Hilu (1993), Shashi *et al*. (2007) and Desai (2012).

The salient features of the variety Phule Nachani the station are presented in Table 4. The variety has late maturity group (115-120 days), plant height (80-95 cm), non-lodging in nature with erect plant habit, dark green leaf colour, no pigmentation and semi drooping leaf angle, flag leaf angle curved at tip with light brown colour. The variety Phule Nachani showed 2-3 productive tillers per plant, 7-8 fingers, finger length (6.5-7.5) with 3.02 g test weight (1000 grain weight). The variety Phule Nachani is registered at NBPGR, New Delhi with accession number IC 588750.

Overall, the variety Phule Nachani was observed as high yielder over the national check PR 202, indicating the stable grain yield performance in sub montane and Ghat zone with varied ecological situation of Maharashtra state. Due to the high yield potential (25.04 q ha^{-1}) with late maturity Phule Nachani (KOPN 235) was recommended for release in Sub montane and Ghat zone of Maharashtra state during the year 2011 and released by the State Variety Release Committee, Govt. of Maharashtra (Anonymous. 2011 b).

The finger millet variety Phule Nachani will fulfill the demand of finger millet farmers of high yield and late maturity group. Simultaneously, will also helps in increasing the production and productivity of the state through large adoption of this variety in Sub montane and Ghat zone of Maharashtra state.

Table 4. Salient features of the variety Phule Nachani.

Characteristics	Description state
Growth habit	Erect
Plant pigmentation	No pigmentation
Culm branching	Absent
Ear shape	Semi compact
Finger branching	Absent
Ear size	Intermediate
Discontinuity of spikelets on finger	Absent
Culm strength	Intermediate
Spikelet density	Sparse
Synchrony at maturity	Synchronous
Spikelet shattering	Absent
Grain covering by glumes	Partially covering
Number of grains per spikelet	Low (4 grains)
Grain colour	Light Brown
Grain shape	Round
Grain surface	Non wrinkled
Pericarp persi stance after threshing	Non persistent
Plant height (cm)	80-95 cm
Productive tillers	2-3 tillers plant^{-1}
Finger number	7-8 per ear
Finger length (cm)	6.5 to 7.5 cm
Days to 50 % flowering	80-85 days
Days to maturity	115-120 days
1000 grain weight (g)	3.02 gm
Reaction to Diseases :	
Blast on neck	Resistant (score 1)
Blast on leaf	Resistant (score 1)

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Performance of Sapota Cultivars in Laterite Zone of West Bengal

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Abstract

Significant variation in yield and physico-chemical characteristics of fruit from different cultivars of Sapota was observed. At 8th year of age the cultivar Cricket Ball had highest average production of 67.6 kg tree^{-1} with the peak of 110.5 kg tree^{-1} followed by DSH 2 which had average production of 52.2 kg tree-1 with peak of 137.3 kg plant^{-1}. The highest fruit weight (110 g) with maximum size (7.3 x 6.1 cm) was observed in CO 2 and lowest fruit weight (39 g) with minimum in size (5.8 x 4.7 cm) was in Guthi. The seed number was more in Cricket Ball (4.5) and less in CO 2 (1.7). Maximum TSS (23.9°B) with highest total sugar (16.1%) was recorded from DSH 2. Minimum PLW and rotting of fruits were observed in DSH 1 during storage. Considering overall performance, the cultivars DSH 2 and Cricket Ball are recommended for commercial orcharding in red and laterite zone of West Bengal.

Key words : Sapota, cultivars, laterite zone, yield, fruit quality, shelf life.

Sapota or chicku [*Manilkara achras* (Mill) Fosbery] is one of the delicious fruits of humid tropical and subtropical region in the country. Due to wide adaptability in diverse agro-climatic condition, hardy nature, less management cost and having higher productivity with maximum net return, the area under sapota is increasing at a faster rate. The crop is commercially cultivated in the states like Maharashtra, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh and West Bengal. In West Bengal, sapota is mainly grown in coastal belt of Purba Medinipur and South 24 Parganas districts. But it can also be grown in red and laterite zone of the state covering 5 districts, where more land is available which could be explored for commercial cultivation of sapota. It is well established fact that the production of a crop is mainly depends on the variety, suitable for the region or locality. A number of variety or cultivars have been recommended for growing in different states of India (Chaudhary *et al*. 1995; Shirol *et al.*, 2007) but no such varietal recommendation is available particularly for red and laterite zone of West Bengal. It is another established fact that to recommend a variety or cultivar for any agro-climatic zone, varietal trial with released or elite genotypes is the most appropriate, efficient and quick approach method for getting desired results. With the view to find out suitable cultivars of sapota for red and laterite zone, a long term study was therefore conducted in this direction, selecting some important released varieties of sapota.

Materials and Methods

The investigation was made in the orchard of an agro-based organization at Jhargram, Paschim Medinipur district of West Bengal during 2007-2011, a sub-humid agro-climatic region with annual rainfall between 1200-1500 mm of which about 80 per cent received from 2nd week of June to end of September. Grafted plants of ten cultivars *viz*., DSH 1, DSH 2, Kalipatti, CO 1, CO 2, CO 3, PKM 2, H 7/1, Guthi and Cricket Ball, planted at 8 x 8 m

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spacing during July 2003, were selected for the study following randomized block design having four replications with two plants in each. The soil of the orchard was laterite having pH 5.8. The trees were fertilized with 50 kg FYM, 300 g N, 100 g P_2O_5 and 200 g K_2O plant^{-1} year^{-1}. The observation was recorded on tree growth, fruit yield, physico-chemical characteristics of fruits, foliar N, P, K status and storage life of fruits of different cultivars. Ten fruits from each tree were taken randomly for recording observations on physico-chemical parameters. The TSS was recorded with the help of hand refractometer while acidity, total and reducing sugar and ascorbic acid content were estimated following standard technique (A.O.A.C., 1990). For foliar analysis of N, P and K, the leaves were collected from growing tip in September from four directions of each tree (Bhargava, 1999). Leaf N was determined using micro-kjeldahl method, P by vandomolybdophosphoric acid method and K by flame photometer. Storage studies of fruits were undertaken under ambient conditions prevailed (31°C to 37°C).

Results and Discussion

These tree growth in respect of height, basal girth and spread of the tree was recorded at the age of 8th year and the growth data has been presented in Table 1. It is cleared from the data that Cricket Ball was the tallest tree (640 cm) followed by Hybrid 7/1 (630 cm) while Guthi was the shortest tree (450 cm) in respect of plant height. The basal girth was measured maximum in Kalipatti (59.7 cm) followed by DSH 2 (47.0 cm) and minimum in Guthi (30.0 cm). The plant spread in both the directions was maximum in Kalipatti (657 x 740 cm) followed by DSH 2 and it was minimum in Guthi (510 x 520 cm). The result was close conformity with the findings of Shirol *et al*. (2007) who also noted significant difference of growth parameters like plant height stem circumference and plant spread among the cultivars of sapota.

The data presented in Table 2 indicated that the cultivars under study had expressed their yield potentiality at different magnitude in the present agro-climatic situation. The cultivars which were taken for the study, reported to be good yielder (Chundawat, 1998; Kamraj *et al*. 2008), but at the present situation, some cultivars produced very low yield. Among the ten cultivars, Cricket Ball gave a good yield in most of the years with two highest peaks at 5th

Table 1. Plant growth and foliar N, P, K status of different cultivars of sapota grown in laterite soil.

Name of the cultivars	Plant height (cm)	Basal girth (cm)	Plant spread (cm)		Foliar nutrients status		
			East-West	North-South	Nitrogen (%)	Phosphorus (mg %)	Potassium (%)
DSH1	538	40.5	545	635	1.40	75	0.75
DSH2	580	47.0	610	678	1.65	94	0.82
Kalipatti	595	59.7	657	740	1.60	90	0.82
CO 1	534	41.2	575	620	1.50	84	0.80
CO 2	565	36.0	570	620	135	70	0.84
CO 3	477	39.7	580	515	1.44	80	0.76
PKM 2	570	43.0	530	520	0.38	72	0.80
H 7/1	630	44.0	550	515	1.58	88	0.92
Guthi	450	30.0	510	520	1.30	68	0.90
Cricket Ball	640	44.5	590	680	1.70	98	0.85
C.D. at 5%	7.2	2.2	4.8	5.2	0.20	2.4	N.S.

Table 2. Yield, fruit weight and size of different cultivars of sapota.

Cultivars	Fruit* yield tree^{-1} (kg)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)
DSH1	20.9	105	7.3	6.3
DSH2	52.2	76	5.9	5.9
Kalipatti	33.9	99	6.3	6.3
CO 1	28.5	80	6.4	5.9
CO 2	6.1	110	7.3	6.1
CO 3	23.4	90	5.7	6.2
PKM 2	6.1	84	7.0	5.8
H 7/1	30.4	68	6.5	5.6
Guthi	2.9	39	5.8	4.7
Cricket Ball	67.6	83	5.5	6.2
C.D. at 5%	4.5	3.4	0.3	0.2

* Mean of 2007-2011

year (98.8 kg tree^{-1}) and 8th year of tree age (110.5 kg tree^{-1}) with highest average yield of 67.6 kg plant^{-1}. The second highest yield was recorded by cultivar DHS 2, a hybrid (Kalipatti x Cricket Ball) released from the UAS, Dharwad, Karnataka. It was observed that DSH 2 showed a highest peak of 137.3 kg yield tree^{-1} at the age of 8th year and calculated as 26.8 kg more as compared to 'Cricket Ball'. From its increasing trend of yield potentiality, it is expected that DSH 2 may give more yield with the increase in tree age. As compared to the present level of production of DSH 2 (i.e. 137.3 kg yield tree^{-1} at 8th year of tree age) in Karnataka, where maximum yield was reported as 63.54 kg tree^{-1} at Dharwad (Chundawat, 1998) and 74.00 kg tree^{-1} at Arabhavi (Kamraj *et al*., 2008) at the age of 11 years, it could be concluded that DSH 2 performed better in laterite zone of West Bengal than Karnataka. It was noted that performance of the cultivars CO 2, PKM 2 and Guthi were unsatisfactory as their yield was only 2.1 to 6.1 kg tree^{-1}. However, 'Kalipatti' was reported to produce higher yield of 78.8 kg tree^{-1} under Maharashtra condition (Chaudhary *et al*., 1995) which yielded 105.8 kg fruit tree^{-1} at 8th year of age under present situation and is expected to be one of the potential yielder.

Leaf nutrient content of sapota cultivars showed significant difference for N and P and non significant for K (Table 1). Highest foliar N value was recorded from Cricket Ball (1.70%) followed by DSH 2 (1.65%) and lowest from Guthi (1.30%). Like nitrogen, P value was highest in Cricket Ball (98 mg%) followed by DSH 2 (94 mg%) and lowest in Guthi (68

Table 3. Physico-chemical characteristics of fruits of different cultivars of sapota grown in laterite soil of West Bengal.

Cultivars	Seeds fruit^{-1}	Pulp texture	T.S.S. (°B)	Acidity (%)	T.S.S./ acid ratio	Total sugar (%)	Reducing sugar (%)	Ascorbic acid (mg 100^{-1} g pulp)
DSH1	2.6	Melting	20.8	0.07	297.1	13.4	5.5	4.1
DSH2	3.0	Melting	23.9	0.09	265.6	16.1	6.5	4.4
Kalipatti	2.2	Melting	19.4	0.07	277.1	14.2	6.6	8.2
CO 1	2.6	Crispy	20.4	0.05	408.0	14.7	5.6	5.1
CO 2	1.7	Melting	19.5	0.09	216.7	13.0	5.2	3.7
CO 3	3.1	Melting	17.3	0.08	216.3	11.3	4.4	3.2
PKM 2	2.5	Melting	21.2	0.10	212.0	12.4	7-4	2.8
H 7/1	2.8	Crispy	19.8	0.09	220.0	12.2	4.1	5.5
Guthi	2.0	Melting	22.8	0.08	285.0	14.0	5.2	5.9
Cricket Ball	4.5	Melting	18.8	0.09	208.9	13.9	6.8	4.5
C.D. at 5%	0.2	Melting	0.5	0.02	-	0.3	0.4	1.2

mg%). The results indicated that foliar N and P values could be considered as one of the indicators for judging suitability of a variety in a zone.

Regarding fruit weight (Table 2), it was noted maximum in CO 2 (110 g) followed by DSH 1 (105 g) and Kalipatti (99 g) and minimum in Guthi (39 g). In a study Ghosh *et al*. (2002) observed fruit weight in different types of local selection of sapota in West Bengal varied between 88.1 and 22.2 g. DSH 2 and Kalipatti could be considered as round shaped fruit, while DSH 1, CO 2, PKM 2 and H 7/1 are considered as oblong type and rest cultivars may be considered as oval type. The number of seeds fruit^{-1} vary between 1.7 (CO 2) and 4.5 (Cricket Ball) in different cultivars of sapota (Table 3). Chundawat (1998) reported variation of seed number from 2.5 and 4.5 fruit^{-1} of different varieties of sapota grown in Dharwad. The pulp texture of CO 1 and H 7/2 was crispy i.e. slightly gritty and in other cultivars, it was melting.

The total soluble solids content in the fruits of different cultivars ranged between 17.3 and 23.9 °B (Table 3). The maximum was noted from DSH 2 (23.9 °B) followed by Guthi (22.8 °B) and minimum was in CO 3 (173 °B). The findings was close conformity with results of Shirol *et al*. (2009) in sapota where they observed maximum TSS in DSH 1 and DSH 2 (22.7 °B) and minimum in Gavarayya (19.4 °B). The acidity content in all the cultivars was low i.e. 0.05 (CO 1) to 0.10 per cent (PKM 2). This is in conformity with the findings of Shirol *et al*., (2009) who noted acidity content in different sapota cultivars ranges from 0.13 and 0.19 per cent. It is interesting to note that if we compare the TSS/acid ratio (which indicates the taste of the fruits), between the cultivars grown in Karnataka (Shirol *et al*., 2009) and in the present study area (Table 3), it is appeared that the cultivars under present study were better in taste than that were grown at Arabhavai (Karnataka). The total sugar content in different cultivars ranged between 11.3 (CO 3) and 14.7 per cent (CO 2) while reducing sugar was 4.1 (H 7/2) and 7.4 per cent (PKM 2). This finding is in consonance with Mitra *et al*., (2006) in sapota. The ascorbic acid content of fruits was highest in Kalipatti (8.2 mg 100^{-1} g) and lowest in PKM 2 (2.8 mg 100^{-1} g). Ghosh *et al*., (2002) also observed ascorbic

Table 4. Storage behavior of fruits of different cultivars of sapota grown in laterite soil.

Cultivars	3 DAS		6 DAS		9 DAS		12 DAS		15 DAS		18 DAS	
	PLW (%)	Rotting (%)	PLW (%)	Rotting (%)	PLW (%)	Rotting (%)	PLW (%)	Rotting (%)	PLW (%)	Rotting (%)	PLW (%)	Rotting (%)
DSH1	8.2	0	12.8	5	23.6	15	35.9	53	63.5	84	87.3	100
DSH2	12.8	0	21.3	10	34.2	35	56.7	100	-	-	-	-
Kalipatti	11.0	0	18.5	15	36.7	35	55.4	85	91.0	100	-	-
CO 1	10.7	0	18.2	0	24.3	15	41.0	75	83.5	100	-	-
CO 2	11.7	0	19.4	27	49.6	27	53.2	60	77.5	93	96.5	100
CO 3	9.8	0	20.9	5	31.5	21	46.0	42	64.1	84	90.2	100
PKM 2	12.4	0	20.2	10	32.9	15	37.9	70	77.7	100	-	-
H 7/1	8.4	0	13.1	10	29.4	20	40.1	70	78.5	100	-	-
Guthi	13.1	0	18.5	20	38.4	40	58.2	80	85.9	100	-	-
Cricket Ball	12.8	0	20.7	10	41.6	20	47.6	80	86.1	100	-	-
C.D. at 5%	0.3	-	0.6	1.5	1.1	1.8	4.5	5.5	5.9	6.8	N.S.	N.S.

DAS-Days After Storage.

acid content in different sapota types ranged between 1.78 and 6.89 mg 100^{-1} g pulp. So, the ascorbic acid content of different sapota cultivars under study was not very encouraging. Sastry (1970) also reported that sapota fruits content low amount of vitamin C.

Storage behavior of fruits of sapota cultivars in respect of physiological loss in weight (PLW) and fruit rotting have been presentedjn Table 4. It was appeared that the PLW of different cultivars was progressively increased with the increase m storage duration. Initially, i.e. upto 6th day of storage, the PLW was minimum in H 7/2 and maximum in DSH 2 and Cricket Ball. on 9th day of storage, the PLW was highest in CO 2 (49.6%) followed by Cricket Ball (41.0%) and lowest in DSH 1 (23.6%). The different degree of PLW of sapota cultivars on storage may be due to their different internal and external tissues structures. On 12 days of storage, the PLW was so high which indicated that fruits should not be stored beyond 9 days under West Bengal condition. The observations are in line with the findings of Shirol *et al*. (2009) who also observed maximum PLW of fruits of different sapota cultivars on 10 days of storage at whhich the fruits of most of the cultivars were unfit for consumption.

The data on rotting of fruits (Table 4) showed that on 3rd day of storage, no rotting of fruits was observed in any cultivar. On 6th day of storage, rotting was observed in CO 1, DSH 1, CO 3, ranged between 5 to 27 per cent respectively in cv, CO 2 (27%) and Guthi (20%). On 9th day of storage, minimum rotting of fruits (10 to 15%) was noted in the cultivars Cricket Ball, PKM 2, CO 1 and DSH 1 and maximum in DSH 2 and Kalipatti (35%). On 12th day of storage, all the cultivars showed more than 50 per cent rotting of fruits. From this finding it is concluded that shelf life of sapota fruits under normal room temperature may be considered as nine days.

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Generation Mean Analysis for Quantitative Traits in Castor (*Ricinus communis* L.)

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Abstract

The generation mean studies of three crosses of castor *viz*., JP 96 x JI 368, JP 96 x JI 372 and JP 101 x SKI 215 revealed the importance of additive-dominance model only for days to flowering of main raceme in cross JP 96 x JI 368. The results of the rest of the cases suggested the presence of additive, dominance and epistatic gene interactions for the traits indicating the importance of both additive and non-additive gene actions in the inheritance of these characters. This could be utilized by attempting biparental crosses to get desirable transgressive segregants in castor. Duplicate type epistasis played a greater role than complementary epistasis in most of the cases. Suitable breeding strategies were suggested for the improvement of seed yield in castor.

Key words: Castor, scaling tests, gene effects, generation mean

Castor is a highly cross pollinated crop in which most of the cultivars have been developed through hybridization followed by selection. In Gujarat, breakthrough in castor production has been realized with the development and release of hybrids for commercial cultivation. Still there is potential to further increase in yield level of castor through genetic improvement. Analysis of generation means allow testing of adequacy of different types of genetic models as well as quantification of various genetic parameters in a given model (Mather and Jinks, 1980). Information on the presence of type of epistatic gene effects in the inheritance of various quantitative traits is important for adopting suitable breeding procedures to improve the traits. Hence, the present study was undertaken to estimate different kinds of gene effects and to know their relative importance in the inheritance of seed yield and its eleven component traits in castor.

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Materials and Methods

The experimental material was comprised of three castor crosses *viz*., JP 96 x JI 368 , JP 96 x JI 372 and JP 101 x SKI 215 each with six basic generations *viz*., P_1, P_2, F_1, F_2, BC_1 and BC_2. The experiment was laid out in compact family block design with three replications at Oilseeds Research Station, Junagadh Agricultural University, Junagadh (Gujarat). The single row plot was sown for both parents and its F_1; five rows for each F_2 generation and three rows for each backcross during *kharif* 2010-11. The seed was dibbled at 90 and 60 cm inter and intra row spacing, respectively, with 7.2 m of row length. All the recommended cultural and plant protection practices were followed to raise good crop. The data were recorded on individual plant basis in each replication on randomly sampled five competitive plants in each of parents and F_1, 20 plants in each of backcross and 40 plants in F_2 generations for 12 characters (Table 1). The data were first subjected to estimates of individual scaling test A, B and C of Mather

(1949) and joint scaling test of Cavalli (1952) to detect the presence of epistasis. The gene effects were estimated using the models suggested by Jinks and Jones (1958) and Mather and Jinks (1980). The significance of the scales and gene effects were tested by using the t-test (Singh and Chaudhary, 2004).

Results and Discussion

The analysis of variance among progenies within each family (cross) indicated significant differences among six generation means for all the characters studied in all the three crosses except number of nodes up to main raceme in JP 96 x JI 368 and number of effective branches plant^{-1} in JP 96 x JI 368 and JP 96 x JI 372. These characters which failed to show significant variation among the generations in respective crosses were not subjected to further genetic analysis of generation means. The estimates of individual scaling tests A, B and C were non-significant for days to flowering of main raceme in JP 96 x JI 368 indicating the adequacy of simple additive-dominance model for this trait. When the simple additive-dominance model was found adequate to explain the variation among generation means, three parameters model proposed by Cavalli, (1952) was employed. Both additive (d) and dominance (h) gene effects in this non-interacting JP 96 x JI 368 were important in the inheritance of days to flowering.

The significance of any one, two or all the three individual scaling test A, B or C in all the crosses for all traits except days to flowering of main raceme in JP 96 x JI 368 indicated adequacy of epistasis model. This was also confirmed by joint scaling test showing significant chi-square values for these cases, indicating involvement of digenic interaction parameters in the inheritance of these characters. The joint scaling test was found to be more efficient in detection of epistasis compared to individual scaling tests; Ketata *et al*. (1976) in wheat had also concluded superiority of joint scaling test over the simple scaling tests. When the simple additive-dominance model failed to explain the variation among generation means, six parameter perfect fit model proposed by Jinks and Jones (1958) was employed.

Among interacting crosses, both additive (d) and dominance (h) gene effects contributed significantly towards the inheritance of days to maturity of main raceme, plant height up to main raceme, length of main raceme, effective length of main raceme, shelling out turn, 100-seed weight in JP 96 x JI 368; days to maturity of main raceme, plant height up to main raceme, shelling out turn, 100-seed weight and seed yield plant^{-1} in JP 96 x JI 372; days to flowering of main raceme, days to maturity of main raceme, length of main raceme, effective length of main raceme, number of capsules on main raceme and shelling out turn in JP 101 x SKI 215. Only additive (d) was significant for number of capsules on main raceme and oil content in JP 96 x JI 368; oil content in JP 96 x JI 372; and plant height up to main raceme, number of nodes up to main raceme, 100-seed weight, oil content and seed yield plant^{-1} in JP 101 x SKI 215.While only dominance (h) was significant for seed yield plant^{-1} in JP 96 x JI 368; and length of main raceme, effective length of main raceme and number of capsules on main raceme in JP 96 x JI 372. Neither additive (d) nor dominance (h) was significant for days to flowering of main raceme and number of nodes up to main raceme in JP 96 x JI 372; and number of effective branches plant^{-1} in JP 101 x SKI 215. Several workers have earlier reported importance of additive and dominance gene effects in the inheritance of seed yield and its components by Thakkar (1987), Pathak *et al*. (1988) and Golakia *et al*. (2004). Importance of only additive effects for seed yield was depicted by Giriraj *et al*. (1973)

Table 1. Estimates of individual scaling tests, joint scaling test and gene effects for various traits in three castor crosses.

Cross	Individual scaling tests			Joint scaling test [χ^2]	M	[d]	[h]	[i]	[j]	[l]	Type of epistasis
	A	B	C								
1	2	3	4	5	6	7	8	9	10	11	12
Days to flowering of main raceme											
C_1	-	-	-	-	56.62**±0.37	1.84**±0.36	-0.60**±0.85	-	-	-	-
C_2	**	-	**	**	57.10**±2.74	0.80±0.45	-1.16±7.03	3.16±2.70	-2.25*±1.04	6.20±4.70	D
C_3	**	*	**	**	47.76**±3.40	3.46**±0.24	19.83**±7.86	10.10**±3.40	-5.31**±0.89	-4.86±4.61	D
Days to maturity of main raceme											
C_1	**	**	**	**	183.70**±4.43	1.83**±0.38	-120.06**±11.52	-31.93**±4.41	-1.15±1.66	86.03**±7.45	D
C_2	**	**	**	**	149.86**±4.65	-156**±0.19	-48.00**±11.91	1.96±4.65	-0.65±1.66	38.66±7.52	D
C_3	**	**	**	**	145.50**±5.18	-2.90**±0.49	-46.36**±13.31	4.26±5.15	0.80±1.91	55.06**±8.36	D
Plant height up to main raceme (cm)											
C_1	**	*	**	**	117.33**±14.64	-2.83**±0.57	-69.50*±35.19	-51.83**±14.62	-0.83±4.38	20.16±21.14	D
C_2	**	**	-	**	49.50*±24.29	-12.33**±0.46	106.83*±53.16	25.83±24.28	-1.51±4.84	-94.66*±29.51	D
C_3	*	*	**	**	90.990**±20.04	-31.16**±3.26	18.36±51.01	-16.40±19.77	-3.66±7.58	-37.60±31.89	D
Number of nodes up to main raceme											
C_2	**	-	-	**	16.00**±1.20	0.60±0.40	-4.86±3.18	-0.20±1.13	-1.73**±0.57	2.06±2.12	D
C_3	**	*	**	**	14.56**±1.71	-4.00**±0.24	3.83±4.43	-0.03±1.69	0.65±0.63	-6.26*±3.15	D
Length of main raceme (cm)											
C_1	**	-	**	**	18.33**±6.69	-4.50*±1.88	91.66**±17.02	37.83**±6.42	12.58**±2.84	-51.33**±0.79	D
C_2	**	**	**	**	47.50**±7.41	2.00±1.68	52.66**±18.90	-1.16±7.21	5.66±2.99	-61.83**±11.88	D
C_3	*	-	-	*	61.36**±5.74	-5.66**±0.93	-36.93*±15.20	-15.03**±5.67	-3.23±2.33	26.23**±10.18	D
Effective length of main raceme (cm)											
C_1	**	-	**	**	19.66**± 6.48	-4.50*±1.82	86.16**±16.33	36.50**±6.18	12.66**±2.71	-47.16**±10.37	D
C_2	**	**	**	**	45.66**±7.04	2.00±1.68	54.66**± 18.06	0.66±6.84	5.50±2.90	-62.33**±11.41	D
C_3	**	-	-	*	60.53**±5.59	-5.66**± 0.93	-36.93*±14.78	-14.20*±5.51	-3.06±2.27	27.06**±9.93	D
Number of effective branches per plant											
C_3	*	-	-	**	1.93*±0.79	-0.33±0.23	0.61± 0.36	2.60**±0.76	0.61±0.36	-3.76**±1.37	D
Number of capsules on main raceme											
C_1	-	**	**	**	36.36**±9.91	-5.66*±2.69	31.40±26.06	21.70*±9.54	9.13*±4.41	1.10±16.89	C
C_2	**	**	**	**	32.80**±8.36	-1.76±2.21	73.96**± 22.05	14.56±8.06	5.23±3.71	59.50**±14.43	D
C_3	-	**	-	**	81.70**±9.82	-14.90**±2.04	-76.00**±25.07	-21.20*±9.61	5.31±3.84	54.16**±16.65	D

Table 1. Contd.

1	2	3	4	5	6	7	8	9	10	11	12
Shelling out turn (%)											
C_1	**	-	**	**	58.06**±2.49	3.33**±0.13	12.10*±6.15	4.86*±2.44	-0.28±0.81	-0.83±3.75	D
C_2	*	**	**	**	73.90**±1.84	1.30**±0.08	-26.20**±4.94	-8.93**±1.84	-0.91±0.73	13.70**±3.15	D
C_3	-	-	**	**	52.58**±2.14	2.35**±0.07	17.71**±5.30	5.23*±2.14	0.60±0.70	-5.63±3.24	D
100-seed weight (g)											
C_1	**	-	**	**	23.48**±2.17	4.42**±0.05	17.09**±5.25	6.79**±2.17	-0.54±0.65	-5.05±3.16	D
C_2	-	**	**	**	27.21**±1.68	3.02**±0.09	11.70**±4.07	4.55**±1.68	-1.28*±0.51	-4.92*±2.45	D
C_3	**	-	-	*	22.05**±1.06	1.85**±0.15	3.35±2.61	0.89±1.05	-0.85**±0.36	-0.63±1.58	D
Oil content (%)											
C_1	**	-	*	**	52.80**±1.42	2.33**±0.20	-0.53±3.18	1.58±1.41	-0.80*±0.36	0.28±1.79	D
C_2	**	**	**	**	54.85**±1.40	0.99**±0.04	-6.02±4.03	0.44±1.39	-1.15±0.65	7.41**±2.64	D
C_3	-	**	-	**	42.66**±1.94	2.52**±0.04	7.69±4.92	3.18±1.94	-1.32*±0.65	-3.96±3.04	D
Seed yield plant^{-1} (g)											
C_1	**	**	**	**	164.50**±19.18	1.80±3.56	-375.66**±46.79	-29.36±18.85	-15.46*±6.62	383.56**±30.04	D
C_2	**	-	**	**	146.30**±23.38	36.46**±3.76	-224.30**±52.41	-39.96±23.07	-41.41**±6.14	149.20**±30.72	D
C_3	**	**	**	**	79.50**±17.96	-10.90**±2.80	-73.53±44.32	-24.20±17.74	9.21±6.26	117.50**±27.45	D

C_1=JP 96 x JI 368; C_2=JP 96 x JI 372; C_3=JP 101 x SKI 215; m=mid point; [d]=additive; [h]=dominance; [i]=additive x additive; [j]=additive x dominance; [l]=dominance x dominance. *, ** indicates significant at 5 and 1%, respectively. D=Duplicate; C=Complementary.

and Kandaswamy (1977), while non-additive gene effects for seed yield was reported by Patel *et al*. (1986), Thakkar (1987) and Golakia *et al*. (2004).

In the present study, main effects [m, (d), (h)] as well as all the three digenic interactions [(i), (j), (l)] were significant for length of main raceme and effective length of main raceme in JP 96 x JI 368; and for 100-seed weight in JP 96 x JI 372 indicated the involvement of additive, dominance as well as epistasis gene interaction for controlling these traits. Solanki *et al*. (2003) observed additive, dominance and epistasis with high (l) for plant height up to main raceme, number of nodes up to main raceme, total length of main raceme, effective length of main raceme and number of capsules on main raceme, while Golakia *et al*. (2004) advocated presence of additive, dominance and epistasis gene effects for number of nodes up to main raceme, total length of main raceme, effective length of main raceme and seed yield plant^{-1}. Looking at the interaction components [(i), (j), (l)], any one or any two or all the three interaction parameters were found significant for most of the traits in most of the crosses indicating interaction parameters also played an important role in the inheritance of majority of the characters in almost all the crosses.

A perusal of gene action revealed that both additive and non-additive gene effects governing seed yield and its component traits were

observed in three crosses of castor (Table 1). Further, the classification of gene action showed importance of duplicate type of gene action for all the characters in all the three crosses except number of capsules on main raceme in JP 96 x JI 368, where complementary type of epistasis was observed. The presence of duplicate epistasis for most of the cases could impose restrications in rapid progress, making it difficult to fix genotypes with increased levels of character manifestation. It is suggested that for the characters showing influence of digenic interaction in addition to main effects (d) and (h), population improvement approach in the form of biparental mating coupled with recurrent selection may be adopted. Such programme shall allow mild inbreeding in the population and enhance the possibilities of transgressive segregation and the span of selection over generations. This is especially important to develop inbred lines having superiority in different characters. Such lines can give better hybrids. While in case of complementary type of epistasis, material can be utilized directly in breeding programme.

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Genetic Diversity Studies in Proso Millet (*Panicum miliaceum* L.)

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Abstract

Significant treatment mean sum of squares were observed for all the characters studied. The magnitude of GCV and PCV were high for grain yield, productive tillers plant^{-1}, 1000 grain weight, harvest index, ear head length and plant height, whereas, days to 50 per cent flowering, days to maturity and protein content exhibited least GCV and PCV. The high differences between GCV and PCV magnitude were observed for days to 50 per cent flowering, ear head length, harvest index, productive tillers plant^{-1} and 1000 grain weight. The character plant height showed very high heritability with high genetic advance. On the basis of D^2 values, all genotypes were grouped into 9 clusters. Cluster I was the largest among all clusters with 19 genotypes followed by cluster II, cluster III and IV containing 74 and 4 genotypes respectively. The remaining five clusters *viz*., V, VI, VII, VIII and IX were solitary. The inter cluster distance (D) was ranged between 10.90 (cluster VI and VIII) and 32.59 (cluster II and III). The variances of cluster means indicated that grain yield plant^{-1}, 1000 grain weight, productive tillers plant^{-1} and days to 50 per cent flowering contributed towards the genetic divergence.

Key words : Proso millet, Genetic diversity, D^2.

Genetic variability and diversity are the basic requirement for the success of any breeding programme and selection of elite genotypes. Genotypic and phenotypic coefficient of variations allow to evaluate the extent of variability whereas heritability suggested the relative role of genetic factors in expression of phenotypes. Diversity analysis helps in avoiding the duplicates by getting first hand information about the level of diversity present in genotypes based on morphological characters. So the present study was carried out to assess the genetic divergence among the genotypes using Mahalanobis D^2 statistics and determine the relative contribution of each component character to select the suitable genotypes for further utilization in proso millet breeding programme.

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Materials and Methods

The experimental material consisted of thirty nine genotypes of proso millet collected from Associate Director of Research, Igatapuri Dist. Nashik (M.S). All the genotypes were grown in a randomized block design with three replications at Post Graduate Farm, College of Agriculture, Kolhapur, (M.S). during *kharif* 2011. Each genotype was dibbled by double row of 3 m length with a spacing of 22.5 cm between rows and 10 cm between the plants within rows on 14th June 2011. Recommended agronomic package of practices were adopted to raise said crop. Observations on five randomly selected plants from each germplasm in each replication were recorded on days to 50 per cent flowering, days to maturity, plant height, productive tillers plant^{-1}, ear head length, 1000 grain weight, grain yield plant^{-1}, harvest index and protein content (%). The analysis of variance was done as suggested

by Panse and Sukhatme (1985). The genotypic and phenotypic coefficients of variation were calculated as suggested by Burton and De Vane (1953). Heritability and genetic advance was calculated as suggested by Burton (1952) and Johnson *et al*. (1955) respectively. The data was subjected to analysis of divergence by following Mahalanobis's (1936) D^2 statistics and contribution of different characters to total divergence was based on Touchers method (Rao, 1952).

Results and Discussion

The analysis of variance revealed highly significant differences among the genotypes for all nine characters studied indicating appreciable amount of variability among the genotypes. The estimates of GCV and PCV were high for grain yield plant^{-1}, productive tiller plant^{-1} and 1000 grain weight. Similar results were reported by Akhtar Ali *et al*. (1996) in proso millet and Ganapathy *et al*. (2011) in finger millet. The moderate GCV and PCV were observed for plant height, ear head length and harvest index. The days to 50 per cent flowering, protein content and days to maturity exhibited low GCV and PCV estimates suggesting narrow range of variation for these characters. The differences between GCV and PCV magnitude were high for days to 50 per

Table 1. Variability in 39 genotypes of proso millet.

Characters	Mean	Range	GCV (%)	PCV (%)	Heri-tability % (bs)	Genetic advance	Genetic advance as % of mean
Days to 50 % flowering	82.39	69.00-88.6	4.74	5.21	82.8	7.32	8.88
Days to maturity	113.28	99.00-118.00	3.38	3.52	92.0	7.56	6.68
Number of productive tillers plant^{-1}	3.25	1.3-4.6	24.31	24.69	96.9	1.60	49.32
Plant height (cm)	121.30	80.2-148.0	13.08	13.16	98.8	32.51	26.80
Ear head length (cm)	26.45	20.5-33.9	14.97	15.41	94.2	7.92	29.93
1000 grain weight (g)	2.40	1.82-3.40	24.15	24.51	97.1	1.17	49.02
Harvest index (%)	19.41	13.74-27.32	19.25	19.66	95.8	7.54	38.82
Protein content (%)	11.6	10.24-12.56	5.53	5.59	97.7	1.31	11.25
Grain yield plant^{-1} (g)	7.57	3.52-12.23	31.03	31.13	99.3	4.82	63.69

Table 2. Distribution of 39 genotypes of proso millet into different clusters.

Clusters	Genotypes included	Name of the genotypes included
I	19	PM-1-1, PM-19, PM-19-1, IPPM-2, IPPM-4, IPPM-6, PM-4, PM-18, PM-12, PM-6-2, PM-8-1, PM-3-1, PM-13, 2007-1, PM-2, PM-15, PM-7, PM-17, PM-10-1
II	7	PM-1, IPPM-8, IPPM-10, IPPM-5, IPPM-9, IPPM-1, PM-5
III	4	PM-14, IPPM-3, PM-16, PM-8
IV	4	IPPM-10-1, PMS-9 (ch), PM-21, PM-6-1
V	1	PM-10
VI	1	PM-1 7-1
VII	1	PM-6
VIII	1	PM-3
IX	1	PM-9

cent flowering, ear head length, harvest index, productive tillers plant^{-1} and 1000 grain weight suggesting the role of environment in the expression of these characters. These results are in conformity with the results of Sasamala *et al*. (2011) in common millet. Narrow differences between GCV and PCV magnitude were observed for days to maturity, grain yield plant^{-1}, plant height and protein content suggesting little role of environment in the expression of these characters. Thus more scope for improvement of these traits by simple selection.

The grain yield plant^{-1} recorded the maximum heritability followed by plant height, protein content, 1000 grain weight, productive tillers plant^{-1}, harvest index, ear head length,

Table 3. Average intra and inter cluster D^2 values in 39 genotypes of proso millet.

Cluster	I	II	III	IV	V	VI	VII	VIII	IX
I	65.77 (8.11)	376.74 (19.41)	297.90 (17.26)	148.10 (12.17)	126.56 (11.25)	136.42 (11.68)	348.56 (18.67)	196.84 (14.03)	243.04 (15.59)
II		82.99 (9.11)	1062.10 (32.59)	236.54 (15.38)	313.64 (17.71)	574.56 (23.97)	143.04 (11.96)	768.95 (27.73)	282.91 (16.82)
III			98.80 (9.94)	593.40 (24.36)	322.92 (17.97)	272.58 (16.51)	906.61 (30.11)	266.34 (16.32)	520.75 (22.82)
IV				124.54 (11.16)	220.81 (14.86)	261.14 (16.16)	278.89 (16.70)	387.69 (16.69)	247.11 (15.72)
V					0.00	237.16 (15.40)	294.80 (17.17)	386.12 (19.65)	120.78 (10.99)
VI						0.00	510.76 (22.60)	118.81 (10.90)	327.61 (18.10)
VII							0.00	684.86 (26.17)	257.28 (16.04)
VIII								0.00	423.12 (20.57)
IX									0.00

Figures in parenthesis denote D values.

Table 4. Mean performance of cluster for 9 characters in 39 genotypes of proso millet.

Cluster	Days to 50% flowering	Days to maturity	Productive tillers plant^{-1}	Plant height (cm)	Ear head length (cm)	1000 grain weight (g)	Harvest index (%)	Protein content (%)	Grain yield plant^{-1} (g)
I	82.74	113.70	3.03	120.98	25.38	2.24	18.26	11.69	6.63
II	83.90	114.52	4.24	140.78	30.51	3.33	24.14	11.47	11.23
III	81.08	115.08	2.02	86.48	21.23	1.88	14.94	11.78	4.08
IV	79.67	110.75	4.08	131.07	28.48	2.24	18.81	11.98	8.36
V	84.67	117.00	3.37	104.00	28.00	3.15	20.75	11.74	7.76
VI	72.00	99.00	2.77	115.67	24.80	1.82	22.99	11.13	6.70
VII	86.00	114.00	2.23	136.00	31.87	2.60	25.98	11.65	11.66
VIII	84.67	107.67	2.40	119.07	21.57	1.80	15.77	10.25	5.00
IX	83.67	115.00	4.33	102.00	31.10	2.37	20.62	10.92	9.84

days to maturity and days to 50 per cent flowering indicating that these characters were least influenced by environment. Similar results were reported by Baghel and Maloo (2004). High heritability coupled with genetic advance was found for plant height suggested the additive geneaction in expression of the character. The traits, days to 50 per cent flowering, days to maturity, productive tillers plant^{-1}, ear head length, 1000 grain weight, harvest index, protein content and grain yield plant^{-1} had high heritability with low genetic advance suggested non additive effects variance for expression of these characters (Table 1).

The cluster formation of 39 genotypes was done by following Touchers method as described by Rao (1952). D^2 values between all possible pairs ranged between 6.54 (between genotypes PM-1-1 to PM-19) to 1555.54 (between genotypes PM-14 to IPPM-9) indicating substantial amount of diversity in the material used for investigation. Nine clusters were formed for these 39 genotypes (Table 2). Cluster I was the largest with 19 genotypes followed by cluster II (7 genotypes), cluster III and cluster IV (4 genotypes each). While cluster V, V,I, VII, VIII and IX were monogenotypic. Akhtar-Ali *et al*. (1996) in proso millet, Arunachalam *et al*. (2005) in little millet, Nirmalakumari and Vetriventhan (2010) and Shingane (2012) in foxtail millet grouped genotypes into different clusters.

The maximum intra-cluster distance was observed for cluster IV (D=11.16) followed by cluster III (D=9.94) and cluster II (D=9.11) suggesting that the genotypes present in these clusters might have different genetical architecture (Table 3). The cluster V, VI, VII, VIII and IX showed no intra cluster distance being monogenotypic. Maximum inter-cluster distance was observed between clusters II and III (D=32.59) followed by between clusters III and VII (D=30.11) and cluster II and VIII (27.73) indicating wide divergence among these clusters. This also suggests that genotypes present in one cluster differ entirely from those present in other cluster. The minimum inter-cluster distance was found between clusters VI and VIII (D= 10.90) indicating that the genetic constitution of the genotypes in one cluster had close proximity with the genotype was not so genetically diverse.

Based on mean performance of the clusters for 9 characters (Table 4), it was observed that the cluster VII exhibited highest grain yield plant^{-1} and was characterized by maximum mean ear head length and harvest index. These characters played important role in determining the grain yield of this cluster. Cluster II was characterized by maximum plant height, productive tillers plant^{-1}, 1000 grain weight and harvest index, whearas cluster IX had more number of productive tillers plant^{-1} and ear head length.

The relative contribution of nine characters towards divergence (Table 5) revealed that grain yield plant^{-1} (41.03%), plant height (20.65%) and protein content (20.11%) contributed maximum towards genetic divergence. The magnitude of contribution by harvest index

Table 5. Contribution of various characters towards genetic diversity in proso millet genotypes.

Characters	Number of times expression in first time	Per cent contribution
Days to 50 % flowering	4	0.54
Days to maturity	30	4.05
Number of productive tillers plant^{-1}	30	4.05
Plant height (cm)	153	20.65
Ear head length (cm)	12	1.62
1000 grain weight (g)	27	3.64
Harvest index (%)	32	4.32
Protein content (%)	149	20.11
Grain yield plant^{-1} (g)	304	41.03

(4.32%), productive tillers plant^{-1} and days to maturity (4.05%) and 1000 grain weight (3.64%) was moderate. Other characters *viz*., ear head length and days to 50 per cent flowering were contributed least (less than 2%) towards genetic divergence. The cluster combinations were classified into four divergence classes following the method suggested by Arunachalam and Bandopadhyay (1984). Crosses were suggested between clusters in a pair from inter cluster D values, which fall in divergence classes DC2 and DC3 i.e. having intermediate inter cluster distance between them, which would give higher chances of producing high frequency and magnitude of heterosis in future when they will be crossed. The genotypes PM-1, PM05, PM-6, PM-6-1, PM-9, IIPM-1, IIPM-5, IIPM-8, IIPM-9 and IIPM-10 can be used for breeding programme based on divergence studies in proso millet.

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Stability for Grain Yield in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract

The genotypes and environments were observed to be significant, indicating presence of sufficient genetic variability among genotypes and environments studied. Considering the environmental indices the locations Aurangabad, Dhule and Buldhana were observed to be more favourable for grain yield of pearl millet. Based on performance across locations, genotypes *viz*., Shanti, BBH-830, DHBH-7103, DHBH-7105 and AHB-927 were found stable for grain yield. Released hybrid Shraddha was found suitable specifically for unfavourable environmental conditions. Whereas genotypes DHBH-7100 and DHBH-7107 were found suitable for favourable environmental conditions for grain yield.

Key words : Pearl millet, locations, genotype yield.

The importance of homeostasis in living organism has stimulated plant breeders awareness for the need to develop well buffered varieties. This has led to a greater emphasis on phenotypic stability in breeding programmes. Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the most important component of dryland system and grow extensively in *kharif* season in Maharashtra. The varietal adaptability to environmental fluctuations is important for stabilization of crop production, both over location and seasons. Thus, stability reflects the suitability of a variety hybrid for general cultivation over wide range of environments. In the evolutionary terms, the breeders objective is to produce populations/varieties/hybrids that are better adapted to given environment (Simmonds, 1962). Therefore, efforts are required to increase production and productivity of pearl millet crop across the diverse environments by providing seed of suitable population/variety/hybrids. Keeping this view in mind, the present investigation was carried out.

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Materials and Methods

The experimental material comparised of twenty eight genotypes of pearl millet. Comparision of fifteen hybrids and five populations with 8 (five hybrid and three populations) checks. They were grown at five locations in Maharashtra State *viz*., Buldhana, Ambejogai, Dhule, Niphad and Aurangabad, in a randomized block design with three replications in a net plot size of 4.20 x 1.50 m with 50 x 10 cm spacing under rainfed condition during *kharif* 2009. The recommended package of practices was followed to raise a good and healthy crop. The data on grain yield was recorded and subjected to analysis of stability as per Eberhart and Russel (1966).

Results and Discussion

The analysis of variance (Table 1) indicated the significance of genotypes and environment suggesting presence of considerable variability in genotypes as well as influence of differential environments on grain yield. The differences

between the mean square due to environment + (G x E) was highly significant for grain yield. The genotype x environment interaction was found significant. The G x E interaction was partitioned into linear and nonlinear components. On partitioning of G x E interaction, both components were significant, suggesting their importance in expression of grain yield performance in pearl millet. However, the linear component was larger in magnitude; indicating the prediction of performance across locations is possible. This is also confirmed from overall ANOVA, where linear component is 1.5 times more than non linear. In prediction of performance, non linear component may have its role, since it is also significant. The significant pooled deviation (non-linear component), mean sum of squares for grain yield indicated that the genotypes differed considerably with respect to their stability for this character. Considering the environmental indices (Table 2) the locations Aurangabad, Dhule and Buldhana were observed to be more favourable for grain yield of pearl millet. Thus, the present findings are in consonance with those of Baviskar (1990), Suryavanshi *et al*. (1991) and Anarase *et al*. (2000 and 2002).

The assessment of stability parameters, mean ($\bar{X}$) regression coefficient (S^2di) and deviation from regression (tfdi) helped to categorize the genotypes into different groups (Table 3) *viz*., those suitable for favourable environmental conditions, characterized by xi.>0...,bi>l, $S^2di=0$ and those suitable for poor environments had xi>0...,bi<l, $S^2di=0$ and genotypes showing general adaptability to all environmental conditions characterized by xi>0, bi=l and $S^2di=0$. Accordingly, the hybrid Shanti, BBH-830, DHBH-7103, DHBH-7105 and AHB-927 have shown average stability. Whereas, the hybrid Shraddha was found stable for unfavourable environmental conditions. The genotypes DHBH-7100 and DHBH-7107 were found suitable for favourable environmental conditions for grain yield of pearl millet.

For grain yield of pearl millet the genotypes Shanti, BBH830, DHBH 7103, DHBH 7105 and AHB 927 showed regression coefficient nearer to one and values for deviation from regression as small as possible, mean higher than general mean, showing their general adaptability to all environmental conditions. Out of twenty eight genotypes newly released hybrid Shanti has expressed highest grain yield of 31.55 q ha^{-1}. Suryavanshi *et al*. (1991) and Anarase *et al*. (2000) also reported same results in pearl millet. The genotypes DHBH - 7100 and DHBH - 7107 have shown regression coefficient value more than one, coefficient of determination nearer to unity and deviation from regression as small as possible, indicating their suitability for favourable conditions. The hybrid Shraddha hybrid has shown less than one regression coefficient, as small as possible deviation from regression and higher mean grain yield, indicating its suitability for unfavourable conditions. Due to this typical character, it is a most popular and stable hybrid of pearl millet in Maharashtra state.

Thus, based on above discussion it is concluded that the genotypes and environment studied have shown sufficient variability. The

Table 1. ANOVA for stability in peral millet.

Sources of variation	df	Mean sum of squares
Genotypes	27	0.2425**
Environment	4	10.8225**
Genotype x Environment	108	0.0543**
Env. + (Genotype x Environment)	112	0.4594**
Environment (linear)	1	43.29013**
Genotype x Env. (linear)	27	0.0856*
Pooled deviation	84	0.07651**
Pooled error	270	0.1412

*, ** Significant at p=0.05 and 0.01 respectively.

genotype x environment interaction was significant suggesting prediction of performance over locations can be possible. Further on partitioning of G x E interaction,

Table 2. Location wise seed yield (q ha^{-1}) and different stability parameters of pearl millet.

Genotype	Locationwise seed yield (q ha^{-1})					Mean performance (q ha^{-1}) ($\bar{X}$)	Regression coefficient (bi)	Deviation from regression (S^2di)	Coefficient determination r^2
	Buldhana	Ambejogai	Dhule	Niphad	Aurangabad				
BBH-831	33.65	14.55	33.21	15.08	26.23	24.54	0.743	0.156**	0.613
BBH-832	32.80	34.04	32.83	8.78	36.67	29.02	0.875	0.272**	0.571
AHB-903	22.74	23.18	30.70	6.88	31.42	22.98	0.880	0.094**	0.773
AHB-961	25.39	20.47	31.63	8.47	37.33	24.66	1.088	0.014	0.943
DHBH-7100	32.27	14.55	35.99	13.23	40.80	27.37	1.264	0.004	0.968
DHBH-7103	31.74	17.19	35.71	15.87	43.96	28.90	1.213	0.004	0.975
AHB-927	31.21	22.49	30.28	10.79	34.74	25.90	0.923	0.021	0.909
BBH-830	30.68	24.34	34.98	16.93	30.04	28.99	0.848	0.014	0.975
BBH-3	36.82	19.84	25.55	15.35	41.12	27.74	0.991	0.109**	0.792
DHBH-4/186	29.10	19.18	36.41	22.75	40.17	29.52	0.828	0.039*	0.851
DHBH-7097	27.51	15.18	36.58	18.52	36.87	26.93	0.934	0.057*	0.848
DHBH-7099	31.74	14.55	37.84	16.40	31.91	26.49	0.919	0.110**	0.765
AHB-1666 (C)	24.60	15.56	29.12	8.73	36.87	22.97	1.118	0.017	0.990
Shraddha (C)	28.84	19.84	28.57	14.81	33.65	25.14	0.767*	0.019	0.986
Saburi (C)	22.22	19.05	29.45	12.22	42.54	25.10	1.092	0.069**	0.869
Shanti (C)	32.54	15.45	-36.47	26.99	46.32	31.55	0.970	0.016	0.701
ICMH356 (C)	29.63	16.56	27.74	9.31	41.35	24.92	1.232	0.006	0.963
DHBH-7104	30.16	17.46	24.91	18.52	29.29	24.07	0.521	0.021	0.757
DHBH-7105	32.80	14.55	31.75	14.29	40.88	26.85	1.176	0.013	0.952
DHBH-7107	35.71	16.44	36.91	15.61	42.30	29.33	1.240	0.016	0.953
BBC-10	14.81	11,90	23.91	8.20	39.70	19.70	1.138	0.149**	0.795
BBC-12	24.86	12.49	24.15	13.28	26.94	20.35	0.665	0.001	0.905
ABPC 4-3	19.05	12.06	24.92	7.15	31.19	18.87	0.965	0.010	0.974
ABPC 4-1	23.81	15.71	25.72	4.23	27.41	19.38	0.926	0.020	0.911
ABPC 5-7-1	24.86	17.62	29.32	4.92	31.19	21.58	1.039	0.024	0.922
92901 (C)	29.10	22.96	29.08	4.87	31.66	23.53	0.983	0,109**	0.780
PPC 6 (C)	26.19	15.45	28.92	5.87	44.42	24.17	1.446	0.020	0.961
ICTP 8203 (C)	19.57	10.05	22.24	5.77	38.04	19.13	1.217	0.045*	0.918
Mean	28.02	17.59	30.53	12.28	36.54	-	-	-	-
Environmental index	3.0267	-7.4031	5.5419	-1.2711	11.5454	-	-	-	-
SE±	2.5958	1.7570	2.6028	1.9272	3.9086	-	-	-	-
CD at 5 %	5.2043	3.5226	5.2183	3.8637	7.8363	-	-	-	-
CV%	11.35	12.24	10.44	19.22	13.10	-	-	-	-

Table 3. Categorization of promising genotypes based on stability parameters.

Genotypes showing general adaptability to all environmental conditions. xi>0..,bi, S^2di-0	Shanti, BBH830, DHBH 7103, DHBH 7105 and ABH 927
Genotypes specific for favourable environmental conditions xi>0..,bi, S^2di-0	DHBH 7100 and DHBH 7107
Genotypes specific for unfavourable environmental conditions xi>0..,bi, S^2di-0	Shraddha

both linear and nonlinear components have expressed their important role in expression of grain yield in pearl millet crop. The genotypes *viz*., Shanti, BBH-830, DHBH-7103, DHBH-7105 and AHB-927 have shown average stability for grain yield. Simultaneously, the genotypes DHBH-7100 and DHBH-7107 were found suitable for favourable environmental conditions. Whereas released hybrid Shraddha was found stable for unfavourable environmental conditions for grain yield of pearl millet.

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Effect of Chemical and Cultural Weed Management Methods on Weed Dynamics, Growth, Yield and Economics in Groundnut

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Abstract

The treatment weed free check (two hand weedings at 20 and 40 DAS and two manually uprooting of weeds at 60 and 80 DAS) was found more effective to control weeds in groundnut and recorded the lowest weed density, weed dry matter and weed index with the highest weed control efficiency. Weed free check also recorded significantly the highest growth and yield attributes of groundnut *viz*., plant height, dry matter weight of plant, number of pods plant^{-1} and pod yield hectare^{-1} over rest of the treatments. Though the highest gross monetary return (Rs. 1,09,845 ha^{-1}) was recorded in the treatment weed free check, maximum net monetary return (Rs. 61,460 ha^{-1}) and B:C ratio (1.42) were recorded in the treatment application of pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one hand weeding at 40 DAS which was found most economically profitable weed management practice for groundnut.

Key words : Weed management, groundnut, chemicals, cultural methods, weed dynamics, growth, yield and economics.

Groundnut is an important oilseed crop of India which is cultivated on nearly 6.0 million ha area with the production of 7.5 million tonnes and average productivity of 1,268 kg

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ha^{-1} (Anonymous, 2012). Though India ranks first in the world under groundnut area, there is need to import 8.03 million tonnes of edible oil (Anonymous, 2012). The principle reasons behind this is lower productivity of oil seeds and groundnut as such. Among various causes of low productivity, severe weed infestation in crop is a foremost reason as weed compete with the crop for growth resources. In India yield losses of groundnut due to weeds ranges from 13 to 80 per cent (Ghosh *et al*., 2000).

Weeding and hoeing are common manual and cultural weed management methods for groundnut; but due to scarcity of labours, these methods are very costly and tedious. Mechanically operated power weeders cannot be used after peg initiation of groundnut. On the other hand, use of herbicides alone has also limitations due to their selectivity and herbicides cannot control total weeds in groundnut. Hence, the agronomic investigation was conducted to find out practically feasible and economically viable combination of chemical and cultural methods of weed management in groundnut.

Materials and Methods

The experiment was conducted at Breeder Seed Production Farm of Mahatma Phule Krishi Vidyapeeth, Rahuri for two consecutive *kharif* seasons of the years 2010 and 2011 in a randomized block design with 12 treatments replicated thrice. The experimental site was located at 19° 47' N latitude and 74° 81' E longitude with average annual rainfall of 520 mm. The soil of experimental field was medium deep with pH- 6.2, available N-380 kg ha^{-1}, P-14.5 kg ha^{-1} and K-275 kg ha^{-1}. Treatments consisted combination of hand weeding with pre plant incorporation of fluchloralin @ 1.5 kg a.i. ha^{-1}, pre emergence application of pendimethalin @ 1.5 kg a.i. ha^{-1} and post emergence application of imazethapyr @ 0.150 kg a.i. ha^{-1} (Table-1).

Groundnut variety 'TAG- 24' was sown in first fortnight of July during both the years with plant spacing of 45 x 15 cm on flat beds. The recommended dose of fertilizers 25 kg N + 50 kg P_2O_5 + 0 kg K ha^{-1} was applied as basal dose at the time of sowing. Protective irrigations were applied whenever necessary during the crop growth. Fluchloralin was applied one day before sowing as pre plant incorporation in soil and pendimethalin was applied one day after sowing as pre emergence, whereas imazethapyr was applied 20 days after sowing as post emergence as per the treatment details given in Table-1 with knapsack sprayer. Weed free check was achieved by two hand weedings at 20 and 40 DAS and two times manual uprooting of weeds at 60 and 80 DAS. Randomly five plants were selected from each plot and regular biometric observations of crop and weed parameters were recorded from 30 DAS up to harvest. However, the observations recorded at the peak growth period of crop i.e. at 90 DAS are presented in Tables. Weed density (number m^{-2}) and dry weight of weeds (g m^{-2}) were recorded by putting a quadrat of 0.25 m^2 at two random spots in each plot. Weed control efficiency was calculated by the formula given below

$$WCE\ (\%) = \frac{DMC - DMT}{DMC} \times 100$$

Where, DMC is dry matter weight of weeds in the control plot and DMT is dry matter weight of weeds in treated plot. The weed index was calculated by the formula,

$$WI\ (\%) = \frac{X - Y}{X} \times 100$$

Where, X is yield from weed free plot and Y is yield from treated plots.

For economic study, prevailing market prices were considered for different inputs and outputs. Constant results were obtained during both the years for all the characters, therefore, the data have been pooled for two years and results have been presented.

Results and Discussion

Effect on weeds : Predominant weeds in experimental groundnut field were *Parthenium hysterophorus, Amaranthus viridis, Portulaca oleracea, Argemone mexicana, Euphorbia spp., Solanum nigrum, Echinochloa colonum, Cyperus rotundus, Cynedon dactylon*, etc. All the weed management treatments significantly reduced weed density and dry weight of weeds over control. Treatment weed free check resulted in the lowest weed density and dry weight of weeds. The highest weed control efficiency and lowest weed index percentage were observed in treatment weed free check. Treatment pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one HW at 40 DAS was found next superior treatment after weed free check in respect of all weed parameters which was on par with

Table 1. Effect of different weed management methods on weed parameters in groundnut (pooled mean).

Treatment	Weed density (no. of weeds m^{-2}) at 90 DAS	Dry weight of weeds (g m^{-2}) at 90 DAS	Weed control efficiency (%)	Weed index (%)
T_1 : Weed, free check	0.00	0.00	100.00	0
T_2 : Fluchloralin @ 1.5 kg a.i. ha^{-1} as PPI + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE	47.88	89.04	74.60	43.93
T_3 : Imazethapyr @ 0. 150 kg a.i. ha^{-1} as POE + one HW at 40 DAS	30.62	60.67	87.44	26.98
T_4 : Pendimethalin @ 1.5 kg a.i. ha^{-1} as PE	67.94	126.78	67.94	61.78
T_5 : Fluchloralin @ 1.5 kg a.i. ha^{-1} as PPI + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one HW at 40 DAS	25.19	46.85	87.83	18.26
T_6 : Imazethapyr @ 0.150 kg a.i. ha^{-1} as POE	55.54	108.33	69.31	54.52
T_7 : Fluchloralin @ 1 .5 kg a.i. ha^{-1} as PPI + one HW at 20 DAS	41.34	77.30	78.71	38.22
T_8 : Pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one HW at 40 DAS	21.54	43.24	89.94	5.13
T_9 : Pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + one HW at 20 DAS	38.71	64.44	82.53	35.37
T_{10} : Fluchloralin @ 1.5 kg a.i. ha^{-1} as PPI	70.28	131.18	65.66	57.91
T_{11} : Pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE	46.29	81.89	73.82	41.97
T_{12} : Weedy check (control)	144.39	286.41	0	69.52
SE±	1.54	2.83	-	-
CD at 5%	4.63	8.49	-	-

PPI- Pre Plant Incorporation, PE- Pre Emergence, POE- Post Emergence, HW- Hand Weeding and DAS- Days After Sowing

treatment fluchloralin @ 1.5 kg a.i. ha^{-1} as PPI + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one HW at 40 DAS. This might be due to pre plant soil incorporation of fluchloralin and pre emergence application of pendimethalin that prevented emergence of monocot and grassy weeds by inhibiting root and shoot growth, while imazethapyr was responsible for inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS) in broad leaf weeds which caused destruction of these weeds at 3-4 leaf stage. Remaining monocot weeds were controlled by hand weeding at 40 DAS and two times manual uprooting at 60 and 80 DAS.The lowest weed control efficiency and highest weed index percentage were recorded in treatment weedy check (control). Integration of hand weeding with pre and post emergence herbicides resulted significant reduction in dry matter production by weeds (Walia *et al*., 2007). Dubey and Gangwar (2012) also found lower weed biomass, weed index and higher weed control efficiency with post emergence application of imazethapyr and two hand weedings in groundnut.

Effect on crop : Treatment weed free check recorded significantly taller plants and higher dry matter production and pod yield $hectare^{-1}$ over all the other treatments. This was followed by treatment pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one HW at 40 DAS. However, in respect of number of pods $plant^{-1}$, treatment weed free check and treatment pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0. 1 50 kg a.i. ha^{-1} as POE + one HW at 40 DAS were found to be on par with each other. This might be due to reduced competition of weeds with crop for grwoth resources *viz*., space, light, nutrients and moisture with adaption of effective weed control methods. Singh and Giri (2001) also concluded that, proper weed control was responsible for increase in plant height and dry matter production in groundnut. Weed free environment in crop also facilitates better peg initiation and development of groundnut which tends to increase in number of pods $plant^{-1}$ and pod yield $hectare^{-1}$. Higher profitable pod yield of summer groundnut was also reported by Raj *et al.* (2008) with keeping the crop weed free

Table 2. Effect of different weed management methods on growth, yield and economics of groundnut (pooled mean).

Treatment	Plant height (cm) at 90 DAS	Dry matter weight (g) at 90 DAS	Pod yield (q ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1	29.12	58.54	24.54	1,09,845	60,045	1.21
T_2	22.27	43.92	13.76	61,920	22,660	0.58
T_3	25.18	48.36	17.92	80,640	38,840	0.93
T_4	21.61	39.46	9.38	42,210	4,910	0.13
T_5	25.37	49.15	20.06	90,270	46,970	1.08
T_6	22.03	46.11	11.16	50,220	12,420	0.33
T_7	24.21	47.87	15.16	68,220	26,920	0.65
T_8	26.49	51.73	23.28	1,04,760	61,460	1.42
T_9	24.9	46.30	15.81	71,145	29,845	0.72
T_{10}	20.06	34.53	10.33	46,485	9,185	0.25
T_{11}	22.46	40.22	14.24	64,080	24,780	0.63
T_{12}	16.84	29.62	7.48	33,660	-2,140	-0.05
SE±	0.68	1.59	0.41	1114	964	-
CD at 5%	2.01	4.77	1.20	3,336	2,900	-

by application of herbicides coupled with one hand weeding at 45 days after sowing. Significantly lower values of plant height, number of pods plant^{-1} and pod yield hectare^{-1} were recorded in treatment weedy check (control).

The highest number of kernels pod^{-1} was recorded in treatment weed free check, but there was no significant effect of weed management practices on number of kernels pod^{-1} in groundnut.

Effect on economical parameters : Treatment weed free check recorded significantly the highest gross returns hectare^{-1} (Rs.1,09,845 ha^{-1}) whereas, the highest net return (Rs. 61,460) and B:C ratio (1.42) were recorded in treatment pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one HW at 40 DAS. This might be due to the increased cost of cultivation of groundnut in treatment weed free check due to higher human labours and high wage rate. This cost was reduced in treatment pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one hand weeding at 40 DAS by using herbicides for effective control of weeds with reduced human labours. Sasikala *et al.* (2004) and Rao *et al*. (2011) also reported higher net return and B:C ratio with integration of pre and post emergence application of herbicides with hand weeding in groundnut. Treatment weedy check (control) recorded the lowest gross monetary return (Rs. 33,660 ha^{-1}), net monetary return (Rs.-2,140 ha^{-1}) and B:C ratio (-0.05).

Considering the present situation of scarcity and high wage rate of labours for higher yield and B:C ratio from groundnut with efficient weed control, treatment pendimethalin @ 1.5 kg a.i. ha^{-1} as PE + imazethapyr @ 0.150 kg a.i. ha^{-1} as POE + one HW at 40 DAS proved more effective and economically profitable integrated weed management practice for groundnut.

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Effect of Post-Inoculation Application of Amino Acids on Incubation Period and White Rust Disease of Mustard at True Leaf Stage of cv. Varuna

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Abstract

In the present study, following post inoculation application of amino acids, the maximum incubation period was recorded in T_9 L-Cys Hyd (13.40 days) followed by T_8 Gly (12.60), T_6 L-Arg Mon (12.50 days), T_1 L-Pro (12.25 days), T_{10} L-His Mon (12 days) and (11.75 days) in rest of the treatments except T_3 L-Tyr (11.50 days) in comparison to check (11 days) after twenty one days of post-inoculation application of amino acids. The significant minimum disease index was observed in T_9 L-Cys Hyd (7.70%) at par with T_8 Gly (7.94%) followed by T_6 L-Arg Mon (9.88%), T_1 L-pro (10.20%), T_2 L-Lys Mon (10.80%), T_5 L-Cys (11.20%). The treatment T_9 L-Glu acid showed (12.06%) disease index at par with T_4 L-Len (12.21%) and T_3 L-Tyr (13.28%). The ten amino acids used to study the host reaction of mustard cv. Varuna against white rust following post inoculation of *A. candida*, showed significant reduction in the white rust severity (7.80-13.68%) in comparison to check at true leaf stages of susceptible mustard cv. Varuna, indicating thereby their role in inducing the plant to show resistance against white rust. Mustard plants acquire resistance against white rust caused by *Albugo candida* by previous or subsequent inoculation with chemicals and biotic agents. In the present study results revealed that abiotic inducers (amino acids) provide protection against the oomycete *Albugo candida* when post-inoculation application of amino acids were given at true leaf stage of cv. Varuna.

Key words : *Albugo candida*, incubation period, Varuna, post inoculation application, amino acids.

White rust (WR), caused by *A. candida* has been an economic constraint in production of rapeseed mustard. White rust (*Albugo candida* (pers)Kunze) is a serious disease causing heavy yields losses in mustard (*Brassica juncea* (L). Economically significant yield losses due to foliar and staghead infection varies from 20 to 60 per cent have been reported in severely infected fields (Bisht *et al*., 1994). The disease appears in different proportions on rapeseed and mustard crop (Kolte *et al*., 1982).

Some biological plant defense inducers such as *Trichoderma, Pseudomonas*, *Bacillus*, *Serratra*, non-pathogenic strains of Fusarium and yeast have been developed as commercial product to manage various diseases (Droby *et al*., 2002; Benhamon and Garand, 2001, Varhagen *et al*., 2004).

In recent years, a new group of chemicals that activate host defense mechanism and protect the plant against pathogens has been developed to manage crop diseases. These chemicals are called "plant defense activators"or "plant activators" (Romero *et al*.2001). Salicylic acid mimic compound (acibenzolar-s-methyl, Bion), phosphorus salts (Foli-R-Fos 400, Nutri-Phite-P) and micronutrient potassium salts (Canon, Phytogard and Nutrol) have been developed as commercial plant activator (Becot *et al*., 2000; Macmillan *et al*., 2000; Pajot *et al*., 2001; Graham and Leite, 2004; Reuveni *et al*., 2000).

In the present studies efficacy of ten amino

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acids (plant defense activators) in the control of mustard white rust was tested under glass house conditions.

Materials and Methods

The laboratory- cum- glasshouse experiments were conducted on white rust susceptible mustard cv. Varuna at, GBPUA and T., Pantnagar. The healthy seeds maintained through selfing were obtained from Oilseed Pathology Laboratory, GBPUA and T., Pantnagar. All chemicals and reagents were of analytical and guarantee grade.

Preparation of inoculum : WR infected leaves were collected from field -grown WR-susceptible mustard cultivar "Varuna" at the Crop Research Centre (CRC) GBPUA and T., Pantnagar and further maintained as generation of single WR pustule on the same cultivar on pot-grown mustard plants under glasshouse conditions. Zoosporangial powder was obtained by scrapping the surface of pustules with sterilized blade. Sporangia of *A. candida*, i.e. about 200 mg sporangial powder was added to 100 ml of double glass distilled water in 200 ml of flask. The flask was then covered with parafilm and shaken vigorously to obtain uniform suspension of sporangia in water. The culture was then incubated for about 4 hr. at 15°C to obtain germination of sporangia so as to obtain zoospores suspension which in the true sense served as the inoculum for inoculation of the true leaves. The zoospore concentration was approximately adjusted to 105 zoospores per ml. Ten amino acids were used @500, 1000, 1500 and 2000 ppm. as L-Proline (T_1 L-Pro), L-Lysine Monohydrochloride (T_2 L-Lys Mon), L-Tyrosine (T_3 L-Tyr), L-Leucine (T_4 L-Leu), L-Cystine (T_5 L-Cys), L-Arginine Monohydrochloride (T_6 L-Arg Mon), L-glutamic acid (T_7 L-Glu Acid), Glycine (T_8 Gly), L-Cysteine Hydrochloride (T_9 L-Cys Hyd), L-Histidine Monohydrochloride (T_{10} L-His Mon) and unsprayed check/ control.

Application of amino acids : Mustard plants with fully expanded leaves were inoculated with *A. candida* and after 24 hours, treatments of amino acids were given keeping suitable control. The amino acid solutions were sprayed on the same adaxial surface of the leaf with atomizer. For each treatment, 3 replications were maintained. Propagator trays were covered with polythene to obtain 90 to 100 per cent relative humidity for 72 hours.

Humid chambers : The humid chambers were prepared by putting the iron frame of 1.5 x 0.6 x 0.7m size over the cement pit of 1.45 x 0.45 x 0.45m size containing water and covered by plastic sheet. This helps in providing high humidity for infection. Four sets of such humid chambers were prepared maintaining the inoculating treatments in isolation treatments to avoid any drift. Another type of humid chamber was prepared by propagators trays of size 41 x 30 x 7cm containing water

Table 1. Effect of post-inoculation application of amino acids at different concentrations on incubation period of mustard white rust at true leaf stage of cv. Varuna.

Treatment	Incubation period*				
	Concentration (ppm)				
	500	1000	1500	2000	Mean
T_1 L-Pro	12	12	12	13	12.25
T_2 L-Lys Mon	11	11	12	13	11.75
T_3 L-Tyr	11	11	12	12	11.50
T_4 L-Leu	11	11	12	13	11.75
T_5 L-Cys	11	11	12	13	11.75
T_6 L-Arg Mon	12	12	13	13	12.50
T_7 L-Gluacid	11	11	12	13	11.75
T_8 Gly	11.66	12	13	14	12.60
T_9 L-CysHyd	13	13.3	13.3	14	13.40
T_{10} L-HisMon	11	12	12	13	12.00
Check	11	11	11	11	11

and covered by plastic sheet.

Observation on WR severity : Observations on WR severity on true leaves were recorded on 15 and 2 Idays after inoculation by using an interaction phenotype (IP) rating scale of 0-5 given by Williams (1985).

Results and Discussion

Following post inoculation application of amino acids, the minimum incubation period was recorded in cv. Varuna at true leaf stage in check (11 days). The maximum incubation period was recorded in T_9 L-Cys Hyd (13.40 days) followed by T_8 Gly (12.60), T_6 L-Arg Mon (12.50 days), T_1 L-Pro (12.25 days), T_{10} L-His Mon (12 days), T_2 L-Lys Mon (11.75 days), T_4 L-Leu (11.75 days), T_5 L-Cys (11.75 days), T_7 L-Glu acid (11.75) and T_3 L-Tyr (11.50 days) (Table 1). All treatment showed

Table 2. Effect of post inoculation application of amino acids at different concentrations against white rust of mustard at true leaf stage of cv. Varuna under glasshouse conditions.

Treatment	Disease index (%)									
	Concentration (ppm)									
	14DAI					21DAI				
	500	1000	1500	2000	Mean	500	1000	1500	2000	Mean
T_1 L-Pro	8.90	7.20	5.26	4.00	6.59	11.38	10.46	9.80	9.86	10.20
	(17.35)	(15.53)	(13.24)	(11.77)	(14.47)	(19.70)	(18.85)	(18.17)	(17.59)	(18.58)
T_2 L-LysMon	8.30	7.45	5.69	4.20	6.41	11.26	11.55	10.39	10.00	10.80
	(16.74)	(15.83)	(13.79)	(11.87)	(14.56)	(19.59)	(19.86)	(18.79)	(18.37)	(19.15)
T_3 L-Tyr	9.66	8.90	7.56	6.14	8.11	14.20	13.12	13.00	12.80	13.28
	(18.10)	(17.35)	(15.94)	(13.97)	(16.34)	(22.13)	(21.22)	(21.22)	(20.93)	(21.35)
T_4 L-Leu	9.50	8.05	7.00	6.13	7.67	13.27	12.79	11.78	11.00	12.21
	(17.93)	(16.48)	(15.33)	(14.37)	(16.03)	(21.34)	(20.93)	(20.05)	(20.44)	(20.69)
T_5 L-Cys	8.90	6.82	6.72	5.00	6.86	12.00	11.54	11.46	9.8	11.20
	(17.35)	(15.13)	(15.01)	(12.91)	(15.10)	(20.54)	(19.85)	(19.77)	(18.21)	(19.59)
T_6 L-ArgMon	6.90	6.00	5.04	4.10	5.51	11.06	10.15	9.55	8.76	9.88
	(15.22)	(14.14)	(12.92)	(11.77)	(13.31)	(19.99)	(18.54)	(17.98)	(17.21)	(18.43)
T_7 L-Gluacid	8.14	6.87	6.52	4.90	6.39	13.37	13.00	10.66'	10.66	12.06
	(16.57)	(15.19)	(14.74)	(13.17)	(14.92)	(21.43)	(19.55)	(19.03)	(19.03)	(20.28)
T_8 Gly	6.79	4.55	3.48	1.66	4.12	8.96	8.54	7.92	6.34	7.94
	(15.10)	(12.31)	(10.74)	(7.91)	(11.51)	(17.42)	(16.98)	(14.57)	(14.57)	(16.32)
T_9 L-CysHyd	6.58	4.77	2.98	1.51	3.96	9.21	8.32	7.61	5.66	7.70
	(14.85)	(12.61)	(9.93)	(7.61)	(11.25)	(17.65)	(16.73)	(15.97)	(13.67)	(16.01)
T_{10} L-HisMon	9.72	8.16	6.04	5.00	7.23	12.26	11.69	11.77	9.28	11.46
	(18.15)	(16.58)	(14.14)	(12.91)	(15.44)	(20.46)	(19.98)	(19.94)	(17.71)	(19.52)
Check	13.8	13.8	13.8	13.8	13.8	30.76	30.76	30.76	30.76	30.76
	(21.69)	(21.69)	(21.69)	(21.69)	(21.69)	(33.63)	(33.63)	(33.63)	(33.63)	(33.63)
C.D. at 5%										
Treatment					0.93					1.17
Concentration					0.56					0.71
Interaction					1.87					2.53

Figures in parenthesis are angular transformed values. *DAI = Days after inoculation.

increase in incubation period in comparison to check, similar observations were recorded by other workers in some host pathogen system (Urena-Padila *et al*., 2002, Pria *et al*., 2003 and Scherm and Ojiambo 2004).

After fourteen days of post-inoculation application of amino acids, maximum WR index was observed in T_{11} check (13.8%). The significant minimum WR index was observed in T_9 L-Cys Hyd (3.96%), which was at par with T_8 Gly (4.12%) followed by T_6 L-Arg Mon (5.51%). The treatment T_7 L-Glu acid (6.39%) showed disease index which was at par with T_2 L-Lys Mon (6.41%) T_1 L-Pro (6.59%), T_5 L-Lys (6.86%) followed by T_4 L-Len (7.67%) and T_3 L-Tyr (8.11%) in comparison to check (Table 2).

After twenty one days of post-inoculation application of amino acids, the significant minimum disease index was observed in T_9 L-Cys Hyd (7.70%) at par with T_8 Gly (7.94%) followed by T_6 L-Arg Mon (9.88%), T_1 L-pro (10.20%), T_2 L-Lys Mon (10.80%) and T_5 L-Cys (11.20%). The treatment T_9 L-Glu acid showed (12.06%) disease index at par with T_4 L-Len (12.21%) and T_3 L-Tyr (13.28%). After fourteen and twenty one days of inoculation, it was also observed that there was highly significant difference among all the treatments concentrations (Table 2).

In the present study all the ten amino acids used to study the host reaction of mustard cv. Varuna against WR at true leaf stages following post inoculation of *A. candida*, all amino acids showed significant reduction in the WR severity (7.80-13.68%) in comparison to check at true leaf stages of susceptible mustard cv. Varuna indicating thereby their role in inducing the plant to show resistance against WR (Table 2). This also indirectly reveals the curative effect of these amino acids against WR infection of mustard. In the present studies, the amino acids as tested for their in vitro effect on *A. candida* indicated the tendency of reduction of sprorangial germination of *A. candida* and mycelial growth of *A. brassicae*. However, the result on inhibition on the fungal growth was non-significant. This is for the first time the present study has generated information on the effectiveness of amino acids on the induction of host resistance.

Mustard plants acquire resistance against white rust caused by *Albugo candida* by previous or subsequent inoculation with chemicals and biotic agents (Vishwanath *et al*. 1999; Singh *et al*. 1999; Kaur and Kolte 2001; and Mishra *et al*. 2009). In the present study results revealed that abiotic inducers (amino acids) provide protection against the oomycete *Albugo candida* when post-inoculation application of amino acids were given. This information on the effectiveness of post inoculation application of amino acids on reaction of mustard to WR infection will be useful in designing the experiments in future studies.

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Studies on Effect of Sulphur Oxidizing Microorganisms with Sulphur on Nutrient Uptake in Green gram (*Vigna radiata* L.)

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Abstract

All the cnltures under study revealed significantly higher nutrient uptake and protein percentage in grains over uninoculated control. However, the effects of cultures were more pronounced in conjugation with elemental sulphur. The composite culture treatment found significantly superior followed by *Thiobacillus* bacteria, *Aspergillus* and *Trichoderma* fungi at all levels of sulphur and maximized at 60 kg ha^{-1} sulphur level. Nitrogen uptake was significantly increased from 59.40 to 84.49 mg 100 g^{-1} of dry weight of plant and maximum uptake was observed under composite culture treatment. Phosphorus uptake from 15.07 to 27.87 mg 100 g^{-1}, potassium uptake from 16.51 to 28.74 mg 100 g^{-1} and sulphur uptake was considerably, increased from 282.67 to 382.67 mg 100 g-1 of dry weight of plant under composite culture treatment at 60 kg 'S' ha^{-1}. The average protein content in grains was also increased from 23.34 to 24.36 per cent. Composite culture of bacteria and fungi were found more effective over rest of the treatments at 60 kg 'S' ha^{-1} and the cultures survived longer time in the sulphur oxidation process. These sulphur oxidizing micro-organisms showed synergistic effects to promote the uptake of nutrients in green gram. The composite culture of bacteria and fungi in combinations with various sulphur levels was found most effective in increasing the uptake of nutrients in green gram.

Key words : Sulphur oxidizing cultures, N, P, K and S uptake, protein, green gram.

The major reservoir of sulphur in soil is unavailable elemental and reduced form. Plants generally utilize the oxidized state of sulphate (SO_4) and as a result of reduced forms of element must be first oxidized before they can be used by the plants. The microorganisms are mainly responsible for oxidizing unavailable elemental and reduced form of sulphur to make plant available (SO_4).

The role of chemolithotrophic bacteria of the genus *Thiobacillus* in the process of sulphur oxidation has been emphasized. But there is possibility of having heterotrophic microorganisms in soil for sulphur oxidation which are easy to multiply and application as bio-inoculants for seed and soil treatments in legumes and oilseed crops. In the course of biological oxidation of elemental sulphur, it produces plant available sulphetic (SO_4) and sulphuric acid (H_2SO_4) and both of these products of reaction playing very vital role in nutrient availability, plant growth and soil fertility. Therefore, it was felt worthwhile to undertake the study on sulphur oxidizing microorganisms and their effect on growth and yield of green gram at graded levels of elemental sulphur.

Materials and Methods

The isolation of sulphur oxidizing bacteria, fungi and actinomycetes were made by using sulphur enrichment liquid medium *viz*.; thiosulphate medium (Waksman, 1922) for bacteria and modified thiosulphate medium (Wainwright, 1978) for fungi and actinomycetes. In all 10 isolates were obtained from 25 soil samples and further screened for

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sulphur oxidizing ability and pH reduction. Thus three efficient isolates were selected and further identified as *Thiobacillus* sp., *Aspergillus terreus* and *Trichoderma harzianum*. These selected cultures and its combinations were used in glasshouse study to asses the effect on green gram with graded levels of elemental sulphur.

The glasshouse experiment was laid out in a factorial complete randomized design comprising five cultures as main treatments while four sulphur levels as sub treatments. The experiment was randomized in three replications. The sterilized earthen pots were filled with 5 kg soil each and recommended dose of NPK fertilizers was mixed. The elemental sulphur powder as per the treatments was mixed in the soil. The cultures were multiplied in the laboratory and mixed in the soil @ 10 cfu ml^{-1} pot^{-1}. Five seeds of green gram were sown in each pot and finally maintained four seedlings pot^{-1} for further observations. The nutrient uptake, nitrogen, phosphorus, potash and sulphate were recorded after harvesting of crop by adopting standard analytical methods. The protein content in green gram grains was estimated by Micro Kjeldahl method (Bremner, 1965).

Results and Discussion

The data on effect of sulphur oxidizing microorganisms with various sulphur levels on nitrogen uptake (Table 1) in green gram (mg 100 g^{-1} dry matter weight) revealed that nitrogen uptake by plant were significantly increased due to inoculation of sulphur oxidizing microorganisms with various sulphur levels. Nitrogen uptake were was ranged between 59.40 to 84.49 mg 100 g^{-1} of dry weight of plant sample. Maximum nitrogen uptake was observed under composite culture (84.49) at 60 kg sulphur ha^{-1} treatment followed by *Thiobacillus* sp. (82.11), *Aspergillus terreus* (80.83), *Trichoderma harzianum* (78.69) and lowest in the control (59.401 mg 100 g^{-1} dry weight of plant). The result is in agreement with the findings of Teotia *et al*. (2001). Nitrogen uptake was significantly increased due to application of various sulphur oxidizing cultures over uninoculated control.

Table 1. Effect of sulphur oxidizing micro organisms with various sulphur levels on 'N' and 'P' uptake by green gram (mg 100 g^{-1} dry weight of plant).

Culture/Sulphur levels	**0kg 'S' ha^{-1}**		**20kg 'S' ha^{-1}**		**40kg 'S' ha^{-1}**		**60kg 'S' ha^{-1}**		**Mean**	
	'N' uptake	**'P' uptake**	**'N' uptake**	**'P' uptake**	**'N' uptake**	**'P' uptake**	**'N' uptake**	**'P' uptake**	**'N' uptake**	**'P' uptake**
Control (C_1)	59.40	15.07	63.46	15.99	65.39	16.46	67.67	17.66	68.98	16.29
Thiobacillus sp. (C_2)	69.28	19.13	72.63	20.17	76.71	25.23	82.U9	26.20	75.20	22.68
Aspergillus terreus (C_3)	68.82	19.20	71.43	20.00	75.47	24.07	80.83	24.50	74.14	21.94
Trichoderma harzianum (C_4)	68.53	19.06	70.99	19.92	74.42	21.74	78.69	22.32	73.16	20.76
Composite culture (C_2-C_4)	70.29	19.66	73.38	20.68	77.56	25.69	84.49	27.87	76.43	23.47
Mean	67.27	18.43	70.38	19.35	73.91	22.64	78.77	23.71		
Characters	SE±	SE±	CD at 5%	CD at 5%						
Culture (C)	0.8	0.05	0.24	0.13						
Sulphur (S)	0.07	0.04	0.21	0.12						
Cultures (C) x Sulphur (S) interaction	0.1	0.09	0.48	0.29						

*Means, of three replications.

The treatment of sulphur application also increased the nitrogen uptake by green gram plant from 67.27 to 7-8.77 mg. Maximum nitrogen uptake was observed under 60 kg 'S' ha^{-1} followed 40 kg and 20 kg i.e. 78.77, 73.91 and 70.38 mg respectively.

The phosphorous uptake (Table 1) was significantly increased due to various culture inoculation from 16.29 to 23.47 mg 100 g^{-1}. Maximum phosphorus uptake was observed in composite culture followed by *Thiobacillus* spp; *Aspergillus terreus*; *Trichoderma harzianum* and minimum with the control. Sulphur application also showed significant increase in 'P' uptake in green gram from 18.43 to 23.71 and highest 'P' uptake was observed under 60 kg 'S' ha^{-1}. It was noticed that the uptake of 'P' was significantly increased due to inoculation of culture. However, maximum uptake of 'P' (27.87 mg) was observed under composite culture at 60kg 'S' ha^{-1} followed by *Thiobacillus* sp., *Aspergillus terreus*, *Trichoderma harzianum* with 60 kg 'S' ha^{-1} and minimum in uninoculated control i.e. 26.20, 24.50, 22.32 and 15.07 mg 100^{-1} g of dry weight respectively. Sulphur uptake was increased due to sulphur oxidizing micro-organisms with various levels of sulphur and was ranged from 15.07 to 27.87 mg 100^{-1} g dry matter weight. Similar results were also recorded by Kumar and Rana (2007).

The effect of sulphur oxidizing culture on potassium uptake (Table 2) in green gram plant (mg 100 g^{-1}) showed that application of sulphur oxidizing culture have significantly increased the 'K' uptake in green gram from 18.34to 23.99 mg 100 g^{-1}. Highest 'K' uptake was in composite culture treatment (23.99) followed by *Thiobacillus* sp. (23.47); *Aspergillus terreus* (23.05) and minimum in the control 18.34 mg 100 g^{-1} dry weight of plant, respectively. Sulphur application shown significant positive interaction with 'K' uptake. Maximum 'K' uptake observed at 60 kg 'S' ha^{-1} followed by 40, 20 and 0 kg ha^{-1}. Maximum uptake of 'K' were observed under composite culture (28.74 mg 100 g^{-1}) at 60 kg 'S' ha^{-1} followed by *Thichoderma* sp., *Aspergillus terreus*; *Tricoderma harzianum* with 60 kg 'S' ha^{-1} and minimum with the control, i.e. 27.12,

Table 2. Effect of sulphur oxidizing micro organisms with various sulphur levels on 'K' and 'S' uptake of gram (mg 100 g^{-1} dry weight of plant).

Culture/Sulphur levels	**0kg 'S' ha^{-1}**		**20kg 'S' ha^{-1}**		**40kg 'S' ha^{-1}**		**60kg 'S' ha^{-1}**		**Mean**	
	'K' uptake	**'S' uptake**	**'K' uptake**	**'S' uptake**	**'K' uptake**	**'S' uptake**	**'K' uptake**	**'S' uptake**	**'K' uptake**	**'S' uptake**
Control (C_1)	16.51	282.67	17.67	289.67	19.07	296.00	20.10	308.00	18.34	294.08
Thiobacillus sp. (C_2)	20.78	319.00	22.80	323.00	23.17	340.00	27.12	368.00	23.47	337.50
Aspergillus terreus (C_3)	20.53	314.00	22.74	319.67	22.99	335.00	25.93	362.00	23.05	332.67
Trichoderma harzianum (C_4)	20.19	309.00	22.00	322.00	22.07	330.00	24.36	342.00	22.16	325.75
Composite culture (C_2-C_4)	20.93	322.33	22.37	322.00	23.91	344.33	28.74	382.67	73.99	342.83
Mean	19.79	309.40	21.52	315.27	22.24	329.07	25.25	352.53		
Characters	SE±	SE±	CD at 5%	CD at 5%						
Culture (C)	0.06	1.28	0.17	3.66						
Sulphur (S)	0.05	1.14	0.15	3.27						
Cultures (C) x Sulphur (S) interaction	0.12	2.26	0.34	7.31						

*Means, of three replications.

25.93, 24.36 and 16.51 mg 100 g^{-1} respectively. The results were in agreement with Chettri and Mondal (2004).

The data on effect of sulphur oxidizing microorganisms with various sulphur levels on sulphur uptake in green gram (mg 100 g^{-1}) revealed that the sulphur uptake by green gram plant (Table 2) was also increased significantly in all the culture treatments with various levels of sulphur over control. The maximum sulphur uptake was recorded under composite culture treatment (342.83) followed by *Thiobacillus* sp. (337.50), *Aspergillus terreus* (332.67 g) and *Trichoderma harzianum* (325.75 mg) irrespective of sulphur levels. The sulphur treatments also increased the sulphur uptake by plant significantly over without sulphur treatment i.e. from 309.40 to 352.53 mg 100 g^{-1} dry weight of plant. The culture in combination with sulphur levels has shown significant effect on sulphur uptake. The maximum sulphur uptake (382.67) was observed under treatment of composite culture with 60 kg 'S' ha^{-1} followed by *Thiobacillus* sp., *Aspergillus terreus*, *Trichoderma harzianum* with 60 kg 'S' ha^{-1} and minimum in uninoculated control i.e. 368.00, 362.00, 308.00, and 282.67 mg 100 g^{-1} respectively of dry weight of plant. This trend corroborates with the findings of Bharathi and Poongothai (2008), they also pointed out that application of sulphur to crops resulted in increasing sulphur uptake by as direct or residual effect in green gram-maize planting.

The application of sulphur showed linear response to increase in uptake of N, P, K and S in green gram. The result is in agreement with the findings of Teotia *et al*. (2001).

The protein percentage in green gram grains was increased (Table 3) due to inoculation of sulphur oxidizing cultures and sulphur alone but the effects of culture were more pronounced when sulphur was added with cultures in soil. Th maximum protein (25.40%) was observed in composite culture treatment followed by *Thiobacillus* (25.25%), *Aspergillus terreus* (25.00%) and *Trichoderma harzianum* (24.19%) while minimum in the uninoculated control (23.60%) at 60 kg ha^{-1} sulphur application. Shahi *et al*. (2002) studied the improvement in nutrition quality of green gram as influenced by fertilization and cultures and they observed increased protein percentage and sulphur amino acids due to sulphur with rhizobacterial culture inoculation. Similar results were also

Table 3. Effect of sulphur oxidizing micro organisms with various sulphur levels on protein content (%) in grains.

Culture/Sulphur levels	**0kg 'S' ha^{-1}**	**20kg 'S' ha^{-1}**	**40kg 'S' ha^{-1}**	**60kg 'S' ha^{-1}**	**Mean**
Control (C_1)	23.17	23.21	23.38	23.60	23.34
Thiobacillus sp. (C_2)	23.66	23.93	24.08	25.25	24.23
Aspergillus terreus (C_3)	23.62	23.89	24.11	25.00	24.15
Trichoderma harzianum (C_4)	23.63	23.76	24.02	24.90	24.08
Composite culture (C_2-C_4)	23.72	23.90	24.43	25.40	24.36
Mean	23.56	23.74	24.01	24.83	
Characters	SE±	CD at 5%			
Culture (C)	0.04	0.12			
Sulphur (S)	0.04	0.11			
Cultures (C) x Sulphur (S) interaction	0.09	0.25			

*Means, of three replications.

reported by Shinde *et al*. (1996) and Shririivasan *et al*. (2000) in green gram and black gram respectively.

The results thus indicated that composite culture of bacteria and fungi were found more effective over rest of the treatments at 60 kg 'S' ha^{-1} and the cultures survived longer time in the sulphur oxidation process. These sulphur oxidizing micro-organisms showed synergistic effects to promote the uptake of nutrients in green gram. The composite culture of bacteria and fungi in combinations with various sulphur levels was found most effective in increasing the uptake of nutrients in green gram.

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Effect of Bio-Fertilizer and Levels of Nitrogen on Microbial Activity and Grain Yield of Maize

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Abstract

The fertilizers used in this study had a significant effect on soil microbial count, grain yield of maize hybrid Rajarshi and N uptake. Among nitrogen levels, 50 per cent RDN and combined inoculation of *Acetobacter* and *Azospirillum* induced the highest increase in microbial count. The grain yield obtained due to application of 75 per cent RDN conjugated with *Acetobacter* + *Azospirillum* was on par with application of 100 per cent RDN ha^{-1}. The total nitrogen uptake in the plant also improved by artificial inoculation of these bio-inoculants. These findings explicitly indicated, the possibility of saving chemical nitrogen fertilizer to an extent of 25 Kg N ha^{-1}.

Key words : Bio-fertilizer, Acetobacter, Azospirillum, microorganisms, soil, nitrogen, maize, yield.

Fertilization is among the most important soil amendment operations used in modern agricultural production. The judicious efficient use of chemical fertilizers and can be practicable only through the adoption of a complex approach that gives importance to microbiological studies. The count and activity of soil microorganisms as important indicators of soil biological productivity can be indicative of the economic justifiability of the use of different types, combinations and rates of fertilizers (Cerny *et al*., 2003; Stark *et al*., 2007). The long term use of chemical fertilizers, particularly high rates of nitrogen fertilizers, may be harmful, as it leads to increased gaseous nitrogen losses, deteriorating physical, chemical and biological properties of the soil and, eventually, reduce safety of the plant products obtained (Ayoola and Adeniyan, 2006). Accordingly, attention has been focused on the use of different biofertilizers (microbial inoculants) as an alternative and/or a supplement to costly chemical fertilizers. Hence, in the present study, an attempt has been made to assess the unique effect of nitrogen fertilizer as well as biofertilizers on soil microbial communities, aketobacter count and grain yield of maize.

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Materials and Methods

An experiment was conducted at the experimental field of the College of Agriculture, Kolhapur on 1st July, 2011. The soil of the experimental field was medium black, alkaline in pH (7.4), EC (0.10 dSm^{-1}), available nitrogen, phosphorus and potash was 247.74, 8.53 156.80 kg ha^{-1} respectively before sowing of maize crop. The experiment consisted of 12 treatment combinations consisting of three nitrogen fertilizer levels (100, 75 and 50% N of recommended dose) and four seed bio-inoculants treatments (uninoculated, *Acetobacter*, *Azospirillum*, *Acetobacter* and *Azospirillum*) *viz*., 1. N_1B_0 (100% N + no inocluant), 2. N_1B_1 (100% N + *Acetobacter*), 3. N_1B_2 (100% N + *Azospirillum*), 4. N_1B_3 (100% N +

Acetobacter + *Azospirillum*), 5. N_2B_0 (75% + no inocluant), 6. N_2B_1 (75% N + *Acetobacter*), 7. N_2B_2 (75% N + *Azospirillum*), 8. N_2B_3 (75% N + *Acetobacter* + *Azospirillum*), 9. N_3B_0 (50% N + no inocluant), 10. N_3B_1 (50% N + *Acetobacter*), 11. N_3B_2 (50% N + *Azospirillum*), 12. N_2B_3 (50% N + *Acetobacter* + *Azospirillum*). The experiment was laid out in split plot design replicating each treatment thrice. The net plot size was 4.60 x 3.00 m with 75 x 20 cm spacing between the rows and plants. A basal recommended dose of phosphorus and potash @ 60 kg P_2O_5 and 40 kg K_2O ha^{-1} through single super phosphate and murate of potash, respectively were applied to each plot respectively. The nitrogen through urea was applied as per treatments in splits, i.e. half at time of sowing and remaining half at 30 DAS. Carrier based inoculants of *Azospirillum* and *Acetobacter* sp. alone and in combination with each other were applied to the seeds of maize hybrid Rajarshi as per the treatments @ 25 g kg^{-1} of seed by slurry method.

Microbiological analyses were carried out at the Laboratory of Plant Pathology and Agril. Microbiology, College of Agriculture, Kolhapur. The soil was sampled for microbial analysis at sowing, 30, 60 and 90 DAS at a depth of 5 to 30 cm and Dilution plate counting method was employed for the enumeration of soil microbial population. The count of *Acetobacter* in stem of maize plant was determined at flowering and harvesting (Alexander, 1977). The total N content from the plant on dry matter basis and grain was determined after harvesting by Micro-kjeldhal's digestion and distillation method (Parkinson and Alien, 1975) and accordingly N uptake was estimated. The mean data were subjected to statistical analysis by following standard method of analysis of variance (Panse and Sukhatme, 1985).

Table 1. Effect of different N fertilizer levels and bioinoculant treatments on microbial count of soil at different stages and yield of maize hybrid Rajarshi.

Treatments	Bacteria (C.F.U. x 10^{-6})			Fungi (C.F.U. x 10^{-4})			Actinomycetes (C.F.U. x 10^{-6})			*Acetobacter* count in stem (C.F.U.x10^{-5}) at		Grain yield (q ha^{-1})	N uptake (kg ha^{-1})
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	Flowering	Harvest		
N fertilizer :													
N_1 = 100% N of RDN	19.58	8.58	4.83	9.08	7.58	2.92	6.75	4.33	3.33	8.66	5.66	72.97	139.4
N_2 = 75% N of RDN	22.75	9.50	5.17	10.00	7.67	3.25	6.64	4.83	3.58	10.16	6.75	67.30	112.51
N_3 = 50% N of RDN	26.08	11.17	5.50	11.50	8.25	3.58	7.33	5.17	4.12	12.25	7.00	60.80	89.91
SE ±	0.38	0.41	0.19	0.19	0.12	0.17	0.21	0.13	0.16	0.32	0.29	0.15	0.28
CD at 5 %	1.49	1.62	0.73	0.76	0.46	0.65	0.83	0.5	0.64	1.28	1.15	0.59	1.09
Biofertilizer :													
B_0 = unioculated	17.22	9.00	4.67	9.33	6.67	2.89	5.89	4.33	3.33	6.55	4.44	62.09	90.69
B_1 = *Acetobacter*	24.67	10.22	5.33	10.67	8.22	3.33	7.22	4.89	3.78	13.66	8.11	68.52	119.02
B_2 = *Azospirilium*	24.11	9.44	5.00	9.89	7.89	3.11	7.00	4.67	3.56	6.88	4.33	66.99	116.93
B_3 = *Aceto. + Azosp.*	25.22	10.33	5.67	10.89	8.56	3.67	7.56	5.22	4.11	14.33	9.00	70.48	129.54
SE ±	0.54	0.36	0.24	0.26	0.25	0.17	0.20	0.18	0.19	0.46	0.32	0.2	0.51
CD at 5 %	1.62	1.07	0.72	0.78	0.76	0.51	0.60	0.55	0.57	1.37	0.94	0.61	1.50

Results and Discussion

Microbial activity : The results obtained suggest that soil microbial count of soil and *Acetobacter* count in maize hybrid Rajarshi were significantly affected by nitrogen fertilization and bioinoculant treatments. The interaction between the nitrogen fertilizer and bioinolculants were significant only for bacteria count at 30 DAS and *Acetobacter* count (Table 1 and 2).

Among the nitrogen fertilizer, the N_3 (50 % N of RDN) treatment recorded significantly highest while down cfu of bacteria fungi, actinomycetes bacteria, fungi and actinomycetes population than 75 and 100 per cent of RDN at 30, 60 and 90 DAS. Whereas, the bio-inoculant treatment either with *Acetobacter*. *Azospirillum* or combined treatment of both recorded significantly higher bacterial, fungi and actinomycetes population than uninoculated treatment. Considering the interaction effect, the treatment combination of N_3B_3 (50% RDN + *Acetobacter* + *Azospirillum*) and N_3B_1 (50% RDN + *Acetobacter*) recorded higher bacterial, fungi and actinomycetes count than the rest of the treatment combinations.

The positive effects of biofertilizers on soil biological parameters during the first months upon treatment have been reported by other scientist as well (Park *et al*., 2005 and Biari *et al*., 2008). The lower nitrogen fertilization rates (50 and 75% RDN) significantly stimulated the development of the tested groups of

Table 2. Interaction effect of different N fertilizer levels and bio-inoculant treatments on microbial count of soil at different stages and yield of maize hybrid Rajarshi.

Treatments	Bacteria (C.F.U. x 10^{-6})			Fungi (C.F.U. x 10^{-4})			Actinomycetes (C.F.U. x 10^{-6})			*Acetobacter* count of stem juice (C.F.U.x10^{-6}) at		Grain yield (q ha^{-1})	N uptake (kg ha^{-1})
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	Flowering	Harvest		
N_1B_0	15.33	8.33	4.33	8.67	6.33	2.67	5.33	4.00	3.00	6.33	4.33	68.95	111.67
N_1B_1	21.00	8.67	5.00	9.33	8.00	3.00	7.33	4.33	3.33	10.66	7.00	74.57	146.91
N_1B_2	20.33	8.33	4.67	8.33	7.67	2.67	7.00	4.33	3.33	6.66	4.66	72.36	143.72
N_1B_3	21.67	9.00	5.33	10.00	8.33	3.33	7.33	4.67	3.67	11.00	6.66	75.99	155.33
N_2B_0	17.33	8.67	4.67	9.00	6.67	2.67	6.00	4.33	3.33	6.66	4.66	61.20	83.25
N_2B_1	24.33	10.00	5.33	10.67	8.00	3.33	6.67	5.00	3.67	11.33	8.33	69.09	120.81
N_2B_2	24.00	9.00	5.00	10.00	7.67	3.33	6.67	4.67	3.33	7.00	4.66	67.86	115.34
N_2B_3	25.33	10.33	5.67	10.33	8.33	3.67	7.33	5.33	4.00	13.66	9.33	71.05	130.63
N_3B_0	19.00	10.00	5.00	10.33	7.00	3.33	6.33	4.67	3.67	6.66	4.33	56.13	77.17
N_3B_1	28.67	12.00	5.67	12.00	8.67	3.67	7.67	5.33	4.33	17.00	9.00	61.90	89.33
N_3B_2	28.00	11.00	5.33	11.33	8.33	3.33	7.33	5.00	4.00	7.00	3.66	60.75	91.71
N_3B_3	28.67	11.67	6.00	12.33	9.00	4.00	8.00	5.67	4.67	18.33	11.00	64.40	101.47
SE±	0.94	0.63	0.42	0.45	0.44	0.30	0.35	0.32	0.33	0.80	0.55	0.35	0.88
CD at 5%	2.80	NS	NS	NS	NS	NS	NS	NS	NS	2.37	1.63	1.05	2.61

N_1 = 100% N, N_2 = 75% N, N_3 = 50% N as recommended. B_0 = uninoculated, B_1 = *Acetobacter*, B_2 = *Azospirillum*, B_3 = *Acetobacter* + *Azospirillum*.

microorganisms, which was in agreement with the results of Barabasz *et al*. (2002) who reported an increase in the count and diversity of bacterial, actinomycetes and fungal species under lower mineral nitrogen application rates.

The data on viable count of *Acetobacter* at flowering stage proved the improvement in soil population of *Acetobacter* due to artificial inoculation of the *Acetobacter*. The *Acetobacter* population among different treatment combinations at flowering stage ranged between 6.33 (N_1B_0) to 18.33 (N_3B_3), while it ranged between 3.66 (N_3B_2) to 11.00 (N_3B_3) at harvesting stage of maize crop. The highest *Acetobacter* count was observed in N_3B_3 (50% RDN + *Acetobacter* + *Azospirillum*) at flowering stage (18.33) and at harvesting stage (11.00). More or less similar trends of results were observed at flowering and at harvesting stage. It was also noticed, that the population of *Acetobacter* was increased at flowering and then decreased at harvesting stage of maize crop. Similar results were also obtained by Rojas and Caballaro-Mellado (2003) in sugarcane and Pawar (2009) in sweet sorghum.

Yield and N uptake : The treatment 100 per cent RDN fertilizer application has gave significantly higher grain yield and N uptake than the treatment 75 and 50 per cent RDN. As regarding the bio-inoculants treatments, the significantly higher grain yield and N uptake was recorded in the combined inoculants of *Acetobacter* + *Azospirillum* followed by *Acetobacter* and *Azospirillum* over uninoculated treatment. Among the interaction, the treatment combination N_1B_3 i.e. 100 per cent RDN + *Acetobacter* + *Azospirillum* recorded higher grain yield and N uptake which was followed by 100 per cent RDN + *Acetobacter* and 100 per cent + *Azospirillum*. Further, it was also noticed that the treatment combination N_2B_3 (75% RDN + *Acetobacter* + *Azospirillum*) produced significantly higher grain yield and N uptake than N_1B_0 (100% RDN alone). Caballero-Mellado *et al*. (1997), Natrajan and Oblisami (1980), Pawar (2009) and Yadav *et al*. (2011) revealed that combined inoculation of *Acetobacter* and *Azospirillum* was more responsive with Nitrogen fertilizers in maize.

The results in general, showed that bio-inoculants *viz*., *Acetobacter* and *Azospirillum* sp. were superior in respect of all growth parameters studied. The composite inoculation of these were found to be synergistic leading to improved growth and nutrient uptake by the crop plants compared to single culture inoculations. The grain yield and N uptake obtained due to application of 75 per cent RDN conjugated with *Acetobacter* + *Azospirillum* was on par with application of 100 per cent RDN ha^{-1} without inoculants. These findings explicitly indicated the possibility of saving of nitrogen fertilizer to an extent of 25 kg N ha^{-1}. The results proved the efficiency of biofertilizers to enhance growth and yield of maize and have the possibility of substituting a part of the chemical fertilizers.

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Biology of *Helicoverpa armigera* Hubner on Pigeonpea

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Abstract

The incubation period of eggs *H. armigera* was 3.87 ± 0.82 days and their size was 0.48 ±0.07 mm in length and 0.50 ± 0.07 mm in breadth. The average duration of first, second, third, fourth, fifth and sixth instar larvae were 2.50±0.69, 2.92±0.65, 2.40±0.90, 3.10±0.95, 3.45±0.68 and 5.10±1.10 days, respectively. The length and breadth of corresponding stages were 1.35±0.05 and 0.41±0.02, 2.86±0.24 and 0.66 ±0.11, 9.48±1.07 and 2.16±0.39, 10.58±1.79 and 3.02±0.25, 19.05±2.12 and 3.47±0.18, and 27.65±1.98 and 4.02±0.22 mm, respectively. Aged larva showed lateral brown strips and yellow to green colour. The larval period was 19.60±1.47 days while, pupal period was 15.80±1.30 days. The average length and breadth of male and female was 16.93±1.87 and 4.85±0.046 , and 20.04±1.30 and 5.96 ± 0.58 mm, respectively. The average longevity of male was 9.00±0.85 days whereas, that of female was 10.90±0.80 days. The duration of total life span (egg to death of adult) for male was 43.80±3.78 days while, for female it was 48.60±4.20 days. The average number of eggs laid by female was 1168±248.83. The hatching percentage of eggs was 93.57±2.37. The pre-oviposition, oviposition and post oviposition periods were 2.65 ± 0.70, 6.10 ± 0.80 and 0.90 ± 0.40 days, respectively. The sex ratio of male:female was 1:0.76.

Key words : Bimology, pigeonpea, *Helicoverpa armigera* larvae.

Pigeonpea pod damage due to pod borer complex has been reported to be 33.8 to 49.9 per cent (Vishwa Dhar *et al*. 2005). Among various pod borers, gram pod borer *H. armigera* (Noctuidae : Lepidoptera) is the most serious pest harboring over 181 plant species pertaining to 45 families (Srivastava *et al*., 2005) is a dominant field pest. Freshly emerged larvae feed on tender leaves by nibbling and then reach to the flower bud. At pod stage, the larvae make a hole into the pods and feed inside the pod. By considering the importance of the pest management, knowledge on basic biology of this pest is required. Since a major information on biology of *H. armigera* on pigeonpea particularly in Westeran Maharashtra conditions is available, the present experiment was conducted to study the biological characteristics of *H. armigera* on pigeonpea in an ambient condition at Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar-413 722 during October, 2012 to December, 2012.

Materials and Methods

Initial culture of *H. armigera* was established in the laboratory by collecting larvae from pigeonpea crop. These larvae were reared separately in the clean specimen individual glass vial (15 x 25 cm) covered with a fine muslin cloth and fresh leaves and twigs as well as pods of Pigeonpea were provided daily, in each petridish as a food for the larvae. Grown up larvae were transferred into the rearing glass jar. One third part of the glass jar was filled with moist soil to help the grown up larvae for pupation in the soil. The pupae when formed in the soil were collected and transferred into

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petridishes individually for the emergence of adults. A pair of newly emerged male and female was confined in a glass chimney cage prepared by placing the chimney on blotting paper in petridish. A top of the chimney was covered with muslin cloth secured firmly by a rubber band to prevent escape of adults. Fresh uninfected leaves, twigs and pods of Pigeonpea were provided in the chimney cage for egg laying and were replaced daily for oviposition and food was also given every day in the morning till the adults died. These eggs were kept in separate petridishes and used for maintaining a pure culture of the pest (Bhatt and Patel, 2001).

The size of eggs was obtained with help of sterio-zoom binocular ocular meter, whereas, other life stages (larvae, pre-pupa, pupa and adult) were measured with vernier caliper as well as simple scale. The colour, shape and periods of eggs, larva, pupa and adults and pre-oviposition, oviposition and post-oviposition periods, sex ratio, fecundity and longevity of adults were also studied. The data collected on development, morphometrics and fecundity of *H. armigera* were subjected to analysis of standard error of means with help of statistics software.

Results and Discussion

Egg : The freshly laid eggs were hemispherical in shape with a flat base and yellowish white in colour and changed to deep yellow after a day and then changed to dark or grey black a day before hatching. Average length and breadth of egg was 0.48 ± 0.07 and 0.50 ± 0.07 mm, respectively (Table 1). The average incubation period was recorded as 3.87 ± 0.82 days (Table 2). The eggs did not hatched within six days were discarded and termed as infertile eggs. The infertile eggs were yellow, become increasingly yellow and shriveled after 3-4 days. The average percentage of eggs hatched was 93.57 ± 2.67 per cent.

Larva : The larval period of *H. armigera* passed through six distinct instars. Freshly

Table 1. Morphometrics of different life stages of *H. armigera* on pigeonpea.

Stage	Individual observed	Length (mm)			Breadth (mm)		
		Mini.	Maxi.	Average ± S.D.	Mini.	Maxi.	Average ± S.D.
Egg	60	0.20	0.65	0.48 ± 0.07	0.10	0.60	0.50 ± 0.07
Larva :					0.40	0.45	0.41 ± 0.02
I instar	60	1.10	1.40	1.35 ± 0.05			
II instar	60	2.95	3.35	2.86 ± 0.24	0.65	0.79	0.66 ± 0.11
III instar	60	8.40	10.00	9.48 ± 1.07	1.95	2.40	2.16 ± 0.39
IV instar	60	11.00	13.10	10.58 ± 1.79	2.80	3.35	3.02 ± 0.25
V instar	60	16.60	22.00	19.05 ± 2.12	3.25	3.72	3.47 ± 0.18
VI instar	60	27.40	30.10	27.65 ± 1.98	3.78	4.40	4.02 ± 0.22
Prepupa	60	20.00	26.45	23.89 ± 2.40	3.95	5.10	4.50 ± 0.43
Pupa :							
Male	60	16.00	18.00	16.93 ± 1.87	4.00	5.50	4.85 ± 0.46
Female	60	19.80	22.10	20.04 ± 1.30	5.00	6.70	5.96 ± 0.58
Adult :							
Male	60	12.90	15.30	13.69 ± 0.70	30.00	35.00	32.93 ± 1.55
Female	60	14.10	17.20	15.63 ± 1.08	33.50	36.00	44.33 ± 1.90

Table 2. Development of various life stages of *H. armigera* reared on pigeonpea.

Particulars	Individual observed	Development period (days)		
		Mini.	Maxi.	Average ± S.D.
Egg period		3	5	3.87 ± 0.82
Larval period				
I instar	60	2	4	2.50 ± 0.69
II instar	60	2	4	2.92 ± 0.65
III instar	60	2	3	2.40 ± 0.90
IV instar	60	3	3	3.10 ± 0.95
V instar	60	3	4	3.45 ± 0.68
VI instar	60	3	6	5.10 ± 1.10
Total larval period	60	15	22	19.60 ± 1.47
Prepupal period	60	1	4	2.35 ± 0.65
Pupal period	60	13	19	15.80 ± 1.30
Adult period				
Male	60	7	10	9.00 ± 0.85
Female	60	11	15	10.90 ± 0.80
Total life period				
Male	60	35	58	43.80 ± 3.78
Female	60	39	63	48.60 ± 4.20

emerged first instar larvae were translucent and yellowish white in colour with black head, while second instar larva was yellowish green in colour with black thoracic legs. During the first and second instars, the colour of larva was more uniform and movement was very little. The full grown larva was brownish or pale green with brown lateral stripes and distinct dorsal stripe and it was long and ventrally flattened but convex dorsally. The average length and breadth of first, second, third, fourth, fifth and sixth instar larva, were 1.35 ± 0.05 and 0.41 ± 0.02 mm, 2.86 ± 0.24 and 0.66 ± 0.11mm, 9.48 ± 1.07 and 2.16 ± 0.39 mm, 10.58 ± 1.79 and 3.02 ± 0.25 mm, 19.05 ± 2.12 and 3.47 ± 0.18 mm and 27.65 ± 1.98 and 4.02 ± 0.22, respectively (Table 1). Total larval development period was on an average 19.60 ± 1.47 days (Table 2).

Pre-pupa : In this stage, the full grown larva became sluggish, wrinkled with suspended feeding and movement. The pre-pupa was light green yellowish in colour but later on it turned to dark brown. The average length and breadth of prepupal stage was 23.39 ± 2.40 and 4.50 ± 0.43 mm, respectively. The average duration of prepupal stage was 2.35 ± 0.65 days.

Pupa : Freshly formed pupa was light green yellowish in colour but later on turned into dark brown prior to emergence of moth. The pupa was obtect type, broadly rounded interiorly and tapered posteriorly. The average length and breadth of male pupa 16.93 ± 1.87 and 4.85 ± 0.46 mm, respectively, while in case of female it was 20.04 ± 1.30 and 5.96 ± 0.58 mm, respectively (Table 1). The average length and breadth of pupa was 16.93 ± 1.87 and 4.85 ± 0.46 , and 20.04 ± 1.30 and 5.96 ± 0.58 mm, respectively, in male and female (Table 1). The average pupal period was 14.80 ± 1.30 days (Table 2).

Adult : The adult moth was stout bodied with brownish colour. The forewings were pale

Table 3. Pre-oviposition, oviposition, post-oviposition, fecundity and hatching percentage of *H. armigera*.

Stages	Individual observed	Development period		
		Mini.	Maxi.	Average ± S.D.
Pre-oviposition period (days)	60	2	4	2.65 ± 0.70
Oviposition period (days)	60	5	8	6.10 ± 0.80
Post-oviposition period (days)	60	0	1	0.90 ± 0.40
Fecundity	60	885	1583	1168.53 ± 248.83
Hatching percentage	60	90.00	98.90	93.57 ± 2.67

brown with a series of dots on margins and a-black kidney shaped mark on the underside of each forewings. However, the hind wings were highter in colour with dark patch at the apical end. The female moth was slightly bigger than male moth and was identified by the presence of tuft of hairs on the tip of the abdomen. The average length and breadth (with expanded wings) of male was 13.69 ± 0.70 mm and 32.93 ± 1.55 mm, respectively. Whereas, the female measured on an average 15.63 ± 1.08 mm in length and 44.33 ± 1.90 mm breadth (with expanded wings) indicating the male being smaller in size than females.

The average number of eggs laid by a female was 1168 ± 248.83 (Table 3). The hatching percentage of eggs was 93.57 ± 2.67. The average longevity of male was 9.00±0.85 days whereas, that of female was 10.90 ± 0.89 days.

Oviposition periods : The average pre-oviposition, oviposition and post-oviposition periods were 2.65 ± 0.70, 6.10 ± 0.80 and 0.90 ± 0.40 days, respectively (Table 3).

Sex ratio : The adults emerged from pupae were critically examined and sex was determined by observing presence of tuft of hairs on the tip of the abdomen. It was present in case of female only. Out of the 60 pupae reared in laboratory, 34 were males and 25 were females. Thus, the sex ratio of male to female was 1:0.76.

Life span : The entire life span of H. armigera from eggs to the death of adult male was completed with an average of 43.8±3.78 days whereas, that of female completed with an average of 48.6±4.20 (Table 2).

The present findings are comparable with Bhatt and Patel (2001) and Ali *et al*., (2009) who reported the biology of *H. armigera* on chickpea.

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Evaluation of Native *Nomuraea rileyi* (Farlow) Samson Against *Spodoptera litura* (Fabricius) Infesting Soybean*

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Abstract

The isolation of the fungus from freshly collected diseased larvae/cadavers of *S. litura* from field crops in Western Maharashtra yielded eight *N. rileyi* isolates. Amongst these isolates, NrAc was found to be the most virulent to 3rd instar larvae of *S. litura* and caused highest mortality (86.67%) after 10 days post spore treatment at 1 x 10^9 conidia ml^{-1} in laboratory. The application of *N. rileyi* @ 2.5 kg ha^{-1} through spray in field experiment recorded lower population of *S. litura* (2.31 larvae m^{-1} row), higher larval mycosis (49.26%), less pod damage (18.43%), higher yields (25.68 q ha^{-1}) with higher net returns (Rs.14,455 ha^{-1}) in soybean as compared to untreated check.

Key words : *Nomuraea rileyi* (Farlow) Samson, bio-efficacy, *Spodoptera litura* (Fabricius), soybean.

Among the several existing entomopathogens, *Nomuraea rileyi* (Farlow) Samson is a cosmopolitan species which occurs regularly in different crop ecosystems on number of noctuid pests. It has a potential for developing into myco-insecticide (Shanthakumar *et al*., 2010). The mycopathogen grow and sporulate profusely at temperature range of 20 to 30°C and rate of infection is positively correlated with rainfall or high relative humidity (RH) suggesting that fungal survival and spread under warm and high humid situations. These conditions make the fungus best fit for use against tropical and subtropical pests like *Spodoptera litura* (Fabricius). Apart from certain basic laboratory studies, efforts made towards establishing its real field potential are very few in India.

In the present study, considering the serious losses caused by *S. litura* in soybean during last 5-6 years in Maharashtra, efforts were made to isolate *N. rileyi* from different geographical areas and to test the pathogenicity of the most virulent native *N. rileyi* isolate in laboratory and in fields against *S. litura*.

Materials and Methods

The isolation of the *N. rileyi* fungus was made from freshly collected diseased larval specimens of *S. litura* collected from Western Maharashtra. The pure cultures of eight isolates obtained were maintained on SMAY (Sabourad's Maltose Agar) slants fortified with one per cent yeast extract. Pathogenicity tests were conducted according to Koch's Postulates. The most virulent strain (NrAc) was mass multiplied on solid substrate i.e. crushed rice grains by following standard procedure described by Ramegowda (2005) with some modifications.

The experiments were conducted for two seasons to test the efficacy of *N. rileyi* on *S. litura* in soybean field at Research farm,

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College of Agriculture, Pune during 2010 and 2011 in *kharif* season. Soybean variety JS 335 was sown on 5th July, 2010 and 29th June, 2011 at a spacing of 30 x 10 cm. The crop was raised following the recommended agronomic practices.

N. rileyi fungus (NrAc isolate) cultured on crushed rice grains was used in the field study. There were seven treatments including untreated check replicated three times in a randomized block design. The application of treatments was made at 15 days interval in August.

The efficacy of the treatments was assessed based on surviving larval population and number of diseased larvae meter^{-1} row a day before and at 7 and 14 days after application, pod damage by *S. litura* on selected 5 plants and grain yield from net plot at harvest. The number of live larvae present in each meter row as well as mycosed larvae were counted at three locations in each plot. The post treatment observations taken after 14 days were served as pre treatment for second application. The damage of *S. litura* to pods on 10 plants selected at random in each treatment was observed for the number of healthy and damaged pods and per cent damage was computed at harvest. Data were subjected to statistical analysis after arc sin transformations. Grain yield at harvest was recorded and data were analyzed for variance by using ANOVA technique.

Results and Discussion

Pathogenicity of NrAc isolate : The data indicated (Table 1) that the *N. rileyi*, NrAc native isolate at different concentrations was most pathogenic to third instar *S. litura* at 6, 8 and 10 days after spore treatment (DAST). The treatment with higher concentration of 1 x 10^9 conidia ml^{-1} recorded 86.67 per cent *S. litura* larval mortality at 10 DAST. It was recorded and 1 x 10^7 conidia ml^{-1}. As time progressed after spore treatment, the mortality of larvae was increased and similar pattern of mortality was noticed between concentrations and larval mortality at 10 DAST.

Field efficacy of NrAc isolate : The performance of *N. rileyi* against *S. litura* on soybean under field conditions was evaluated at two dosages with spray and broadcasting application methods in comparison to chlorpyriphos and SLNPV, the recommended chemical and virus in the package of practices for high yield of soybean crop. The parameters of assessment included were survival of larval population (number m^{-1} row), pod damage (%) and seed yield (q ha^{-1}) during *kharif* 2010 and 2011.

The data on larval counts made in each treatment plots before and after the first and

Table 1. Pathogenicity of *N. rileyi* NrAc isolates to 3rd instar larvae of *S. litura* in laboratory.

Dose Conidia ml^{-1}	Per cent mortality of *S. litura* larvae at DAST*		
	6	8	10
1 x 10^9	30.00	66.67	86.67
	(32.99)**	(54.76)	(68.83)
1 x 10^8	26.67	56.67	83.33
	(30.98)	(48.83)	(66.12)
1 x 10^7	16.67	33.33	73.33
	(23.84)	(35.20)	(58.98)
1 x 10^6	6.67	23.33	53.33
	(12.28)	(28.77)	(46.90)
1 x 10^5	3.33	20.00	43.33
	(6.14)	(26.55)	(41.14)
1 x 10^4	3.33	13.33	23.33
	(6.14)	(21.14)	(28.77)
Untreated	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
S.E.±	(4.45)	(1.85)	(2.13)
CD at 5%	(13.64)	(5.67)	(6.53)

* DAST : Days after spore treatment values, Figures in parentheses are arc sin values.

second applications are furnished in Table 2. The population of *S. litura* before application ranged from 9.74 to 10.89 larvae m^{-1} row during the first year and 9.93 to 11.50 during the second year of the study. When the data were pooled, the mean larval population ranged from 10.00 to 11.19 $meter^{-1}$ row. The larval population was uniform in all the treatments and was at moderate level.

From this data, it was noticed that larval population.among the *N. rileyi* treatments failed to differ, but established superiority by recording lowest population of 2.19 larvae $meter^{-1}$ row as against 3.15 larvae in chlorpyriphos. Pooled data over two years disclosed at par effectiveness of *N. rileyi* treatments and effectiveness of chlorpyriphos. The fungal pathogen was highly effective in reducing larval population as revealed by higher surviving number in untreated control (14.47 larvae m^{-1} row).

Mycosis in *S. litura* in soybean : With respect to pooled means for two years (Table.3) significantly highest mycosis (56.22%) was noticed in the treatment with spray of *N. rileyi* @ 2.5 kg ha^{-1}. Spraying of *N. rileyi* @ 2.0 kg ha^{-1} was found next best treatment in causing higher percentage mycosis (39.32%) in *S. litura* larvae in soybean and it was on par with broadcasting application of *N. rileyi* @ 2.5 kg ha^{-1} (36.57%).

Pod damage : During 2010, amongst *N. rileyi* treatments the extent of *S. litura* damage to pods was significantly low (21.57%) in spray application @ 2.5 kg ha^{-1} and was at par with broadcasting of *N. rileyi* @ 2.5 kg ha^{-1}. The chlorpyriphos reduced the pod damage to significantly least (15.31%). Unabated damage in the untreated check registered 38.61 per cent. The performance of treatments in the second year (2011) was more or less similar to 2010. The pod damage in *N. rileyi* treatments ranged from 19.28 to 23.53 per cent compared to 16.73 per cent in the chlorpyriphos treatment and 32.47 per cent in untreated control. Pooled analysis of data over two years indicated that application of higher doses of *N. rileyi* (2.5 kg ha^{-1}) with broadcasting and spray methods were effective

Table 2. Effect of *N. rileyi* on the population of *S. litura* in soybean (pooled).

Treatment	Av. No. of *S. litura* larvae per meter row					
	Precount mean	First application (40 days after planting		Seconf application (55 days after planting		Mycosed larvae (%)
		7DAA	14DAA	7DAA	14DAA	
		Mean	Mean	Mean	Mean	
Broadcasting of *N. rileyi* @ 2.0 kg ha^{-1}	10.31 (3.29)	7.88 (2.89)	7.50 (2.83)	4.73 (2.29)	3.12 (1.90)	29.70 (32.94)
Broadcasting of *N. rileyi* @ 2.5 kg ha^{-1}	10.35 (3.29)	7.10 (2.76)	6.88 (2.72)	3.87 (2.09)	2.19 (1.64)	36.57 (37.07)
Spray of *N. rileyi* @ 2.0 kg ha^{-1}	10.34 (3.29)	7.33 (2.80)	7.33 (2.80)	5.12 (2.37)	3.18 (1.92)	39.32 (38.82)
Spray of *N. rileyi* @ 2.5 kg ha^{-1}	10.00 (3.29)	6.89 (2.72)	6.36 (2.62)	4.51 (2.24)	2.24 (1.65)	56.22 (48.64)
SlNPV @ 0.5 L ha^{-1}	10.13 (3.26)	4.73 (2.29)	6.04 (2.56)	5.15 (2.38)	3.83 (1.82)	13.86 (21.88)
Chlorpyriphos 20EC @1 L ha^{-1}	11.19 (3.41)	3.53 (2.00)	4.27 (2.18)	3.63 (2.08)	3.15 (1.91)	17.93 (24.80)
Untreated check	10.51 (3.32)	12.62 (3.62)	15.86 (4.04)	14.53 (3.88)	14.47 (3.87)	23.28 (28.88)
S.E.±	0.03	0.04	0.03	0.03	(0.02)	0.76
CD at 5%	(NS)	0.12	0.09	0.10	(0.06)	2.35

DAA : Days after application, *Figures in parentheses are $\sqrt{n + 0.5}$

and significantly superior to the untreated control (35.54%) in restricting the damage to new pods. On the contrary, chlorpyriphos treatment was superior to all the *N. rileyi* treatments (16.02%).

Seed yield : Yield as reflection of degree of protection offered to the crop by the treatments reiterated the treatment superiority of chlorpyriphos with 24.25 q ha^{-1} of soybean seed yield followed by at par performance of spray of *N. rileyi* fungus (24.82 q ha^{-1}) during 2010. Unchecked *S. litura* damage in the control led to realize seed yield only 17.68 q ha^{-1}. The second year results were similar to the first year. In general, the yield levels were slightly high in *N. rileyi* treatments, but the treatment superiority remained unchanged during two consecutive years of study.

The mean seed yield data from two years indicated that chlorpyriphos sprayed plots yielded significantly highest (25.80 q ha^{-1}) followed by at par yield levels (25.68 q ha^{-1}) in the *N. rileyi* sprayed plots @ 2.5 kg ha^{-1} and significantly least in the untreated control. The control yield was low due to greater pod damage. From the pooled analysis of data, it was found that lower dose of *N. rileyi* was as good as higher dose in broadcasting and spray methods by producing at par seed yield (23.60 to 25.68 q ha^{-1}). Chlorpyriphos distinguished as best treatment by producing 25.80 q ha^{-1} seed yield with 6.40 q ha^{-1} higher than untreated check.

Cost economics : The cost effective analysis of treatments is made in Table 3. It is seen that as the dosage of *N. rileyi* increased the input cost (plant protection cost) also increased. It was Rs. 1,120 and 1,245 in *N. rileyi* sprays at 2 kg ha^{-1} and 2.5 kg ha^{-1}, respectively as against minimum cost (Rs. 1,000) with chlorpyriphos treatment. As the dosage of *N. rileyi* increased, there was an incremental yield and returns too. Incremental yields as well as returns were highest with chlorpyriphos and thus it proved to be most cost effective treatment. Among the *N. rileyi* dosage levels and mode of applications, maximum incremental benefit cost ratio (11.61) was obtained with dose of *N. rileyi* (2.5 kg ha^{-1} spray).

Irrespective of method of application, while the trend remained same, the incremental net returns were Rs. 9,092/- and Rs. 10,791/-for broadcasting of *N. rileyi* and Rs. 9,380/- and

Table 3. Effect of *N. rileyi* on the pod damage by *S. litura* and yield of soybean (pooled).

Treatment	Pod damage (%)	Pod yield (q ha^{-1})	Addl. yield over control (q ha^{-1})	Addl. return (Rs. ha^{-1})	Addl. expend-iture (Rs. ha^{-1})	Net return (Rs. ha^{-1})	ICBR ratio
Broadcasting of *N. rileyi* @ 2.0 kg ha^{-1}	22.55 (28.23)	23.44	4.04	10100	1008	9092	9.02
Broadcasting of *N. rileyi* @ 2.5 kg ha^{-1}	20.17 (26.65)	24.17	4.77	11925	1134	10791	9.51
Spray of *N. rileyi* @ 2.0 kg ha^{-1}	20.31 (26.64)	23.60	4.20	10500	1120	9380	8.37
Spray of *N. rileyi* @ 2.5 kg ha^{-1}	18.43 (25.38)	25.68	6.28	15700	1245	14455	11.61
SlNPV @ 0.5 L ha^{-1}	19.80 (26.41)	24.46	5.06	12650	1500	11150	7.43
Chlorpyriphos 20EC @1 L ha^{-1}	16.02 (23.52)	25.80	6.40	16000	1000	15000	15.00
Untreated check	35.54 (36.04)	19.40	-	-	-	-	-
S.E.±	0.24	0.11	-	-	-	-	-
CD at 5%	0.80	0.35	-	-	-	-	-

Figures in parantheses are arc sin transformation, *Selling rate of soybean considered @ Rs.3000 q^{-1}.

Rs. 14.455/- for spray application of *N rileyi* @ 2 and 2.5 kg ha^{-1}, respectively. The total net returns of *N. rileyi* treatments were second highest to that of chlorpyriphos and the most economical treatment proved to be dosage of 2.5 kg ha^{-1} (spray application) with the highest net returns in pooled analysis. Chlorpyriphos gave highest net returns of Rs.15,000/- from pooled mean data.

The results obtained in the present study are in conformity with results of Kulkarni (1999) and Chaudhari (2010). *N. rileyi* applied 1.2 x 10^{12} conidia L^{-1} was reported to perform as infective as SLNPV in lowering the pest population, while at the same dose it proved superior to pathogen infection 50 per cent reduction of the pest in soybean after 14 days of spray (Kulkarni, 1999). He further reported that treatment effect was not noticed at 3rd day after spray, but increased gradually at 7th days after spray with maximum at 14th day after spray.

The per cent mycosed larvae of *S. litura* were higher after 15 days of second application (70 days after planting) in *N. rileyi* spray and broadcasting treatments as compared to others in soybean ecosystem. The possible reason is that the soybean crop is infested by *S. litura* during the favourable period of cropping season (August to September) for *N. rileyi* infection (Lingappa *et al*., 2000). However, the fungal infection, in general, depends on availability of hosts, suitable environmental conditions, prevailing microclimate in the crop ecosystem and quantum of inoculum.

The data over two years revealed that the higher dose of *N. rileyi* (spray @ 2.5 kg ha^{-1}) was superior to untreated control in reducing per cent pod damage in soybean. Superiority of the fungus was obviously due to non-specificity of hosts and therefore the pest activity was lowered to restrict pod damage. Sprenkel and Brooks (1975) reported the *N. rileyi* treated plot had less pod damage due to *H. zea* in soybean.

N. rileyi spray treatments, during present study in soybean at highest dose (2.5 kg ha^{-1}) resulted as much seed yield as in SLNPV but lesser than in chlorpyriphos. Gross returns, net returns and ICBR ratio were highest in treatment with chlorpyriphos closely followed higher (2.5 kg ha^{-1}) and lower (2 kg ha^{-1}) dosages of N. rileyi sprays in soybean. Higher net returns in chlorpyriphos treatment are because of increased yield, while it is due to lesser intervention cost in *N. rileyi* treatments. In conclusion, the higher benefit:cost ratio, apart from environmental safety and with increasing demand for organically grown produce, local *N. rileyi* isolate fits well as the best candidate for the management of *S. litura* in soybean ecosystem.

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Studies on Preparation and Evaluation of Different Value Added Products of Kokum (*Garcinia indica* Choisy) Fruits

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Abstract

The rind powder prepared from fresh fruit recorded more score (7.5%) than rind residue powder. The *churna, churna goli, pachak* and *pachak goli* recorded 7.24,16.67,6.11 arid 7.05 organoleptic score respectively. The product like ice-cream prepared from amrit kokum recorded the highest average organoleptic score 8.16 amongst all the products under study. Kokum lassi and shrikhand showed acceptance on the basis of orgenoleptic evaluation. The sweet (*Burfi*) prepared from kokum, *amrit* kokum and rind residue was acceptable on the basis of organoleptic evaluation. The sweet prepared from the fresh kokum pulp + coconut + potato recorded the maximum organoleptic score (8.1) among the different types of *burfies*.

Key words : Kokum, products, preparations.

As the kokum fruits are utilized for many household purposes, value added commercial products and the medicinal products. Now a days it is deemed to be the (most commercial crop, next to mango and cashew. The demand for the kokum products, within and out side countries is increasing, therefore, standardization for preservation and processing of kokum fruits is an urgent need, for the preparation of quality products on large scale. These fruits could be used at the fullest extent for processing them into suitable kokum products, since the taste of this fruit is relished only after processing.

Materials and Methods

Kokum rind powder : The ripe, fresh and sound kokum fruits were selected, washed thoroughly. The fruits were cut into pieces, inner pulp and the seeds were removed. The rind left after preparation of kokum syrup, squash and RTS by crushing and pressing the rind was used for preparation of rind powder. The rind was dried in cabinet drier at 50-55°C and then powdered in electrically operated grinder. The powder, was then sieved through 1 mm mesh sieve and packed in polythene bags and stored at cool and dry place at ambient temperature.

Kokum leather : The pieces of rind (1 kg) were crushed in the mixer, along with sugar (1 kg) to obtain homogenous pulp. The mixture was collected in steel vessel. The mixture was heated with continuous stirring to evaporate some quantity of water and to obtain slight thick consistency. Cumin powder (150 g) was added in it. The preservative sodium benzoate 250 mg kg^{-1} was added. The mixture was poured in stainless steel plate to get 0.2 to 0.3 cm thick layer. It was then, dried in oven at 55°C untill it dries completely. It was cut into pieces, packed in polythene bags and stored at cool and dry place at ambient temperature.

***Churan* :** The kokum rind powder (6 g)

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obtained by crushing and pressing the rind was used for preparation of kokum *Churana* by additing ginger powder (6 g), salt (6 g), cumin powder (6 g) and sugar (30 g). The product was packed in polythene bags and stored at cool and dry place at ambient temperature. The *churna* was also prepared in pellete (goli) type form by addition of nector squash and syrup by softening (cooking).

***Pachak* :** The fruits were destalked and cut into 4 pieces by quartering. The pulp and the seeds were removed. The rind was boiled in water upto the stage at which the rind was just soften but not broken. For boiling 1 kg rind, 1 litre of water was taken when the water starts boiling, the rind was boiled for 5 minutes only. After boiling it was drained through muslin cloth, so as to remove the water completely.

The ingradients used for preparation of *pachak* were kokum powder (100 g), kokurn fresh fruit pulp (100 g), *samudra lavan* (34 g), sugar (158 g), cumin powder (56 g), black pepper powder (42 g), *nimbusaar* (23 g), *suntha* (28 g), *pippali* powder (23 g), *krishna lavan* (42 g), *saidhav* salt (42 g), and *navasagar* (6 g). All the ingredients were mixed together for the preparation of *churna* in powder form. The product was packed in polythene bags, sealed and stored at cool and dry place at ambient temperature.

***Burfi* :** The ingredients kokum fresn fruit (500 g), *Amrit* kokum (600 g), rind residue (500 g), *khoa* (500 g), coconut (grated) (500 g), potato (600 g), sugar (1200 g), cashewnut (25 g) and *charaoli* (10 g) mixed and allowed to stand for 1 hour to dissolve the sugar. The mixture was slowly heated to obtain desired consistency and end point was judged by sheet and flake test. The mixture was poured in stainless steel plate to 1.5 cm thick layer, was cut with stainless steel knife to get a piece of 3 x 3 cm. The mixture was allowed to cool and stored in cool dry place at ambient temperature.

Kokum lassi : The ingredient curd (100 g), *amrit* kokum (200 g), sugar (5 g) and *elaichi* powder were mixed thoroughly and allowed to stand for 15 minutes to dissolve sugar in the mixture. The product was kept in refrigerator for 6 to 8 hours.

Ice-cream : *Amrit* kokum (syrup) was used for the preparation of ice-cream. The ingradients includes milk (100 ml), sugar (200 g), whole milk powder (175 g), gelatin (2 g) and *amrit* kokum (160 g). The milk was boiled to get slightly thick consistency. The gelatin was dissolved in warm water and then added to hot boiling milk. The whole milk powder was first mixed with little quantity of milk and then added to boiled milk. The mixture was stirred vigorously till paste. The mixture was cooled completely and stirred well. *Amrit* kokum was added to the mixture and kept for aging at 50°C in the refrigerator for 2 to 3 hours. After aging the ice-cream mixture was placed in ice-cream pot (soft-tel) for 2 to 3 hours.

***Shrikhand* :** The *Amrit* kokum and kokum fresh fruit rind (crushed, homogenous pulp) was used to prepare *shrikhand* ingredients include *amrit* kokum (150 g), kokum fresh fruit rind pulp (100 g), *chakka* (400 g), sugar (450 g) and *charoli* (25 g). All the ingredients were mixed together in a desired proportion to prepare *shrikhand*.

All the kokum products were evaluated organoleptically just after preparation for their colour, flavour, texture by a panel of 5 judges with score of 1-9 hedonic scale (Amerine and Pangbom 1965). Kokum rind powder, kokum leather, *churna* and *churna goli*, *pachak* and *goli* were evaluated twice just after preparation and 8 months after storage..

The data recorded in various experiments

were anlaysed statistically as per the method described by Panse and Sukhatme (1995).

Results and Discussion

The T.S.S. and pH of the kokum products increased slightly during storage, whereas acidity was found to decline in all the kokum product throughout the storage period at ambient storage condition.

Kokum rind powder : The kokum powder prepared was organoleptically acceptable. The maximum average score of 7.51 was obtained in case of powder prepared from fresh fruit rind and the minimum (7.01) was for the residue powder. The organoleptic score of colour, flavour and texture of the powder prepared from fresh fruit rind was 6.38, 7.66 and 7.63 respectively. The average score was 7.51.

It could be noticed that the organoleptic score of the products remained more or less same throughout the storage period. Shinde (1993) and Joshi (1994) prepared sapota and kokum powder respectively, which were acceptable.

Kokum leather : The kokum leather was acceptable. The organoleptic score for its colour, flavour and texture was 6.35, 6.80 and 7.66, respectively with an average being 6.96.

***Churna and churna goli* :** The data indicate that these products were organoleptic acceptable. The *churna* recorded an average scale of 7.90 and it was 6.67 with *churna goli*. The organoleptic score of the product remained more or less the same throughout the storage period. The changes in organoleptic score and the chemical composition of the *churna* and the *churna goli* have been reported so far in kokum.

***Pachak and goli* :** The *pachak* recorded an average scale of 6.11 and it was 7.06 with *pachak goli*. The organoleptic score of the product remained more or less the same throughout the storage period.

Burfi : All the types of *burfi* were acceptable. As far as the average score was concerned the *burfi* prepared from *amrit* kokum + coconut recorded the maximum average score (8.2), followed by the *burfi* of fresh fruit rind pulp + coconut + potato (8.1). Other types of *burfies* were also organoleptically acceptable and palatable.

***Shrikhand* :** The *shrikhand* prepared from fresh fruit rind pulp and from *amrit* kokum organoleptically acceptable at the time of their preparation.

***Lassi* :** The data indicated that the product was organoleptically acceptable at the time of its preparation which recorded the score of 8.14, 7.46 and 8.04 for colour, flavour and texture respectively, with an average of 7.88 at the time of its preparation.

Ice-cream : The ice-cream prepared from the *amrit* kokum was acceptable at the time of its preparation. The organoleptic score for its colour, flavour and the texture was 8.04, 8.30 and 8.16 respectively with an average being 8.16 at the time of its preparation.

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Production and Export Performance of Cashewnut from India

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Abstract

The state wise performance of production in terms of growth rates of cashewnut was positive and significant. During the study period, highest production was seen in Maharashtra. The export share of cashewnut kernel was highest (41.71%) to USA from India. This indicates that, the export performance is taking place in desired direction. It can be suggested from the study that, there is a lot of prospectus for improving the export performance of cashewnut by bringing the cultivable waste land under cashewnut cultivation. Government should also undertake special policy for encouraging the export of cashewnut kernel.

Key words : Production, export, cashewnut, India.

Cashew (*Anacardium occidentale* L.) a native of Eastern Brazil was introduced to India by the Portuguese nearly five centuries back. In the beginning, it was mainly considered as a crop for afforestation and soil binding to check erosions but in course of time, it has become one of the India's major foreign exchange earners and the second biggest dollar earner. Till recently, India had virtual monopoly in the world supplies of cashew kernels. But with the development of domestic industries in some of East African countries, India would increasingly begin to face stiff competition from these sources in export market. It was also observed that, the growth rate of kernel export was 5.37 per cent with instability index of 8.70 per cent and export of CNSL was 6.15 per cent with instability index of 41.92 per cent during the post liberalization period (Harish Kumar and Chinappa, 2010). Based on all these facts, an attempt has been made to access the export performance of cashewnut in India's export trade with respect to production and export volume of cashewnut.

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Materials and Methods

In order to fulfill the objective of the present study to analyze the trends of India's exports of cashewnut in international market. The secondary data pertaining to production and export quantity were collected from various sources *viz*., Horticulture Statistics, National Horticultural Board- Gurgaon, Spices Board - Cochin, Centre for Monitoring Indian Economy (CMIE) - Mumbai, Agricultural and Processed Food Product Export Development Authority (APEDA) - New Delhi and Directorate General of Commercial and Intelligence (DGCIS), Ministry of Commerce - Kolkata. To assess the performance of production during study period, data were divided into four halves viz., period-I (1990-95), period-II (1996-2000), period-III (2001-2005) and period IV (2006-10). Growth rates of export in terms of quantity were computed separately for each period and overall period which was termed as period V (1990-2009). On the contrary to assess the performance export during study period, data were divided into two halves *viz*., period-I (1990-1999) and period-II (2000-2009). Growth rates of export in terms of quantity

were computed separately for each period and overall period which was termed as period III (1990-2009).

Coefficient of variance : To judge instability in production and export of cashewnut from India to different countries, CV was computed by using the formula. C.V. = $\sqrt{\text{Variance}}$ / Mean x 100

Linear average growth rate (LGR) : The linear average growth rate was calculated by using formula : Y = a + bX

$$\text{Linear average growth rate} = \frac{b}{y} \times 100$$

Where, Y = Estimated production/export volume for the base year, a = Intercept, b = Regression coefficient, X = Time period.

Compound growth rate : The semi log trend equation used for computing compound growth rate : $Y = aX^b$

Per cent compound growth rate = (antilog b-1) x 100,

Where, Y = Estimated production / export volume, a = Intercept, b = Regression coefficient, X = Time period

The significance of growth rates was tested with the help of correlation coefficient (r).

Table 1. State wise production of cashewnut in India (000 tonnes).

Period	States					
	Andhra Pradesh	**Karnataka**	**Kerala**	**Maharashtra**	**Orissa**	**All India**
Mean :						
I	43.940	25.860	145.220	29.320	37.980	333.740
II	73.680	44.000	112.160	84.260	43.600	437.560
III	73.200	39.880	70.880	121.000	66.600	499.800
IV	101.800	53.200	71.600	202.600	86.200	631.400
V	73.155	40.435	99.965	109.295	58.595	475.625
Coefficient of variation :						
I	11.088	42.377	3.338	8.633	19.539	9.707
II	23.839	26.358	16.239	29.282	9.540	13.406
III	42.115	14.680	19.102	25.419	10.649	8.103
IV	7.653	10.415	7.162	7.778	7.536	7.704
V	36.766	31.950	33.647	61.758	35.105	24.884
Linear growth rate :						
I	6.964***	22.158	0.744	-0.102	12.217***	5.876**
II	10.206	9.545	0.214	13.340	0.917	5.357
III	4.456	7.823*	3.485	13.967*	6.306*	5.062***
IV	2.652	4.511	0.140	2.863	2.668	2.170
V	4.788***	4.165***	-4.871	10.039***	5.675***	4.035***
Compound growth rate :						
I	7.274***	39.799	0.739	-0.108	13.297***	6.117**
II	9.786	9.782	0.348	12.563	0.788	5.181
III	3.995	8.690*	3.026	13.893**	6.590	5.221***
IV	2.737	4.816	0.108	2.947	2.750	2.220
V	5.000***	5.655***	-4.688	12.768***	6.002***	4.224***

* - Significant at 10%, ** Significant at 5%, *** - Significant at 1%.

Results and Discussion

In agriculture, export basket of fruits and horticultural crops hold a great promise for accelerating the income of farmers. Realizing the importance of fruit crops, the production under fruits has been increasing steadily. This chapter was divided into two sections viz., State wise performance of production of cashewnut in India and country wise export by volume of cashewnut kernel from India.

State wise production of cashewnut in India : Andhra Pradesh, Karnataka, Kerala, Maharashtra and Orissa were the major cashewnut growing states in India during the period of 1990-2009. On perusal of Table 1, it was seen that, on an average the production of cashewnut in India for the period 1990-2009 was 475625 MT per annum. Sub period wise production of cashewnut in India revealed that, during period I the production of cashewnut was 333740 MT per annum, which increased to 437560, 499800 and 631400 MT per annum during the period II, III and IV, respectively. This clearly indicated that, after period I production of cashewnut increased at increasing rate. During period I Kerala tops in production in cashewnut (145220 MT per annum). The similar trend was observed in period II. However, during period III and IV Maharashtra recorded highest production of cashewnut which was 121000 and 202600 MT per annum respectively. During the overall period highest production of cashewnut was observed in Maharashtra (109295 MT per annum) and lowest production was observed in Karnataka (40435 MT per annum).

The coefficient of variation in production of cashewnut in the study period of 1990-2009 was 24.884 per cent. For period I, II, III and IV, it was 9.707, 13.406, 8.103 and 7.704 per cent respectively. The statewise CV of

Table 2. Country wise export of cashew nut kernel from India (MT).

Period	Countries							
	USA	Nether lands	UAE	UK	Japan	France	Othres	Total
Mean :								
I	50506.20	14266.40	5129.20	6197.80	4845.60	2632.40	20220.40	103798.00
II	39893.40	15129.0	12550.00	4536.60	4923.80	3743.60	32156.60	112933.00
III	45199.80	14697.70	8839.59	5367.20	4884.70	3188.00	26188.50	108365.50
Coefficient of variation :								
I	15.434	11.286	30.177	13.982	13.678	16.916	22.210	13.433
II	15.480	25.313	31.206	23.693	10.216	6.090	6.358	3.696
III	19.191	19.096	64.464	23.669	11.387	21.140	27.108	9.996
Linear growth rate :								
I	8.403***	-1.776	17.488**	-0.169	1.465	6.101	13.136**	7.481**
II	-8.620	-14.936	19.403***	10.453	5.128	2.599	3.485***	-1.865
III	-3.342	-1.183	17.289***	-5.784	1.045	6.262***	8.728***	1.910*
Compound growth rate :								
I	8.818*	-1.816	20.156**	-0.389	1.590	5.791	13.917**	7.560**
II	-8.693	-14.328	21.711***	-9.179	5.187	2.697	4.069***	-1.858
III	-3.597	-1.521	19.944***	-5.955	1.106	6.696***	9.808***	2.050*

*Significant at 10%, **Significant at 5%, ***Significant at 1%

production of cashewnut during period I observed that, CV was highest in Karnataka (42.377%) and lowest in Kerala (3.338%). During the overall period it showed highest value in Maharashtra (61.758%) and lowest in Karnataka (31.950%).

The present study revealed that, during period (1990-2009) the National level linear growth rate and compound growth rate was positive. The state wise growth rate of cashewnut for linear and compound growth rate during period I for Andhra Pradesh (6.964%) and Orissa (12.217%). For period III significant growth rate was observed in Karnataka (8.690%), Maharashtra (13.967%) and Orissa (6.306%) per annum. Period II and IV showed that, all the states were having positive but non significant growth rate. During overall period, linear and semi-log trend showed that, all the states registered significant growth rates except Kerala. Amongst them, highest growth rate was observed in Maharashtra (LGR 10.039% and CGR 12.768%).

Country wise export by volume of cashewnut kernel from India : USA, Netherlands, UAE, UK, Japan, France were the major importer of the cashewnut kernel from India. The country wise and period wise mean, CV and growth rates for export by volume of cashewnut kernel from India during the period of 2000-2009 are given in Table 2.

It was observed that, on an average, the annual export of cashewnut kernel from India, for the period 2000-2009 was 108365.50 MT. Whereas, period wise mean for exports during period I and II were 103798 MT and 112933 MT, respectively. This indicated that, the volume of export for cashewnut kernel for period II increased as compared to period I. The country wise breakup of the total exports of cashewnut kernel from India for the period 2000-2009 revealed that, USA alone had imported 50506.200 MT during period I, out of the total cashewnut kernel exported from India. The export was to the Netherlands (14266.400 MT), UAE (5129.200 MT), UK (6197.80 MT), Japan (4845.600 MT), France (2632.400 MT) during period I. During overall period of cashewnut kernel was highest for USA 45199.806 MT and lowest for France (3188 MT).

The coefficient of variation in export of cashewnut kernel for the study period of 2000-2009 was 9.99 per cent whereas for periods I and II it was 13.43 per cent and 3.69 per cent, respectively. A fairly high growth rate was accompanied by high value of CV for the first two periods. The highest CV for export of cashewnut kernel was observed for UAE and UK which was 64.464 and 23.669 per cent for the overall study period.

Positive linear growth rate was observed during period I and period II for USA, UAE, Japan, France and others, respectively. During overall period, it was observed in UAE, Japan, France and out of this, significant were UAE (17.289% per annum) and France (6.262% per annum). In case of compound growth in overall period also UAE (19.944 % per annum) and France (6.696 % per annum) showed positive and significant growth rate.

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Development of Pigeonpea Husk Fiber Fortified Bread: Sensory and Nutritional Evaluation

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Abstract

The bread samples with 2 to 6 per cent of pigeonpea husk (PPH) had sensorily overall acceptable scores. The control bread and the PPH fortified breads up to 6 per cent level had statistically similar scores (6.08 ± 0.24 to 9.06 ± 0.09). The control and the PPH fortified dreads did vary statistically wilh regard to the contents of muisuae (41.20 ± 0.72 to 42.09 ± 0.79%), protein (10.87 ± 0.20 to 11.18 ± 0.01%), fat (3.50 ± 0.73 to 3.59 ± 0.05%) and ash (0.7 ± 0.03 to 0.83 ± 0.01%). The carbohydrate level in PPH added breads was marainuily less (79.45 ± 0.58 to 82.51 ± 1.33%) as compared to that of control sample (82.65 ± 1.11%). The control bread had negligible amount of total fiber (0.31 ± 0.06%). Whereas, fiber content in the PPH supplemented breads increased from 2.05 ± 0.03 to 5.26 ± 0.05 per cent with the increase in PPH level in the blend. It is concluded that sensorily acceptable fiber enriched bread could be developed by replacing the RWF up to 6 per cent. One serving (4-5 slices, about 100 g) PPH liber enriched bread at breakfast would be able to supply 1/6th of the total recommended daily allowance of fiber for an adult.

Key words : Pigeonpea husk, fiber, bread, nutritional, sensory, evaluation.

The modern dieticians recommend adequate intake of dietory fibre in the daily diet for health benefits (Fries, 2012). Bread is one of the popular ready to eat breakfast food. The commercial breads, made up of refined wheat flour (maida) as the base material with addition fat and sugar and as such are calorie dense with little or negligible fiber content. Dhal mill by-products are well recognized as a source of dietary fiber. It is estimated that about 2.5 million tones of dhal mill by-products are generated annually in the country (Ramakrishnaiah *et al*., 2004). The waste generated in the pulse milling industry contains very good proportion of edible fiber. Such by products can be used to enhance the fiber content and thereby add to the nutritive value of the bakery products.

Different sources of fiber such as wheat

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bran, rice bran, oat hulls, barley bran, corn bran, pea hulls etc., were used for production of high fiber bakery products (Rao, 1993). Pigeon pea is the major legume crop in the country and is milled into dhal. While milling pigeon pea, about 13 per cent husk is generated (Joshi *et al*., 1999). The pigeon pea milling by-product contains a substantial quantity (about 40%) of husk and cotyledon material, and it is estimated that about 4 lakh tones of husk is produced in India every year (Ramakrishnaiah *et al*., 2004). The pigeon pea fiber enriched bread as a functional food could be beneficial to a large section of specific targeted human population with chronic digestive problems like constipation. Therefore, attempts were made to develop bread fortified with different levels of pigeon pea husk (PPH) and subjected for sensory and nutritional evaluation.

Materials and Methods

Preparation of dough and bread : The commercial straight dough method of bread preparation was modified with minor changes as per the formula of School of Baking, Anand Agricultural University, Anand (Kamaliya and Kanialiya. 2001). Changes were made with regard to type and proportion of raw ingredients as well a processing conditions. Table 1 shows the baker's formula (commercial) and its modifications for the experimental dough composition. Good quality raw ingredients were procured from the local market (Anand). The pigeon pea husk (PPH) was received on gratis from a reputed pulse processing mill located at Vasad.

Refined wheat flour (RWF, 150 g) was sieved to ensure uniform blending. Sugar was dissolved in 90 ml lukewarm water and strained. About 40 ml solution was separated, yeast was crumbled into this and transferred to an oven at 37°C for one minute for disintegration. Salt was dissolved in the remaining sugar solution and transferred into the oven maintained at 37°C until used. About 17-18 g of RWF was added to the yeast water mixture and mixed into a thin paste. It was whisked gently and transferred to the oven at 37°C for 5 minutes (flying ferment). The Hour was made into a circular mass to which strained salt and sugar solution was added and thoroughly mixed. The yeast paste was added to this and kneaded well into smooth dough. Vanaspati was added just before kneading was about to get over, mixed properly and obtained clear dough. It was transferred to an aluminum bowl previously dusted with RWF. The dough was covered with wet cloth and allowed to ferment for 60 minutes at 26.6°C temperature. Then the dough was pressed to knock-back and allowed to re-ferment for 30 minutes at the same temperature. Further, the dough was transferred on to a working table and divided into 250 g uniform portion, rounded and rested

Table 1. Composition of commercial baker's dough and experimental dough.

Ingredients	Commercial dough (baker's)	Quantity in experimental dough (Per cent of baker's receipe)				
Refined wheat flour (RWF)	100	98	96	94	92	90
Pigeon pea husk (PPH)	Nil	2	4	6	8	10
Vanaspati	2	2	2	2	2	2
Sugar	5	5	5	5	5	5
Baker's yeast	1	1.00	1.00	1.00	1.00	1.00
		1.25	1.25	1.25	1.25	1.25
Water	90	105	107	1 10	115	118
Salt	2	2	2	2	2	2

Table 2. Sensory (composite) score of bread prepared by replacing refined wheat flour with different levels of PPH:Yeast at 1 per cent.

Treatment	Product	Volume (15)	Crust colour (5)	Symmetry of shape and uniformity of bake (10)	Texture (15)	Crumb colour (10)	Grain (15)	Taste and aroma (20)	Overall acceptability (10)
Baking	Control	$13.38^{c}\pm0.14$	$4.59^{e}\pm0.04$	$9.21^{d}\pm0.08$	$13.47^{d}\pm0.08$	$9.15^{e}\pm0.06$	$13.34^{e}\pm0.17$	$17.96^{d}\pm0.16$	$9.06^{e}\pm0.09$
temperature	2% PPH	$13.56^{c}\pm0.13$	$4.51^{e}\pm0.05$	$8.94^{d}\pm0.10$	$13.22^{d}\pm0.15$	$8.52^{d}\pm0.13$	$12.72^{d}\pm0.21$	$17.46^{d}\pm0.28$	$8.83^{e}\pm0.12$
210°C	4% PPH	$13.71^{c}\pm0.11$	$4.21^{d}\pm0.06$	$8.46^{c}\pm0.16$	$12.47^{c}\pm0.23$	$7.54^{c}\pm0.19$	$11.72^{c}\pm0.28$	$15.54^{c}\pm0.39$	$8.06^{d}\pm0.17$
	6% PPH	$12.53^{b}\pm0.30$	$3.84^{c}\pm0.12$	$7.85^{b}\pm0.22$	$10.72^{b}\pm0.42$	$6.73^{b}\pm0.22$	$10.44^{b}\pm0.35$	$14.25^{b}\pm0.41$	$7.00^{c}\pm0.20$
	8% PPH	$7.66^{a}\pm0.14$	$2.69^{b}\pm0.05$	$7.13^{a}\pm0.21$	$7.56^{a}\pm0.12$	$6.30^{b}\pm0.24$	$7.69^{a}\pm0.11$	$9.98^{a}\pm0.19$	$3.73^{b}\pm0.10$
	10% PPH	$7.31^{a}\pm0.16$	$2.42^{a}\pm0.07$	$7.17^{a}\pm0.14$	$7.41^{a}\pm0.20$	$4.27^{a}\pm0.11$	$7.44^{a}\pm0.14$	$9.92^{a}\pm0.19$	$3.23^{a}\pm0.09$
	F value	**295.42****	**191.88****	**30.58****	**145.50****	**70.21****	**125.24****	**139.91****	**362.88****
Baking	Control	$13.25^{d}\pm0.18$	$4.47^{e}\pm0.05$	$8.85^{d}\pm0.10$	$13.22^{e}\pm0.11$	$8.81^{e}\pm0.07$	$13.22^{e}\pm0.11$	$17.71^{c}\pm0.14$	$8.33^{e}\pm0.08$
temperature	2% PPH	$13.48^{d}\pm0.16$	$4.45^{e}\pm0.07$	$8.75^{d}\pm0.09$	$12.84^{e}\pm0.16$	$8.56^{e}\pm0.11$	$12.69^{de}\pm0.17$	$17.46^{de}\pm0.27$	$8.33^{e}\pm0.06$
220°C	4% PPH	$13.83^{d}\pm0.16$	$4.09^{d}\pm0.08$	$8.40^{d}\pm0.16$	$11.94^{d}\pm0.23$	$7.58^{d}\pm0.22$	$12.03^{d}\pm0.29$	$16.50^{d}\pm0.40$	$8.15^{d}\pm0.17$
	6% PPH	$12.25^{c}\pm0.32$	$3.82^{c}\pm0.11$	$7.63^{c}\pm0.31$	$10.50^{c}\pm0.41$	$6.63^{c}\pm0.26$	$10.50^{c}\pm0.41$	$14.54^{c}\pm0.71$	$7.19^{c}\pm0.28$
	8% PPH	$8.13^{b}\pm0.14$	$2.64^{b}\pm0.06$	$6.71^{b}\pm0.27$	$7.88^{b}\pm0.14$	$5.71^{b}\pm0.15$	$7.56h\pm0.12$	$10.04h\pm0.15$	$3.87^{b}\pm0.09$
	10% PPH	$6.78^{a}\pm0.22$	$2.17^{a}\pm0.08$	$5.42^{a}\pm0.29$	$6.31^{a}\pm0.29$	$3.83^{a}\pm0.25$	$5.84^{a}\pm0.28$	$8.29^{a}\pm0.41$	$2.88^{a}\pm0.08$
	F value	**185.15****	**158.14****	**36.78****	**132.46****	**97.46****	**137.44****	**97.00****	**313.31****

Values are means of four replications ± SEM. Values in parentheses indicate maximum score. Means bearing the same superscript within the column do not differ significantly ($p< 0.05$). **$p<0.01$

for 10 minutes. The dough portions were then moulded, placed in a greased bread tin, covered with lid and rested for 60 minutes at 37°C temperature for proofing. The bread tins were transferred to a pre-heated oven maintained at 210°C temperature and baked for 15 minutes. The bread tins were immediately transferred to a cooling rack. After cooling, the breads were evenly sliced, packed in polyethylene pouches, sealed with electrical heaters and stored at room temperature. The experimental breads were prepared on the similar lines, except that instead of RWF, the RWF having different proportions of PPH was used. Two varying levels of yeast (1 and 1.25%) and baking temperature (210 and 220°C) were employed. The breads were evaluated on the day of preparation itself.

A panel of 6 judges for sensory evaluation was formed from among the faculty members of the institute. The freshly prepared experimental bread samples were served to the judges. The panelists were instructed to rate each sample on the composite scoring test. The ratings were converted into scores. The evaluation was done for volume, colour and nature of crust, uniformity of bake and shape, texture, crumb colour, grain taste, aroma and overall acceptability. The breads with sensorily acceptable scores (2 to 6% PPH) were subjected to analysis of proximate principles (AOAC, 1980). The data were analyzed by the SPSS programme and tested for significance using the ANOVA and Least Significant Difference Test of means of various parameters (Steel and Torrie, 1980).

Table 3. Sensory (composite) score of bread prepared by replacing refined wheat flour with different levels of PPH:Yeast at 1.25 per cent.

Treatment	Product	Volume (15)	Crust colour (5)	Symmetry of shape and uniformity of bake (10)	Texture (15)	Crumb colour (10)	Grain (15)	Taste and aroma (20)	Overall acceptability (10)
Baking	Control	$13.41^{c}\pm0.15$	$4.46^{e}\pm0.04$	$9.10^{d}\pm0.09$	$13.28^{e}\pm0.11$	$9.04^{d}\pm0.04$	$13.09^{e}\pm0.14$	$17.71^{e}\pm0.20$	$8.92^{e}\pm0.08$
temperature	2% PPH	$13.44^{c}\pm0.13$	$4.45^{e}\pm0.06$	$8.98^{d}\pm0.12$	$12.91^{e}\pm0.19$	$8.67^{d}\pm0.13$	$12.59^{e}\pm0.23$	$17.33^{e}\pm0.25$	$8.71^{e}\pm0.13$
210°C	4% PPH	$13.57^{c}\pm0.12$	$4.22^{d}\pm0.06$	$8.58^{d}\pm0.16$	$11.66^{d}\pm0.19$	$7.75^{c}\pm0.16$	$11.66^{d}\pm0.19$	$16.21^{d}\pm0.29$	$7.90^{d}\pm0.13$
	6% PPH	$11.31^{b}\pm0.24$	$3.55^{c}\pm0.09$	$7.15^{c}\pm0.28$	$9.22^{c}\pm0.39$	$5.60^{b}\pm0.25$	$9.03^{c}\pm0.34$	$12.29^{c}\pm0.50$	$6.08^{c}\pm0.24$
	8% PPH	$7.88^{a}\pm0.17$	$2.59^{b}\pm0.04$	$6.02^{b}\pm0.16$	$7.78^{b}\pm0.16$	$5.23^{b}\pm0.18$	$7.69^{b}\pm0.19$	$10.00^{b}\pm0.23$	$3.94^{b}\pm0.05$
	10% PPH	$7.41^{a}\pm0.25$	$2.36^{a}\pm0.08$	$5.33^{a}\pm0.23$	$6.78^{a}\pm0.25$	$3.83^{a}\pm0.14$	$6.81^{a}\pm0.30$	$8.79^{a}\pm0.32$	$3.44^{a}\pm0.12$
	F value	**215.51****	**209.59****	**77.30****	**139.22****	**165.66****	**122.05****	**136.47****	**300.60****
Baking	Control	$13.34^{d}\pm0.14$	$4.53^{c}\pm0.05$	$9.08^{d}\pm0.07$	$13.53^{d}\pm0.08$	$9.00^{d}\pm0.06$	$13.25^{d}\pm0.10$	$17.83^{c}\pm0.10$	$8.98^{e}\pm0.04$
temperature	2% PPH	$13.50^{d}\pm0.13$	$4.55^{c}\pm0.02$	$8.92^{d}\pm0.07$	$13.56^{d}\pm0.10$	$8.94^{d}\pm0.09$	$13.38^{d}\pm0.12$	$17.75^{c}\pm0.15$	$9.02^{e}\pm0.04$
220°C	4% PPH	$13.81^{d}\pm0.10$	$4.39^{c}\pm0.06$	$8.71^{d}\pm0.11$	$12.72^{c}\pm0.25$	$8.06^{C}\pm0.19$	$12.44^{c}\pm0.24$	$17.08^{c}\pm0.28$	$8.54^{d}\pm0.14$
	6% PPH	$11.31^{c}\pm0.28$	$3.58^{b}\pm0.07$	$7.31^{c}\pm0.18$	$10.28^{b}\pm0.38$	$6.67^{b}\pm0.15$	$10.09^{b}\pm0.33$	$13.96^{c}\pm0.46$	$6.83^{c}\pm0.19$
	8% PPH	$7.69^{b}\pm0.20$	$2.41^{a}\pm0.07$	$5.44^{a}\pm0.26$	$7.25^{a}\pm0.20$	$4.83^{a}\pm0.17$	$7.31^{a}\pm0.16$	9.833 ± 0.23	$4.60^{b}\pm0.09$
	10% PPH	$6.91^{a}\pm0.23$	$2.28^{a}\pm0.07$	$6.33^{b}\pm0.15$	$6.75^{a}\pm0.17$	$4.67^{a}\pm0.10$	$6.91^{a}\pm0.26$	9.293 ± 0.27	$3.40^{a}\pm0.08$
	F value	**263.35****	**300.01****	**93.03****	**196.09***	**215.44****	**180.70****	**205.66***	**490.60****

Values are means of four replications ± SEM. Values in parentheses indicate maximum score. Means bearing the same superscript within the column do not differ significantly ($p< 0.05$). **$p<0.01$

Results and Discussion

Sensory evaluation : The composite sensory scores of samples of experimental bread prepared with 1 and 1.25 per cent yeast (baked at 210 and 220°C temperature) are presented in Table 2 and 3, respectively.

Volume : Increase in level of PPH supplementation up to 4 per cent got higher sensory scores for volume. However, further increase in addition of fiber level resulted in significant decreasing trend in the score. The sensory scores for volume of control, and 2 or 4 per cent PPH supplemented

Breads were statistically at par in all the four treatments, where it was highest for 4 per cent PPH bread with 1 per cent yeast and baking at 220°C (13.83 ± 0.16). The sensory scores for volume significantly lowered with the increase in proportion of PPH to 6 per cent or more, where the least scores were recorded for 10 per cent PPH bread in all the four treatments (6.78 ± 0.22 to 7.41 ± 0.25). The observations were similar when volume was measured physically.

Crust colour : The sensory score for crust colour of control and 2 per cent PPH supplemented breads were statistically similar (4.45 ± 0.06 to 4.59 ± 0.04) in all the four treatments. Further addition of PPH resulted in developing black spots and accordingly revealed decreasing trend in sensory scores, where it was lowest at 10 per cent PPH (2.17 ± 0.08 to 2.42 ± 0.07).

Symmetry of shape and uniformity of bake : The sensory scores for shape and bake of control,

and 2 or 4 per cent PPH supplemented breads was not much variable in all the four treatments (8.40 ± 0.16 to 9.21 ± 0.08). Further increase in PPH level resulted in gradual and significant reduction in the scores. Similar are the findings of Kamaliya (2005) who tried to develop high fiber bread replacing refined wheat flour with wheat bran.

Texture : Replacing the RWF with PPH by 4 per cent or higher levels tended to significantly lower the scores for the texture, where it was drastic at 10 per cent PPH in all the four treatments (6.31 ± 0.29 to 7.41 ± 0.20). Addition of too much fiber resulted in bread of poor quality in terms of texture and appearance (Dubois, 1978).

Crumb colour : The sensory scores for crumb colour of control and 2 per cent PPH supplemented breads in all the treatments were similar (8.52 ± 0.13 to 9.15 ± 0.06). The scores gradually reduced with the increase in PPH proportion and were least at 10 per cent PPH (3.83 ± 0.14 to 4.67 ±0.10).

Grain characteristics : The sensory scores for grain characteristics of contraband 2 per cent PPH supplemented breads in all the treatments were similar (12.59 ± 0.23 to 13.34 ± 0.17). The scores gradually and significantly reduced with the increase in PPH proportion and were least at 10 per cent PPH (5.84 ± 0.28 to 7.44 ± 0.14). Increased PPH level resulted in gritty sensation in the mouth and ultimately made the bread unacceptable, even though the husk was ground to allow it to pass through an 800-micron sieve.

Taste and aroma : The taste and aroma are the major contributing factors in deciding the acceptability of the product. The breads of control and 2 per cent PPH supplementation and prepared with 1 per cent yeast (at both the baking temperatures) had statistically similar scores (17.46 ± 0.27 to 17.96 ± 0.16); while the scores significantly lowered with further increase in PPH level. However, with 1.25 per cent yeast, the control bread and those with 2 to 6 per cent PPH had statistically similar scores for taste and aroma (12.29 ± 0.50 to 17.96 ± 0.16). Rao and Rao (1991) developed wheat bran bread and found adverse effect on texture, grain and loaf volume, but improvement in its aroma due to typical flavour similarity. While in the present experiment the PPH with different taste and aroma resulted in reduced scores for taste and aroma.

Overall acceptability : The sensory evaluation for overall acceptability revealed that the control bread and the PPH fortified breads up to 6 per cent level had statistically similar

Table 4. Nutritional composition of the sensorily selected breads compared with raw ingredients.

Product	Moisture	Protein	Fat	Carbohydrate	Total fiber	Ash
RWF	10.60^{b}±0.03	12.24^{c}±0.10	1.63^{a}±0.02	85.01^{d}±0.58	0.34^{a}±0.03	0.78^{a}±0.02
PPH	6.79^{a}±0.13	4.11^{a}± 0.10	1.66^{a}±0.03	5.74^{a}±0.15	85.89^{d}±0.32	2.60^{b}±0.12
Control	41.20^{c}±0.72	11.16^{b}±0.33	3.54^{b}±0.35	82.65^{cd}±1.11	0.31^{a}±0.06	0.71^{a}±0.03
2% PPH	42.13^{c}±0.28	11.18^{b}±0.01	3.50^{b}±0.15	82.51^{cd}± 1.33	2.05^{b}±0.03	0.76^{a}±0.03
4 % PPH	42.09^{c}±0.79	11.05^{b}±0.04	3.57^{b}±0.04	80.99^{bc}±0.27	3.60^{c}±0.38	0.80^{a}±0.06
6 % PPH	42.03^{c}±0.84	10.87^{b}±0.20	3.59^{b}±0.05	79.45^{b}±0.58	5.26^{d}±0.05	0.83^{a}±0.01
F value	**909.214****	**303.90****	**38.03****	**1561.73****	**27442.48****	**173.38****

RWF : Refined wheat flour

PPH : Pigeon pea husk, Control - 100% refined wheat flour (bakers %), Values are mean of percentages of three replications ± SEM scores, Except moisture content all parameters are expressed on dry weight basis, Means bearing the same superscript within the column do not differ significantly ($p < 0.05$), **$p<0.01$

scores (6.08 ±0.24 to 9.06 ± 0.09) indicating that RWF could be replaced upto 6 per cent with of PPH to enrich the bread with fibre.

The above findings reveal that the bread with PPH fortification up to 6 per cent level has satisfactory (acceptable) scores as per the individual sensory criterion as well as the overall acceptability.

Nutrient analysis : Based on the sensory evaluation by expert panelists, the experimental bread samples with PPH up to 6 per cent supplementation, considered sensorily acceptable, were analyzed for nutrient content and expressed in percentage on dry matter basis, except moisture (Table 4). The control bread as well as the PPH fortified breads did not vary statistically with, regard to moisture (41.20 ± 0.72 to 42.09 ± 0.79%), protein (10.87 ± 0.20 to 11.18 ± 0.01%), fat (3.50 ± 0.15 to 3.59 ± 0.05%) and ash (0.71 ± 0.03 to 0.83 ± 0.01%) contents. The carbohydrate level in PPH added breads was slightly less (79.45 ± 0.58 to 82.51 ± 1.33%) as compared to that of control sample (82.65 ± 1.11%). The control bread had negligible amount of total fiber (0.31 ± 0.06%). However, the fiber content in the PPH supplemented breads increased with the proportionately increase in PPH level in the blend from 2.05 ± 0.03 per cent at 2 per cent PPH to 5.26 ± 0.05 per cent at 6 per cent PPH. The whole PPH contained significantly lesser amounts of moisture, protein and carbohydrate. However, the levels of total fiber and ash were much higher in PPH than in RWF. The nutrient levels of RWF observed in the study were similar to earlier reports (Gopalan *et al.*, 1999).

Thus, from the observations made in the present study it may be concluded that sensorily acceptable fiber enriched bread could be prepared by replacing the RWF with PPH up to 6 per cent. One serving (4-5 slices, about 100 g) bread at breakfast would supply $1/6^{th}$ of the total RDA (Recommended Daily Allowance) of fiber for an adult. Hence, the newly developed fibre enriched bread could be beneficial to the specially targeted or aged adults suffering from chronic digestive ailments for better health.

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Effect of Mulching on Drip Irrigated Cucumber

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Abstract

The water requirement of cucumber treated with black plastic mulch combined with 100 and 70 per cent evapo-transpiration levels was found to be 266.62 and 190.26 mm, with water saving of 60.17 and 71.57 per cent over control. The mulched treatments showed better performance in plant growth and yield. The black plastic mulch with drip irrigation @ 90 per cent evapo-transpiration at alternate days showed high marketable yield (21.75 t ha^{-1}).

Key words : Mulches, evapo-transpiration, irrigation.

Cucumber (*Cucumis sativa* L.) is susceptible to excess as well as shortage of irrigation water; hence optimum water supply at appropriate time is necessary. Water is a limited natural resource and its efficient use is possible by adoption of water saving methods like drip-irrigation system thereby increasing the productivity and production of crops.

Mulching is a cultural practice used in conservation of soil moisture, increasing penetration of water in soil, maintaining soil temperature, reducing weed growth, increasing flowering, dry matter content and yield.

Materials and Methods

The field experiment was conducted at the farm of K. K. Wagh, College of Agricultural Engineering and Technology, Puriya Park, Nasik during Feb-2010 in plot 11. The source of irrigation was open well. The mean pan evaporation ranged from 7.5 to 8.8 mm day^{-1} during the period of 4th March to 21st May 2010. The topography of the experimental field was uniform and leveled. The soil was, well drained, sandy clay loam with a depth of 45cm. The EC and pH of the experimental plot were 0.22 dSm^{-1} and 8.25, respectively. Available N, P and K were observed as 225, 20.80 and 201.60 kg ha^{-1}, respectively. The experiment was laid out in split plot design with four main-plot and three sub-plot with one control treatment each having three replications. The main-plot treatments included 100, 90, 80 and 70 per cent of crop evapotranspiration (ETc). Sub-plot treatments included black plastic mulch with drip irrigation (BPM), organic mulch with drip irrigation i.e. soybean straw mulch (SSM) and No mulch with drip irrigation (NM).

The experiment was laid out with thirteen treatment combinations on a field of 40 x 25 m size with spacing of 1.0 x 0.5 m. The size of each treatment plot was 5 x 3 m with buffer of 1 m left between two successive treatments plots in order to avoid lateral movement of water from one treatment plot to another. One lateral commauded two rows of cucumber plants. The seeds of cucumber (var. Phule Himangi) were sown on 13th February 2010 at the seed rate of 1.50 kg ha^{-1} in coco pit, for

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Table 1. Total depth of water applied, effective rainfall, seasonal water requirement and saving in irrigation water.

Treatment	Water applied (mm)	Effective rainfall (mm)	Seasonal water reuirement (mm)	% saving in irrigation water
T_1 (BPM + 100%ETc)	254.52	12.1	266.62	60.17
T_2 (BPM + 90% ETc)	229.07	12.1	241.17	63.97
T_3 (BPM + 80% ETc)	203.61	12.1	215.71	67.77
T_4 (BPM + 70% ETc)	178.16	12.1	190.26	71.57
T_5 (SSM + 100% ETc)	254.52	12.1	266.62	60.17
T_6 (SSM + 90% ETc)	229.07	12.1	241.17	63.97
T_7 (SSM + 80% ETc)	203.61	12.1	215.71	67.77
T_8 (SSM + 70% ETc)	178.16	12.1	190.26	71.57
T_9 (NM + 100% ETc)	254.52	12.1	266.62	60.17
T_{10} (NM + 90% ETc)	229.07	12.1	241.17	63.97
T_{11} (NM + 80% ETc)	203.61	12.1	215.71	67.77
T_{12} (NM + 70% ETc)	178.16	12.1	190.26	71.57
Control	650	19.4	669.4	-

seedlings preparation and then were transplanted on 4th March 2010 on each treatment plot by dibbling at a spacing of 1.0 x 0.5 m

Farm yard manure of 500 kg (50%) and vermi-compost of 250 kg (50%) was distributed equally among the plots before sowing. Water-soluble fertilizer (Ultrasol) of grade 19:19:19 was used for drip irrigated treatment plots whereas in case of control, solid fertilizers were used in the form of urea (46% N), single super phosphate (16%), murate of potash (60% K_2O). In case of water soluble fertilizers (Ultrasol), the basal dose was divided into four splits as 10, 30, 30 and 30 per cent, respectively and was applied weekly after sowing, whereas the dose for top dressing was divided into four equal splits as 12.5 per cent and was applied weekly in the next month. While in case of solid fertilizers, half dose of N and full dose of P and K were given at the time of sowing and remaining half dose of N was given one month after sowing.

A black-silver colour plastic mulch (BPM) of thickness 30 microns and soybean straw mulch (SSM) of 500 kg was spread in respective plots up to a depth of 10 cm. The strips of 3.0 x

Table 2. Yield of cucumber as influenced periodically by different treatments.

Treatment	Yield (t ha^{-1})
Mulches :	
M_1 (BPM)	20.16
M_2 (SSM)	19.10
M_3 (NM)	17.78
'F' test	Sig.
S.E.±	6.78
C.D.at 5 %	20.14
Irrigation levels :	
I_1 (100% ETc)	20.01
I_2 (90% ETc)	19.90
I_3 (80% ETc)	18.53
I_4 (70% ETc)	17.60
'F' test	Sig.
S.E.±	2.29
C.D.at 5 %	9.02
Interaction :	
'F' test	N.S.
S.E.±	7.78
C.D.at 5 %	-
Mean	19.01

1.50 m of BPM were made for its respective plots and the holes were made on it for dibbling of cucumber seeds.

The effect of irrigation levels and mulching materials were studied in terms of main vine length, diameter of fruit, length of fruit, weight of fruit, yield of fruit and water saving. The cost economics of organic and inorganic mulching for drip-irrigated cucumber crop was found out.

Results and Discussion

Biometric and yield observations : Maximum length (15.46 cm), diameter (3.99 cm) and weight of fruit (190.18 g) were recorded in M_1 whereas, length (15.39 cm), diameter (4.07 cm) and weight of fruit (191.86 g) were recorded maximum in irrigation level with I_1. Minimum values of above parameters were recorded in control treatment. The yield of cucumber was significantly influenced by mulches (Table 2.). The maximum yield of cucumber (20.16 t ha^{-1}) was due to M_1 which was significantly superior over that of M_2 (19.10 t ha^{-1}) and M_3 (17.78 t ha^{-1}). The minimum yield of cucumber (17.78 t ha^{-1}) was due to M_3. Conservation of soil moisture and creation of favorable microclimate due to the different mulches might have promoted the better yield performance in cucumber cultivation. In addition to this the effective weed control due to mulches might have contributed the increased yields in cucumber. In conformity with this, the maximum weed population was observed in control (non mulch, surface irrigation) treatment. Similar results were reported by Firake *et al*. (1987), Surve (1998) and Shirgure *et al*. (2003).

The yield of cucumber was also significantly influenced by irrigation levels. The maximum yield of cucumber was 20.01 t ha^{-1} due to I_1 (100% ETc), which was at par with I_2 (90% ETc) with the yield of 19.90 t ha^{-1} and both were significantly superior over that of I_3 (80% ETc) and I_4 (70% ETc). The minimum yield of cucumber 17.60 t ha^{-1} was due to I_4 (70% ETc). It might be due to the use of drip irrigation system. These findings were in conformity with the results of Miller *et al*. (1976) and Mane *et al*. (1987). The interaction effect between irrigation levels and mulches was observed to be non-significant in respect of average yield $hectare^{-1}$. The total water applied was 669.4

Table 3. Cost of production, gross and net returns and benefit cost ratio .as influenced by different treatments.

Treatment combinations	Seasonal cost of production (Rs. ha^{-1})	Gross monetary returns (Rs. ha^{-1})	Net income (Rs. ha^{-1})	Benefit cost ratio
T_1 (BPM+ 100%ETc)	48232	82000	33768	1.70
T_2 (BPM + 90% ETc)	47712	87000	39288	1.82
T_3 (BPM + 80% ETc)	47192	79200	32008	1.68
T_4 (BPM + 70% ETc)	46673	74400	27727	1.59
T_5 (SSM + 100% ETc)	46252	83000	36748	1.79
T_6 (SSM + 90% ETc)	45733	78600	32867	1.72
T_7 (SSM + 80% ETc)	45212	74600	29388	1.65
T_8 (SSM + 70% ETc)	44693	69400	24707	1.55
T_9 (NM + 100% ETc)	42072	75200	33128	1.78
T_{10} (NM + 90% ETc)	41552	73200	31648	1.76
T_{11} (NM + 80%ETc)	41032	68600	27568	1.67
T_{12} (NM + 70% ETc)	40512.5	67400	26887.5	1.66
(Control)	38395	58000	19605	1.51

mm in surface method followed by 266.62, 241.17, 215.71 and 190.26 mm as in I_1 (100% ETc), I_2 (90% ETc), I_3 (80% ETc) at I_4 (70% ETc) through drip irrigation system as depicted in Table 1. The maximum saving in water of 71.57 per cent was achieved from I_4 (70% ETc) over surface irrigation. The average emission uniformity of drip system was 90.73 per cent.

The maximum (97.76 kg ha^{-1} mm) field water use efficiency (FWUE) was reported in treatment combination M_1I_4 (BPM + 70% ETc) whereas minimum FWUE of 21.66 kg ha^{-1} mm was in surface (control) irrigation due to more seasonal water requirement and comparatively less yield. It is revealed from Table 3 that the maximum B:C ratio was observed in treatment combination BPM + 90 per cent ETc (1.82) due to lower cost of production and maximum gross income and the minimum value of B:C ratio was found in control treatment (1.51). Also, the maximum net income was gained from the same treatment combination BPM + 90 per cent ETc which was Rs. 39288 ha^{-1} whereas minimum net income was reported in control treatment which was Rs. 19605 ha^{-1} due to lower yield of cucumber with comparatively higher cost of production.

The study revealed that, though the effect of interaction between mulching and irrigation level was found statistically non-significant but the individual effects of mulching and irrigation level gave significant results. Thus, it was concluded that the black plastic mulch with alternate days drip irrigation @ 90 per cent ETc showed better performance over other treatments on sandy clay loam soil in respect of growth, yield and economics of cucumber.

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Response of Garlic to Different Irrigation Systems

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Abstract

Average irrigation water requirement of garlic was found to be 87.59 ha-cm for check basin while 47.49 ha-cm under microirrigation system. The online drip irrigation system recorded higher yield of garlic production which saved 45.78 per cent of irrigation water over traditional check basin method with 20 per cent more yield (water use efficiency 0.95 q ha^{-1} cm^{-1}) with B:C ratio of 1.96.

Key words : Garlic, microirrigation, water use efficiency.

Micro-irrigation systems account 40-50 per cent of water saving and also result in 15-20 per cent more yield coupled with 30 per cent saving of fertilizer and labour as compared with surface irrigation (Singandhupe *et al*. 1998).

Garlic (*Allium sativum* L) is second most important bulbous crop grown throughout the country, which has higher nutritive value as compared to other bulbous crops. It is rich source of carbohydrates, proteins and phosphorus and having the protective values against heart disease, cancer and infectious disease. India rank second in area and production of garlic next to China. Water requirement of garlic is 425 mm. Traditionally garlic is irrigated by flood irrigation methods (Sankar *et al*. 2008).

The appropriate selection of microirrigation system from .market is a critical task. In order to generate the information in respect to selection of appropriate microirrigation system to the farmers for garlic production, a field experiment was carried out at Research Farm of Department of Irrigation and Drainage Engineering, College of Agriculture Engineering and Technology, Dr. PDKV, Akola during the year 2008-11.

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Materials and Methods

The experiment was set in a randomized block design with four replications. The treatment included four irrigation systems T_1 - online drip (dripper of 4 Iph, spaced 40 cm), T_2 - inline drip (dripper of 4 Iph, spaced 40 cm), T_3 - microsprinkler (single microsprinkler of 64 Iph discharge) and T_4 - check basin (IW/CPE = 1.2 with CPE = 40 mm). The garlic variety G-41 was grown in a gross plot size of 3.6 x 3.6 m with spacing of 15 x 10 cm. The seed rate used was 500 kg ha^{-1} and crop fertilized with 100:50:50 NPK kg ha^{-1} in two splits. The crop was sown on 17.11.2008; 24.11.2009 and 19.11.2010 and harvested on 23.03.2009; 23.03.2010 and 19.03.2011 respectively.

The amount of irrigation water required for all treatments to bring the soil to field capacity was calculated by using equation of Michael, (1978). Quantity of water required per plot in litre was calculated by using equation, Q = d x A, where, d = Net amount of water to be applied during an irrigation, cm and A= Area of plot, m^2.

Table 1. Amount of irrigation water applied to garlic during different growth stages (Average for 3 years).

Growth stages	Duration (days)	Average water applied, (ha-cm)	
		T_1, T_2, T_3	T_4
Before sowing	-	6.01	6.01
Initial	18	2.61	8.00
Crop development	60	18.20	35.19
Mid season	28	13.97	25.59
Late season	15	6.70	12.80
Total		47.49	87.59
Water saved over traditional method		45.78%	

Micro-irrigation treatments : After application of first common irrigation to all the treatments to bring the soil moisture content at field capacity level, the micro irrigation treatments were daily irrigated. The daily water requirement of micro-irrigation system was worked on the basis of class 'A' open pan evaporation, crop coefficient and pan coefficient. The daily pan evaporation data was collected from the Meteorological Observatory, Department of Agronomy. Dr. PDKV, Akola during the period of investigation. The values of crop coefficient for different growth stages of garlic (Doorenbos and Pruitt, 1977) are at initial 0.48 (18 days), at crop development 0.94 (60 days), mid season 1.07 (28 days) and at late season 0.86 (15 days). The value of pan coefficient was taken as 0.7. The water requirement for garlic crop day^{-1} was calculated by using equation of Sivanappan, (1988).

Check basin irrigation system : For check basin irrigation method the irrigation was scheduled at CPE = 40 mm with IW/CPE = 1.2. The amount of water required for each plot of the check basin irrigation system was

Table 2. Water use efficiency under different irrigation treatments.

Year	Water applied (ha-cm)		Yield (q ha^{-1})				Water use efficiency (q (ha-cm)$^{-1}$)			
	T_1, T_2, T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
2008-09	48.53	96.18	46.92	45.86	23.72	43.96	0.96	0.94	0.49	0.46
2009-10	46.58	83.06	28.70	27.21	24.90	24.69	0.61	0.58	0.53	0.30
2010-11	47.36	83.51	61.79	59.65	43.97	45.43	1.30	1.26	0.93	0.54
Mean	47.49	87.58	45.80	44.24	30.86	38.04	0.95	0.92	0.65	0.43

Table 3. Total cost required (Rs. ha^{-1}) by various treatments.

Treatment	Initial cost without pump and filter unit	Fixed cost		Fixed cost of pump and filter	Total fixed cost annum^{-1}	Fixed cost season^{-1}	Variable cost		Total cost season^{-1}
		Interest on initial cost @10%	Depreciation on cost @10%				Management and input cost	Interest on management cost @10%	
T_1	217564	21756.40	19580.76	1635.40	42972.56	14324.19	57250	5725	77299.19
T_2	194844	19484.40	17535.96	1635.40	38655.76	12885.25	57250	5725	75860.25
T_3	99993.70	9999.37	8999.433	1635.40	20634.20	6878.07	57250	5725	69853.07
T_4	5371	537.10	483.39	1278.40	2298.89	766.30	63370	6337	70473.30

Table 4. Benefit cost analysis of garlic production.

Treatment	Pooled mean yield (q ha^{-1})	Gross return (Rs. ha^{-1})	Total cost (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1	45.80	229000	77299.19	151700.81	1.96
T_2	44.24	221200	75860.25	145339.75	1.92
T_3	30.86	154300	69853.07	84446.93	1.21
T_4	38.04	190200	70473.30	119726.70	1.70

calculated by using equation IW/CPE = 1.2.

Quantity of water required per plot was calculated by using equation Q = IW x A, where, IW = Irrigation water, mm, CPE = Cumulative pan evaporation, mm, Q = Quantity of water delivered per plot, litres, IW = Net amount of water to be applied during irrigation, mm, A = Area of plot, m^2.

After harvesting of garlic, it was cured in shed for about a month. Yield was recorded before and after drying. The statistical analysis of the recorded yield was carried out and benefit cost ratio was worked out.

Results and Discussion

Irrigation water requirement : The amount of water applied to different irrigation method during various crop growth stages of crop (Table 1) clearly indicated that the maximum water was required for garlic during crop development stage while lowest during initial stage. During crop development stage maximum vegetative growth took place and also it was longest duration stage. The mid-season stage is characterized with ceasing of vegetative growth and development of bulb. Water requirement was decreased during the late season stage. During this stage vegetative growth as well as bulb development completely ceases. Cumulative irrigation water requirement of garlic over the cropping period under microirrigation treatments was 47.49 ha-cm while under check basin irrigation treatment, it was 87.59 ha-cm. Thus 45.78 per cent water was saved under micro-irrigation system over check basin irrigation system. Hence, an additional area of 0.84 ha could be irrigated for garlic cultivation by using saved water through the micro-irrigation system.

Water use efficiency : Data in respect of yield in terms of average weight of bulb, yield before and after drying were recorded during 2008-09, 2009-10 and 2010-11 and was used for statistical analysis. Yield before and after drying (Table 2) was recorded maximum in online drip treatment whereas lowest yield was recorded under microsprinkler treatment. Yield recorded in online and inline drip treatment was significantly higher than that of check basin irrigation treatment. While yield recorded under microsprinkler treatment was significantly lower

Table 5. Incremental benefit cost analysis.

Treatment	Benefit	Cost	B:C ratio	Comparision of treatments	Incremental		Incremental B:C ratio (B/C)
					Benefit	Cost	
T_3	84446.93	69853.07	1.21				
				T_3 and T_4	35279.77	620.23	56.88 (PickT_4)
T_4	119726.7	70473.30	1.70				
				T_4 and T_2	60892.81	6007.19	10.14 (Pick T_2)
T_2	145339.75	75860.25	1.92				
				T_2 and T_1	6361.07	1438.93	4.42 (Pick T_1)
T_1	151700.81	77299.19	1.96				

than that in check basin irrigation treatment. The yield recorded under online and inline drip irrigation treatment was at par. The bulb weight was found significantly higher in online drip irrigation treatment as compare to in check basin irrigation treatment which was at par with inline drip irrigation treatment. Water use efficiency for various irrigation treatments was estimated. Water use efficiency was found maximum (Table 2) for online drip irrigation system followed by inline, microsprinkler and lowest was found under check basin treatment.

Benefit cost analysis : Benefit cost analysis was carried out for garlic production under different treatments of irrigation. Market rate of garlic was assumed as Rs.5000 q^{-1}. Actual cost of items (Table 3) in respect of micro-irrigation system was taken into consideration accordingly benefit cost ratio for various treatments were calculated. It was observed that benefit cost ratio for online irrigation treatment (Table 4) was found maximum (1.96) followed by inline drip, microsprinkler and check basin irrigation treatment. There was a very little difference in B:C ratio recorded under online and inline drip irrigation treatment, incremental cost benefit ratio was calculated.

Table 5 clearly indicated that by putting an additional cost of Rs. 1439/- for installation of online drip irrigation system, additional benefit of Rs. 6361/- could be obtained over inline drip irrigation system. Hence, online drip irrigation system should be preferred for garlic production.

As online drip irrigation system recorded 20 per cent higher yield and 46 per cent water saving over traditional check basin irrigation method and it is advised to use it for garlic production under Akola climatic condition.

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Distribution Pattern of Rainfall in Osmanabad District of Marathwada Region (MS)

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Abstract

Annual rainfall of Osmanabad district is in range of 550-750 mm. Out of total annual rainfall about 80-87 per cent rainfall received as SW monsoon, while remaining 12-18 per cent from NE monsoon. Onset of monsoon ranged between MW 23-24 while withdrawal of monsoon was in MW-42-43. Generally higher variability found in MW 28 to 31 and MW 34 to 36 indicating the need for contingency crop planning.

Key words : Rainfall, rainfall characterifation, variability, probability, monsoon.

Crop growth and yield variation primarily attributed to inter seasonal climatic variability in terms of change in temperature, rainfall and input management (Agrawal, *et al*. 1994). Efficient cropping system for a specific location can be evolved by understanding the rainfall pattern. Random nature of rainfall occurrence suggests need for sound statistical analysis and logical interpretations. Rainfall studies particularly, its probability analysis are of great use in crop management practices, plant protection measures and other related farm practices for sustainable crop production in area under reference. The major part of Osmanabad is situated in Balaghat plateau. The mean annual maximum and minimum temperature of Osmanabad district is 40°-15°C respectively. The major rivers flowing on district are Manjara, Terna, Sina, Kheri, Nali, Gharni, Bori. Mean annual rainfall of Osmanabad district is in the range of 550-750 mm. Though the mean annual rainfall of Osmanabad district comes in the category of assured rainfall zone but, the inter taluka variation are wide so the intra seasonal behavior warrants timely management for sustainable crop production.

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Materials and Methods

The historical daily data of rainfall at each taluka of Osmanabad district were collected from State Department of Agriculture, Collectorate of Osmanabad, Department of Agricultural Meteorology, College of Agriculture, Parbhani and Agriculture Research Station, Tuljapur. The daily data collected for each taluka were summed up on meteorological weekly, monthly, seasonal and annual basis. For calculation of weekly basis the year was partitioned as per meteorological calendar, starting from 1st January of each year and ending on 31st December of the same year.

The data collected for each taluka of Osmanabad district were subjected to statistical analysis such as standard deviation, coefficient of variation, extreme lowest and highest, starting, ending and duration of rainy season, initial and conditional probability, dry and wet spell probability using Markov and Marshall chain probability model, starting and ending of rainy season by frequency analysis of weekly rainfall were estimated from the computerized programme developed by (CRIDA) Hyderabad and different formulae used for analysis of

annual rainfall variability initial rainfall probability and conditional rainfall probabilities (W/W and W/D).

Results and Discussion

Annual rainfall variation : The daily rainfall data recorded at each taluka headquarter for the period of 1981 to 2006,was summed up for annual total and presented in Table 1. The data indicated that the highest mean annual rainfall (782 mm) was recorded at Tuljapur followed by Kalamb (740 mm). The lowest mean annual rainfall was recorded in Paranda taluka (566 mm).

The statistical analysis for variability of rainfall indicated that year to year variation ranged between 33.3 to 54.1 per cent on annual basis with standard deviation values of 248.8, 277.1, 231.1, 253.8, 332.1 and 234.9 mm for Osmanabad, Tuljapur, Omarga, Kalamb, Paranda and Bhoom taluka respectively.

Monsoon season variability : The highest amount of seasonal rainfaliTecbraed in each taluka during south west monsoon season were 1255 mm in Osmanabad (1988), 1470 mm in Tuljapur (1988), 1147mm in Omarga (1989), 1227 mm in Kalamb (1988), 935 mm in Paranda (1983) and 1018 mm in Bhoom (1998). Lowest amount of rainfall were 286 mm in Osmanabad (1984), 377 mm in Tuljapur (1984), 246 mm in Omarga (1986), 243 mm in Kalamb (1986), 185 mm in Paranda (1982) and 236 mm in Bhoom (1995). This study indicated that the seasonal rainfalls in these talukas were much erratic and the agricultural production was at risk.

The statistical analysis for variability of rainfall indicated that monsoon seasonal variation ranged between 34.7-66.9 per cent with standard deviation values of 236.9, 257.6, 225.4, 219.2, 336.4, and 215.7 mm for Osmanabad, Tuljapur, Omarga, Kalamb, Paranda and Bhoom taluka respectively.

Table 1. Talukawise variability in annual rainfall (mm) of each talukas of Osmanabad district (1981-2006).

Year	Osman-abad	Tulja-pur	Ome-rga	Kala-mb	Para-nda	Bho-om
1982	568	795	659	472	312	444
1983	1014	1032	997	801	957	1002
1984	337	470.6	551	539	438	601
1985	563	508	500	517	506	285
1986	538	649	341	258	430	379
1987	582	873	827	861	848	636
1988	1264	1491	894	1137	758.9	723
1989	1041	909	1161	976	589	864
1990	916	930	1000	1027	841.6	517
1991	467	532	474	569	289	351
1992	486	402	355	525	385	559
1993	709	1060	499	818	839	1103
1994	424	573	514	515	343	451
1995	688	621	651	678	590	661
1996	718	959	817	954	750	966
1997	576	632	550	824	552	756
1998	1314	1455	1173	1470	980	1233
1999	591	599	611	867	478	717
2000	960	778	822	780	626	795
2001	594	658	447	567	422	431
2002	634	546	601	556	360	621
2003	431	494	643	531	249	443
2004	752	870	709	667	487	517
2005	786	838	855	932	656	714
2006	558	993	505	629	522	648
Mean	706	782	693	740	566	654
S.D	248.8	277	231.1	253.8	189.7	234.9
C.V.(%)	35.3	35.5	33.3	34.3	54.1	35.9

Post monsoon seasonal variability : Post monsoon rainfall (Table 3) indicated that mean highest post monsoon rainfall ranged between 88 to 110 mm in different talukas. The highest post monsoon seasonal rainfall was 241.1 (1998), 355.0 mm (1993) 233 mm (1990), 348 mm (1998), 363 mm (1993) and 273 mm (1997) in Osmanabad, Tuljapur, Omarga, Kalamb, Paranda and Bhoom talukas

respectively. However, lowest rainfall recorded was 0.0 in all talukas more than two years during 26 year.

The statistical analysis for variability of rainfall indicated that post monsoon season variation ranged between 60, 3-91.0 per cent with standard deviation values 67.1, 86.8, 66.6, 87.7, 95.0,and 80.2 mm in Osmanabad, Tuljapur, Omarga, Kalamb, Paranda and Bhoom talukas respectively.

The data further revealed that the crop growing season or length of growing period may be extended even up to end of October due to receipt of post monsoon seasonal rain showers, these rains are helpful in establishment and early growth stages of *rabi* crop. These finding are in confirmation with the earlier findings of Raghavan (1964).

Monthly rainfall variation : Trend of monthly rainfall (Table 4) of that location seems to be ideal for delineating the cropping pattern to be suggested for that particular location. The data indicated that major part of the annual rainfall was concentrated during June to September i.e. south west monsoon season. However, a good quantum of rainfall was also recorded during October in almost all talukas. During January to May the amount of rainfall receipt was very meagre. The variation in rainfall receipts was lower during rainy season June, September as compared to off-season variation. Month wise rainfall indicated that there were no rainfall in the month of February except Paranda taluka. The month wise rainfall data further indicated that Osmanabad, Tuljapur, Omarga, Kalamb, Paranda and Bhoom taluka received 182.7mm, 233.5mm, 176.0mm, 191.7mm, 167.6mm and 180.0mm respectively during September. These finding are conformation with the finding of Gadre and Umrani (1972) who suggested cropping pattern for each tahasils of Solapur district based on monthly rainfall data.

Table 2. Talukawise variability in SW monsoon season 1 (June-Sept) of Osmanabad district (1981-2006).

Year	Osman-abad	Tulja-pur	Ome-rga	Kala-mb	Para-nda	Bho-om
1981	737	616	748	673	443	521
1982	512	708	570	390	185	328
1983	866	830	813	721	935	956
1984	286	377	421	444	285	376
1985	507	446	402	408	443	235
1986	452	615	246	243	381	315
1987	423	595	707	619	492	456
1988	1255	1470	843	1127	753	719
1989	1020	902	1147	957	584	859
1990	769	797	768	732	576	360
1991	461	529	471	565	254	339
1992	476	401	355	525	385	559
1993	502	705	355	647	476	833
1994	325	425	340	330	219	337
1995	528	445	462	545	442	533
1996	585	798	678	833	675	786
1997	395	467	303	594	332	432
1998	1037	1239	930	1092	753	1018
1999	517	500	470	732	413	601
2000	875	706	709	732	617	703
2001	518	559	349	507	263	331
2002	600	492	494	469	271	569
2003	431	494	615	529	225	440
2004	588	758	550	548	389	402
2005	779	831	850	920	645	709
2006	516	897	441	566	410	596
Mean	614.0	677.0	578	632.6	451.5	550.6
S.D	236.9	257.6	225.4	210.2	336.4	215.7
C.V. (%)	38.6	38.0	39.0	34.7	66.9	39.2

Weekly rainfall variability : The major rains were concentrated during MW 22 to 43. The statistics of the weekly total rainfall indicated that low coefficient of variance was noticed during this period indicating the surety of rainfall during this period. However, coefficient of variance in remaining weeks is higher because of low rainfall. Generally higher variability found in MW 28 to 31 and MW 34

to 36 indicating that need for contingency crop planning. These results are similar to rainfall analysis in scarcity zone of Maharashtra given by Jadhav *et al*. (1999).

The statistics of rainfall from 23 to 44 MW recorded lowest coefficient of variations indicating assurance of good quantum of rainfall. The highest rainfall was recorded in 39 MW in all talukas except Paranda (38 MW) of Osmanabad district. The rainfall during 39MW ranged between 45.5mm to 68.5 mm. Bhatia *et al*. (1975) also reported that data on weekly rainfalls was more important than data on monthly and yearly rainfall for selection of suitable crops and their cultivars in the monsoon season under rainfed condition.

In respect of taluka wise week's total of rainfall, it can be concluded that once monsoon is set, the rainfall persist for about 24 to 25 MW these finding are in conformation with the finding of Patil and Kale (1988) and Vaidya *et al*. (2008) they have classified these districts under assured rainfall agro climate zones of Maharashtra State.

Onsets and withdrawal : Mean start rainy season ranged from 23-24 MW in different talukas. An early onset was at 22 MW in all taluka. While late onset ranged between 25-27 MW. Mean termination of rainy season was in 42-43 MW. Early termination occurs in 35-38 MW in all talukas. Mean duration of rainy season ranged 18-19 weeks. Minimum duration ranged between 11 and 14 weeks in those district, while maximum duration of 28 to 30 weeks was estimated.

Probability of rainfall occurrence : The data indicated that the probability of occurrence of rainfall decreases as the quantum of rainfall increases in almost all talukas and all week considered. From MW 29 onwards the amount of rainfall was either equal or exceeding the weekly PET values and the crop sown in MW 24 or 25 coincide that period with the grand growth to reproductive stages.

Table 3. Talukawise variability in NE monsoon season (Oct-Dec) of Osmanabad district (1981-2006).

Year	Osman-abad	Tulja-pur	Ome-rga	Kala-mb	Para-nda	Bho-om
1981	76	41	12	84	72	66
1982	55	86	88	82	127	116
1983	147	202.2	184	81	22	46
1984	78	93	13	95	153	225
1985	56	62	98	109	63	50
1986	86	34	94	15	50	64
1987	159	277	120	187	273	150
1988	8	21	51	10	6	4
1989	21	7	14	19	5	5
1990	147	132	233	295	265	156
1991	6	3	3	4	36	12
1992	9	0.6	0	0	0	0
1993	206	355	144	171	363	270
1994	99	148	174	195	124	114
1995	161	176	189	133	148	128
1996	104	126	115	102	59	153
1997	156	110	183	152	220	272
1998	241	170	216	348	173	192
1999	74	99	141	135	65	116
2000	84	7	113	49	9	92
2001	76	99	99	60	159	100
2002	33	54	107	87	89	52
2003	0	0	2	2	24	3
2004	164	112	159	119	98	115
2005	0	0	0	0	0	0
2006	42	96	64	63	112	52
Mean	88.1	99.1	110.4	99.5	104	98
S.D	67.1	86.8	66.6	87.5	95	80
C.V. (%)	76.2	87.6	60.3	88.1	91.0	81.6

Probability of dry and wet spells : During SW monsoon period occurrence of dry spell was common phenomenon in Osmanabad district. A break in the occurrence of rainfall during crop growing period affects the crop growth and ultimately the yield was affected, which was called as dry spell. It may be of any duration ranging from 2 days to more than 20

days and even in some events it was 30 day, during that period the crops survive till soil was sufficiently wet to meet the evaporatived demand of atmosphere. The dry spell was common feature of Osmanabad Distriot. The probability of 2 days dry spell per week with 20 mm rainrall data, it ranged between 11-51 per cent with more chance of occurrence at MW 34 while less chance in MW 38 in Osmanabad taluka. In Tuljapur very less chance of dry spell. In Omerga at 20 and 30 mm rainfall dry spell probability was less. For Paranda and Bhoom there was always chance of dry spell in all probability levels i.e. 20, 30 and 40 mm.

Probability of 2 day wet per week was common at 20, 30 and 40 mm at Osmanabad, Tuljapur, Omarga and Kalamb taluka. While chance of 2 days wet per week was less in Paranda and Bmoom taluka. Same results were found by Maniyar *et al*. (2005).

Table 4. Talukawise standard deviation and coefficient of variation of Osmanabad District (1981-2006).

Month	Osmanabad			Tuljapur			Omerga		
	RF (mm)	S.D (mm)	C.V (%)	RF (mm)	S.D (mm)	C.V (%)	RF (mm)	S.D (mm)	C.V (%)
Jan.	0.2	1.1	509.9	0.4	2.0	509.9	0.3	1.6	509.9
Feb.	0.0	0.0	****	0.0	0.0	****	0.0	0.0	****
Mar.	0.6	3.0	509.9	1.2	5.4	434.8	0.4	2.1	509.9
April	1.0	4.1	394.0	2.0	7.7	375.5	3.1	10.0	318.7
May	1.8	6.6	362.4	1.9	8.2	437.9	0.7	2.8	393.0
June	124.2	58.3	47.0	126.9	55.2	43.5	108.9	594	54.6
July	152.7	98.1	64.2	152.7	82.5	54.0	150.5	109.8	73 .0
Aug.	154.4	93.2	60.4	163.9	108.2	66.5	143.0	85.4	59.8
Sept.	182.7	112.5	61.5	233.5	169.2	72.5	176.0	131.0	74.4
Oct.	76.8	61.3	79.8	86.1	80.7	93.8	94.5	70.3	74.4
Nov.	6.9	13.6	198.4	9.2	18.1	1966	9.7	21.9	225.7
Dec.	4.4	13.8	316.6	3.8	8.6	223.7	6.2	15.6	251.8
	Taluka								
Month	Kalamb			Paranda			Bhoom		
	RF (mm)	S.D (mm)	C.V (%)	RF (mm)	S.D (mm)	C.V (%)	RF (mm)	S.D (mm)	C.V (%)
Jan.	0.3	1.4	411.3	0.5	2.7	509.9	0.4	1.8	423 7
Feb.	0.0	0.0	****	0.2	0.9	509.9	0.0	0.0	****
Mar.	1.2	5.1	432.4	0.0	0.0	****	0.0	0.0	****
April	2.2	9.1	407.4	0.6	2.9	509.9	2.7	10.3	383.8
May	3.7	11.5	306.1	5.0	16.2	325.2	2.2	6.2	287.2
June	130.1	65.1	50.1	155.1	256.8	165.5	128.3	51.5	40.2
July	156.5	103.7	66.2	102.5	74.0	72.1	123.4	81.4	660
Aug.	154.2	95.8	62.1	77.8	51.0	65.6	118.8	72.0	60.6
Sept.	191.7	123.4	64.3	167.6	127.7	76.2	180.0	126.6	70.3
Oct.	81.1	74.7	92.2	82.6	78.6	95.2	80.6	67.6	83.9
Nov.	13.4	28.6	214.3	15.7	30.4	193.1	14.5	27.8	102.0
Dec.	5.1	16.4	323.0	6.0	17.4	291.3	3.1	10.5	337.2

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Studies on Solar-Biomass Hybrid Drying System for Turmeric (*Curcuma longa* L.)

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Abstract

A solar-biomass hybrid dryer was designed and fabricated. A biomass combustor retrofitted to natural convection solar tunnel dryer used solar energy for drying during day time and *Prosopis juliflora* as fuel in biomass combustor cum hot air generator during off sunshine hours and thus extended the working time of the dryer. The results indicated that drying was faster. The quantitative analysis showed that the traditional drying i.e., open sun drying took 4 to 15 days to dry the rhizomes while solar biomass dryer took only 1.5 to 4 days for drying and produced better quality product. The maximum efficiency of biomass combustor and solar-biomass hybrid dryer were found to be 79.79 and 14.00 per cent, respectively. On the basis of economic analysis it was revealed that drying of 0.5 cm processed and fresh slice, 3 cm cut and whole processed turmeric seems to be economical in SBHD. It was found that the system could generate an adequate and continuous flow of hot air in the temperature range of 50 to 60°C required for drying.

Key words : Solar tunnel dryer, solar biomass hybrid dryer, biomass combustor, drying.

Turmeric is the dried rhizome of *Curcuma longa* L. of the ginger family. It is one of the extensively used spices in the Indian subcontinent (Sarker and Nahar, 2007). Only a small quantity of curcumin is used in pharmaceuticals and cosmetics (Chattopadhyay

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et al., 2004; Chtrangini *et al*., 2004; Barker and Nahar, 2007; Rouhani *et al*., 2009). Antioxidant activity and free radical scavenging potential are the most important characteristics (Nagarajan *et al*., 2010). The most valued constituent of turmeric is yellow pigment i.e. curcumin (Rakhunde *et al*., 1998) as it is an important factor in sensory and consumer acceptance of products (Wang *et al*., 2009).

Turmeric contains on an average 6 per cent of curcuminoid pigments and 5 per cent of essential oils (Bambirra *et al*., 2002). The common practice in India is to boil the rhizomes in water/alkaline water prior to dehydration. This along with drying conditions influences the level of curcuminoid pigments in the rhizomes (Sampathu *et al*., 1988).

The natural convection solar tunned dryer is suitable for small-scale industries because it is easy and inexpensive to construct, simple to run and can produce a good quality of products under favorable climatic conditions. One significant disadvantage of solar drier is that it works in the sunlight only. For commercial producers, this factor limits its ability to dry a produce when there is not adequate solar radiation. Drying time also extends as drying takes place during daytime only. Prasad *et al*. (2006) indicated that there have been a few attempts made to overcome this limitation in simple natural convection solar driers. This paper evaluates the techno economic performance of the solar biomass hybrid dryer for drying of turmeric operated on both solar and biomass mode and open sun drying, for comparison.

Materials and Methods

Indian cultivar Salem of turmeric was procured from local farmers of Akola districts of Maharashtra State (India). Following samples were used during the test run in open sun drying (OSD) and (SBHD). The code and

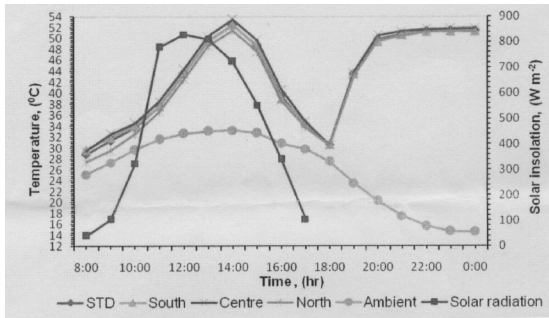

Fig. 1. Average temperature variation during no load test in SBHD of winter season (Dec. 2012).

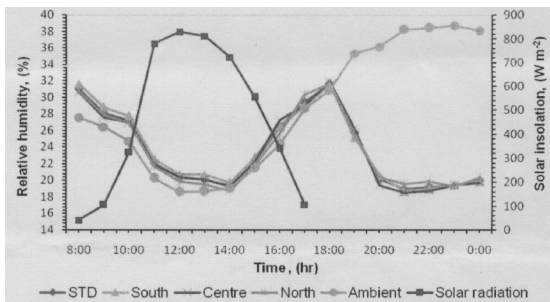

Fig. 2. Average relative humidity during no load test in SBHD of winter season (Dec. 2012).

nomenclature was given to the turmeric samples for their drying (Table 1).

Solar-biomass hybrid system consist of solar tunnel dryer and biomass combustor. Solar tunnel dryer of size 3 x 6 x 2m. was used for experimentation purpose. Biomass combustor cum hot air generator produced hot air was retrofitted to the solar tunnel dryer and used during test run.

Biomass combustor cum hot air generator : This equipment basically consisted of a combustor, a blower, a heat exchanger, pre-heater and a chimney for flue gases. A high efficiency biomass combustor of 2.50 to 3.00 kg h^{-1} capacity was used during expertimentation.

The efficiency of the biomass combustor

was calculated (Anonymous, 2010). The performance of the system was evaluated by conducting no load test of solar-biomass hybrid dryer and full load test of solar-biomass hybrid dryer.

Drying efficiency : The overall thermal efficiency of the drier is therefore defined as, $\eta = (M \times \lambda) / (S \times A) - (C \times m)$. Where M is the mass of water evaporated (kg); k is the latent heat of vaporization (MJ kg^{-1}); S is the total solar radiation on the dryer (MJ m^{-2}); A is the solar collection area (m^2); C is the calorific value of wood (MJ kg^{-1}); m is the mass of used biomass (kg).

Economic analysis of the system : The economic analysis of the system was carried out by using annualized cost method to access the economic viability of the system. The economic analysis was carried out by considering the assumptions: the capacity of the solar biomass hybrid system as 50 kg $batch^{-1}$. The total finished product produced $batch^{-1}$ at 8 per cent moisture as 10.5 kg. No. of batches performed in the solar biomass hybrid system and open sun drying (Jan. to May). The average purchase price of freshly harvested turmeric as Rs. 15 kg^{-1}. Discounting rate was assumed to be 10 per cent as compared to bank lending rate of interest. The average selling price of the turmeric powder as Rs. 160 kg^{-1}. The cost of solar tunnel drier and biomass combustor cum hot air generator as Rs. 45,000/- and Rs. 45,700/-, respectively. The useful life of solar biomass hybrid drying system as 15 years. The system was operating on *Prosopis juliflora* and consumed 2.70 kg $batch^{-1}$. The cost of fuel wood as Rs. 58.50 day^{-1}. The electricity rate for commercial use as Rs. 6/kWh based on existing rates in Maharashtra. Labour requirement for feeding fuel wood and operation of system as 1.5 man-h day^{-1}. The cost of labour as Rs. 120 day^{-1} (8 h). The annual repair and maintenance cost as Rs. 2600 considering replacement of UV sheet etc.

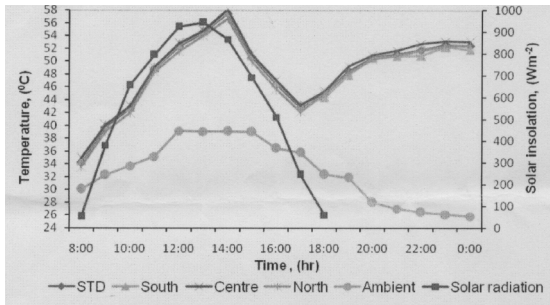

Fig. 3. Average temperature variation during no load test in SBHD of winter season (March 2013).

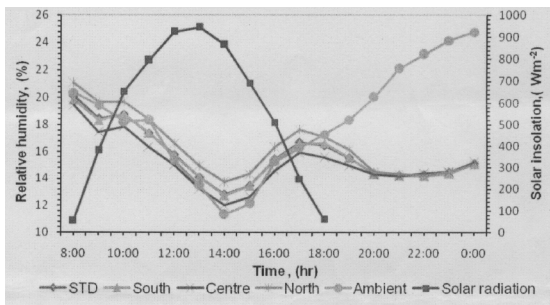

Fig. 4. Average relative humidity during no load test in SBHD of winter season (March 2013).

The different economic indicators net present worth (NPW), benefit cost ratio (B/C ratio) and payback period were used for economic analysis of solar-biomass hybrid drying system under this study.

Net present worth (NPW) :

$$NPW = \sum_{t=1}^{t=n} (B_t - C_t)/(1 + i)^t$$

Where, C_t = Cost in each year B_t = Benefit in each year t=1,2, 3.....n, i = discount rate.

Benefit-cost ratio =

$$\sum_{t=1}^{t=n} (B_t)/(1 + i)^t \ / \ \sum_{t=1}^{t=n} (C_t)/(1 + i)^t$$

Where, C_t = Cost in each year B_t = Benefit

in each year t= 1, 2, 3.....n (year), i = discount rate

$$\text{Payback period} \quad P = \frac{I}{E}$$

Where, P = Payback period of the project in years, I = Investment of the project in Rs. and E = Annual net cash revenue in Rs.

Results and Discussion

During winter season the maximum temperature inside the solar tunnel dryer was found to be 53.55°C at the center followed by the south (52.60°C) and north (51.69°C). The average day temperature inside the solar tunnel dryer at center, south and north were found to be 42.85, 43.49 and 42.09°C, respectively. The maximum temperature achieved inside the dryer was found to be 53.55°C at the location of 0.9 m height from the floor at center corresponding with ambient temperature (33.23°C), solar intensity 722.24 Wm^{-2} and relative humidity (19.10 per cent). After 17.00 h drying period was extended by using hot air generated by biomass combustor. The temperature variation during night time showed that highest temperature of 51.87°C achieved at center height of 0.9 m from the floor followed by south (51.31°C) and north (51.28°C). The average temperature variation inside solar tunnel was found in between 31.28 to 52.47°C during day time and 30.52 to 51.42°C during night time (up to 12.00 h).

The maximum temperature inside the solar tunnel dryer (Fig. 2) achieved its peak value (58.62°C) at 14.00 h of the day with corresponding ambient temperature (39.12°C), ambient relative humidity (11.32%) and solar intensity (870.50 Wm^{-2}). The average day-night temperature inside the solar tunnel dryer was found to be 48.31°C with corresponding relative humidity (15.72%) and solar intensity (556.11 Wm^{-2}).

The drying time was extended after 17.00 h to 12.00 h by using hot air generated through biomass combustor. The temperature variation in the dryer operated during night time was 48.43 to 52.56°C. The average temperature inside the dryer was found to be 48.31°C

Table 1. Code and nomenclature of the turmeric samples.

Open sun dryring samples	Solar-biomass hybrid dryer samples	Nomenclature
SBP 1	HBP1	Whole blanched peeled
SBP 2	HBP2	3 cm blanched peeled
SBP 3	HBP3	0.5 cm slice blanched peeled
SBN 1	HBN 1	Whole blanched unpeeled
SBN 2	HBN2	3 cm blanched unpeeled
SBN 3	HBN 3	0.5 cm slice blanched unpeeled
SUP 1	HUP1	Whole unblanched peeled
SUP 2	HUP 2	3 cm unblanched peeled
SUP 3	HUPS	0.5 cm slice unblanched peeled
SUN 1	HUN1	Whole unblanched unpeeled
SUN 2	HUN 2	3 cm unblanched unpeeled
SUN 3	HUNS	0.5 cm slice unblanched unpeeled

Table 2. Total drying hours required to dry turmeric samples in SBHD and OSD.

Turmeric dried in SBHD	Drying hours	No. of days	Turmeric dried in OSD	Drying hours	No. of days
HBP 1	33	2.25	SBP 1	40	5
HBP 2	29	2	SBP 2	38	5
HBP 3	27	1.5	SBP 3	29	4
HBN 1	36	2.25	SBN 1	45	6
HBN 2	31	2	SBN 2	40	5
HBN 3	28	1.5	SBN 3	30	4
HUP 1	42	3	SUP 1	46	6
HUP 2	30	2	SUP 2	44	5.5
HUP 3	27	2	SUP 3	30	4
HUN 1	68	4.5	SUN 1	120	15
HUN 2	57	4	SUN 2	115	15
HUN 3	28	2	SUN 2	38	5

Table 3. Overall efficiency of solar biomass hybrid dryer.

Sample	Total drying hours	Total moisture evepo-rated (kg)	Heat gain (MJ)	Heat input (MJ)	Eff. (%)
HBP 1	31	36.27	83.97	806.88	10.41
HBP 2	28	36.14	82.52	667.91	12.35
HBP 3	26	35.43	82.56	575.26	14.35
HBN 1	34	33.65	83.21	853.21	09.75
HBN 2	30	34.03	85.10	760.55	11.18
HBN 3	27	35.82	83.98	621.58	13.51
HUP 1	40	34.50	84.11	853.21	09.86
HUP 2	29	35.34	85.18	720.76	11.82
HUP 3	26	35.52	83.78	575.26	14.56
HUN 1	66	34.54	82.08	1499.21	05.48
HUN 2	55	30.27	84.94	1176.05	07.22
HUN 3	27	33.85	82.93	621.59	13.34

corresponding to ambient temperature (32.79°C) and ambient relative humidity (18.22%). The maximum temperature achieved its peak value 53.12°C at 22.00 h of the night with corresponding ambient temperature (26.43°C) and ambient relative humidity (23.14%) the air velocity inside the dryer was maintained in between 3.02 to 3.20 ms^{-1} for efficient drying of turmeric.

Overall efficiency of solar biomass hybrid dryer

Turmeric sample HUPS dried in SBHD required less time for drying and thus attained maximum overall efficiency than HBN1 and HBN2. The overall efficiency of unblanched and unpeeled turmeric sample of HUN1, HUN2 and HUNS were found to be 5.48, 7.22 and 13.34 per cent corresponding to total drying hours (66, 55 and 27 h) and total moisture evaporated (34.54, 30.27 and 33.85 kg) respectively. The overall efficiency of HUNS was found more than HUN1 and HUN2.

It is revealed from the result that the

Table 4. Economic analysis of solar-biomass hybrid dryer for different turmeric samples.

Description	Fresh slice (0.5 cm)	Processed slice (0.5 cm)	Fresh slice (3 cm)	Processed slice (3 cm)	Whole rhizomes (fresh)	Whole rhizomes (Processed)
Initial investment (Rs.)	90,700.00	90,700.00	90,700.00	90,700.00	90,700.00	90,700.00
Annual batches	133.50	133.50	57.50	100.00	50.00	89.00
Cost of raw turmeric (Rs. yr^{-1})	1,00,125.00	100,125.00	43,125.00	75,000.00	37,500.00	66,750.00
Cost of labour for drying (Rs. yr^{-1})	36,000.00	56,020.00	36,000.00	36,000.00	36,000.00	36,000.00
Operation and maintenance cost (Rs. yr^{-1})	2,600.00	2,600.00	2,600.00	2,600.00	2,600.00	2,600.00
Total dried product (kg)	1,402.00	1,402.00	604.00	1,050.00	525.00	934.5
Total cost of finished product @ Rs 160 kg^{-1}	2,24,320.0 0	2,24,320.0 0	96,640.00	1,68,000.0 0	84,000.00	1,49,520.00
Economic indicators :						
Net present worth, Rs.	3,45,546.69	2,23,697.30	-1,31,354.00	13,199.05	-1,78,702.34	35,446.83
Benefit- cost ratio	1.25	1.15	0.85	1.01	0.78	1.03
Payback period	4 month and 26 days	4 month and 26 days	-	6 month 15 days	-	7 month 9 days

turmeric slices required less drying time than 3 cm cut and whole turmeric samples. Also peeled turmeric slices required less drying time compared with unpeeled turmeric and therefore, overall drying efficiency was found more in peeled turmeric slices dried in SBHD. It was obvious that more surface area was available for moisture evaporation in turmeric slices during thin layer drying thus accelerated drying process.

Economics of solar biomass hybrid dryer for drying of turmeric : Economics of SBHD for drying of turmeric the different economic parameter of SBHD are summarized in Table 4. The details of cash inflow and outflow upto 15 years was calculated.

Net present worth : The present worth of total cash inflow and outflow for drying of 0.5 cm orocessed and fresh turmeric slices in SBHD were found to be Rs. 345546.69 and 2,23,679.30, respectively. Based on NPW it could be concluded that the drying of 0.5 cm turmeric slices in fresh and processed forms seems to be economical.

NPW for drying of 3 cm and whole (processed and fresh turmeric) were found to be Rs. 13,199.05, -13,1354.49, 35,446.83 and -1,78,702.34 respectively. Thus drying of turmeric of 3cm cut and whole in processed forms in SBHD could be economical. Drying of turmeric of 3cm cut and whole in fresh forms seems to be uneconomical in SBHD because of negative values of NPW.

Benefit cost ratio : The BC ratio of the system was calculated by dividing present worth of benefit stream and present worth of cost stream. Table 4 revealed benefit cost ratio of 0.5 cm processed and fresh slices turmeric dried in SBHD and found to be 1.15 and 1.25 respectively. B.C. ratio for processed 3 cm cut, fresh 3 cm cut, whole processed and whole fresh turmeric were found to be 1.01, 0.85, 1.03 and 0.78 respectively. Thus, it is concluded that investment is justified and drying of processed and fresh 0.5 cm slice, processed 3.0 cm cut and processed whole turmeric is economically viable.

Payback period : Payback period for drying of 0.5 cm turmeric slices in fresh and processed form was found to be 4 month and 26 days. Payback period for processed (3 cm size and whole rhizome) turmeric was found to be 6 month and 15 days, 7 month and 9 days, respectively.

From all the above economic indicators it was concluded that drying of 0.5 cm processed and fresh slice, 3.0 cm cut processed and whole processed turmeric seems to be economical drying operation in SBHD. Drying of fresh 3.0 cm cut and whole fresh turmeric could not be economically viable operation in SBHD.

The overall efficiency of biomass combustor for hot air generation was found to be 79.79 per cent at average ambient air flow rate (650.45 kg h^{-1}), fuel wood consumption (2.70 kg h^{-1}) and heat input (11070 kcal h^{-1}). It is revealed that biomass combustor was able to produce sufficient hot air for drying of turmeric slices. It is revealed that the overall efficiency for peeled turmeric slices achieved more efficiency of drying than unpeeled slices since more surface area was available for moisture removal in turmeric slices during thin layer drying. On the basis of economic analysis it is revealed that drying of 0.5 cm processed and fresh slice, 3 cm cut and whole processed turmeric seems to be economical in SBHD. Considerable reduction in drying time is the major advantage reported with this hybrid dryer. While overcoming the limitations of solar drying during cloudy days, the solar-biomass hybrid dryer also enables drying during night time.

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Housing and Feeding Management Practices of Non-Descript Cattle in Raigad District of Maharashtra

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Abstract

The 69 per cent farmers provided housing to the cattle. Only 70 per cent farmers provided separate byres and remaining provided through extension to the residence. The kaccha floor was observed in 92 per cent of byres. None of the housing found drainage facility of urine and manger for feeding. Most of the farmers (88.5%) used paddy straw, dry grasses and kadabbi as a dry fodder at 76.5, 17.5 and 6 per cent, respectively. All the farmers provided natural green grasses (8.88 kg day^{-1}) in rainy season and in off season they provided 0.4 kg day^{-1} animal^{-1} only. None of the farmers cultivated fodder crops for non-descript cattle. Concentrate was fed by 7 per cent farmers at the time of milking only. It was observed that the farmers allowed their cattle for grazing on an average 10.27 hrs in rainy season and 11.54 hrs in off season.

Key words : Non-descript cattle, housing, feeding, management.

India has the largest livestock population in the world having 199.10 million cattle; of which 166 million are indigenous cattle and rests are classified as crossbred population (Livestock census, 2007). Non-descript cattle population in Maharashtra is 23.70 million and in Raigad district of Konkan region 3.32 lakh population (Census R.Z.P., 2007). Average production of non-descript cow is about 1.50 kg day^{-1}. The main reasons for low milk production in the region are poor genetic potential, typical and unfavorable agro-climatic condition, qualitative and quantitative shortage of feeds and fodder and lack of proper housing and feeding management.

Housing and feeding management plays a very significant role in exploiting genefic potential of dairy animals (Sinha *et al*. 2009) and both of them constitute about 75 per cent of total cost incurred on milk production in dairy animals (Gangwar 1988). Productivity of animals can be improved by providing proper housing and feeding as the energy put in climatic stress and diseases is saved. Understanding of livestock management practices followed by the farmers is crucial to identify the strength and weakness of the animal rearing system and to devise appropriate intervention policies. The present investigation was undertaken to collect information by survey regarding existing housing and feeding management practices adopted by dairy farmers of Raigad district of the Konkan region of Maharashtra.

Materials and Methods

Information on feeding and housing management practices followed by the farmers was collected by interviewing the farmers using structural questionnaires in the Raigad district of Konkan region of Maharashtra. Three stage stratified random sampling method was adopted for collection of data. At first stage five tahsils *viz*., Alibag, Roha, Murud, Pen and Khalapur were selected randomly and from each tahsil ten villages were selected randomly.

1. Associate Professor and 2. Head.

In the third stage, four farmers from each village were selected randomly those having non-descript cattle which constituted a total 200 respondents. While selecting respondents due care was taken to ensure that they were evenly distributed in the village and truly represented animals' management practices prevailing in the area.

After interview with the farmers, the observations with respect to the feeds and feeding management, housing and milk production performance were also collected from farmers through personal interview and recorded in the questionnaire.

Results and Discussion

In Raigad district most of the respondents (69.00%) provided housing for non-descript cattle while 31.00 per cent farmers did not provide housing to the animals. Most of the farmers provided separate housing (70%) whereas 30 per cent farmers had made arrangements for housing of cattle by providing extension to the residence (Table 1).

Total 92 per cent farmers provided *kaccha* floor to cattle and only 8 per cent provided *pakka* floor. None of the housing found drainage facility of urine and manger for feeding in Raigad district of Konkan region of Maharashtra.

Gaur *et al*. (2003) reported that the animals were kept in the open in summer and the rainy season and in rice and bamboo thatched structure called chappar in winter in case of Ponwar cattle. Sabapara *et al.* (2010) reported close type of house was provided by 98 per cent farmers. *Kaccha* type of floor was found by 87 per cent of houses. Earthen platue with thatched roof present in 94 per cent of animal shed and wooden poles used to support roof in 85.5 per cent of the house. *Pakka* drainage facility for urine was found only in 6 per cent animal shed. Singh *et al*. (2007) reported majority of farmers provided *kaccha* floors to cattle for sitting but it is found that *pakka* floor was good as compared to *kaccha* floor for animal sitting in Rajaslhan. Khirari (2010) observed that the 78.5 per cent farmers provided housing and 21.5 per cent farmers did not provide housing to the animals. In housing providing farmers, only 71 per cent provide separate housing and 29 per cent farmers had made arrangements for housing of cattle by providing extension to the residence in Ratnagiri district of Maharashtra. Yewale (2011) observed that the 81.5 per cent farmers provided housing and 18.5 per cent farmers did not provide housing to the animals. For housing, only 80 per cent provided separate

Table 1. Tahsilwise housing management of cattle provided by the farmers (%) in Raigad district.

Tahsil	No. of farmers	Housing		Separate housing	Part of residence	Kaccha floor	Pakka floor
		Provided	Not provided				
Alibag	40	80.00 (32)	20.00 (08)	77.50 (31)	22.50 (09)	90.00 (36)	10.00 (4)
Roha	40	60.00 (24)	40.00 (16)	57.50 23)	42.50 (17)	95.00 (38)	05.00 (2)
Murud	40	65.00 (26)	35.00 (14)	65.00 (26)	35.00 (14)	92.50 (37)	07.50 (3)
Pen	40	77.50 (31)	22.50 (09)	80.00 (32)	20.00 (08)	85.00 (34)	15.00 (6)
Khalapur	40	62.50 (25)	37.50 (15)	70.00 (28)	30.00 (12)	97.50 (39)	02.50 (1)
Total	200	138	62	140	60	184	16
Mean	100	69	3l	70	30	92	08

Figures in the parenthesis indicate number of farmers.

housing and 20 per cent farmers had made arrangements for housing of cattle by providing extension to the residence in Thane district of Maharashtra. Avinashingam *et al*. (2011) also reported in Nilgiri district of Tamilnadu by that only 51 per farmers provided housing practices to their animals.

Feeds and feeding management : In the Raigad district, 88.50 per cent of the farmers had their own feeds and fodder for feeding the cattle. Mostly paddy straw and dry grasses, having poor nutritive value were fed to the animals. Only 11.5 per cent farmers purchased feeds and fodder from market. Feeds and fodders constituted 76.50 per cent paddy straws, 17.50 per cent dry grasses and 6.00 per cent *kadabbi*. Concentrate feeding was practiced by 7.00 per cent farmers only.

Sabapara *et al.* (2010) reported that paddy straw as a dry fodder used by 98 per cent farmers. All farmers provided green natural grass of cultivated plots and grasses from fallow land. In addition to that 75 per cent farmers grew fodder crops. Concentrate feed provided by 91 per cent of farmers after milking of cows in Vansada taluka of Navsari district of south Gujrat. Khirari (2010) observed that the 87.5 per cent of the farmers had their own feeds and fodder and only 12.5 per cent farmers purchased feeds and fodder from market for animal feeding. Only 9.5 per cent farmers feeding concentrate feed for local cattle of Ratnagiri district of Maharashtra. Yewale (2011) observed that 82.5 per cent of the farmers had their own feeds and fodder and only 17.5 per cent farmers purchased feeds and fodder from market for animal feeding. Only 15.50 per cent farmers fed concentrate feed for local cattle of Thane district of Maharashtra. Gajebasia *et al*. (2011) in Punjab reported that dairy animals were sparingly offered as part of diet and most of them moderately sodium depleted which had direct correlation with milk production.

Feeding management : Proper feeding is the most important factor in maintaining the production performance of an animal at desired level. It was observed that, on an average 8.88 kg of green roughages. 2.98 kg of dry roughages, 0.72 kg concentrate and 10.27 hrs grazing were provided to the nondescript cattle per day during rainy season (July-October). During the off season, the quantity of green fodder available to the cow was 0.40 kg, dry

Table 2. Feeding practices adopted by farmers in Raigad district.

Category		Frequency	Per cent
Roughages	Paddy straw	153	76.5
	Kadabbi	12	6
	Dry grass	35	17.5
Concentrate	Yes	19	7
	No	181	93

Table 3. Average quantity of feed and fodder provided by farmers per day per cattle (kg).

No. of animals	Season	Roughages		Concentrate	Grazing hrs.
		Dry	Green		
360	Rainy season	2.98	8.88	0.72	10.27
360	Off season	7.8	0.4	1.08	11.54

Table 4. Health and sanitation measures adopted by respondents in Raigad district.

Category	Frequency	Per cent
Vaccination : Yes	124	62
No-	76	38
Disease treatment : Herbal	14	7
Allopathic	186	1 93
Cleaning of milking utensils	200	100
Cleaning of shed before milking	200	100
Washing of udder before milking	200	100
Washing floor before milking	28	14

fodder 7.80 kg, concentrate 1.08 kg and 11.54 hrs grazing day^{-1} (Table 3).

Khirari (2010) also observed that on an average 8.98 kg of green roughages and 3.16 kg of dry roughages were provided day^{-1} during rainy season (July-October) and during the off season, 0.40 kg green fodder and 7.58 kg dry fodder day^{-1} provided to the local cattle of Ratnagiri district of Maharashtra. Yewale (2011) observed that on an average 9.04 kg of green roughages and 2.94 kg of dry roughages were provided day^{-1} during rainy season (July-October) and during the off season, 0.40 kg green fodder and 7.62 kg dry fodder day^{-1} provided to the local cattle of Thane district of Maharashtra.

Karthikeyan *et al*. (2006) reported that the animals were sent out around 8 a.m. for grazing and remain in the grazing area until 5 p.m. in the evening. Few farmers fed their cows with two kg of concentrate mixture.

Health and sanitation : In Raigad district, all the livestock owners followed health and sanitation measures such as cleaning of milking utensils, cleaning of shed before milking and washing of udder before milking. Vaccination of cattle against infectious diseases was done by 62.00 per cent farmers. Herbal treatment was practiced by 7.00 per cent farmers to control the disease while 93.00 per cent adopted allopathic treatment to control the diseases (Table 4).

Khirari (2010) observed that the vaccination of cattle against infectious disease was done by 73.5 per cent farmers. Herbal treatment was practiced by 10 per cent farmers to control the disease while 90 per cent adopted allopathic treatment to control the disease in Ratnagiri district of Maharashtra. Yewale (2011) observed that the vaccination of cattle against infectious disease was done by 72.50 per cent farmers. Herbal treatment was practiced by 12.50 per cent farmers to control the disease while 87.50 per cent adopted allopathic treatment to control the disease in Thane district of Maharashtra.

In Raigad district, it was observed that on an average lactation milk yield and average daily milk yield in non-descript cattle were 256.842 ± 1.88 and 1.47 ± 0.21 kg. The average lactation length and dry period in cattle were 202.086 ± 1.48 and 165.75 ± 2.49 days, respectively.

The results of the study could be compared well with that of Banerjee (1998) reported that the average lactation milk yield in Kangayam, Krishna galley, Tharparkar, Hallikar and Hariyana cattle were 666, 916, 680 to 2,268, 227 to 1,134 and 1400 kg, respectively. Thombre *et al*. (2010) reported average lactation milk yield in Deoni cow is 868 liters and Singh *et al*. (2007) for Gangatiri breed (700-1500 kg).

Karthikeyan *et al*. (2006) reported the daily

Table 5. Average productive performance of non-descript cattle in Raigad district.

Tahsils	No. of animals	Lactation milk yield (kg)	Daily milk yield (kg)	Lactation length (days)	Dry period (days)
Alibag	60	265.96 ± 1.20	2.37 ±2.92	200.84 ±1.20	165.53 ±2.92
Roha	70	222.28 ± 3.84	1.05 ±2.52	200.31 ±3.84	165.83 ±2.52
Murud	70	278.60 ± 1.10	1.22 ±2.53	202.95 ± 1.10	165.85 ±2.53
Pen	80	257.62 ±1.74	1.32 ±2.24	212.96 ±1.74	164.88 ±2.24
Khalapur	80	259.75 ±1.56	1.52 ±2.24	203.37 ±1.56	166.67 ±2.24
Mean	360	256.842 ±1.88	1.47 ±2.49	202.086 ±1.88	165.75 ±2.49

milk yield of 3.17 ± 0.53 kg in the Krishna valley cattle breed. Pundir (2007) reported that the average daily milk yield was 3.6 ± 0.1 kg and 2.0 ± 5.0 kg in Binjharpuri and Kankrej breed of cattle, respectively. Khirari (2010) reported for Local cow of Ratnagiri district in Maharashtra (1.62 ± 0.03 kg).

Al-Amin *et al*. (2007) and Dhal (2007) noted the average lactation length and dry period in Khariar cattle as 281.20 ± 2.03 and 232.30 ± 2.36 days, respectively. Pundir *et al*. (2009) noted that the average lactation length in Bargur cattle and Gir cows was 180 ± 0.40 gpfi and 332.57 ± 11.42 days, respectively. Khirari (2010) reported that the average lactation length and dry period for local cow of Ratnagiri district in Maharashtra as 200.50 ± 5.26 and 173.05 ± 3.34 days, respectively. Yewale (2011) reported for local cow of Thane district in Maharashtra as 200.96 ± 0.36 days and 174.00 ±0.13 days, respectively. Zafer *et al*. (2008) reported that the population least squares mean for dry period was 172 ± 1.44 days in Sahiwal cows.

It was concluded that the scientific feeding and housing management practices adopted poorly in survey area. Majority of cattle houses were *kaccha* type and had *kaccha* floor. None of the housing found drainage facility for urine and manger for feeding animals. The productive performance of non-descript cattle was very low. Most of the feeding and housing management practices needs to be improved a lot in this area.

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RESEARCH NOTES

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Effect of Packaging and Storage Temperature on Chemical Composition of Some Gourd Vegetables

Vegetables not only adorn the dining table but also enrich health of human. They form most nutritive menu of human diets and tone of his energy and vigor. The ancient people for their tempting, succulence, pleasing flavors, high nutritive value and regulatory effect, appreciated them. Vegetables abundance in vitamins and minerals are called protective foods. Vegetables neutralize excess acidic condition and provide alkaline reactions for normal metabolism. Cellulose, pectin and other constituents present in the fibers of vegetables help to clear the bowls, reduce constipation and also promote digestion.

Buying fresh vegetables daily from the market is difficult because of fast life and where both members of the family are working. When fresh vegetables are store their several physiological and biochemical changes can reduce the nutritive value. Some of the methods adopted for extending storage life of vegetables are pre-cooling, low temperature and controlled atmospheric storage, curing, irradiations, waxing, and post-harvest treatments with chemicals.

Fruits at edible stage of newly developed five cultivars of each bottle, ridge, sponge, and bitter gourds were obtained from Senior Vegetable Breeder, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri and analyzed for their chemical components such as dry matter, crude fiber, crude protein, ash, iron and phenolics according to A.O.A.C. methods (1990), calcium by Black *et al*., (1965), potassium and phosphorus by Chapman and Pratt (1961), sugars by Nelson (1944), β-carotene and vitamin C by Ranganna (1977).

One cultivar from each gourd group (5 fruits each) such as 1 x 4 cultivar (V_1) of bottle gourd, 3 x 1 cultivar (V_2) of ridge gourd, CHSG-1 cultivar (V_3) of sponge gourd, and Phule green gold (V_4) of bitter gourd were stored at ambient (27 ± 2°C, C_1) condition in open (P_1) and in polythene bag (P_2) and at refrigerator (10 ± 2°C, C_2) temperature in open (P_1) and in polythene bag (P_2) upto 15 days for studying their shelf-life. The loss in weight, crude protein, sugars and vitamin C content were determined at an interval of 3 days according above mentioned procedures and decay of

Table 1. Effect of packaging and storage conditions on total sugars and vitamin "C" content ' of gourd cultivars on wet weight basis.

Treat-ment	Storage period (days)					
	0	**3**	**6**	**9**	**12**	**15**
$V_1C_1P_1$	0.99	1.02	1.09	*	*	*
$V_1C_1P_2$	0.99	1.00	1.03	1.05	1.06	1.09
$V_1C_2P_1$	0.99	1.00	1.02	*	*	*
$V_1C_2P_2$	0.99	0.99	1.00	1.02	1.03	1.06
$V_2C_1P_1$	2.16	2.22	2.37	*	*	*
$V_2C_1P_2$	2.16	2.19	2.24	2.29	2.32	2.34
$V_2C_2P_1$	2.16	2.17	2.23	*	*	*
$V_2C_2P_2$	2.16	2.16	2.18	2.23	2.25	2.28
$V_3C_1P_1$	2.44	2.51	2.67	*	*	*
$V_3C_1P_2$	2.44	2.47	2.53	2.59	2.62	2.65
$V_3C_2P_1$	2.44	2.46	2.52	*	*	*
$V_3C_2P_2$	2.44	2.45	2.42	2.51	2.54	2.57
$V_4C_1P_1$	2.28	2.34	2.49	*	*	*
$V_4C_1P_2$	2.28	2.30	2.35	2.41	2.44	2.46
$V_4C_2P_1$	2.28	2.29	2.34	*	*	*
$V_4C_2P_2$	2.28	2.28	2.29	2.33	2.37	2.40
Vitamin C (mg 100^{-1} g) :						
$V_1C_1P_1$	7.60	6.20	4.96	*	*	*
$V1C_1P_2$	7.60	7.03	6.37	6.20	6.15	5.87

fruits was also observed during storage period. Statistical analysis was done as per the standard method.

Five cultivars each of bottle, ridge, sponge and bitter gourd were analyzed for dry matter, crude fiber, crude protein, sugars, ash, minerals, vitamins, total phenolics and shelf-life of one promising cultivar from each gourd group family. The dry matter content ranged from 3.91 per cent in bottle gourd (cv. NDBG-15) to 8.10 per cent in bitter gourd (cv. Phule Green Gold). Out of these four types of gourd cultivars bitter gourd had more dry matter content followed by sponge gourd, ridge gourd and bottle gourd. This variation in dry matter content may be due to their genetic variability and synthesis system during growth. Crude fiber content was observed at higher level in sponge gourd followed by bitter gourd, bottle gourd and ridge gourd. These results are supported by the Aykroyed (1941) and Gopalan *et al*., (1982). The crude protein content for bitter gourd was relatively higher than other three gourd species. The differences in crude protein content are attributed to genetic variability of that particular gourd. Kale *et al*., (1991) reported the similar results for different types of gourd vegetables. Total sugars content was similar in bitter gourd and sponge gourd followed by ridge and bottle gourd. The CHSG-1 had the highest total sugar (2.44%) content than all other gourd cultivars. The results of total sugars content in gourd cultivars are in accordance with Jaiswal *et al*. (1990) and Kale *et al*. (1991). Among four gourd species sponge gourds contain higher amount of phenolic compounds followed by bitter gourd, ridge gourd and bottle gourd. Similar amount of phenolics are reported for bitter gourd and in some cucurbitaceous by Jaiswal *et al*. (1990) and Aykroyed (1941) respectively.

β-carotene content ranged from 27 µg 100^{-1} g in Pusa Nasdar of ridge gourd to 134 µg 100^{-1} g in Phule green gold of bitter gourd. The highest β-carotene content was found in bitter gourd followed by sponge gourd and ridge gourd (Table 1). β-carotene was not detected in bottle gourd. Similarly vitamin C was not found

Table 1. Contd

Treatment	Storage period (days)					
	0	**3**	**6**	**9**	**12**	**15**
$V_1C_2P_1$	7.60	7.36	7.21	*	*	*
$V_1C_2P_2$	7.60	7.47	7.38	7.00	6.98	6.79
$V_2C_1P_1$	7.62	5.90	4.67	*	*	*
$V_2C_1P_2$	7.62	6.73	6.41	6.08	5.81	5.52
$V_2C_2P_1$	7.62	7.12	6.69	*	*	*
$V_2C_2P_2$	7.62	7.22	6.76	6.70	6.61	6.31
$V_3C_1P_1$	-	-	-	-	-	-
$V_3C_1P_2$	-	-	-	-	-	-
$V_3C_2P_1$	-	-	-	-	-	-
$V_3C_2P_2$	-	-	-	-	-	-
$V_4C_1P_1$	118.56	96.68	77.41	*	*	*
$V_4C_1P_2$	118.56	108.95	104.53	99.45	96.08	91.84
$V_4C_2P_1$	118.56	114.52	112.58	*	*	*
$V_4C_2P_2$	118.56	116.32	115.16	112.61	109.47	106.61
Protein (%) :						
$V_1C_1P_1$	0.22	0.24	0.26	*	*	*
$V_1C_1P_2$	0.22	0.23	0.25	0.27	0.28	0.29
$V_1C_2P_1$	0.22	0.24	0.26	*	*	*
$V_1C_2P_2$	0.22	0.24	0.25	0.26	0.27	0.28
$V_2C_1P_1$	0.58	0.66	0.71	*	*	*
$V_2C_1P_2$	0.58	0.64	0.70	0.73	0.76	0.78
$V_2C_2P_1$	0.58	0.65	0.69	*	*	*
$V_2C_2P_2$	0.58	0.64	0.70	0.71	0.74	0.76
$V_3C_1P_1$	1.20	1.44	1.56	*	*	*
$V_3C_1P_2$	1.20	1.42	1.54	1.60	1.66	1.72
$V_3C_2P_1$	1.20	1.41	1.52	*	*	*
$V_3C_2P_2$	1.20	1.40	1.50	1.56	1.62	1.67
$V_4C_1P_1$	1.72	2.08	2.26	*	*	*
$V_4C_1P_2$	1.72	2.05	2.22	2.31	2.40	2.48
$V_4C_2P_1$	1.72	2.04	2.20	*	*	*
$V_4C_2P_2$	1.72	2.02	2.18	2.25	2.33	2.41

V_1 = Bottle gourd, V_2 = Ridge gourd, V_3 = Sponge gourd, V_4 = Bitter gourd, C_1 = ambient temperature, C_2 = Refrigerator temperature, P_1 = Open condition, P_2 = Polythene bag packaging, - Vitamin C was not detected, * Samples spoiled during storage.

in sponge gourd. It was highest in bitter gourd, varied from 0.3 to 1.0 per cent Highest ash content was found in bitter gourd followed by bottle, sponge and ridge gourd. For calcium content the cultivars of sponge gourd were found prominent than other three gourd species. Potassium was dominant in bitter gourd followed by bottle, sponge and ridge gourd. Phosphorus was highest in bitter gourd than ridge, sponge and bottle gourd. Sponge gourd was a rich source of iron followed by bitter, bottle and ridge gourd. These results are in accordance with results of Gopalan *et al*.,(1982) and Jaiswal *et al*., (1990).

The fruits of gourd species packed in polythene bags and stored at ambient condition led to rise in sugar, crude protein and fall in vitamin C and physiological loss in weight. Similar trend but at a slower rate was observed in a refrigerator storage. The fruits stored at ambient and cold condition but without polythene packaging spoiled within 6 days of storage. Due to high temperature of room storage condition and regular respiration of vegetables their shelf life was upto 6 days only. However, the vegetables packed in polythene bags and stored at ambient or cold condition remained in good condition upto 15 days (Table 1). This is due to low storage temperature reduce the respiration rate of vegetables. Baviskar (1993), Lawande *et al*., (1994), and Waskar *et al*. (1999) also reported similar storage shelf-life for other vegetables and fruits.

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Exploitation of Heterosis in CMS Based Hybrids in Pigeonpea (*Cajanus cajan* L. Millsp.)

Pigeonpea (*Cajanus cajan* (L.) Millsp) is one of the important legumes of the dry land agricultural production system. A number of pigeonpea varieties have been released for cultivation. The area has increased to a certain extent but to date the yield has remained unacceptably low. There are two pre requisites for commercial exploitation of hybrid vigour in pigeonpea, an efficient natural out crossing ranged from 25 to 70 per cent (Saxena *et al*. 2005) and availability of stable male sterile source. Total five cytoplasm based CMS lines have been developed so far in pigeonpea and cytoplasm *Cajanus cajanifolius* has been found to be stable across environments and being used in the hybrid breeding programme (Saxena *et al*. 2006).

The present investigation was undertaken to study the extent of heterosis in newly developed CMS based hybrids and to exploit the possibility of utilizing the hybrid vigour at commercial level.

Four newly developed *Cajanus cajanifolius* based cytoplasmic genetic male sterile lines *viz*., ICPA 2043, ICPA 2047, ICPA 2048 and ICPA 2092 were crossed with 12 identified restorers in line x tester manner. The resulting 48 hybrids along with their parents and three checks including two varieties *viz*., BSMR 736, ICP 8863 and one CMS based hybrid *viz*., GTH 1 were evaluated in randomized block design with two replications at Agricultural Research Station, Badnapur during *kharif* 2007-08. Each entry was sown in two rows of 3m length spaced 75 cm apart. Five plants were randomly selected for recording the observations on days to 50 per cent flowering, days to maturity, plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1}, 100 seed weight and seed yield plant^{-1}.

The per cent heterosis over better parent (heterobeltiosis) and standard check viz. BSMR 736 having highest mean on the basis of per se performance for seed yield and its attributing characters among the three checks were estimated as per Fonesca and Patterson (1968).

Analysis of variance revealed significant differences for seed yield and it's attributing characters studied (Table 1). The phenomenon of heterosis (Table 2) was of a general occurrence and its magnitude varied with characters. The standard heterosis and better parent heterosis for days to 50 per cent flowering ranged from -6.03 to 9.48 and -7.94 to 24.00 per cent, respectively. Whereas standard heterosis and better parent heterosis for days to maturity ranged from -4.12 to 12.94 and -2.84 to 18.99 per cent, respectively. The crosses ICPA 2043 x ICPR

Table 1. Analysis of variance for yield and yield contributing characters in pigeonpea.

Characters	Mean sum of squares		
	Replications (df=1)	Treatments (df=66)	Error (df=66)
Days to 50% flowering	20.18	104.18**	13.06
Days to maturity	5.05	186.95**	14.77
Plant height	71.23	825.95**	60.23
Primary branches plant^{-1}	1.20	4.63*	0.67
Secondary branches plant^{-1}	8.83	28.91**	5.07
Pods plant^{-1}	92.61	1461.31**	52.22
100 seed weight	0.14	4.11*	0.09
Seed yield plant^{-1}	15.11	288.77**	7.82

* and ** significant at 5 and 1 per cent level of significance, respectively.

2671 and ICPA 2043 x ICPR 3473 were early in maturity having significant negative standard heterosis. Whereas the cross ICPA 2047 x ICPR 3514 had highest negative heterobeltiosis for days to 50 per cent flowering and days to maturity. Wankhede *et al*. (2005), Kandalkar (2007) and Pandey *et al*. (2013) reported significant negative heterosis for days to 50 per cent flowering and days to maturity in pigeonpea.

Standard heterosis and better parent heterosis for plant height ranged from 27.07 to -20.40 and 32.74 to -23.90 per cent, respectively. The range of standard heterosis and better parent heterosis among the cross combination for number of primary branches plant^{-1} varied from 18.89 to -40.00 per cent and 28.41 to -37.50 per cent, respectively. The standard heterosis and heterobeltiosis for number of primary branches plant^{-1} was found in positive direction in 12 and 13 out of 48 crosses, respectively. The range of standard heterosis and better parent heterosis among the cross combination for number of secondary branches plant^{-1} varied from -47.31 to 35.48

Table 2. Per cent standard heterosis and better parent heterosis for yield and yield contributing characters in pigeonpea.

Characters	Better parent peterosis (%)		Standard heterosis (%)	
	Range	Best crosses	Range	Best crosses
Days to 50% flowering	-7.94 to 24.00	ICPA 2092 x ICPR 2766 (-7.94) ICPA 2047 x ICPR 3514 (-4.92) ICPA 2092 x ICPR 3514 (-4.76)	-6.03 to 9.48	ICPA 2043 x ICPR 3473 (-6.03) ICPA 2043 x ICPR 2671 (-5.17) ICPA 2043 x ICP 13991(-5.17)
Days to maturity	-2.84 to 18.99	ICPA 2047 x ICPR 3514 (-2.84) ICPA 2047 x ICPR 2671 (-1.70)	-4.12 to 12.94	ICPA 2043 x ICPR 2671 (-4.12) ICPA 2043 x ICPR 3473 (-4.12) ICPA 2043 x ICPR3477 (-1.76)
Plant height	-23.90 to 32.74	ICPA 2047 x ICP 13991 (32.74) ICPA 2043 x ICPR 3473 (17.71) ICPA 2043 x ICPR 3513 (16.63)	-20.40 to 27.07	ICPA 2047 x ICP 13991 (27.07) ICPA 2048 x ICPR 3473 (20.36) ICPA 2047 x ICPR 3513 (17.96)
Primary branches plant^{-1}	-37.50 to 28.41	ICPA 2043 x ICPR 3473 (28.41) ICPA 2047 x ICPR 2766 (25.30) ICPA 2047 x ICPR 3514 (22.54)	-40.00 to 18.89	ICPA 2043 x ICPR 3473 (25.56) ICPA 2043 x ICPR 2671 (18.89) ICPA 2043 x ICPR 3514 (15.56)
Secondary branches plant^{-1}	-45.50 to 37.00	ICPA 2043 x ICPR 3513 (26.30) ICPA 2043 x ICPR 3473 (25.90) ICPA 2043 x ICPR 3477 (24.10)	-47.31 to 35.48	ICPA 2043 x ICPR 2671 (35.48) ICPA 2043 x ICPR3473 (27.96) ICPA 2092 x ICPR2671 (25.81)
Pods plant^{-1}	-48.68 to 46.87	ICPA 2047 x ICP 10934 (46.87) ICPA 2043 x ICPR 2671 (35.44) ICPA 2043 x ICPR 3473 (29.74)	-47.30 to 44.59	ICPA 2043 x ICPR 2671 (44.59) ICPA 2092 x ICPR 2671 (36.76) ICPA 2048 x ICPR 3473 (36.35)
100 seed weight	-25.81 to 22.00	ICPA 2043 x ICP 87119 (22.00) ICPA 2043 x ICP 10934 (16.00) ICPA 2043 x ICPR 3473 (12.38)	-21.43 to 16.07	ICPA 2092 x ICPR 2766 (16.07) ICPA 2048 x ICPR 2766 (11.61) ICPA 2043 x ICPR 3513 (10.71)
Seed yield plant^{-1}	-53.32 to 59.28	ICPA 2043 x ICPR 3473 (59.28) ICPA 2043 x ICPR 2671 (53.81) ICPA 2043 x ICPR 3477 (52.26) ICPA 2043 x ICPR 3514 (48.64) ICPA 2047 x ICPR 2671 (35.38) ICPA 2048 x ICPR 2671 (31.59)	-43.14 to 77.94	ICPA 2043 x ICPR 2671(77.94) ICPA 2043 x ICPR 3473 (72.55) ICPA 2043 x ICPR 3477 (64.95) ICPA 2043 x ICPR 3514 (61.03) ICPA 2048 x ICPR 2671 (60.29) ICPA 2047 x ICPR 2671 (56.62)

Figures in parenthesis indicate per cent standard heterosis and better parent heterosis.

per cent and -45.50 to 37.00 per cent, respectively. The standard heterosis and heterobeltosis for number of secondary branches plant^{-1} was found in positive direction in 14 and 17 out of 48 crosses, respectively.

The maximum standard heterosis for number of pods plant^{-1} were recorded by ICPA 2043 x ICPR 2671 (44.59 %) followed by ICPA 2092 x ICPR 2671 (36.76 %), ICPA 2048 x ICPR3473 (36.35 %) and maximum better parent heterosis were reported by ICPA 2047 x ICP10934 (46.87 %) followed by ICPA 2043 x ICPR 2671 (35.44 %) and ICPA 2043 x ICPR 3473 (29.74 %). For 100 seed weight standard heterosis ranged from -21.43 to 16.07 per cent and it was found highest in the cross ICPA 2092 x ICPR 2766. Maximum heterobeltosis for 100 seed weight was recorded by the cross ICPA 2043 x ICP 87119 (22.00 %).

The seed yield plant^{-1} had wide range of standard heterosis (-43.14 to 77.94%) and heterobeltiosis (-53.32 to 59.28%). The maximum standard heterosis over check, BSMR 736 for seed yield plant^{-1} was observed in the crosses *viz*., ICPA 2043 x ICPR 2671 (77.94%), ICPA 2043 x ICPR 3473 (72.55%), ICPA 2043 x ICPR 3477 (64.55%), ICPA 2043 x ICPR 3514 (61.03) and ICPA 2048 x ICPR 2671 (60.29%). These five hybrids also recorded highest better parent heterosis for seed yield plant^{-1} to the extent of 53.81, 59.28, 52.26, 48.64 and 31.59 per cent respectively. These hybrids also exhibited maximum standard heterosis and heterobeltiosis for plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1} and 100 seed weight. Pande and Singh (2002), Sarode *et al*. (2009), Shoba and Balan (2010) and Pandey *et al*. (2013) reported significant positive heterosis for number of primary branches plant^{-1}, secondary branches plant^{-1}, pods plant^{-1} and seed yield plant^{-1}. Similar results were also reported by Kandalkar (2007) for number of pods plant^{-1}, 100 seed weight and seed yield plant^{-1}. Sekhar *et al*. (2004) reported best hybrids exceeding 40 per cent standard heterosis as promising for seed yield plant^{-1} in pigeonpea. These results revealed the promising crosses *viz*., ICPA 2043 x ICPR 2671, ICPA 2043 x ICPR 3473, ICPA 2043 x ICPR 3477, ICPA 2043 x ICPR 3514 and ICPA 2048xICPR 2671 may be further tested on larger plots over different locations and season before recommending them for commercial utilization in pigeonpea.

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Evaluation of Muskmelon (*Cucumis melo* L.) Germplasm for Yield Contributing Parameters

An evaluation of germplasm gives considerable data to classify the material. Germplasm collection, maintenance and its evaluation for economically important traits is a pre-requisite for starting any breeding programme for the genetic improvement of the crop. Estimation of variation in a population is an effective tool for the breeder to design the testing procedures in order to identify superior genotypes. An attempt has been made in the present study to evaluate the germplasm of different eco-geographic sources for some important characters under Western Maharashtra conditions.

The material under investigation consisted of 37 genotypes obtained from different geographical conditions and maintained at All India Coordinated Research Project on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth Rahuri, Dist.-Ahmednagar (M.S). The experimental material was grown in summer season (February-May) of 2011, in a randomized block design with two replications. The plot size was 5.40 x 1.50 m containing five plants in each plot spaced at 1.5 x 0.90 m. Four seeds hill^{-1} were dibbled at the time of sowing and subsequently thinned out to single plant hill^{-1}. Cultural practices such as mannuring, irrigation, weeding, plant protection, etc. were carried out as per the prescribed package of practices.

Three plants were selected from each genotype replication^{-1} to study the yield contributing parameters and other physical characters *viz*., fruit shape, fruit colour and flesh colour. Observations were recorded on eight quantitative traits *viz*., poler diameter (cm), equatorial diameter (cm), flesh thickness (cm), number of fruits plant^{-1}, average weight of single fruit (g), total soluble solids (%), yield (kg plot^{-1}) and (q ha^{-1}). The mean value of data recorded on above traits were subjected to statistical analysis to obtain analysis of variance following Panse and Sukhatme (1985).

The results (Table 1) indicated that there was substantial variation among the genotypes for all the characters under study. Among the 37, genotypes studied, the 23 were round, 7 were oval, 3 were round flat, 2 were oblong and 2 were long for the character fruit shape. There was also variation for fruit colour from green to greenish black, cream, yellowish white with ridges and netting on fruit surface. The flesh colour was varied from light green, orange and white for different genotypes. This may be due

Table 1. Evaluation of Musk melon germplasm for yield contributing characters.

Name of genotype	Fruit shape	Fruit colour	Flesh colour	Polar diameter (cm)	Equatorial diameter (cm)	Flesh thickness (cm)	No. of fruits plant^{-1}	Av. weight of fruit (g)	TSS (%)	Yield (kg plot^{-1})	Yield (q ha^{-1})
Durgapura Selection	Round flat	Yellowish with green ridges	Light Green	10.65	13.75	2.80	1.70	810	11.25	9.20	113.57
Punjab Sunhari	Round	Cream with netting	Orange	9.60	10.65	2.15	3.83	490	7.75	11.04	136.35
IVMM-3	Oval	Yellowish green ridges and netting	Orange	13.75	10.65	2.55	2.41	726	7.70	8.77	108.26
Sweet melon-1	Round	Yellow with green ridges and netting	Light Green	8.75	10.00	2.20	1.62	425	8.25	7.10	87.65
IVMM-1	Round	Green with netting	Orange	12.75	12.75	2.30	3.06	875	7.75	11.85	146.29
Hara Madhu	Round	Cream with Green ridges	Light Green	13.00	13.50	2.70	2.33	945	7.25	13.13	162.09
NDM-21	Round	Yellow with netting	Light Green	8.75	10.25	2.50	3.01	502	9.25	8.15	100.61
NDM-18	Round	Cream with ridges and netting	Orange	10.75	11.75	2.80	1.96	781	10.25	8.21	101.41
Punjab Rasila	Round	Cream with Green ridges and netting	Light Green	11.00	11.00	2.55	2.96	765	7.25	9.10	112.34
MM-3	Round	Greenish yellow	Light Green	10.75	9.75	2.25	2.98	440	9.25	8.45	104.31
MM-28-1	Round	Cream with ridges	Orange	8.75	10.65	2.35	2.91	487	8.15	8.10	100.00
Ambegoan Oblong	Oblong	Greenish yellow	Light Orange	12.75	9.60	2.15	1.70	561	8.35	7.67	94.68
Ambegaon Round	Round	Yellow smooth	White	12.50	12.50	2.25	1.51	540	7.25	6.95	85.80
VRM-42-2	Round flat	Cream with netting	Light Green	9.45	12.40	2.60	3.36	856	9.75	8.95	110.49
VRM42-4	Round	Yellowish with netting	Orange	10.25	11.25	2.60	2.25	854	10.75	11.67	144.13
Sweet melon yellow	Round	Yellow smooth	Light Green	10.75	9.90	2.25	1.40	695	7.25	6.95	85.80
Sweet melon-2	Oval	Yellowish with netting	Light Orange	9.75	10.25	2.55	1.65	846	10.50	8.19	101.10
MM-2	Round	Yellow with netting	Light Green	7.25	8.75	2.20	3.10	338	10.25	8.05	99.38
Durgapura Madhu	Oval	Yellowish smooth	Light Green	13.75	10.00	2.60	1.70	660	6.25	7.97	98.47
Pusa Madhurus	Round flat	Yellowish with green ridges	Orange	8.15	9.60	2.85	1.62	665	7.25	8.08	99.81
GMM-3	Oval	Yellow with green ridges	Light Green	13.75	11.25	1.55	1.91	670	10.75	8.98	110.92
NDM-18-1	Round	Yellowish with green ridges and netting	Orange	9.25	10.25	2.65	3.20	575	8.75	12.45	153.70
NDM-48	Round	Yellowish with green ridges and netting	Orange	9.15	10.35	2.25	1.86	546	10.50	7.85	96.91
Tapi-1	Round	Brownish with netting	Light Orange	14.75	16.75	1.85	1.90	959	7.45	13.35	164.81
Tapi-2	Round	Greenish with netting	Light Orange	12.75	13.75	1.75	1.86	737	6.45	13.20	162.95
Tapi FT-3	Long	Greenish	Light Orange	18.25	10.75	1.55	1.75	560	5.60	13.50	166.66
Tapi-4	Round	Greenish with netting	Light Orange	13.25	14.25	1.60	1.25	570	6.75	13.00	160.55
Tapi-5	Round	Green with netting	Light Orange	14.25	17.00	1.70	2.51	480	6.80	12.12	149.58
MHY-3-1	Round	Cream with netting & green ridges	Light Green	9.25	8.25	2.25	3.46	545	8.25	10.85	133.94
MHY-5	Oval	Yellow with netting	Light Green	13.25	10.50	2.55	4.62	761	8.45	12.97	160.11

Table 1. Contd.

Name of genotype	Fruit shape	Fruit colour	Flesh colour	Polar diameter (cm)	Equatorial diameter (cm)	Flesh thickness (cm)	No. of fruits plant^{-1}	Av. weight of fruit (g)	TSS (%)	Yield (kg plot^{-1})	Yield (q ha^{-1})
MHY-5-1	Oblong	Yellowish green with netting	Light Green	15.25	10.00	1.85	3.33	626	6.75	11.75	145.06
RM-50-1	Round	Yellowish with green ridges & netting	Light Green	11.45	10.35	2.20	3.46	482	9.25	9.15	112.96
MHY-3	Round	Cream with netting	Light Green	9.35	9.90	1.70	3.51	528	6.45	11.15	137.64
IVMM-3-1	Oval	Yellowish with netting	Light Green	13.25	9.50	2.60	1.81	519	6.25	6.67	82.34
RM-43	Oval	Yellow with green ridges & netting	Light Green	13.75	10.75	2.60	3.62	907	10.25	13.85	170.98
Kajari	Long	Yellow	Light Orange	14.90	6.50	1.50	2.40	310	5.60	6.10	75.30
RM-50	Round	Pale Green Rind with Green sutures	Green	10.25	11.70	2.40	3.51	775	10.75	13.17	162.59
S.E.±	-	-	-	0.41	0.54	0.10	0.06	15.17	0.20	0.36	4.48
C.D. 5%	-	-	-	1.18	1.09	0.29	0.19	43.51	0.59	2.02	12.85
C.V.%	-	-	-	6.03	6.86	7.37	4.76	5.33	4.52	8.16	9.36

to genetic make up of genotype, different geographical regions and adaptability of that genotype to particular location and consumers liking for different physical characters of muskmelon.

A wide range of variation was observed for various quantitative traits studied in muskmelon. The polar diameter of fruit was ranged from 8.15 cm for genotype Pusa Madhurus to 18.25 cm for genotype Tapi FT-3. The equatorial diameter was ranged from 6.50 cm for genotype Kajari to 17.00 cm for genotype Tapi-1. The flesh thickness has no more variation but it was ranged from 1.50 cm for genotype Kajari to 2.80 cm for Durgapura selection. The number of fruits was ranged from 1.25 (Tapi-4) to 3.83 (Punjab Sunhari). The average weight of fruit (g) was ranged from 310 (Kajari) to 959 (Tapi-1) and 945 (Hara Madhu). The TSS per cent was ranged from 5.60 (Kajari) to 11.25 (Durgapura Selection). The yield kg plot^{-1} was ranged, from 6.10 (Kajari) to 13.85 (RM-43). The yield (q ha^{-1}) was also ranged from 75.30 (Kajari) to 170.98 (RM-43), however, all the genotypes ranged between these genotypes for the trait yield (q ha^{-1}). Mehta *et al*. (2009) reported that the average fruit weight was ranged from 310 to 850 g, fruit length from 15.67 to 19.23 cm, number of fruits plant^{-1} from 2.03 to 5.99 and fruit yield plant^{-1} in kg was in the range of 0.97 to 3.42. The present findings were confirming the results of above findings of Mehta *et al*. (2009). Moderate variations for fruit weight, TSS and flesh thickness which has been strongly supported by findings of Kalloo *et al*. (1983) and Dhaliwal *et al*. (1996).

The assessment of available germplasm for its nature and magnitude of genetic variability is an important pre-requisite for developing any variety with high yield potential and the desired morphological characters. This helps the breeder to assess and identify superior

genotypes better initiating the breeding programme for improvement of any crop. In the preset study, involving thirty seven genotypes of muskmelon, a wide range of variability was observed for quantitative character.

The yield of any crop is an important metric trait. Besides inherent genetic potential of a genotype, the yield is also influenced by the environment. In muskmelon, number of fruits plant^{-1}, average weight of fruits, polar diameter, equatorial diameter and flesh thickness were the main yield contributing characters. Wide range of variability for these metric traits was observed in the present investigation. The polar diameter ranged from 8.15 to 18.25, equatorial diameter ranged from 6.50 to 17.0, flesh thickness from 1.50 to 2.80, number of fruits from 1.25 to 3.83, average weight of fruit from 310 to 959, TSS per cent ranged from 5.60 to 11.25 and yield ranged from 75.30 to 170.98 q ha^{-1}. Significant variability for various quantitative characters has been reported by earlier workers (Kalloo *et al*. 1983 and Dhaliwal *et al*. 1996 and Mehta *et al*. 2009). The present findings were in conformity with the reports of the above workers.

The variations observed in the present studies for quantitative characters can be exploited for improvement of this crop and also useful in characterization traits during selection. The TSS is also a most important character in muskmelon. The genotypes which have high TSS would have greater significance in improvement of this crop. For higher TSS Durgapura selection, RM-43, RM-50, GMM-3 would be exploited for this trait. The orange colour flesh is also an important criteria in relation to consumers preference. For orange flesh colour Punjab Sunhari, IVMM-3, IVMM-1, Pusa Madhurus would have significance. The genotypes Punjab Sunhari, IVMM-1, Kara Madhu, VRM 42-4, Tapi-1 to 5, MHY-5, RM-43, RM-50 were more promising for yield improvement. Further, most of the genotypes having better acceptance in particular regions and better taste during summer months, the hottest days. There is possibility of getting high yielding and better genotypes, if used in crop improvement for selected traits in muskmelon.

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Effect of Transplanting Methods and Spacings on Yield and Economics of Pigeonpea

Though India is largest producer of pulses, large quantity of pulses is being imported every year from other countries to fulfill the demand of our country (Anonymous 2008). To become a self sufficient in pulses production, it is necessary to develop new technology in pulses particularly in high potential crops like pigeonpea. Among the different agronomic practices limiting the yield, choice of suitable method of establishment and geometry is one of the important limiting factors in production of pigeonpea. The pigeonpea growth and yield is also substantially influenced by soil type (Anonymous, 1984). Therefore, the technology was experimented for transplanting of pigeonpea with spacings for production of higher returns from the farmer's field.

The field experiments were carried out on deep black soil for three years from 2008 to 2010 at Agricultural Research Station, Badnapur in three replications. There were three methods of establishment i.e. P_1. Normal sowing, P_2. Transplanting of seedlings from raised beds and P_3. Transplanting of seedlings from polythene bags with four spacings i. e. S_1.60 x 30 cm, S_2.90 x 90 cm, S_3.120 x 45 cm and S_4.150 x 30 cm. The seedlings prepared in polythene bags of 9" x 3" size with two seeds in each bag were sown one month before transplanting in last week of May. The raised bed of 10 x 2.20 m^2 size with 30 cm row spacing were sown one month before transplanting. The transplanting was done after normal onset of rainfall in each year. The

Table 1. Pooled grain yield, gross and net monetary returns and benefit cost ratio of pigeonpea as influenced by planting methods and different spacing.

Treatment	Grain yield (kg ha^{-1})	Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	Benefit cost ratio
Planting methods (P) :				
P_1 Normal sowing	1313	42363	24263	2.33
P_2 Trans. seedlings from raised beds	1583	51673	30873	2.48
P_3 Trans. seedling from polythene bags	1653	53390	32230	2.58
SE±	40	930	269	0.04
CD at 5%	110	2579	744	0.13
Spacing (S) (population ha^{-1}) :				
S_1 60 x 30 cm (55,555)	1334	43652	23652	2.18
S_2 90 x 90 cm (12,345)	1466	47282	27282	2.36
S_3 120 x 45 cm (18,518)	1584	50162	30162	2.50
S_4 150 x 30 cm (22,222)	1727	55472	35472	2.76
SE±	46	1074	1074	0.05
CD at 5%	127	2979	2977	0.15
Interaction P x S :				
SE±	79	1862	1860	0.09
CD at 5%	219	5159	5157	0.27
Mean	1527	49142	29142	2.45

polythene bags were filled with mixture of 50 per cent soil + 40 per cent FYM + 10 per cent fine sand which was properly sieved. Three to four holes were made at the bottom of each polythene bags to drain the excess water. The watering was given every day by sprinkling water with water can. The weeding and spraying of insecticide for sucking pests was undertaken. Transplanting was done at four weeks age when rainfall was received. In field, the seedlings were planted in pre opened pits by digging and putting the soil portion of seedlings in soil with compacting. The irrigation was applied under delayed condition of rainfall. Similarly, the seedlings grown on raised beds were transplanted in the field. In field, all recommended package of practices were undertaken. The statistical analysis was carried out according to Panse and Sukhatme (1967).

The grain yield (Table 1) of pigeonpea as influenced by planting methods and different spacing was significantly increased due to various treatments. Among the planting methods, the transplanting of seedlings from polythene bags recorded significantly higher

Table 2. Pooled interactions of P x S for grain yield, gross monetary returns, net monetary returns and benefit cost ratio of pigeonpea as influenced by planting methods and different spacing.

Treatment	S_1	S_2	S_3	S_4
Grain yield (kg ha^{-1}) :				
P_1 Normal sowing	1275	1286	1337	1413
P_2 Trans. seedlings from raised beds	1392	1528	1605	1827
P_3 Trans. seedling from polythene bags	1419	1559	1715	1884
SE±	79			
CD at 5%	219			
Mean	1362	1467	1552	1708
Gross monetary returns (Rs. ha^{-1}) :				
P_1 Normal sowing	40423	41798	42144	45087
P_2 Trans. seedlings from raised beds	45159	49214	52518	59801
P_3 Trans. seedling from polythene bags	45373	50833	55824	61528
SE±	1862			
CD at 5%	5159			
Mean	43651	47281	50162	55472
Net monetary returns (Rs. ha^{-1}) :				
P_1 Normal sowing	22323	23698	24044	26987
P_2 Trans. seedlings from raised beds	24359	28414	31718	39001
P_3 Trans. seedling from polythene bags	24263	29723	34714	40428
SE±	1860			
CD at 5%	5157			
Mean	23648	27278	30158	35472
Benefit cost ratio :				
P_1 Normal sowing	2.23	2.30	2.32	2.49
P_2 Trans. seedlings from raised beds	2.17	2.36	2.52	2.83
P_3 Trans. seedling from polythene bags	2.14	2.40	2.64	2.91
SE±	0.09			
CD at 5%	0.27			
Mean	2.18	2.35	2.49	2.74

grain yield (1653 kg ha^{-1}) over normal sowing (1313 kg ha^{-1}) but it was at par with transplanting of seedlings from raised beds (1583 kg ha^{-1}). However, the transplanting of seedlings from raised beds was significantly superior as compared to normal sowing. The planting of pigeonpea at 150 x 30 cm recorded significantly higher grain yield of 1727 kg ha^{-1} over all other spacings.

The gross monetary returns were significantly influenced due to different treatments. The transplanting of pigeonpea from polythene bags recorded significantly more gross monetary returns of Rs. 53 390 ha^{-1} over normal planting but it was at par with transplanting of seedlings from raised beds (Rs.51673 ha^{-1}). The sowing of pigeonpea at 150 x 30 cm recorded significantly the highest gross monetary returns of Rs.55472 ha^{-1} over all other spacings. The lowest gross monetary returns of Rs. 43652 ha^{-1} was recorded by 60 x 30 cm spacing.

The net monetary returns were significantly higher (Rs. 32280 ha^{-1}) under transplanting of seedlings from polythene bags over all other planting methods. Similarly, the transplanting of seedlings from raised beds recorded significantly superior (Rs.30873 ha^{-1}) net monetary returns over normal sowing (Rs. 24263 ha^{-1}). The planting of pigeonpea at 150 x 30 cm recorded significantly the highest net monetary returns of Rs. 35472 ha^{-1} over all other spacings; however, planting at 120 x 45 cm spacing recorded higher net monetary returns (Rs. 30162 ha^{-1}) over 60 x 30 cm spacing (Rs. 23652 ha^{-1}) but it was at par with 90 x 90 cm spacing (Rs. 27282 ha^{-1}).

The benefit cost ratio was significantly higher (2.58) due to transplanting of seedlings from polythene bags as compared to normal sowing (2.33) but it was at par with transplanting of seedlings from raised beds (2.48). However, benefit cost ratio with transplanting of seedlings from raised beds was significantly superior over normal sowing. The spacing of 150 x 30 cm recorded maximum benefit cost ratio of 2.76 which was significantly superior over all other spacings followed by 120 x 45 cm spacing (2.50) which was significantly superior over 60 x 30 cm (2.18) and at par with 90 x 90 cm spacing (2.36).

The interactions of grain yield, gross and net monetary returns and benefit cost ratio (Table 2) were significantly influenced due to different planting methods and spacings. The grain yield data of pigeonpea revealed that the interaction of transplanting of seedling from polythene bags at 150 x 30 cm spacing resulted significantly higher pigeonpea yield of 1884 kg ha^{-1}, GMR of Rs. 61528 ha^{-1}, NMR of Rs. 40418 ha^{-1} and benefit cost ratio of 2:91 over all other interactions but it was at par with transplanting of seedlings from raised beds yielding 1827 kg ha^{-1}, GMR of Rs. 59801 ha^{-1}, NMR of Rs. 39001 ha^{-1} and benefit cost ratio of 2.83.

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Heterosis Studies in Line x Tester Crosses of Pearl Millet

The exploitation of heterosis in pearl millet was considered easy with its protogynous flowering and high out-crossing rates. The availability and knowledge of cytoplasmic-nuclear male sterility (CMS), the development of CMS lines, and their maintainers and restorers, made it possible to produce the seed of commercial F_1's grain hybrids in India (Athwal, 1966). Although commercial exploitation of hybrid vigour in pearl millet has resulted in a substantial improvement in the productivity but there is still a need to surpass the plateau achieved in the grain yield. The present investigation was carried out to know magnitude of heterosis for grain yield and its eight components in pearl millet.

In the present study, five male sterile lines (ICMA-98444, JMSA-20081, JMSA-20091, ICMA-65550, ICMA-841) and nine diverse restorer lines (J-2340, J-2405, J-2433, J-2480, J-2482, J-2495, J-2496, J-2507, J-2526) were crossed in a line x tester mating design during summer-2011. A set of 60 genotypes comprising of 45 F_1s along with fertile counter parts of five male sterile lines, nine testers and one standard check hybrid (GHB-744) were sown during rainy season of 2011-12 in a randomized block design replicated thrice at Main Pearl millet Research Station, Junagadh Agricultural University, Jamnagar (Gujarat), India. Each entry was grown in a single row of 5.0 m length with a spacing of 60 x 15 cm. Observations were recorded on five randomly selected competitive plants for each genotype, in each replication for nine characters. The recorded data of each character was subjected to analysis of variance technique as reported by Panse and Sukhatme (1978). The heterosis as percentage over the better parent (heterobeltiosis) and the standard check, GHB-744 (standard heterosis) for each character were worked out as per the standard procedure given by Fonseca and Patterson (1968) and Meredith and Beidge (1972).

The analysis of variance revealed significant differences among the genotypes for all the characters, indicating the existence of considerable amount of genetic variability in the experimental materials. Genotypic variances were further partitioned into variance due to parents, hybrids and parents Vs hybrids. Significant differences due to parents and hybrids for all the characters except threshing index for parents. Mean squares due to parents Vs hybrids were significant for all the characters except for number of effective tillers plant^{-1} and threshing index. The degree and direction of heterosis varied considerably for grain yield and its components. Overall, the magnitude of standard heterosis was high for grain yield plant^{-1}, harvest index and threshing index. The characters *viz*., ear head length, ear head girth and dry fodder yield plant^{-1} depicted moderate standard heterosis. The number of nodes plant^{-1}, number of effective tillers plant^{-1} and ear head weight exhibited the least heterosis.

A large number of nodes are considered as a positive character, because the plant height is a desirable character in pearl millet. The range of heterobeltiosis and standard heterosis varied from-20.64 to 58.97 per cent and -23.56 to 10.22 per cent, respectively. None of the cross exhibited significant and positive heterosis over standard check. However, eight crosses manifested significant and positive heterosis over better parent. The extent of heterosis over better parent was -50.31 to 18.57 per cent,

and over standard check was-53.76 to -4.05 per cent for the trait effective tillers plant^{-1}. Among all crosses studied, only two crosses displayed significant and positive heterosis over better parent. None of the cross exhibited positive heterosis over standard check for this trait. Ear head girth is the major component of the ear head dimension, which is directly reflecting the grain yield. The range of heterobeltiosis and standard heterosis varied from -15.04 to 34.94 per cent and -15.34 to 22.71 per cent, respectively. Among 45 crosses, seven and one hybrids showed significant positive heterosis over better parent and standard check, respectively. Paramount of heterosis has been observed in ear head length, which is an important component of pearl millet. The heterobeltiosis and standard heterosis ranged from -29.71 to 58.15 per cent and -25.12 to 36.17 per cent, respectively for this trait. The cross combination ICMA-65550 x J-2495 (36.17%) recorded the highest positive standard heterosis followed by ICMA-841 x J-2507 (29.90%) and JMSA-20091 x J-2526 (23.73%) for this trait. Out of 45 crosses, 14 and 8 exhibited significant positive heterosis over better parent and standard check, respectively.

High magnitude of heterobeltiosis has been observed for ear head weight, which is the major yield contributing character. A large number of hybrids (22) exhibiting significant positive better parental heterosis with very high magnitude revealed the prevalence of dominance and over dominance. The range of heterobeltiosis and standard heterosis varied from-38.95 to 93.28 per cent and -43.94 to 13.72 per cent, respective for this trait. It is interesting to note that the crosses JMSA-20081 x J-2340 and JMSA-20091 x J-2433 occupied first rank in standard heterosis and heterobeltiosis, respectively, for ear head weight, also had second and third ranks in standard heterosis for grain yield plant^{-1}, suggesting the greater contribution of ear heads weight towards grain yield. The most of cross combinations manifested positive heterosis. Of which, 7 and 12 crosses rendered significant positive heterosis over better parent and standard check, respectively. For the character, harvest index the hybrid JMSA-20081 x J-2495 recorded the highest significant positive economical heterosis (47.41%) followed by ICMA-841 x J-2340 (41.54%) and ICMA-841 x J-2507 (33.34%). The cross combination ICMA-841 x J-2496 exhibited the maximum heterobeltiosis (41.25%), whereas, ICMA-841 x J-2495 recorded the minimum heterosis (-27.60%) over better parent for harvest index.

Table 1. Best standard heterotic crosses along with their *per se* performance, GCA and SCA effects for grain yield plant^{-1} and significant desirable heterosis for other traits in pearl millet.

Crosses	Grain yield plant^{-1} (g)	Heterosis (%) over		SCA	GCA		Traits showing significant heterosis in desirable direction	
		BP	SC		Female	Male	Heterobe-ltiosis	Std. heterosis
ICMA-841 x J-2507	50.70	88.48**	32.61**	10.26**	2.36	-0.46	EE, HI, TI, FY	EE, HI, TI, FY
JMSA-20081 x J-2340	50.10	31.15**	31.04**	8.78**	-1.18	3.97	EW	EW, HI
JMSA-20091 x J-2433	49.40	111.15**	29 21 **	11.00**	0.39	-0.53	NN, EW, FY	TI, FY
ICMA-65550 x J-2482	48.40	25.71**	26.59**	4.27*	1.02	4.57*	EL, EW, FY	EE, FY
ICMA-841 x J-2340	48,10	25.92**	25.81**	3.23	2.36	3.97	HI, Tl	HI, TI

*,** Significant at 5 and 1 per cent , respectively. NN=N umber of nodes plant^{-1}, EL=Ear head length, EW=Ear head weight, HI=Harvest index, TI=Threshing index, FY= Dry fodder yield plant^{-1}.

Threshing index is an important character for the indirect measurement of drought resistant in pearl millet. Among 45 crosses, 4 and 15 hybrids showed significant positive heterosis over better parent and standard check, respectively. The first three top ranking hybrids both for heterobeltiosis and standard had common female parent, ICMA-841, indicating greater contribution of this female towards the threshing index. High magnitude of heterosis and large number of hybrids exhibiting positive significant heterosis revealed the presence of dominant alleles for this trait. Paramount of heterosis has been observed in fodder yield, which is an important component of pearl millet being a dual-purpose crop. The extent of heterosis over better parent and standard check was varied from -46.87 to 64.46 per cent and -33.73 to 30.41 per cent, respectively for dry fodder yield plant^{-1}. Among 45 crosses, 12 and 13 displayed significant positive heterosis over better parent and standard check, respectively, for this trait, suggesting the greater role of fodder yield in the expression of grain yield. It is interesting to note that the crosses ICMA-841 x J-2507 and JMSA -20091 x J-2433 occupied third rank in heterobeltiosis and standard heterosis, respectively, for dry fodder yield plant^{-1}, also had first and third ranks in standard heterosis for grain yield plant^{-1}, suggesting the greater contribution of dry fodder yield plant^{-1} towards grain yield.

Grain yield is the character of economic importance for which considerable degree of heterosis was registered in a number of crosses. Majority of hybrids exhibited positive heterosis over better parental values. In all, 25 and 10 hybrids manifested significant positive heterobeltiosis and standard heterosis, respectively. The magnitude of heterosis ranged from -41.78 to 111.11 per cent over better parent, while it varied between -33.91 to 32.61 per cent over standard check for this trait. Interestingly, the magnitude in positive direction was too high particularly in heterobeltiosis. The number of crosses displaying heterobeltiosis in various yield attributing characters were small, whereas, the number of crosses showing heterobeltiosis in grain yield were large (25).This result indicated that the favourable combination of yield contributing characters resulted in a higher proportion of cross combinations showing significant positive heterobeltiosis. The results are in accordance with the findings of Bhanderi *et al*. (2007), Davda *et al*. (2008), Patel *et al*. (2008), Patil *et al*. (2008), Chotaliya *et al*. (2009), Vaghasiya *et al*. (2009) and Vagadiya *et al*. (2010).

Five most promising hybrids were identified for grain yield, based on magnitude of heterosis over standard check (GHB-744) from evaluation of 45 crosses (Table 1). The highest per se performing hybrid ICMA-841 x J-2507 had first rank in standard heterosis, second position in heterobeltiosis and SCA effect and involving average x average general combining parents. This cross had also significant positive standard heterosis for ear head length, harvest index, threshing index and dry fodder yield plant^{-1}, suggesting the greater role of these traits towards the grain yield. Similarly, JMSA-20091 x J-2433 involving average x average combiners, ranking first in heterobeltiosis and SCA effects, occupied third rank in *per se* performance as well as standard heterosis for grain yield. The cross JMSA-20081 x J-2340 involving average x average combiner parents displayed second rank in *per se* performance, occupied fourth rank in SCA with high heterobeltiosis for grain yield. All the five most superior standard heterotic hybrids for grain yield exhibited significant heterobeltiosis in desired direction for grain yield, while three crosses each for ear head weight and dry fodder yield plant^{-1} and two crosses each for ear head length, harvest index and threshing index; indicating these traits had greater contribution

towards the grain yield. Therefore, in the present study, three top ranking *per se* performance hybrids for grain yield *viz*., ICMA-841 x J-2507, JMSA-20081 x J-2340 and JMSA-20091 x J-2433 exhibited high heterotic status along with high SCA and also recorded high heterobeltiosis for various important yield components. Thus, these hybrids should be evaluated under multiplication trials along with the standard hybrid for their direct release as high yielding hybrids in pearl millet.

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Heterosis for Yield and its Components in Thermosensitive Genetic Male Sterility-Based Hybrids in Safflower

The development of thermosensitive genetic male sterility (TGMS) system in safflower recently has provided an additional tool to harness hybrid vigour (Singh *et al*. 2008) apart from the existing systems of genetic and cytoplasmic-genetic male sterility. In order to determine the usefulness of TGMS system for exploitation of hybrid vigour, an attempt has been made to study the extent of standard heterosis in 38 hybrids evolved by crossing nine TGMS lines with 13 promising genotypes having the same flowering period, over two hybrid checks *viz*., NARI-H-15, a GMS-based hybrid and MRSA-521, a CMS-based hybrid,

Table 1. Range of standard heterosis and heterosis of first five best crosses for seed yield and its components in thermosensitive genetic male sterility-based hybrids in safflower.

Character	Hybrid	Heterosis over GMS hybrid check NARI-H-15		Heterosis over CMS hybrid check MRSA-521	
		Range	Heterosis (%)	Range	Heterosis (%)
Days to maturity	TGMSH-133	-3.01 to 4.37	-3.01*	-3.79 to 3.52	-3.79**
	TGMSH-143		-3.01*		-3.79**
	TGMSH-145		-2.73*		-3.52**
	TGMSH-173		-1.37		-2.17
	TGMSH-139		-1.09		-1.90
Plant height	TGMSH-142	-7.78 to 1.57	1.57	1.29 to 11. 57	11.57**
	TGMSH-151		0.72		10.63**
	TGMSH-152		0.59		10.49**
	TGMSH-128		0.13		9.99**
	TGMSH-130		0.07		9.91**
Primary branches plant^{-1}	TGMSH-136	-30.99 to 14.08	14.08	-36.77 to 4.52	4.52
	TGMSH-257		11.27		1.94
	TGMSH-155		4.23		-4.52
	TGMSH-150		3.52		-5.16
	TGMSH-148		2.82		-5.81
Capitula plant^{-1}	TGMSH-136	-38.12 to 16.83	16.83	-36.06 to 20.72	20.72
	TGMSH-155		0.25		3.58
	TGMSH-257		-1.98		1.28
	TGMSH-159		-1.98		1.28
	TGMSH-142		-2.23		1.02
Seeds capitulum^{-1}	TGMSH-174	-3.44 to 93.12	93.12**	-19.76 to 60.48	60.48**
	TGMSH-159		91.40**		59.05**
	TGMSH-140		90.54**		58.33**
	TGMSH-153		85.67**		54.29**
	TGMSH-128		68.77**		40.24*
100-seed weight	TGMSH-158	-48.10 to 2.11	-48.18**	-44.84 to 4.04	-44.84**
	TGMSH-155		-43.53**		-39.99**
	TGMSH-149		-41.60**		-37.94**
	TGMSH-151		-38.85**		-35.01**
	TGMSH-153		-38.15**		-34.27**
Oil content	TGMSH-129	-6.22 to 13. 42	13.42**	-3. 08 to 17.21	17.21**
	TGMSH-173		7.51**		11.10**
	TGMSH-141		6.30*		9.85**
	TGMSH-157		4.99		8.49**
	TGMSH-130		4.81		8.31**
Seed yield	TGMSH-138	-46. 18 to 24.75	24.75	-28.73 to 65.21	65.21**
	TGMSH-136		15.74		53.29*
	TGMSH-131		11.70		47.94*
	TGMSH-130		7.19		41.95
	TGMSH-257		5.85		40.19

*,** Significant at 5 and 1 per cent respectively.

under rainfed conditions.

The experiment was carried out at the Nimbkar Agricultural Research Institute, Phaltan in a randomized block design with three replications during *rabi* 2009-10. Each entry was sown in a two-row plot of 5 m length with a spacing of 45 cm between rows and 20 cm between plants on November 1, 2009. Standard cultural practices were followed to raise a good crop. Observations were recorded on eight traits as furnished in Table 1. Standard heterosis as increase or decrease (%) over the two hybrid checks was estimated for yield and its components following Meredith and Bridge (1972).

The analysis of variance showed significant differences due to treatments for all the traits under study. This indicated the presence of variation among the safflower hybrids produced using the TGMS system. Considerable extent of standard heterosis was observed for different characters under investigation (Table 1). In the present study, three crosses showed significantly negative heterosis over both the checks for days to maturity. The hybrids TGMSH-133 and TGMSH-143 were found to be the earliest maturing since both recorded the maximum negative heterosis of -3.01 per cent over NARI-H-15 and -3.79 per cent over MRSA-521. For number of seeds capitulum^{-1}, 16 hybrids over NARI-H-15 and 7 hybrids over MRSA-521 recorded significantly positive heterosis. The maximum heterosis to the extent of 93.12 and 60.48 per cent over NARI-H-15 and MRSA-521 respectively was shown by the hybrid TGMSH-174. Negative heterosis estimates for 100-seed weight are considered as desirable since this indicates reduction in hull content of the seed which is inversely proportional to seed oil content and also allows more seed to set in a capitulum as opposed to fewer seeds with thick hull. Twentynine hybrids over NARI-H-15 and 22 hybrids over MRSA-521 showed significantly negative heterosis for 100-seed weight. Three and twelve hybrids showed significantly positive heterosis over NARI-H-15 and MRSA-521 respectively for oil content. The significantly maximum positive heterosis of 13.42 per cent over NARI-H-15 and 17.21 per cent over MRSA-521 was recorded by the hybrid TGMSH-129. None of the TGMS hybrids tested gave significantly higher seed yield over NARI-H-15, however, three hybrids showed significantly positive heterosis over MRSA-521. The hybrid TGMSH-138 recorded the significantly maximum heterosis of 65.21 per cent over MRSA-521 which was followed by the hybrids TGMSH-136 (53.29%) and TGMSH-131 (47.94%).

In the present investigation, the traits like number of seeds capitulum^{-1} and 100-seed weight which are considered to be the least influenced by the environment exhibited high heterosis in desired direction while the oil content showed moderate heterosis. The moderate to high heterosis for these traits has thus resulted in expression of high heterosis for seed yield. The existence of high heterosis for seed yield and number of seeds capitulum^{-1} in safflower has also been reported previously by Patil and Narkhede (1996) and Ratnaparkhi *et al.* (2012). High heterosis for seed yield in safflower was also reported by Shivani *et al*. (2010) and Singh *et al*. (2012). On the basis of significantly high standard heterosis for seed yield over check MRSA-521 and numerically high standard heterosis over NARI-H-15 in the present study, the TGMS hybrids TGMSH-138, TGMSH-136 and TGMSH-131 were identified as promising and these hybrids have been considered for further evaluation at multilocations to identify the most promising one for commercial production. These hybrids can also be used for isolating promising pure lines.

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Variability and Character Association Studies in Fieldpea (*Pisum sativum* L.)

Fieldpea is an important crop among pulses in the country due to its multiple uses in the form of vegetable, chhola, besan and dhal etc. Its productivity is low which may be improved through exploiting the genetic variability. Genetic variability is an essential prerequisite for crop improvement programme for obtaining high yielding varieties. The estimates of heritable variances give a clue for possible improvement of the character under study. On the other hand, yield is a complex character and is associated with some yield contributing characters. The understanding of association of characters is of prime importance in developing an efficient breeding program. The present investigation was therefore undertaken to predict an appropriate plant type for selection so as to improve the seed yield keeping in view the inter relation between characters and heritability.

Seventeen genotypes were grown in a randomized block design with three replications during *rabi* 2011-2012 at the Field Experimentation Center, Department of Genetics and Plant Breeding, SHIATS, Allahabad. Each genotype sown six row plot of 4 meter length with spacing 30 cm between row to row and 10 cm between plant to plant. Observations were recorded on randomly selected plants of each genotype in each replication for eight quantitative characters *viz*., days to 50 per cent flowering, plant height (cm), number of pods plant^{-1}; days to maturity, number of seeds pod^{-1}, pod length (cm), seed index (g) and seed yield plan^{-1} (g). The

genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and heritability in broad sense were estimated as per the formula given by Burton and Devane (1953) and Lush (1949), respectively. Correlation coefficients were computed at genotypic and phenotypic levels between pairs of characters adopting the formula given by Al-Jibouri *et al*. (1958).

Analysis of variance revealed significant differences among the 17 genotypes for all characters under study. Highly significant differences were observed for plant height. In other words, the performance of the genotypes with respect to these characters was statistically different, suggesting scope for yield improvement in fieldpea.

Maximum value of genotypic coefficient of variation (Table 1) was recorded for seed yield plant^{-1} (21.27) followed by number of pods plant^{-1} (21.61) whereas low estimates were observed for days to maturity (3.08) followed by pod length (4.59) and number of seeds pod^{-1} (6.07). Maximum value of phenotypic coefficient of variation was recorded for seed yield plant^{-1} (22.28) followed by number of pods plant^{-1} (21.74) whereas low estimates were observed for days to maturity (3.23) followed by pod length (4.81) and days to 50 per cent flowering (6.75). Sonali *et al*. (2009) reported that seeds plant, shoot height, internode length, grain yield and pod number had high degree of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV).

Heritability estimates were found to be high (more than 60%) for plant height followed by

Table 1. Estimates of genetic parameters for seed yield and other yield component characters in fieldpea.

Characters	Coefficient of variation		Heritability (bs) (%)	Genetic advance	Genetic advance as per cent of mean
	Genotype	Phenotypic			
Days to 50% flowering	6.16	6.75	94.80	9.54	13.12
Plant height	12.97	13.99	97.57	19.11	28.76
Pods plant^{-1}	21.61	21.74	97.43	18.78	44.68
Days to maturity	3.08	3.23	91.20	6.63	6.06
Pod length	4.59	4.81	91.10	0.62	9.02
Seeds pod^{-1}	6.07	7.33	68.40	0.61	10.33
Seed index	15.95	16.18	97.30	5.75	32.40
Seed yield plant^{-1}	21.27	22.28	90.82	10.05	45.84

Table 2. Estimates of genotypic correlation'coefficients of yield component characters with seed yield in fieldpea.

Characters	Plant height	Pods plant^{-1}	Days to matutity	Pod length	Seeds plant^{-1}	Seed index	Seed yield plant^{-1}
Days to 50% flowering	-0.204	-0.578**	0.728**	-0.479**	0.124	-0.204	-0.521**
Plant height	1.000	-0.267	-0.344**	0.027	-0.303	-0.013	-0.107
Pods plant^{-1}		1.000	-0.293*	0.036	0.136	0.301*	0.592**
Days to maturity			1.000	-0.476**	0.109	-0.140	-0.470**
Pod length				1.000	0.331	0.420**	0.667**
Seeds pod^{-1}					1.000	0.104	0.364*
Seed index						1.000	0.657**

*and ** significant at 5% and 1% level of significance, respectively.

number of pods plant^{-1}, seed index, days to 50 per cent flowering, days to maturity, pod length and seed yield plant (Table 1). The genetic advance in per cent of mean was the high for seed yield plan^{-1} followed by number of pods plant^{-1} and seed index, whereas it was low for days to maturity. Singh and Singh (2005) reported high heritability (broad sense) estimates for all characters except days to flower and pod length. High heritability coupled with high expected genetic advance were observed for seed yield plant^{-1} number of pods plant^{-1} and seed index, indicated that these characters were least influenced by environmental interaction. Thus, selection for these characters would be quite effective in enhancing seed yield plant^{-1} and also simultaneously its relative attributes.

Correlation coefficient analysis of seed yield plant^{-1} with other characters revealed that seed yield plant^{-1} showed positive significant association with number of pods plant^{-1}, pod length, number of seeds pod^{-1} and seed index at phenotypic and genotypic levels, respectively (Table 2). Seed yield plant^{-1} recorded significant and negative association with days to 50 per cent flowering and days to maturity. Significant negative association was recorded between days to 50 per cent flowering and number of pods plant^{-1}. Further, days to maturity recorded significant negative association with plant height and number of pods plant^{-1} whereas pod length also registered negative significant association with days to 50 per cent flowering and days to maturity. However, seed index showed positive significant association with number of pods plant^{-1} and pod length Sharma *et al*. (2003) observed significant and positive association of seed yield with pods plant^{-1} and pod length whereas Singh *et al*. (2004) reported that grain yield plant^{-1} exhibited significant and positive association with pod length, number of pods plant^{-1} number of branches plant^{-1}, seeds pod^{-1}, grain weight and harvest index. Nawab *et al*. (2008) reported that seed yield recorded highly positive and significant correlation with number of seeds pod^{-1} and weight of pods plant^{-1} at genotypic and phenotypic levels. Hence plant height, number of pods plant^{-1}, pod length, number of seeds pod^{-1} and seed index appeared to be the selection indices for seed yield improvement in fieldpea.

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Preparation of Basundi Blended with Mango Pulp (*Mangifera indica*) cv. Alphonso

Utilization of milk and milk products in human diet is common from beginning of the human civilization. The milk is a perishable commodity and therefore, is required to be converted into the products having long shelf life. Basundi is one of the desiccated indigenous milk products popular in western part of India, mostly Maharashtra and Gujarat. However, available literature indicates that no work has been so far carried out on utilization of mango, for fortification of basundi. The fortification of different milk products with fruit pulps/juices improves product quality and consumers preference. Mango is well known because of its excellent taste, palatability, flavor and nutritive value. Hence, in the present investigations attempts have been made to explore the possibility of utilizing mango pulp as flavoring agent in developing mango basundi.

The fresh buffalo milk was obtained from the college dairy farm for preparation of basundi. The Alphonso mango pulp and other ingredients were purchased from local market. The basundi was prepared as per the procedure given by Srinivasan and Anantakrishnan (1964) with slight modifications with different levels of sugar and mango pulp. The levels of sugar were 3, 4 and 5 per cent of milk (S_1, S_2 and S_3, respectively) and different levels of mango pulp as 5, 10, 15 and 20 per cent (M_1, M_2, M_3 and M_4, respectively) of plain basundi. The trial was conducted with six replications.

The treatment wise samples of basundi were analysed chemically as per methods like Fat-IS:1224 (part-I), protein, total solid, ash-1479 (part-II), titratable acidity- IS 1479 (part-1) and reducing and non- reducing sugars by methods suggested by Ranganna (1986). The sensory, evaluation of product was carried out by panel of eight judges using nine points hedonic scale as per IS:6273 (part-II), 1971. The data were stastistically analysed according to Snedecor and Cochran (1994) using factorial randomized block design.

Buffalo milk used for basundi preparation had on an average 6.53 per cent fat, total solids 15.82 per cent and acidity 0.14 per cent. These values were within the limits of legal standards for buffalo milk as prescribed by PFA rules (1976) cited by De (1983). The average chemical composition of mango pulp and the chemical quality of plain basundi are presented in Table 1.

The data pertaining to the chemical quality of basundi as influenced by different levels of mango pulp and sugar are presented in Table 2. There was significant decrease in total solids, fat, protein, ash and reducing sugar content of basundi with increase in the level of mango pulp. This might be obviously due to lower content of these nutrients in mango pulp as compared to plain basundi.

Apparently there was significant increase in

Table 1. Chemical quality of mango pulp and plain basundi (%).

Constituent	Mango pulp	Plain basundi
Total solids	29.33	48.82
Fat	0.84	11.98
Protein	0.87	8.92
Ash	0.31	1.62
Acidity	0.42	0.35
Total sugar	15.49	26.27
Reducing sugar	5.32	11.67
Non-reducing sugar	10.17	14.60

Table 2. Chemical quality of mango basundi (%).

Constituents/ Treatment level	Total soils	Fat	Protein	Ash	Reducing sugar	Non-reducing sugar	Titratable acidity
S_1M_1	46.66	10.23	7.93	1.52	11.49	15.52	0.36
S_1M_2	45.02	9.02	7.34	1.45	11.41	15.62	0.40
S_1M_3	43.88	9.97	6.85	1.31	11.32	15.89	0.42
S_1M_4	42.89	6.83	6.63	1.20	11.28	15.98	0.45
S_2M_1	47.61	9.92	8.12	1.59	11.57	16.19	0.37
S_2M_2	46.86	8.79	7.50	1.51	11.44	16.39	0.43
S_2M_3	43.90	7.72	7.01	1.40	11.30	16.52	0.45
S_2M_4	42.81	6.51	6.82	1.27	11.27	16.69	0.48
S_3M_1	48.68	9.46	8.72	1.64	11.65	17.49	0.39
S_3M_2	46.92	8.22	7.61	1.55	11.59	17.57	0.46
S_3M_3	44.58	7.12	7.30	1.46	11.47	17.68	0.49
S_3M_4	43.02	6.11	6.92	1.33	11.33	17.77	0.53
SE± (Interaction)	0.56	0.13	0.09	0.03	0.19	0.19	0.02
CD 1%	1.58	0.36	0.24	0.07	0.64	0.56	0.06

the acidity and non-reducing sugar of basundi due to increase in the level of sugar. The levels of sugar showed non-significant difference for their influence on the fat, protein and reducing sugars of basundi.

The average score for all parameters of sensory quality (Table-3) at any treatment combination of mango pulp and sugar was near about 7.00 indicating that the sensory quality of all samples of basundi was good irrespective of the treatments. The basundi prepared by using 4 per cent sugar and 15 per cent mango pulp was superior amongst all the treatments which showed slight yellowish colour with clear and clean appearance. The reduction in score might be due to effect of light dull colour at lower level as well as dark fellow colour at higher level of mango pulp which was not liked by the judges.

Addition of mango pulp resulted in significant increase in score for flavour of basundi. Basundi prepared with 4 per cent sugar and 15 per cent mango pulp recorded highest score. Increase or decrease in the level of mango pulp showed lower acceptability by the judges.

The good quality basundi had smooth and optimum consistency with small soft flakes (Patel and Upadhyay, 2003 a). Consistency of basundi prepared with higher level of sugar and

Table 3. Sensory quality of basundi.

Treatment	Colour and appearance	Flavour	Consistency	Overall acceptability
S_1M_1	6.38	6.63	6.56	6.52
S_1M_2	6.70	6.65	6.76	6.70
S_1M_3	7.34	7.48	7.04	7.29
S_1M_4	7.26	7.25	6.95	7.18
S_2M_1	7.13	7.19	6.92	7.10
S_2M_2	7.54	7.32	7.02	7.27
S_2M_3	7.66	7.69	7.39	7.58
S_2M_4	7.27	7.23	6.93	7.15
S_3M_1	7.23	7.20	6.94	7.01
S_3M_2	6.82	7.12	6.87	6.89
S_3M_3	6.76	6.98	6.78	6.84
S_3M_4	6.82	7.05	6.79	6.87
Teal. P<0.05	36.05	20.92	13.82	36.51
T table P<0.05	19.68	19.68	19.68	19.68

mango pulp was found to be thick, where as thin consistency possessed by the basundi with 3 per cent sugar and 5 per cent mango pulp which was also not liked by the judges.

It may be concluded from the results of present investigation that mango pulp could be successfully utilized for preparation of basundi. Addition of mango pulp in basundi improved the sensory quality and acceptability of the product. The most acceptable level of sugar and mango pulp was found to be 4 per cent and 15 per cent, respectively for fortification of basundi.

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Effect of Silicon on Yield, Nutrients Uptake by Paddy Plant and Soil Properties

Rice has the ability to absorb and accumulate silicon metabolically while many upland crop plants seem to lack such ability. A rice crop producing 5 t ha^{-1} grain yield in a lateritic soil of India has been found to remove 468 kg Si ha^{-1} (Sahu ,1990). Depletion of Si may occur in traditional soils with continuous monoculture, intensive cultivation of high yielding cultivars of rice and can be a limiting factor for sustainable rice production (Miyake, 1993). Numerous experiments have shown that Si deposition in the plant tissues can improve yield, lodging resistance, insect pest and disease resistance in rice plants. Therefore, silicon has long been recognized as a beneficial element for rice. In view of this, the present investigation was aimed to evaluate various indigenous sources of silicon (Rice Husk Ash, Bagasse Ash and Fly Ash) along with calcium silicate with the objective to study the effect of

sources and levels of silicon on N, P, K, silicon uptake and soil properties. A pot culture experiment was conducted in wire house at Division of Soil Science and Agricultural Chemistry, College of Agriculture, Kolhapur during kharif season, 2011-2012. Earthen pots were filled with 10 kg silicon deficient surface soil (Typic Haplustepts) collected from Agricultural Research Station, Radhanagari. The soil had pH 6.20, EC 0.09 dS m^{-1} and organic carbon content 1.28 per cent and available N, P, K, Si and water soluble Si 249.92, 16.50, 251.40, 179.60, 29.43 kg ha^{-1}, respectively. Five plants of paddy (cv. Bhogavati) were grown in each pot by adopting recommended package of practices. The present experiment was carried out in completely randomized block design. Thirteen treatments comprised of three levels of silicon (250, 500 and 750 kg Si ha^{-1}) through four sources viz. Rice Husk Ash, Calcium Silicate, Bagasse Ash and Fly Ash were replicated thrice along with one control as 0 kg Si ha^{-1}. The uptake of N, P, K and Si was determined by using standard procedures. Similarly after harvest of paddy representative soil samples were analyzed for chemical properties by adopting standard procedures. The available silica was determined colorimetrically from ammonium acetate extract of soil (Fox *et al*., 1967) and the silica content in grain and straw samples were determined as per the method given by Nayar *et al*. (1975).

Yield and uptake : The significantly highest grain yield (18.55 g pot^{-1}) and straw yield (29.74 g pot1) were recorded in calcium silicate 750 kg Si ha^{-1} (T_7), however, it was at par with RHA-750kg Si ha^{-1} (T_4), FA-750 kg Si ha^{-1} (T_{13}), BA-750 kg Si ha^{-1} (T_{10}), CS-500 kg Si ha^{-1} (T_6), RHA-500 kg Si ha^{-1} (T_3), FA-500 kg Si ha^{-1} (T_{12}) and BA-500 kg Si ha^{-1} (T_9). These results are in confirmative with those reported by Sawant *et al*. (1994), Sing *et al*. (2007) and Muriithi *et al*. (2010) who reported increase in growth and dry matter of paddy due to silicon application through different organic and inorganic sources. Similar increase in straw

Table 1. Effect of sources and levels of silicon on yield and total uptake of N, P, K and Si by paddy.

Treatment details	Grain yield (g pot^{-1})	Straw yield (g pot^{-1})	Total uptake of nutrients (mg pot^{-1})							
			N		P		K		Si	
			Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 Control	16.17	26.44	164.84	129.56	61.44	27.26	65.91	370.14	198.44	815.15
T_2 RHA 250	17.45	28.65	186.48	147.08	72.13	34.79	74.83	408.03	240.82	922.64
T_3 RHA 500	18.30	29.41	200.56	157.26	77.52	37.58	80.55	421.21	262.90	957.89
T4 RHA 750	18.52	29.65	206.64	161.89	80.24	43.49	84.32	429.33	280.84	986.36
T_5 CS 250	17.48	28.66	194.16	149.79	73.32	34.56	75.31	410.42	246.01	926.67
T_6 CS 500	18.44	29.45	204.81	155.27	79.64	39.96	82.59	424.02	267.39	966.83
T_7 CS 75O	18.55	29.74	209.86	160.61	80.99	44.62	85.07	431.67	284.38	993.44
T_8 BA 250	17.31	28.36	184.15	142.91	68.06	29.70	72.83	403.80	235.95	907.42
T_9 BA 500	18.23	29.25	199.62	156.01	72.92	35.28	77.31	416.56	258.95	946.83
T_{10} BA 750	18.46	29.46	204.13	159.48	76.82	41.25	79.72	424.24	277.99	977.08
T_{11} FA 250	17.35	28.46	183.79	148.96	69.91	31.61	73.57	407.60	237.12	913.67
T_{12} FA 500	18.27	29.31	201.16	154.52	74.93	37.54	78.96	421.81	261.80	950.86
T_{13} FA 750	18.47	29.54	206.87	159.93	79.37	41.36	82.45	427.78	281.22	980.84
S.E±	0.34	0.37	5.55	5.38	1.77	1.79	2.04	6.22	4.76	13.06
C.D. (P=0.05)	0.98	1.06	16.16	15.67	5.17	5.22	5.96	18.11	13.86	38.06

yields of paddy due to silicon application were reported by Singh *et al*. (2007) and Jawahar and Vaiyapuri (2010). The total uptake of nitrogen (Table 1) increased significantly due to application of silicon. The data on total uptake indicated that significantly the highest N uptake in grain was observed in treatment CS-750 kg Si ha^{-1} (209.86 mg pot^{-1}). The lowest N uptake in grain was observed in treatment control (164.84 mg pot^{-1}). Significantly the highest N uptake in straw was observed in treatment CS-750 kg Si ha^{-1} (160.61 mg pot^{-1}). The lowest N uptake in straw was observed in treatment control (129.56 mg pot^{-1}). The uptake of P and K increased significantly due to silicon application. The significantly highest uptake of P and K in grain was found with treatment CS-750 kg Si ha^{-1} (80.99 and 85.07 mg pot^{-1}, respectively). The uptake of P and K increased significantly due to silicon application. The significantly highest uptake of P and K in straw was found with treatment CS-750 kg Si ha^{-1} (44.62 and 431.67 mg pot^{-1}, respectively). The increase in uptake of nutrients due to Si application might be attributed to beneficial role of Si in increasing the growth of paddy. The increase in uptake of nutrients due to application of silicon were reported by Talashilkar *et al*. (2000) and Singh *et al*. (2006) which was due to the beneficial role of silicon in improving the photosynthesis of plant and phosphorus availability from soil. The total uptake of silicon increased significantly due to application of silicon. The highest uptake of silicon was recorded in grain in treatment CS-750 kg Si ha^{-1} (284.38 mg pot^{-1}) and lowest uptake of silicon was recorded in grain in treatment control (198.44 mg pot^{-1}). The highest uptake of silicon in straw (993.44 mg pot^{-1}) was recorded in CS-750 kg Si ha^{-1} and lowest (815.15 mg pot^{-1}) in treatment control. The increase in total uptake of silica with increase in levels of silicon was also reported by Talashilkar *et al*. (2000) and Mongia *et al*. (2003).

Soil properties : The pH, EC, organic carbon and calcium carbonate, available N, P and K content of soil after harvest of paddy (Table 2) were not differred significantly due to

Table 2. Effect of sources and levels of silicon on chemical properties of soil after harvest of paddy.

Treatment	pH (1:2.5)	EC (dS m^{-1})	Organic carbon (%)	$CaCO_3$ (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available Si (kg ha^{-1})	Water soluble Si (kg ha^{-1})
T_1 Control	6.20	0.12	1.29	0.5	262.38	22.18	258.41	174.20	29.19
T_2 RHA 250	6.22	0.14	1.34	0.6	260.29	22.85	256.20	239.01	35.24
T_3 RHA 500	6.22	0.16	1.36	0.7	259.24	23.07	256.16	264.51	36.46
T_4 RHA 750	6.23	0.16	1.36	0.8	258.20	23.17	255.85	276.27	36.70
T_5 CS 250	6.21	0.15	1.34	0.6	262.38	23.07	255.78	241.32	35.35
T_6 CS 500	6.22	0.15	1.36	0.6	261.33	23.44	255.63	265.81	36.49
T_7 CS 75O	6.22	0.16	1.37	0.8	259.24	23.68	254.16	278.21	36.81
T_8 BA 250	6.20	0.15	1.31	0.5	258.20	22.62	258.00	237.66	34.98
T_9 BA 500	6.22	0.15	1.35	0.6	257.15	22.62	257.73	263.57	36.33
T_{10} BA 750	6.23	0.16	1.35	0.7	256.11	22.85	257.72	272.53	36.53
T_{11} FA 250	6.21	0.14	1.33	0.6	258.72	22.62	257.50	238.26	35.09
T_{12} FA 500	6.21	0.15	1.35	0.7	258.20	22.79	257.17	264.32	36.39
T_{13} FA 750	6.22	0.16	1.36	0.8	257.15	23.12	256.98	273.28	36.56
S.E±	0.01	0.01	0.02	0.07	2.02	0.27	0.83	6.36	0.37
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	18.52	1.06

application of silicon through different sources. The plant available silicon increased significantly over the control due to application of silicon through different sources. The significantly highest available silicon (278 kg ha^{-1}) was observed in CS-750 kg Si ha^{-1} which was followed by RHA-750 kg Si ha^{-1}, FA-750 kg Si ha^{-1}, BA-750 kg Si ha^{-1}, CS-500 kg Si ha^{-1}, RHA-500 kg Si ha^{-1}, FA-500 kg Si ha^{-1} and BA-500 kg Si ha^{-1}. Similarly, significantly highest water soluble silicon (36.81 kg ha^{-1}) was recorded in treatment CS-750 kg Si ha^{-1}. The increase in available silicon and water soluble silicon after harvest of paddy over control might be due to residual effect of application of silicon through different silicon sources. Similar residual effects of calcium silicate were reported by Liang *et al*. (1994) and Dhamapurkar (1999). Considering the availability and cost of material, bagasse ash proved to be good source of silicon for paddy.

The results of the present investigation indicated that application of silicon @ 250 kg ha^{-1} significantly increased growth and yield of paddy, uptake of silicon and macronutrients (N, P, K) through different sources (Rice Husk Ash, Bagasse Ash, Fly Ash and Calcium Silicate). However, considering the availability and cost, bagasse ash may be used as good source of silicon for increasing the growth, yield and nutrient uptake by upland paddy and chemical properties of soil.

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Effect of New Fungicidal Molecules Against Early and Late Blight of Potato Caused by *Phytophthora infestans* (Mont.) de Bary

Late blight is serious disease of potato taking heavy toll of the crop (Rao and Veeresh 1989; Bisht *et al.* 1997).Late blight is a polycyclic disease and both the below ground (tubers) and above ground (foliar) parts of the plant can be affected. Although the pathogen, *P. infestans*, has a complex life cycle, which includes both aerial and soil phases, it is most often viewed as a typical, aerial pathogen with prolific production of short lived asexual infective sporangia (Erwin and Ribeiro, 1996). Currently, when environmental conditions favor the pathogen there are no methods to completely control late blight once it has become established within a field. The primary methods of control are the use of less susceptible cultivars and prophylactic fungicide applications to foliage in the field.

Besides a few resistant varieties, chemical management are advocated by earlier worker with some success (Jehel and Wood 1999; Lansade 2000; Till and Fish 2001; Khot *et al*. 2007). In the present investigation efficacy of Azoxystrobin 23 per cent SC (Amistar 25SC) against late blight in potato is undertaken field condition.

The field trial was conducted at Regional Wheat Rust Research Station, Mahabaleshwar during *rabi* 2007-08 and 2008-09 in a randomised block design with three replications. The susceptible cultivar Kufri Pukharaj was used as a experimental host. The gross and net plot sizes were 4.2 x 3.15 m and 3.6 x 2.25 m, respectively with spacing 45 x 30 cm2. Fertilizers at 120:60:60 kg NPK were given through urea, single super phosphate and sulphate of potash respectively. Half dose of nitrogen with full dose of phosphorus and potash were applied at the time of planting and remaining half dose of nitrogen was applied after one month of planting. Experimental plots were kept weed free by hand weeding. Recommended insecticides such as Endosulphan @ 0.25 per cent, Monocrotophos @ 0.15 per cent were sprayed twice i.e. 30 and 45 days after planting to control foliar pests. Irrigation was given as per need. The treatment includes T_1 - Untreated control, T_2 - Azoxystrobin 23% SC (Amistar 25SC) @ 0.05% (250 ml ha^{-1}), T_3 - Azoxystrobin 23% SC (Amistar 25SC) @ 0.075% (375 ml ha^{-1}), T_4 - Azoxystrobin 23% SC (Amistar 25SC) @ 0.1% (500 ml ha^{-1}), T_5 - Metalaxyl-M+MZB (6 + 64 WP) @ 0.25% (1250 g ha^{-1}), T_6 - Mancozeb 75 WP @ 0.25% (1250 g ha^{-1}), T_7 - Chlorothalonil 75 WP (Kavach) @ 0.3% (1500 g ha^{-1}) and T_8 - Cymoxanil + Mancozeb 72 WP@ 0.3% (1500 g ha^{-1}).

Total three sprays were given. First spray was given as soon as the first disease incidence in traces was noticed. Subsequent two sprays were given at an interval of 10 days. The disease intensity of early and late blight of potato was recorded from the randomly selected 5 plants per plot based on 0-9 scale (Mayee and Datar, 1986). Disease incidence was monitored one day before each spray and final observation on PDI (Per cent Disease Index) was recorded 10 days after final spray. The yield of potato $plot^{-1}$ was recorded after harvesting (tonnes ha^{-1}).

The phytotoxic effect such as yellowing, chlorosis, necrosis, hyponasty and epinasty were recorded 1, 3, 5, 7 and 10 days after 1st spraying. Scale of rating for phytotoxicity symptoms 0 (No symptoms), 1 (01-10), 2 (11-

20), 3 (21 -30), 4 (31 -40), 5 (41 -50), 6 (51-60), 7 (61-70), 8 (71 -80), 9 (81-90) and 10 (91-100) per cent of parts showing symptoms.

The per cent intensity of late and early blight diseases of potato and tuber yield per hectare after crop harvest are presented in Table 1, which indicated that significant difference existed between treatments for these parameters. As regards to late blight intensity, all the fungicidal applications had significantly less disease than control. Amongst fungicidal treatments minimum disease was observed in Azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.1 per cent which was on par with azoxystrobin 23 per cent SC (Amistar 25 SC)@ 0.075 per cent and both these treatments had significantly less disease than rest of the treatments. These treatments were followed by azoxystrobin 23 per cent SC (Amistar 25SC)@ 0.05 per cent, which was on par with metalaxyl-M+MZB (6 + 64 WP) @ 0.25 per cent and had significantly less disease than remaining other treatments. It was followed by mancozeb 75 WP @ 0.25 per cent and cymoxanil +mancozeb 72 WP@ 0.3 per cent. These treatments had significantly less disease than chlorothalonil 75 WP (Kavach) @ 0.3 per cent. Control treatment had significantly highest disease as compared to fungicidal applications.

Early blight disease intensity varied significantly between treatments. All the fungicidal applications had significantly less disease than control. Amongst fungicidal treatments minimum disease was observed in azoxystrobin 23 per cent SC (Amistar 25SC)@ 0.1 per cent, which had significantly less disease than rest of the treatments. It was followed by azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.075 per cent, which had significantly less disease than remaining other treatments. Next promising treatment metalaxyl-M+MZB (6 + 64 WP) @ 0.25 per cent was on par with Azoxystrobin 23 per cent SC (Amistar 25SC)@ 0.05 per cent and had significantly, less disease than mancozeb 75 WP @ 0.25 per cent, chlorothalonil 75 WP (Kavach) @ 0.3 per cent and cymoxanil + mancozeb 72 WP@ 0.3 per cent. Azoxystrobin 23 per cent SC (Amistar 25SC) @ 0.05 per cent was on par with mancozeb 75 WP @ 0.25 per cent and had significantly less disease than

Table 1. Effect of different fungisides on late and early blight diseases and tuber yield of potato during 2007-08.

Treatment	Dose (ha^{-1})	Late blight		Early blight		Yield ($t\ ha^{-1}$)	Yield increase over control (%)
		Mean PDI	PDC	Mean PDI	PDC		
Untreated control	-	95.55 (86.91)	-	65.85 (54.24)	-	13.78	-
Amistar (Azoxystrobin) 23% SC @ 0.05 %	250ml	57.03 (49.05)	40.31	36.29 (37.00)	44.88	16.25	15.20
Amistar (Azoxystrobin) 23% SC @ 0.075 %	375ml	49.62 (44.79)	48.06	28.88 (32.52)	56.14	18.20	24.28
Amistar (Azoxystrobin) 23% SC @ 0.1 %	500ml	45.18 (42.24)	52.71	24.44 (29.60)	62.88	21.30	35.30
Metalaxyl-M+MZB (6 + 64 WP) @ 0.25%	1250 g	58.51 (49.90)	38.76	34.81 (36.14)	47.13	16.40	15.97
Mancozeb 75 WP @ 0.25 %	1250 g	65.92 (54.28)	31.00	39.25 (38.80)	40.39	18.35	24.90
Chlorothalonil 75 WP (Kavach) @ 0.3 %	1500g	74.80 (59.96)	21.71	50.23 (45.11)	23.73	21.05	34.53
Cymoxanil + Mancozeb 72 WP@ 0.3%	1500g	67.40 (55.20)	29.46	43.69 (41.39)	33.65	20.35	30.77
SE±		1.02		0.79		0.35	
CD at 5%		2.87		2.22		0.99	

* Figures in parentheses are arc sin transformed values., PDI: Per cent disease intensity., PDC: Per cent disease control over untreated control.

chlorothalonil 75 WP (Kavach) @ 0.3 per cent and cymoxanil + mancozeb 72 WP @ 0.3 per cent. Cymoxanil + mancozeb 72 WP @ 0.3 per cent had significantly higher disease than all the other fungicidal applications during 2007-08.

The per cent intensity of late and early blight diseases of potato and tuber yield per hectare after crop harvest during 2008-09 are presented in Table 2 which indicated that significant difference existed between treatments for these parameters. All the fungicidal treatments had significantly less late-blight disease intensity than control. Amongst fungicidal treatments, azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.1 per cent had significantly less disease than rest of the treatments. It was followed by azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.075 per cent which was on par with azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.05 per cent and had significantly less disease than remaining other treatments. Azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.05 per cent was on par with metalaxyl-M+MZB (6 + 64 WP) @ 0.25 per cent and had significantly less disease than mancozeb 75 WP @ 0.25 per cent, cymoxanil + mancozeb 72 WP@ 0.3 per cent and chlorothalonil 75 WP (Kavach) @ 0.3 per cent. Metalaxyl-M+MZB (6 + 64 WP) @ 0.25 per cent was on par with mancozeb 75 WP @ 0.25 per cent and had significantly less disease than cymoxanil + mancozeb 72 WP@ 0.3 per cent and chlorothalonil 75 WP (Kavach) @ 0.3 per cent, while the latter treatment was par with cymoxanil + mancozeb 72 WP@ 0.3 per cent and had significantly less disease than chlorothalonil 75 WP (Kavach) @ 0.3 per cent.

Early blight disease intensity varied significantly between treatments. All the fungicidal applications had significantly less disease than control. Amongst treatments minimum disease was observed in treatment azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.1 per cent, which was on par with azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.075 per cent and both these treatments had significantly less disease than rest of the treatments. It was followed by Amistar (Azoxystrobin) 23 per cent SC @ 0.05 per cent which was on par with metalaxyl-M+MZB (6 + 64 WP) @ 0.25 per cent and had significantly less disease than remaining treatments.

Table 2. Effect of Amistar (azoxystrobin) 23% SC on late and early blight diseases and tuber yield of potato 2008-09.

Treatment	Dose (ha^{-1})	Late blight		Early blight		Yield (t ha^{-1})	Yield increase over control (%)
		Mean PDI	PDC	Mean PDI	PDC		
Untreated control	-	97.02 (81.93)	-	60.74 (51.21)	-	14.62	-
Azoxystrobin 23% SC (Amistar 25 SC) @ 0.05%	250ml	62.21 (32.08)	35.88	34.81 (36.12)	42.69	21.60	47.74
Azoxystrobin 23% SC (Amistar 25 SC) @ 0.075%	375ml	56.30 (48.61)	41.97	27.40 (31.51)	54.89	22.80	55.95
Azoxystrobin 23% SC (Amistar 25 SC) @ 0.1%	500ml	46.67 (43.06)	51.90	23.70 (29.07)	60.98	23.87	63.27
Metalaxyl-M+MZB (6 + 64 WP) @ 0.25%	1250 g	66.66 (54.73)	31.29	39.38 (38.76)	35.38	21.60	47.74
Mancozeb 75 WP @ 0.25%	1250 g	71.85 (57.96)	25.94	42.96 (40.93)	29.27	19.77	35.23
Chlorothalonil 75 WP (Kavach) @ 0.3%	1500g	82.21 (65.13)	15.26	54.07 (47.34)	10.98	16.05	9.78
Cymoxanil + Mancozeb 72 WP@ 0.3%	1500g	77.77 (61.92)	19.84	47.40 (43.48)	21.96	17.08	16.83
SE±		1.73		1.35		0.29	
CD at 5%		4.89		3.80		0.82	

* Figures in parentheses are arc sin transformed values., PDI: Per cent disease intensity., PDC: Per cent disease control over untreated control.

Metalaxyl-M+MZB (6 + 64 WP) @ 0.25 per cent was on par with mancozeb 75 WP @ 0.25 per cent and had significantly less disease than cymoxanil + mancozeb 72 WP@ 0.3 per cent and chlorothalonil 75 WP (Kavach) @ 0.3 per cent. Mancozeb 75 WP @ 0.25 per cent was on par with cymoxanil+mancozeb 72 WP@ 0.3 per cent and had significantly less disease than chlorothalonil 75 WP (Kavach) @ 0.3 per cent.

Tuber yield per hectare during 2007-08 was significantly higher in all the fungicidal treatments than control. Amongst fungicidal application azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.1 per cent, chlorothalonil 75 WP (Kavach) @ 0.3 per cent and cymoxanil + mancozeb 72 WP @ 0.3 per cent were on par with each other and had significantly higher tuber yield than rest of the treatments. Mancozeb 75 WP @ 0.25 per cent and Azoxystrobin 23 per cent SC (Amistar 25 SC)@ 0.075 per cent were significantly superior to metalaxyl-M+MZB (6 + 64 WP) @ 0.25 per cent. and Azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.05 per cent.

Tuber yield per hectare 2008-09 was significantly higher in all the fungicidal treatments than control. Amongst fungicidal application azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.1 per cent had significantly higher tuber yield than rest of the treatments. Next best treatment was azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.075 per cent, which had significantly higher yield than remaining treatments. It was followed by azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.05 per cent and metalaxyl-M+MZB (6 + 64 WP) @ 0.25 per cent which had significantly higher yield than mancozeb 75 WP @ 0.25 per cent, cymoxanil + mancozeb 72 WP@ 0.3 per cent and chlorothalonil 75 WP (Kavach) @ 0.3 per cent. Next promising treatments were mancozeb 75 WP @ 0.25 per cent, cymoxanil + mancozeb 72 WP@ 0.3 per cent and chlorothalonil 75 WP (Kavach) @ 0.3 per cent in order of merit where the preceding treatment was superior to succeeding treatments. Considering disease control ability (Late and Early blights) and tuber yield of potato, azoxystrobin 23 per cent SC (Amistar 25 SC) @ 0.1 per cent can be considered as superior over other treatments. Earlier workers (Abeygunawardena 1999; Davidson 1999; Jehale and Wood 1999; Lansade 2000) have reported that copper containing fungicides are effective in the management of the disease was accomplished by combining copper based fungicide with arsenicals and dithiocarbamate (Jehale and Wood 1999; Till and Fish 2001). Chattopadhya and Mukherji (1998) and Abeygunawardena (1999) suggested application of dithiocarbamate fungicide for the management of late blight of potato.

As regards phytotoxic and phytotonic symptoms none of the treatment showed such types of symptoms on potato leaves at all the concentrations used in the experiments.

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Studies on Genetic Variability for Grain Yield and Quality Attributes of Elite Rice Genotypes for Eastern Zone of Uttar Pradesh

Development of high yielding varieties with superior milling and cooking qualities is now one of the most important objectives in all rice improvement programmes. Thus breeding material is evaluated for four components of grain quality *viz*., grain size, shape and appearance, cooking and eating characteristics and nutritive qualities. (Shobha Rani *et al*., 2012). In the present study, genetic variability and evaluation of early duration coupled with higher seed yield and good grain quality parameters were taken into consideration.

The investigation was carried out during *kharif* 2012 at Department of Genetic and Plant Breeding, Faculty of Agriculture, Sam Higginbottom Institute of Agricultural, Technology and Sciences, Allahabad, Uttar Pradesh. A total of 36 elite rice genotypes were taken for the study. The experiment was laid out in a randomized block design with three replications. The spacing of 15 cm between the plants within row and 20 cm between the rows was maintained. All the agronomic package of practices were carried out to ensure healthy plant growth. Observations were recorded on thirteen quantitative traits *viz*., days to 50 per cent flowering, plant height, number of tillers plant^{-1}, panicle length, test weight and grain yield plant^{-1}. Regarding cooking quality, gel consistency and gelatinization temperature were recorded. Tne analysis of variance was done as suggested by Panse and Sukhatme (1967). Variability for different characters was estimated by Burton and De Vane (1953). Heritability and expected genetic advance was calculated according to Hanson *et al*., (1956) and Johnson *et al*., (1955) respectively.

The analysis of variance revealed (Table 1) significant difference among the genotypes for all the quantitative characters studied. Similar results were obtained by Singh *et al*. (2009) and Jayasudha and Sharma (2010) who also observed significant variability for yield and quality components in rice. Based on the mean

Table 1. Mean, range and genetic parameters for yield and yield related characters in rice genotypes.

Characters	Mean	Range		CV		h^2 (bs) (%)	GA	GA as per cent of mean
		Mini-mum	Maxi-mum	GCV (%)	PCV (%)			
Days to 50% flowering	97.72	86.00	108.33	6.21	6.22	99.49	12.47	12.76
Plant height (cm)	115.90	89.33	144.00	9.88	9.89	99.85	23.58	20.34
Flag leaf length (cm)	37.06	21.66	46.00	11.60	11.68	98.67	8.80	23.75
Flag leaf width (cm)	1.40	1.08	1.67	10.16	10.36	96.21	0.28	20.53
Tillers hill^{-1}	12.44	8.00	18.33	19.73	19.85	98.87	5.03	40.43
Panicle hill^{-1}	12.20	803	18.96	22.04	22.07	99.67	5.53	45.33
Panicle length (cm)	27.50	22.33	32.33	9.71	9.88	99.54	5.40	19.66
Spikelets panicle^{-1}	196.64	110.66	360.00	29.74	30.06	97.87	119.19	60.61
Days to maturity	125.01	113.33	125.01	5.25	5,26	99.42	13.48	10.78
Biological yield hill^{-1}	82.93	51.66	148.00	5.25	24.55	99.94	41.92	50.54
Harvest index	36.28	18.50	61.66	21.49	21.54	99.51	16.02	44.16
Test weight (g)	22.14	14.21	22.14	19.33	19.48	98.42	8.74	39.50
Grain yield hill^{-1}	29.61	15.00	29.61	23.71	25.27	87.98	13.56	45.81

performance among 36 genotypes of rice CR2644-2-6-4-3-2(45.66) with early duration (107days) is suited to Eastern Zone of Uttar Pradesh, CR2701-1-47-IR 84882-8-120 (43.33) and PAU 3879-87-1-1 (42.66) were found to the best genotype for grain yield hill^{-1}. The highest gel consistency was recorded for CR2644-2-6-4-3-2 (soft), TRC 2008-6 (medium soft), and PAU 3879-87-1-1 (medium).

The phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters studied (Table 1). The genotypic and phenotypic coefficient of variation was maximum for number of spikelets panicle^{-1} followed by biological yield hill^{-1}. A close relation between GCV and PCV was found in all the charactes and PCV values were slightly greater than GCV, revealing very little influences of environment for their expression.

The heritability estimated in narrow sense was high for almost all the traits (Table 1). The maximum heritability was recorded for biological yield hill^{-1} (99.94), followed by plant height (99.80). Similar results have been reported by Bhandarkar *et al*. (2002); Kuldeep *et al*. (2004); Sabesan *et al*. (2009) and Jayasudha and Sharma (2010). The maximum genetic advance was observed in spikelets panicle^{-1} (1199.19) followed by biological yield hill^{-1} (41.92), however, the maximum genetic advance (as per cent of mean) was observed for spikelets panicle^{-1} (60.65), followed by biological yield (50.54).

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Variability and Correlation Coefficient Analysis in Fieldpea (*Pisum sativum* L.)

Fieldpea (*Pisum sativum* L.) is the most important legume crops of India, largely confined to cooler temperate zone between the tropic of cancer and mediterranean region. Peas are a rich source of protein having essential amino acids particularly lysine. This is considered as the cheapest source of protein in diet. In India, fieldpea is grown in an area of 0.385 million hectares with production of 3.55 million tons (Anonymous, 2012). Availability of genetic variability is crucial for any breeding programme, which provides an opportunity for selection of desirable genotypes. Similarly, mutual association of plant characters which is determined by correlation coefficient is useful for indirect selection. Significance of this makes the crop to minimize the risk and enables to fit to a sustainable and economically profitable production system. This further permits evaluation of relative influence of various components on yield. Determination of correlation coefficients between yield contributing characters and yield is important criteria for the selection of favorable plant types for effective pea breeding programmes. Therefore, the present investigation was undertaken to gather information on these aspects on fieldpea.

The experimental material for the present investigation consisted of 12 genotypes obtained from the Department of Genetics and Plant Breeding, SHIATS under All India Coordinated Research Project for improvement of MULLaRP crops, (ICAR), Indian Institute of Pulses Research, Kanpur. The present experiment was conducted in a randomized block design at Field Experimentation Centre, Department of Genetics and Plant Breeding, Allahabad during *rabi*, 2012. Recommended

cultural practices were followed to raise healthy crop. Five competitive plants from each genotype were randomly selected for recording observations on eight characters, *viz*., days to 50 per cent flowering, plant height (cm), number of pods plant^{-1}, days to maturity, number of seeds pod^{-1}, pod length (cm), seed index (g) and seed yield plant^{-1} (g). Analysis of variance was carried out as per standard procedure (Fisher, 1936), Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) (Burton, 1952), heritability (Burton and Devane, 1953), genetic advance (Lush, 1949) and genotypic and phenotypic correlation (Al-Jibouri *et al*., 1958) were estimated.

The analysis of variance showed significant differences among genotypes for all the characters under study, clearly indicating the

Table 1. Coefficient of variation, heritability and genetic advance for eight yield contributing characters of fieldpea genotypes.

Characters	Coefficirnts of variation		Heritability (bs) (%)	Genetic advance	Genetic advance as per cent of mean
	GVC (%)	PCV (%)			
Days to 50% flowering	7.33	7.54	95.00	12.11	14.69
Plant height	48.10	48.42	99.00	115.66	98.42
No. of pods plant^{-1}	15.45	23.14	45.00	6.80	27.23
Days to maturity	2.34	2.79	70.00	5.22	4.03
Pod length	6.27	7.81	64.00	0.66	10.37
No. of seeds pod^{-1}	16.40	20.36	65.00	1.42	27.22
Seed index	7.09	8.94	63.00	2.02	11.56
Seed yield plant^{-1}	24.36	33.69	52.00	7.70	36.29

Table 2. Estimates of correlation coefficients of yield component characters with seed yield in fieldpea at genotypic and phenotypic levels.

Characters	Level	Plant height	Pods plant^{-1}	Days to maturity	Seeds pod^{-1}	Pod length	Seed index	Seed yield plant^{-1}
Days to 50% flowering	rg	-0.727**	-0.525**	0.660**	0.401*	0.089	-0.068	-0.596**
	rp	-0.698**	-0.313	0.586**	0.258	0.103	-0.078	-0.427*
Plant height	rg		0.744**	-0.481**	-0.764**	-0.296	-0.180	0.930**
	rp		0.513**	-0.393*	-0.612**	-0.234	-0.129	0.650**
No. of pods plant-1	rg			-0.519**	-1.000**	0.016	-0.548**	0.219
	rp			-0.321	-0.599**	0.0005	-0.238	0.172
Days to maturity	rg				0.581**	0.165	0.179	-0.533**
	rp				0.404*	0.147	0.087	-0.393*
No. of seeds pod-1	rg					-0.253	0.474**	-0.691**
	rp					0.101	0.461*	-0.481**
Pod length	rg						-0.434*	-0.205
	rp						-0.241	-0.261
Seed index	rg							-0.155
	rp							-0.100

* and ** significant at 5 and 1 per cent level of significance respectively.

presence of genetic variability in the material for all eight characters. This also suggested that selection can be effectively applied for these characters for seed yield improvement. A comparison by the estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) suggested that estimates PCV were higher than the estimates of GCV for all the characters (Table 1.). This may be due to the involvement of environment and genotype environment interaction effects in characters expression. The estimates of GCV ranged from 2.34 for days to maturity to 48.10 for plant height. The estimates of GCV were high for seed yield plant^{-1} (24.36), number of seeds pod^{-1} (16.40) and number of pods plant^{-1} (15.45). Similarly the estimates of PCV ranged from 2.79 for days to maturity to 48.42 for plant height. The estimates of PCV were high for seed yield plant^{-1} (33.69), number of pods plant^{-1} (23.14) and number of seeds pod^{-1} (20.36). The findings of the present investigation are supported by Sureja and Sharma (2000) and Sirohi *et al*. (2006).

Seed yield plant^{-1} had positive and significant association with plant height at genotypic level (0.930) and at phenotypic level (0.650) (Table 2). Seed yield plant^{-1} had negative and significant association with days to flowering (-0.596 and -0.427), days to maturing (-0.533 and -0.393) and number of seeds pod^{-1} (-0.691 and -0.481) at genotypic and at phenotypic levels, respectively. Among other inter se associations, days to 50 per cent flowering with days to maturity (0.660 and 0.586), plant height with number of pods plant^{-1} (0.744 and 0.513), days to maturity with number of seeds pod^{-1} (0.581 and 0.404) and number of seeds pod^{-1} with seed index (0.474 and 0.461) had highly significant and positive associations at genotypic and phenotypic levels, respectively. This indicated that with an increment of one variable, other variable also increase. The findings of the present investigation are supported by Singh and Singh (2005), Sardana *et al*. (2007), Usmani and Dubey (2007), Singh *et al*. (2008) and Singh *et al*. (2011).

Plant height and seed yield plant^{-1} recorded high estimates of GCV, PCV and heritability, while plant height and seed yield plant^{-1} recorded high estimates of genetic advance as per cent of mean. Seed yield plant^{-1} recorded significant correlation with plant height, days to flowering, days to maturity and number of seeds pod^{-1}. Hence plant height, number of pods plant^{-1}, number of seeds pod^{-1} and days to maturity appeared to be the selection indices for seed yield improvement in fieldpea.

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In Vitro Screening of Cotton Genotypes for *Fusarium* Wilt Resistance Using Fusaric Acid

Wilt caused by *Fusarium* oxysporum f.sp. vasinfectum (FOV) is one of the limiting factor in desi cotton cultivation in India. The disease is reported to cause losses to the extent of 5-60 per cent in diploid cotton species i.e. *Gossypium arboreum* and *G. herbaceum* (Dastur *et al*. 1960). Due to soil borne nature of the pathogen the disease is difficult to manage. The development of disease resistant genotypes is surest and cheapest method. A technique for screening of diploid cotton genotypes against *Fusarium* wilt was developed which is well known as "Poona technique" (Uppal, 1938). This technique is still followed today at All India Coordinated Cotton Improvement Project, Pune Centre for assessing the cotton genotypes against wilt. However, this method is laborious and time consuming, requiring about 9-10 months. Also, well developed and maintained wilt sick plot and glasshouse facilities are prime requirements for this technique.

Considering all these, a simple technique for rapid screening of cotton genotypes against *Fusarium* wilt based on the response of the genotypes to the toxin fusaric acid is reported here. Thirty two F_5 generation genotypes (cross- JLA 794 x PA-402) along with wilt resistant genotypes AKA-7 and susceptible DH-2 were assessed during the present investigation. The seeds of all the genotypes were surface sterilized and germinated by Paper towel method. Ten days old seedlings were used to study their response to varied concentrations of fusaric acid *viz*., 15, 25 and 35 PPM. The cotyledons attached to the seedlings were removed and the seedlings were then placed in test tubes containing 0, 15, 25 and 35 PPM fusaric acid (10 seedlings concentration^{-1}). The test tubes were covered with aluminum foil to protect the roots from light and incubated at room temperature. The seedlings were observed for number of days required for wilting. The genotypes were also tested under sick soil for their wilt reaction. Sick soil was prepared, filled in earthen pots and sown with cotton seeds (10 seeds pot^{-1}). Ten pots were used for each genotype. The pots were kept in glasshouse and observations on wilt incidence

Table 1. Reaction of cotton genotypes to fusaric acid and sick soil.

Cotton genotype	Days for wilting			Wilt incidence (%)
	15 ppm	25 ppm	35 ppm	
F-5/09-1-1	7	5	3	20.15
F-5/09-1-2	15	7	6	3.50
F-5/09-1-3	7	4	3	22.35
F-5/09-1-4	13	6	4	75.00
F-5/09-1-5	5	4	3	24.13
F-5/09-1-6	6	4	3	29.30
F-5/09-1-8	5	4	2	35.00
F-5/09-1-9	6	4	3	24.50
F-5/09-1-11	11	5	3	15.00
F-5/09-1-12	13	5	4	12.50
F-5/09-1-13	6	4	2	41.00
F-5/09-1-14	5	4	2	45.00
F-5/09-2-1	5	4	2	39.60
F-5/09-2-2	13	4	3	11.20
F-5/09-2-3	12	5	3	12.30
F-5/09-2-5	5	6	4	51.25
F-5/09-2-6	5	4	4	47.69
F-5/09-2-7	7	4	3	38.90
F-5/09-2-8	15	7	6	2.27
F-5/09-2-9	7	5	4	35.28
F-5/09-2-12	4	4	2	58.21
F-5/09-2-13	8	4	3	30.15
F-5/09-3-3	13	5	4	14.26
F-5/09-3-4	6	4	3	51.23
F-5/09-3-5	4	4	3	64.20
F-5/09-3-6	5	4	4	67.25
F-5/09-3-7	15	7	5	2.90
F-5/09-3-8	6	5	4	62.22
F-5/09-3-9	5	4	3	65.27
F-5/09-3-10	5	4	2	70.00
F-5/09-3-11	6	4	3	67.14
F-5/09-3-12	7	4	4	64.14
DH-2	4	2	2	100.00
AKA-7	15	7	6	1.20

were recorded. The results are presented in Table 1.

It was observed that fusaric acid at concentration of 25 and 35 ppm caused complete death of cotton seedlings in both resistant and susceptible genotypes within seven days. Symptoms were characterized by breakage of foliage parts at crown area that lead to death of seedlings. However, at 15 ppm concentration, wilting and death of seedlings in susceptible-genotype DH-2 occurred within four days, whereas the resistant genotype AKA-7 was able to survive up to 15 days. In control (0 ppm) seedlings of all the cotton genotypes were able to survive up to 15 days when the experiment was terminated. Thus, fusaric acid at 15 ppm differentiated resistant and susceptible cotton genotypes by causing early death of seedlings in susceptible genotype. Amongst the 32 F_5 generation cotton genotypes, the seedlings of three genotypes *viz*., F-5/09-1-2, F-5/09-2-8 and F-5/09-3-7 remained healthy upto 15 days, whereas remaining genotypes exhibited wilting within 4 to 13 days. Similarly, these three cotton genotypes showed less than 5 per cent of wilt incidence when screened under glasshouse conditions in sick soil. Earlier Ravikumar and Ratna Babu (2007) used fusaric acid for screening chickpea genotypes for *Fusarium* wilt resistance and obtained similar results. Further it was reported that with use of this technique it is possible to differentiate between early and late wilting genotypes in chickpea.

From the results it is concluded that fusaric acid at 15 ppm concentration differentiates resistant and susceptible genotypes and such test can be used for screening of cotton genotypes for *Fusarium* wilt resistance.

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Genetic Variability and Character Association in Groundnut

Groundnut, (*Arachis hypogaea* L.) is one of the important oilseed crop. However, it is prone subjected to various diseases which results into reduce groundnut yield and qualities. The existing fungicidal control measures available for various diseases are not economical apart from causing environmental pollution. Hence an economic and eco-friendly way to manage the disease effectively is the development of high yielding disease resistant varieties resistant to late leaf spot disease. Genetic variability is the most important feature of any crop improvement. The coefficient of variation expressed in phenotypic and genotypic levels are used to compare the variability observed among different characters. The knowledge of estimated and genetic advance of character indicates the scope of improvement through selection. The correlation coefficient helps the breeder to understand correlation between and among the characters. Therefore, the present studies were undertaken to assess the extent of genetic variability, heritability, genetic advance and character association for yield, and disease resistance components in groundnut.

Experimental material comprised of twenty five genotypes including five checks. The genotypes were evaluated in a randomized block design with three replications during *kharif* 2010 at Oilseeds Research Station, Latur (MS). Each genotype was sown in three rows of 5.0 m length with a spacing of 30 x 10 cm. All the necessary cultural practices were under taken to maintain healthy crop except plant protection for late leaf spot disease. The observations were recorded on five randomly selected plants for each genotype in each replication. The characters studied were pod yield plant^{-1} (g), kernel yield plant^{-1} (g), test weight (g). Shelling (%), oil content (%), LLS disease severity index (%), stomata frequency mm^{-2}, stomata size (µm), non reducing sugar (mg g^{-1}), reducing sugar (mg g^{-1}), SPAD chlorophyll meter reading (SCMR) and phenol content (mg g^{-1}),

The per cent disease severity index (PDI) was calculated on leaf lesion of different groundnut cultivars at the time of harvest by using following formula.

$$PDI = \frac{\text{Sum of all rating}}{\text{No. of leaves scored}} \times \frac{100}{\text{Maximum score}}$$

Stomata frequency per mm^2 was calculated by using herbofix impression method using fevicol sticker from middle adaxial and abaxial surface of second leaflet on main branch of each genotype of ten selected plant (Nayeem and Dalvi, 1989). Total sugar content (Dubois *et al*., 1956) and reducing sugar content (Miller, 1972) in the leaves were estimated 75 days after sowing. Total phenol content of leaves was estimated as per Sadasivam and Manickam (1996). The phenotypic and genotypic correlations and parameters of genetic variability were estimated following Singh and Choudhary (1977).

The analysis of variances revealed significant differences among the genotypes for all the traits indicating the presence of variability. Wide range of variation was observed for per cent LLS disease severity followed by harvest index, test weight and shelling (%). The magnitude of GCV and PCV were high for LLS disease severity, reducing sugar, pod yield plant^{-1}, kernel yield plant^{-1} and non reducing sugar (Table 1). These findings

were in accordance with earlier report of John *et al*. (2006) for LLS severity, Vasanthi *et al*. (1998) and Mishra *et al*. (2000) for reducing sugar and Vekataravana *et al.* (2007) for pod yield plant^{-1} and kernel yield plant^{-1}. The lowest value for GCV and PCV were observed for stomata frequency, oil content and shelling. Similar observations were reported by Wani *et al*. (2004) for shelling and oil content. The least differences between PCV and GCV were for LLS disease severity, test weight, oil content, stomata frequency, stomata breadth, non reducing sugar, reducing sugar and phenol content indicating the maximum reflection of genotype into phenotype.

High heritability coupled with high genetic advance as per cent of mean was observed for LLS disease severity, reducing sugar, pod yield plant^{-1} and kernel yield plant^{-1}, harvest index and non reducing sugar suggested that the genotypic variation for such characters are probably due to high additive genetic effects. Thus direct selection will be more effective for improvement of these traits. These results are in accordance with earlier report of Vasanthi *et al*. (1998) and John *et al*. (2006) for LLS disease severity; Chari (2005) for non reducing sugar, pod yield plant^{-1} and kernel yield plant^{-1}. High heritability with moderate genetic advance as per cent of mean was noticed for test weight, stomata length, stomata breadth, SCMR and phenol content. High heritability with low genetic advance as per cent of mean was being also observed for stomata frequency and oil content indicating influence of non additive gene action. Thus selection for these characters may not be fruitful or useful. Suneetha *et al*. (2004) reported similar finding for oil content.

The data in respect of characters association for 17 traits are presented in Table 2. Among all the traits, kernel yield plant^{-1}, harvest index, phenol content, non reducing sugar and test weight exhibited positive and significant correlation with pod yield plant^{-1}. The similar kind of associations were reported by Ramesh

Table 1. Variability parameters in groundnut.

Characters	Range	Mean	GCV (%)	PCV (%)	Heritability (%) (bs)	G. A. as (%) of mean
Kernel yield plant^{-1} (g)	0.93-6.62	4.26	42.77	45.41	88.7	82.99
Test weight (g)	29.34-62.88	41.98	21.59	21.64	99.5	44.34
Shelling (%)	53.27-70.37	62.73	5.53	8.73	40.25	39.42
Oil content (%)	41.55-48.40	46.29	4.01	4.08	96.6	8.12
Harvest index (%)	13.91-51.60	33.99	26.10	32.26	65.4	83.47
LLS severity (%)	0.41-67.26	39.73	76.19	76.19	100	156.93
Stomatal frequency mm^{-2} (Adaxial)	105.20-115.04	110.06	3.16	3.17	99.4	6.49
Stomatal frequency mm^{-2} (Abaxial)	103.85-114.11	108.84	3.25	3.28	98.1	6.63
Stomata length (µm) (Adaxial)	14.07-22.20	17.32	15.18	15.22	99.4	31.16
Stomata length (µm) (Abaxial)	12.14-21.25	16.38	15.66	15.99	96.0	31.61
Stomata breadth (µm) (Adaxial)	5.64-12.44	9.69	23.56	23.66	99.1	48.29
Stomata breadth (µm) (Abaxial)	4.66-11.34	8.63	25.56	26.56	92.6	49.47
Non reducing sugar (mg g^{-1})	5.11-14.85	9.08	39.38	39.61	98.8	80.65
Reducing sugar (mg g^{-1})	0.63-2.63	1.79	43.39	43.55	99.3	89.29
SCMR	22.65-34.20	28.06	11.73	12.75	84.6	22.23
Phenol content (mg g^{-1})	33.41-44.55	38.26	10.71	10.83	97.7	21.79
Pod yield plant^{-1} (g)	0.86-12.08	6.81	42.93	43.99	92.3	83.47

GCV- Genotypic coefficient of variation, PCV- Phenotypic coefficient of variation.

Table 2. Genotypic and phenotypic correlation coefficients in groundnut for different traits.

Characters		Kernel yield (g)	Test weight (g)	Shelling (%)	Oil content (%)	Harvest index (%)	LLS severity (%)	SF mm^{-2} (Adaxial)	SF mm^{-2} (Abaxial)	S L Ad (µm)	S L Ab (µm)	SB Ad (µm)	SB Ab (µm)	N.R. sugar (mg g^{-1})	Reducing sugar (mg g^{-1})	SCMR	Phenol content (mg g^{-1})	Pod yield (g) g^{-1})
Kernel	G	1.000	0.261*	0.058	0.275*	0.798**	-0.662**	-0.715**	-0.718**	-0.735**	-0.801**	-0.535**	-0.520**	0.666**	-0.460**	0.252*	0.673**	0.969**
yield (g)	P	1.000	0.242*	0.142	0.231	0.498**	-0.624**	-0.660**	-0.672**	-0.688**	-0.737**	-0.497**	-0.482**	0.626**	-0.430**	0.210	0.621**	0.978**
Test	G		1.000	-0.889**	0.156	0.058	-0.261*	-0.186	-0.176	-0.256*	-0.287**	-0.192	-0.133	0.227	-0.144	0.370**	0.288**	0.364**
weight (g)	P		1.000	-0.336**	0.154	0.065	-0.260*	-0.186	-0.171	-0.254*	-0.280**	-0.191	-0.127	0.225	-0.145	0.338**	0.285**	0.349**
Shelling	G			1.000	0.513**	0.025	-0.072	0.272*	0.360**	0.382**	0.462**	0.199	0.178	-0.020	0.126	0.031	0.027	-0.132
%	P			1.000	0.134	-0.008	-0.025	0.114	0.073	0.131	0.153	0.080	0.031	-0.023	0.060	-0.062	0.018	-0.038
Oil content	G				1.000	0.119	-0.582**	-0.324**	-0.297**	-0.265*	-0.274*	-0.390**	-0.294**	0.559**	-0.339**	0.380**	0.522**	0.241*
(%)	P				1.000	0.111	-0.572**	0.318**	-0.283**	-0.261*	-0.261*	-0.378**	-0.275*	0.550**	-0.332**	0.362**	0.521**	0.504**
Harvest	G					1.000	-0.372**	-0.434**	-0.504**	-0.522**	-0.583**	-0.205	-0.220	0.388**	0.428**	0.400**	0.390**	0.783**
index (%)	P					1.000	-0.301**	-0.359**	-0.394**	-0.424**	-0.481**	-0.170	-0.162	0.309**	-0.349**	0.308**	0.331**	0.504**
LLS	G						1.000	0.860**	0.854**	0.815**	0.814**	0.790**	0.750**	-0.959**	0.831**	-0.273*	-0.938**	-0.648**
severity (%)	P						1.000	0.857**	0.846**	0.812**	0.798**	0.786*8	0.722**	-0.954**	0.828**	-0.252	-0.927**	-0.623**
SF mm^{-2}	G							1.000	0.994**	0.966**	0.968**	0.901**	0.892**	-0.939**	0.843**	-0.154	-0.901**	-0.721**
adaxial	P							1.000	0.984**	0.960**	0.949**	0.895**	0.851**	-0.930**	0.837**	-0.138	-0.890**	-0.682**
SF mm^{-2}	G								1.000	0.974**	0.985**	0.861**	0.849**	-0.924**	0.840**	-0.161	-0.899**	-0.782**
abaxial	P								1.000	0.961**	0.953**	0.852**	0.816**	-0.911**	0.826**	-0.158	-0.877**	-0.689**
S L	G									1.000	0.989**	0.821**	0.815**	-0.887**	0.817**	-0.126	-0.850**	-0.743**
Ad (µm)	P									1.000	0.973**	0.814**	0.775**	-0.880**	0.812**	-0.107	-0.839**	-0.713**
S L	G										1.000	0.808**	0.799**	-0.886**	0.803**	-0.198	-0.844**	-0.825**
Ab (µm)	P										1.000	0.787**	0.741**	-0.864**	0.782**	-0.162	-0.822**	-0.773**
SB	G											1.000	0.994**	-0.897**	0.807**	-0.163	-0.860**	-0.544**
Ad (µm)	P											1.000	0.964**	-0.888**	0.800**	-0.144	-0.843**	-0.514**
SB	G												1.000	-0.865**	0.810**	-0.063	-0.841**	-0.524**
Ab (µm)	P												1.000	-0.830**	0.784**	-0.042	-0.786**	-0.488**
N.R. sugar	G													1.000	-0.886**	0.258*	0.968**	0.657**
(mg g^{-1})	P													1.000	-0.876**	0.240*	0.958**	0.635**
R. sugar	G														1.000	-0.072	-0.887**	-0.463**
(mg g-1)	P														1.000	-0.067	-0.863**	-0.444**
SCMR	G															1.000	0.240*	0.271*
	P															1.000	0.223	0.231
Phenol	G																1.000	0.663**
cont. (mg g^{-1})	P																1.000	0.625**

SF- Stomatal frequency, SL- Stomata length, SB- Stomata breadth, N.R. Sugar- Non reducing sugar, Ab- Abaxial, Ad- Adaxial * Significant at 5%, ** significant at 1%

Kumar *et al*. (2010) for kernel yield plant, harvest index and test weight; whereas pod yield plant^{-1} had negative and significant association with stomata size followed by stomata frequency, LLS disease severity and reducing sugar. The similar kind of finding was reported by Gopal *et al*. (2006) for LLS disease severity. However, LLS disease severity showed highly positive significant association with stomata frequency, stomata size and reducing sugar, where as highly significant negative association with non reducing sugar, phenol content and pod yield indicating the dependency of these characters on each other.

The inter correlation estimates revealed that kernel yield plant^{-1}, harvest index, non reducing sugar; test weight and phenol content were significantly and positively associated with each other. It indicated the possibilities of simultaneous improvement of these characters by selection. This in turn will improve the pod yield plant^{-1}, since they are positively correlated with pod yield plant^{-1}.

Thus for development of high yielding ,disease resistant varieties in groundnut due emphasis should be given on LLS severity, reducing sugar, non reducing sugar, kernel yield plant^{-1}, harvest index, stomata size and stomata frequency. All these traits had high GCV, PCV and heritability. Positive significant association of pod yield with kernel yield plant^{-1}, harvest index, phenol content, non reducing sugar and test weight and negative significant association with stomata size followed by stomata frequency, LLS disease severity and reducing sugar indicated that these characters can be improved through direct selection.

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Effect of Sowing Dates on Yield and Yield Components of Wheat Cultivars

Temperature is an important weather variable, which determines the productivity levels particularly of *rabi* crops. The effect of temperature on the wheat productivity can easily be seen in Central India because of high inter-annual fluctuations in the productivity due to fluctuations in seasonal temperature. The productivity of wheat is largely dependent on the magnitude of temperature change. One °C increase in temperature throughout the growing seasons will have no effect or slight increase on productivity in north India. But, an increase of 2°C temperature reduced potential grain yield at most of the places (Agrawal and Sinha, 1993). Time of sowing is one of the most important factors which govern the crop phenological development and total biomass production along with efficient conversion of biomass into economic yield. Delayed sowing of wheat crop is exposed to sub-optimal temperatures at establishment and supra-optimal temperatures at reproductive phases resulting into reduction of not only crop duration but also the yield (Sardana *et al.*, 1999). Temperature, being a key component of climate, determines the seeding time and consequently the rate and duration of growth and productivity of any crop.

Field experiment with wheat was conducted during the *rabi* season of 2007-08 in the research farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur, situated in South-Eastern part of Chhattisgarh (Latitudes of 21°. 16' N, Longitude 81°.36' E and Altitude 289.5 m above M. S. L). The treatments consist of four dates of sowing *viz*., 29 November (D_3), 8th December (D_2), 18th December (D_3) and 28th December (D_4) with six cultivars of wheat *viz*., Sujata (V_1), Kanchan (V_2), GW-273 (V_3), Lok-1 (V_4), Ratan (V_5) and Arpa (V_6). The treatments were replicated thrice in randomized block design with dates of sowing in main plots and cultivars of wheat in subplots. Crop was raised using appropriate package of practices. The data on meteorological parameters from the adjacent agrometeorological observatory are used for the study. Data with respect to

Table 1. Test weight (g) of wheat varieties under different sowing dates and per cent reduction in D_2, D_3 and D_4 over D_1.

Varieties	**Date of sowing**					**Percentage reduction**		
	D_1	**D_2**	**D_3**	**D_4**	**Mean**	**D_2**	**D_3**	**D_4**
Sujata	48.2	45.5	45.3	37.9	44.3	5.5	5.9	21.3
Kanchan	44.1	41.8	36.8	35.2	39.5	5.3	16.6	20.2
GW-273	46.2	44.0	41.7	37.8	42.4	4.7	9.8	18.2
Lok-1	50.4	47.3	47.1	46.1	47.7	6.2	6.6	8.5
Ratan	44.3	43.3	41.7	36.4	41.4	2.3	5.7	17.8
Arpa	44.7	43.3	43.4	41.7	43.3	3.0	2.8	6.7
Mean	46.3	44.2	42.7	39.2				
	SEm±	CD (P=0.05)						
D	0.97	2.77						
V	1.18	3.36						
D x Y	2.36	6.7						

growth, yield and yield attributes were carefully recorded from randomly selected plants. At harvest one square meter was taken randomly from the middle area of each plot to determine number of ear heads m^{-2}, length of ears (cm), no. of grains ear^{-1} head and test weight (g). Grain and straw yields (t ha^{-1}) were determined from the whole plot area at harvest.

Significantly mean maximum ear heads m-2 was observed in varieties Sujata (291.8), whereas the minimum was observed in variety GW.273 (263.7). Average maximum ear heads m-2 were significantly observed in first date of sowing as compared to delayed sowing. Similar results were earlier reported by Singh and Dixit (1985) and Behra (1994). Lowest percentage reduction in the ear head was recorded in Arpa followed by Lok-1 and highest percentage reduction was recorded with Kanchan followed by Ratan in last date of sowing as compared to first date of sowing.

Table 2. Straw yield (kg ha^{-1}) of wheat varieties under different sowing dates and per cent reduction in D_2, D_3 and D_4 as compared to D_1.

Varieties	Date of sowing					Per cent reduction		
	D_1	D_2	D_3	D_4	Mean	D_2	D_3	D_4
Sujata	4390	3646	3106	2530	3418	17	29	42
Kanchan	4435	4360	4271	3140	4051	2	4	29
GW-273	4673	4613	3512	3333	4033	1	25	29
Lok-1	5327	5253	3170	3720	4368	1	41	30
Ratan	5179	5015	3869	3720	4446	3	25	28
Arpa	4836	4747	3080	3348	4003	2	36	31
Mean	4807	4606	3501	3299				
	SEm±	CD (P=0.05)						
D	0.42	1.20						
V	0.52	1.47						
D x V	1.03	2.94						

Table 3. Grain yield (kg ha^{-1}) of wheat varieties under different sowing dates and per cent reduction in D_2, D_3 and D_4 as compared to D_1.

Varieties	Date of sowing					Per cent reduction		
	D_1	D_2	D_3	D_4	Mean	D_2	D_3	D_4
Sujata	2991	2842	1760	1071	2166	5	41	64
Kanchan	3348	3051	2664	1488	2638	9	20	56
GW-273	3318	3021	2783	1771	2723	9	16	47
Lok-1	3199	2366	1845	1369	2195	26	42	57
Ratan	3006	2396	2083	1488	2243	20	31	50
Arpa	3080	2693	2827	1949	2638	13	8	37
Mean	3157	2728	2327	1523				
	SEm±	CD (P=0.05)						
D	0.2	0.6						
V	0.24	0.68						
D x V	0.48	1.36						

The length of ear head was significantly higher in 1st sowing dates which decreased as the sowing was delayed. It was also observed that on an average the maximum length of ear head (cm) was significantly observed in varieties GW-273 (9.7) whereas the minimum length of ear head was noted in variety Lok-1 (8.8). Further, it was also found that, maximum per cent reduction of length of ear head in Kanchan followed by Sujata and minimum per cent reduction in Ratan followed by Lok-1 in last date of sowing as compared to first date of sowing. Behera (1994) reported that higher temperature during growth period in delayed sowing caused forced maturity of crop and resulted reduced ear length. Patel *et al*. (1999) have also reported similar trend of observation.

Maximum numbers of grain ear^{-1} head were observed in first date of sowing which decreased when the sowing was delayed. Among different varieties Kanchan and GW-173 (36.7) produced maximum, whereas the minimum was in variety Arpa (29.8). Under last date of sowing the minimum percentage reduction in the number of grain ear^{-1} head was recorded in Kanchan whereas the maximum percentage deviation from first data of sowing was observed in GW-273 followed by Sujata. Singh and Dixit (1985) and Patel *et al*.,(1999) also reported similar findings.

The results (Table 1) revealed that maximum test weight of grains was observed in first date of sowing as compared to late sown conditions. On an average the maximum test weight of grain was observed in Lok-1 (46.1 g) where as the minimum was observed in Kanchan (35.2 g). Sujata showed minimum reduction in test weight from first date of sowing to last date of sowing while Arpa showed maximum reduction in test weight under these sowing dates. It is due to higher temperature during later part of the crop growth in delayed sowing. Similar findings were reported by Pandey (2003) and Khichar and Niwas (2006).

Table 2 showed that straw yield of different varieties were varied due to different sowing dates. Higher straw weight (5327 kg ha^{-1}) was observed in Lok-1 under the first sowing date whereas the lowest (4390 kg ha^{-1}) in the same date of sowing was observed in variety Sujata. On an average, in different sowing dates, highest straw weight (4446 kg ha^{-1}) was recorded in Ratan whereas the lowest value of the same was observed in Arpa (4003 kg ha^{-1}). Highest percentage reduction was observed in Sujata and the minimum percentage was observed in Ratan from first date of sowing to last date of sowing. Naik and Srinivas (1991) also revealed similar effects.

The data showing the influence of different sowing dates on grain yield of different wheat varieties are given in Table 3. Maximum grain yield was observed in first date of sowing as compared to delayed sowing. On an average in different sowing dates, higher grain yield (2723 kg ha^{-1}) was recorded in GW-273 whereas, the lowest value of the same was observed in Sujata (2166 kg ha^{-1}). Highest percentage reduction was observed in Sujata and the lowest percentage reduction was observed on Arpa.

Sowing of wheat on 29 November produced higher yield (3157 kg ha^{-1}) as compared to the sowing on 8, 18, and 28th December. This may be attributed to the fact that sowing of wheat on 29th November provided sufficient period for vegetative growth of the crop and favorable temperature resulting in higher yield. Higher temperature during later part of the crop growth in delayed sowing caused forced maturity of the crop and resulted in lower grain weight ear^{-1} head, lesser ear length, less number of grain ear^{-1} heads and ultimately the lower grain yield. Similar finding were also reported by Singh and Dixit (1985); Patel *et al.* (1999).

The study revealed that 29th November is the most optimum time of sowing wheat as compared to sowing wheat after November. It is further concluded that Kanchan is suitable for early sowing and Arpa shows better yield under late sown condition while GW-273 is suitable for all sowing dates.

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