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CONTENTS

Studies on Groundwater Recharge Assessment and Water level Enhancement as an Impact of Artificial Well Recharge Technology on Farmers Field - M. S. Pendke, D. P. Waskar, S. H. Narale 067

Genetic Variability in F_5 Generation Progenies of Muskmelon (*Cucumis melo* L.) - S. D. Gaikwad, A. V. Chandanshive, M. N. Bhalekar and S. A. Ranpise 071

Effect of Nutrient Management on Quality of Potato - S. D. Thorat, B. S. Raskar and S. S. Patil 076

Impact of MGNREGA on Rural Women Empowerment in Hisar, Haryana - Parveen Nimrayan 080

Progress and Impact of MGNREGA in Rural Tamilnadu - an Economic Analysis - N. Amirthalingam, K. Sita Devi, C. Prabakar and T. Ponnarasi 086

Pragmatic Identification of Agriculture Field Problems Through Participatory Rural Appraisal - Bhagya Vijayan, Himani Priya, Ankitha Kandpal, Deep Mohan, Mahesh Kumar and Chirag Maheshwari 096

Performance of Chopper Harvesters on Quality of Milling Sugarcane and Sugar Recovery - S. M. Nalawade, D. A. Watharkar, M. A. Kharmate 100

Crop Weather Relationships of Fodder Sorghum Varieties under Different Sowing Windows - K. Saimaheswari, T. Prathima, D. Subramanyam and P. Latha 104

Variability Studies for Quality Traits in F_4 Segregating Population of Rice (*Oryza sativa* L) - M. P. Gawai, A. T. Umate, T. J. Bedse and R. L. Kunkerkar 112

Forecasting of Weekly Rainfall using ARIMA Models in Ghod Catchment of Pune District (M.S.) - P. S. Ghule, P. G. Popale, S. D. Gorantiwar and D. S. Pandit 115

Effect of Drip Fertigation on Yield and Water Use of Onion Crop in Inceptisols - R. R. Hasure, D. D. Pawar, K. D. Kale and S. K. Dingre 126

Analysis of the Carbon Sequestration Potential of Multi-Varietal and Mono-Varietal Mango Orchards in Semi-Arid Monsoonal Climate with Dstinct Seasons - T. R. Rupa, A. N. Ganeshamurthy, M. B. Mahendrakumar, R. S. Rajeshwari and N. K. Krishna Kumar 137

Dominant Weed Flora of Soybean and Cotton in Vidharbha Region of Maharashtra - A. S. Jadhav 147

Studies on Pathogens Associated With Leaf Spot of Sorghum (*Sorghum bicolour*) - R. R. Perane, Piush Nema and N. B. Pawar 150

Correlation and Path Analysis in Groundnut (*Arachis hypogaea* L.) Under Stress Condition - C. S. Bodke, D. V. Dahat, M. P. Deshmukh 162

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Studies on Groundwater Recharge Assessment and Water level Enhancement as an Impact of Artificial Well Recharge Technology on Farmers Field

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Abstract

Groundwater is clearly the preferred source for farmers. This is one of the reasons why India has experienced explosive growth in groundwater demand during recent decades. However, India's groundwater position is in precarious situation. Groundwater is a renewable resource. Therefore, its appropriate management has assumed great significance. The groundwater recharge depends on both quantum of precipitation and on pattern of precipitation. During the last decade, the rainfall is found to be variable and rain scares situation was observed in many districts. Assured crop production in rainfed area can only be achieved if supplemental irrigation can be provided. The Groundwater levels in the region had reached alarming levels early this year itself. Hence attention is needed to enhance the ground water potential through artificial recharging techniques. Artificial recharging of 10 open wells and 10 bore wells using designed filtration system was undertaken on farmers field at village Babulgaon, Tq. and Dist. Parbhani during 2016 to 2018 and ground water levels were monitored during pre and post monsoon in recharge and un-recharged open wells and bore wells. A long duration pumping test was conducted on representative bore well. The well characteristics like specific yield and transmissivity were determined as 0.0134 and 572.37 m^2 day^{-1}, respectively. The water level fluctuation in pre and post monsoon season in recharged open well and bore wells are found to be in the range of 4.36 to 8.79 m and 6.01 m to 8.84 m, respectively. The average ground water recharge in treated open well and bore well was found to be 36.39 and 23.33 per cent of annual rainfall respectively. Both, artificial open well as well as bore well recharging was found effective in enhancing ground water potential.

Key words : Bore well, Groundwater Recharge, Open well Specific yield, Transmissivity, Water level fluctuations

In Maharashtra, Out of total area under irrigation, 28.75 lakh hectares (71%) of the agricultural land is irrigated by ground water while 11.83 lakh hectares (29%) by flow or canal irrigation. Out of total groundwater consumed, 85 per cent is for irrigation, 10 per cent for industries and only 5 per cent is for domestic consumption. India is the world's largest groundwater user. The depletion of groundwater resource is a matter of great concern for human society. Large-scale pumping out of groundwater and negligible recharging has created 'water havoc' in these open well as well as bore well-fed areas. The Groundwater levels in the region had reached alarming levels early this year itself.

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Materials and Methods

The study on ground water recharge assessment and water level enhancement as impact of adoption of improved artificial well recharge technology using runoff water was conducted on farmers field at village Babulgaon, Tq. and Dist. Parbhani during 2016 to 2018 The average annual rainfall of the village is 889 mm and falls under assured rainfall zone. The rainfall is uneven and varies from year to year. Artificial open well and bore well recharging technology developed by the AICRP for

Dryland Agriculture, VNMKV, Parbhani were adopted on farmers field. Total 10 open wells and 10 bore wells were monitored for ground water level fluctuations during pre and post monsoon season since 2016. The groundwater level enhancement and ground water recharge were calculated and the impact of adoption these technology with respect to Ground water enhancement and ground water recharge were assessed. The list of farmers who adopted open well and bore well recharge technologies along with details are presented in Table 1 and 2.

Reddy and Khybri (2008) estimated ground water recharge in semiarid watershed following standard procedure of ground water fluctuation for estimation of ground water recharge. Similar procedure was followed in the present study.

Determination of Aquifer Parameters by Pumping Test : Papadopulos and Cooper (1967) curve-matching technique was adopted for determining aquifer properties. A long duration pumping test was conducted on representative bore well. The well characteristics like specific yield and transmissivity were determined as 0.0134 and 572.37 m^2 day^{-1} respectively.

Results and Discussions

Effect of well recharging on ground-water level fluctuation : The ground water levels in different wells were recorded before and after monsoon season between 2016 to 2018 and the data related to water level fluctuation and ground water recharge both in open well as well as bore well are presented in Table 3 and 4.

The specific yield value was used for estimation of ground water recharge from the bore well based on water table fluctuations in the open wells. It was observed that in recharged open wells, the water table fluctuation was in the range of 4.36 m to 8.79 m. It was also revealed that the ground water recharge in treated open well was in the tune of 23.08 % to 51.270% with an average of 36.39% as against average recharge of 14.83% in untreated bore wells. Thus, it is revealed that artificial open well

Table 1. List of Farmers who adopted open well recharge technology

Names of the farmers who adopted open well recharge technology	Diameter of well, m	Depth of well, m
Shri. Daulatrao Maske	6.0	15.0
Shri. Dnyanoba Avhad	6.1	15.4
Shri.Ganpat Pardhe	7.0	16.9
Shri. Girish Pardhe	5.9	13.8
Shri. Vitthal Pardhe	4.9	21.5
Shri.Dnyanoba Pardhe	5.5	20.0
Shri. Shamrao Pardhe	4.9	18.4
Shri. Kailash Dhumal	5.5	21.5
Shri. Vitthal Dalve	5.2	16.5
Shri. Munja Pardhe	4.9	15.5
Control Open wells (Non adoption of recharge technology)		
Shri. Sundar Pardhe	5.5	14.9
Shri. Rama Nemane	4.9	15.7

Table 2. List of Farmers who adopted Bore well recharge technology

Names of the farmers who adopted bore well recharge technology	Depth of bore well, m
Ramkishan Ganpatrao Pardhe	53
Dyanoba Tukaram Pardhe	69
Dyanoba Vishwanath Awahad	62
Rama Sakhare	64
Madhukar Kishan Pardhe	76
Mathurabai Raosaheb Pardhe	59
Girish Manik Pardhe	57
Dyanoba Ganpat Pardhe	59
Vitthal Ganpat Pardhe	52
Rama Manik Pardhe	58
Control bore wells (Non adoption of recharge technology)	
Gangadhar Bhujangrao Pardhe	72
Bimrao Pardhe	60

recharge technology is found to be effective in additional recharging of ground water.

Mehta *et al*., (2002) and Ravichandran *et al*., (2011) conducted study on artificial well recharging and the results of the present study confirms with the previous results.

Table 3. Water level fluctuations and ground water recharge in open wells

Name of the farmer	Pre-monsoon level (meter)	Post-monsoon level (meter)	Water level fluctuation (meter)	Ground water recharge cm	Ground water recharge %
Shri. Daulatrao Maske	15.00	06.21	8.79	20.92	51.27
Shri. Dnyanoba Avhad	14.38	07.45	6.93	16.49	24.42
Shri.Ganpat Pardhe	11.71	06.31	5.40	12.85	31.49
Shri. Girish Pardhe	13.51	09.15	4.36	9.42	23.08
Shri. Vitthal Pardhe	21.34	15.24	5.10	12.14	29.75
Shri.Dnyanoba Pardhe	18.90	12.24	6.66	15.85	38.84
Shri. Shamrao Pardhe	16.29	11.19	5.10	12.14	29.75
Shri. Kailash Dhumal	17.62	09.14	8.48	20.18	49.46
Shri. Vitthal Dalve	17.65	12.56	5.09	12.11	29.68
Shri. Munja Pardhe	18.61	11.71	6.90	16.42	40.24
Average	36.39				
Unrecharged Openwells					
Shri. Sundar Pardhe	18.31	16.27	2.06	4.85	11.88
Shri. Rama Nemane	19.15	16.10	3.05	7.26	17.79
Average	14.83				

Table 4. Water levels fluctuations and ground water recharge in Bore wells

Name of the farmer	Pre-monsoon level (meter)	Post-monsoon level (meter)	Water level fluctuation (meter)	Ground water recharge cm	Ground water recharge %
Ramkishan G. Pardhe	31.45	23.20	8.25	11.055	27.16
Dyanoba Tukaram Pardhe	17.27	10.05	7.22	09.675	23.77
Dyanoba V. Awahad	18.55	12.23	6.32	08.468	20.80
Rama Sakhare	32.69	23.85	8.84	11.845	29.10
Madhukar Kishan Pardhe	33.12	24.51	8.61	11.537	28.34
Mathurabai R. Pardhe	14.34	8.33	6.01	8.053	19.78
Girish Manik Pardhe	21.72	15.09	6.63	8.884	21.82
Dyanoba Ganpat Pardhe	15.85	9.72	6.13	8.214	20.18
Vitthal Ganpat Pardhe	19.20	12.35	6.85	9.179	22.55
Rama Manik Pardhe	72.25	66.23	6.02	8.066	19.81
Average	23.33				
Unrecharged Openwells					
Gangadhar B. Pardhe	74.50	71.18	3.32	4.44	05.94
Bimrao Pardhe	29.50	26.61	2.89	3.87	05.18
Average	5.56				

The specific yield value was used for estimation of ground water recharge from the bore well based on water table fluctuations in the bore wells. It was observed that in recharged bore wells the water table fluctuation was in the range of 6.01 to 8.84 m. It was also revealed that the ground water recharge in treated bore well was in the tune of 19.78% to 29.10 % with an average of 23.33% as against average recharge of 5.56% in untreated bore wells. Bhalerao and Kelkar (2013) and Pratima Patel *et al.*, (2011) conducted study on artificial ground water recharge and resulted that ground water levels were increased due to adoption of these techniques. The results of the present study are also found similar trend.

Conclusions

1. The ground water recharge in treated open well was in the tune of 23.08% to 51.270% with an average of 36.39% as against average recharge of 14.83% in untreated bore wells

2. The ground water recharge in treated bore well was in the tune of 19.78% to 29.10% with an average of 23.28% as against average recharge of 5.56% in untreated bore wells.

3. Both, artificial open well as well as bore well recharging was found effective in enhancing ground water potential

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Genetic Variability in F_5 Generation Progenies of Muskmelon (*Cucumis melo* L.)

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Abstract

The study on variability, heritability, genetic advance, genotypic and phenotypic coefficient of variation was carried out for various yield and related traits in muskmelon. The performance of the cross obtained from the cross IVMM-3 x Pusa Madhuras in F_5 generation showed GCV was lower than the PCV in all quantitative traits. In number of fruits per vine was observed in the range of 2.42 to 3.38 along with an average 3.15 fruits per vine. The number of female flowers per vine was ranged in between 9.94 to 13.52 with an average 12.74. From the present investigation superior progeny were selected for future crop improvement raising next generation based on more than 2.80 to 3.00 kg fruit yield per vine, round fruit shape, greenish yellow fruit color with ridges fruit, netted fruit surface (rind), good TSS, pleasant musky pulp flavor with orange pulp color through selection signifying presence of considerable amount of genetic variation.

Key words : Genetic variability, muskmelon.

Muskmelon is an important summer vegetable (*Cucumis melo* L.), which is delicious in nature, thirst quenching, appetizing, nutritive, therapeutic, very popular and commercial crop of the tropics and sub tropics regions of world originated in Africa Kerge and Grum, (2000). In cucurbits, watermelon ranks first followed by muskmelon Nayar and Singh, (1998) and Jebari *et al*., (2004).

Muskmelon is the favorite crop of riverbed cultivation in north India Jamuna, Ganges, Narmada Rivers and in south India in the banks of Kaveri, Pennar, Krishna and Godavari rivers Singh, (1998) to fetch off season produce with higher prices. *Cucumis melo* L. shows tremendous variation particularly in vegetative stage and fruit morphology. Muskmelon is gaining lot of significance due to its short duration, high production potential under rain fed, irrigated and green house conditions almost throughout the year. Muskmelon is rich in vitamins, minerals, carotene, carbohydrates, sugars, niacin, folic acid and potassium as well as a number of other human health beneficial bioactive compounds.

The genotypic and phenotypic coefficient variation are helpful in exploring the nature of variability in the breeding population whereas, the estimate of heritability provides index of transmissibility of characters. The estimate of direct selection parameters like heritability and genetic advance are useful in formulating suitable selection strategy for higher yield in muskmelon. Burton (1952) suggested that GCV together with heritability estimates would give best picture about the extent of advance to be expected by selection. A muskmelon is an unexploited vegetable crop less breeding work has been done till date. So there is wider scope for exploit available genetic variability in muskmelon. Therefore, an attempt was made to gather information on extent of variability, heritability and genetic advance for qualitative and quantitative characters in muskmelon.

Material and Methods

The present study was carried out at Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, during the summer season. The seeds of cross IVMM-3 x Pusa Madhuras along with parents were obtained from Department of Horticulture, MPKV, Rahuri. The F5 progenies from the cross were selected on the basis of earliness, fruit shape, rind thickness, yield per plant and TSS content. The experiment is laid out in randomized block design with three replications. The recommended package of practices along with spacing of 2 m x 0.60 m and observations were recorded on various growth and yield parameters *viz*., vine length (cm), number of primary branches per vine, days to first female flower appearance, numbers of male flower per vine, number of female flowers per vine, sex ratio, node at which first female flower appeared, days required for first harvest of fruit, number of fruits per vine, fruit yield per vine (kg), average weight of fruit (g), average length of fruit (cm), average diameter of fruit (cm), average rind thickness (cm), average pulp thickness (cm), average fruit cavity (cm), average weight of pulp per fruit (gm), average weight of seed per fruit (gm), T.S.S. (%), acidity (%), ascorbic acid (%), total Sugar (%), reducing sugar (%), non reducing sugar (%).The data were analyzed by following the method as suggested by Johnson (1955), coefficient of variations Burton (1953) and heritability by Lush (1949).

Result and Discussion

The vine growth showed wide range of vine length (167.17 to 227.12 cm) with an average of 209.24 cm. The significant genetic variability GCV (11.37%) and PCV (11.53%) were observed with the influence of environmental factor (ECV 1.92%). The number of primary branches per vine was ranged in between 2.24 and 2.76 with mean value of 2.61. The very close values were recorded for GCV and PCV (11.69% and 11.76% respectively) with certain low influence of environmental factors (ECV 1.30%). The wide range of variability was observed for days to first female flower appearance (36.60-44.29 days) with mean value of 38.64 days (Table 1). The GCV and PCV were recorded (7.71 and 7.89% respectively) with noticeable influence of environmental factors (ECV 1.74%). The male flowers per vine were ranged in between 65.81 to 81.92 with mean value of 76.12. The close association of GCV (10.56%) and PCV (10.65%) were recorded with noticeable environmental variability (ECV 1.42%) similar results were recorded with the study of Jagtap *et al*., (2010) and Reddy *et al*., (2013).

The number of female flowers per vine was ranged in between 9.94 to 13.52 with an average 12.74. The close association of GCV (10.82%) and PCV (10.89%) were observed with certain presence of environmental factor ECV (1.76%). The wide range of variability was observed for sex ratio (5.62 to 8.33) with mean value of 5.97 (Table 1). The genetic variability was contributed as GCV (13.59%) and PCV (13.78%) with noticeable environmental variability ECV (2.18%). Node at which first female flower appeared was observed in wide range 3.97 to 6.24 with an average 4.12 required to initiate first female flower. The close association of GCV (21.69%) and PCV (21.82%) were observed with certain presence of environmental factor ECV 0.52%). The days required for first harvest of fruits was ranged from 71.34 to 84.35 days with an average 73.12 days (Table 1). The genetic variability as of GCV (7.73%) and PCV (8.09%) were observed with influence of environmental factor ECV (2.43%). Similar results have also been reported earlier by Jagtap *et al*., (2010), Choudhary *et al*., (2011), Mishra *et al*., (2012) and Mali, (2015).

In number of fruits per vine was observed in the range of 2.42 to 3.38 along with an average 3.15 per vine. Close values of GCV (12.30%) and PCV (12.38%) were observed with ECV (1.27%). The fruit yield per vine was observed in wide range of 1.62 to 2.13 kg per vine with an average 1.99 kg per vine. The close value of GCV (13.73%) and PCV (14.51%) (Table 1) were observed with noticeable value of environmental variability ECV (4.52%). The average weight of fruit was varied in wide range of 512.32-709.13 g with mean value of 683.24 g. The genotypic coefficient of variation GCV (14.66%) (Table 1) and phenotypic co-efficient of variation PCV (18.81%) were observed with the influence of environmental factor ECV (11.76%). The average length of fruit was ranged in between 8.17 cm to 10.12 cm with an average 9.94 cm (Table 1). The close association of GCV (5.59%) and PCV (5.69%) was observed with certain presence of environmental factor ECV (1.01%). The findings of the same study are in conformity with the Tarsem *et al*., (1997) and Choudhary *et al*., (2011).

The average fruit diameter was ranged from 10.90 cm to 11.98 cm with an average 11.84 cm. The genetic variability of GCV (3.27%) and PCV (3.43%) were observed with certain presence of environmental factor ECV 1.04%. The average rind thickness (cm) was ranged in between 0.18 cm to 0.27 cm. with mean value 0.24 cm (Table 1). The genetic variability GCV

Table 1. Mean, range, GCV, PCV, ECV, heritability, genetic advance and per cent mean of genetic advance of two parents and F5 population of cross IVMM-3 x Pusa Madhuras (C4:4x5)

Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	h2 (bs)(%)	GA	GAM (%)
Vine length (cm)	209.24	167.17-227.12	11.37	11.53	1.92	97.26	45.98	22.00
No. of primary branches per vine	2.61	2.24-2.76	11.69	11.76	1.30	98.81	0.61	23.41
Days to first female flower appearance	38.64	36.60-44.29	7.71	7.89	1.74	95.27	5.98	15.5
Numbers of male flower per vine	76.12	65.81-81.92	10.56	10.65	1.42	98.26	16.82	22.14
Number of female flowers per vine	12.74	9.94-13.52	10.82	10.89	1.76	97.46	2.81	22.16
Sex ratio	5.97	5.62-8.33	13.59	13.78	2.18	97.56	1.74	27.62
Node at which first female flower appeared	4.12	3.97-6.24	21.69	21.82	0.52	99.97	2.01	44.72
Days required for first harvest of fruit	73.12	71.34-84.35	7.73	8.09	2.43	92.08	13.57	18.61
No. of fruits per vine	3.15	2.64-3.38	12.30	12.38	1.27	99.94	0.76	24.15
Fruit yield per vine (kg)	1.99	1.62-2.13	13.73	14.51	4.52	91.23	0.54	27.18
Average weight of fruit(g)	683.24	512.32-709.13	14.66	18.81	11.76	61.72	154.12	22.63
Average length of fruit (cm)	9.94	8.17-10.12	5.59	5.69	1.01	97.12	1.09	11.00
Average diameter of fruit (cm)	11.84	10.90-11.98	3.27	3.43	1.04	91.34	0.76	11.10
Average rind thickness (cm)	0.24	0.18-0.27	14.25	16.35	8.01	76.98	0.07	29.28
Average pulp thickness (cm)	2.21	1.92-2.34	10.12	11.12	1.25	99.32	0.45	20.41
Average fruit cavity (cm)	39.14	32.94-49.35	12.17	12.19	0.52	99.84	9.57	24.53
Average weight of pulp per fruit (gm)	503.62	475.32-530.15	17.67	23.96	16.21	77.16	100.52	20.12
Average weight of seed per fruit (gm)	8.91	8.12-12.24	16.86	16.89	0.36	99.98	3.09	34.71
T.S.S. (%)	11.21	10.81-11.19	15.15	15.84	3.02	89.10	2.47	22.00
Acidity (%)	1.19	1.16-1.48	8.36	8.64	2.10	93.98	0.21	17.66
Ascorbic acid (%)	26.15	24.42-26.48	8.32	8.65	2.36	93.40	4.32	16.51
Total Sugar (%)	10.11	9.13-10.48	5.28	5.29	0.68	98.48	1.09	10.87
Reducing sugar (%)	8.17	7.28-8.47	6.51	6.57	0.31	99.84	1.10	13.51
Non reducing sugar (%)	1.83	1.79-1.96	6.04	6.98	1.55	64.61	0.17	9.35

(14.25%) and PCV (16.35%) were observed with the influence of environmental variability ECV (8.01%). The average pulp thickness was ranged in between 1.92 cm to 2.34 cm with an average 2.21 cm. The contribution of genetic variability of GCV (10.12%) and PCV (11.12%) were observed with certain presence of environmental factor ECV (1.25%) Present findings are similar to the findings of Tomar *et al*., (2008), Reddy *et al*., (2013) and Patil., (2014).

The average fruit cavity was ranged from 32.94 cm to 49.35 cm with an average 39.14 cm (Table 1). The close association of GCV (12.17%) and PCV (12.19%) were observed with certain influence of environmental factor ECV (0.52%). In the average weight of pulp per fruit (g) wide range of variation was observed (475.32 to 530.15 g) with mean value 503.62 g for average weight of pulp per fruit. The significant genetic variability was contributed as GCV (17.67%) and PCV (23.96%) with noticeable environmental variability ECV (16.21%). In F5 generation the wide range of variability was observed for average weight of seed per (8.12 to 12.24 g) with an average 8.91 g. The close association of GCV (16.86%) and PCV (16.89%) were observed with certain presence of environmental factor ECV 0.36% Present findings are similar to the findings of Singh *et al*., (2005), Tomar *et al*., (2008), Reddy *et al*., (2013) and Patil., (2014).

The TSS content of fruit is an important qualitative character in muskmelon, which showed a variation with range of 10.81 to 11.19°Brix (Table 1) with mean value 11.21° Brix. The GCV (15.15%) and PCV (15.84%) were observed with presence of environmental variability ECV (3.02%). The acidity percentage was ranged in between 1.16 to 1.48% with an average 1.19%. The genetic variability is GCV (8.36%) and PCV (8.64%) were observed with presence of environmental factor ECV 2.10%. In case of F5 generation the ascorbic acid content was observed in wide range of 24.42 to 26.48 mg 100^{-1} g with an average 26.15 mg 100^{-1} g (Table 1). The GCV (8.32%) and PCV (8.65%) were recorded with noticeable influence of environmental factor ECV (2.36%).

Total sugar content was ranged in between 9.13 to 10.48% with mean value of 10.11%. The genetic variability was contributed as GCV (5.28%) and PCV (5.29%) with presence of environmental variability ECV (0.68%). In case of reducing sugar ranged in between 7.28 to 8.47% with an average 8.17%. The close association of GCV (6.51%) and PCV (6.57%) were observed with certain presence of environmental factor ECV 0.31% (Table 1). In non reducing sugar ranged from 1.79 to 1.96% with an average 1.83%. The close association of GCV (6.04%) and PCV (6.98%) were recorded with influence of environmental factor ECV (1.55%). The earlier reports of Vishwanatha *et al*. (2003), Tomar *et al*. (2008) and Jagtap *et al*. (2010) and Choudhary *et al*., (2011) support the present findings.

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Effect of Nutrient Management on Quality of Potato

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Abstract

The field experimentation was conducted to access the effect of Effect of nutrient management levels on quality parameters in Onion during *rabi* season at Post Graduate Research Farm MPKV, Rahuri for the duration of 2014-15 and 2015-16. The experiment was laid out in split plot design with three replications. Six combinations of two crop sequences (soybean-onion and soybean-potato) and three levels of GRDF *viz*., 75, 100 and 125% were the main plot treatments in *kharif* season replicated three times in randomized block design. During *rabi* season each main plot treatments of residual effect of GRDF levels was split into three sub plot treatments with three levels of recommended dose of fertilizer *viz*., 75, 100 and 125% to *rabi* season crop resulting in eighteen treatment combinations replicated three times in split plot design. The two year results of the study have showed that application of 125% GRDF and 125 % RDF levels increased the quality parameters but did not show any significant difference among the GRDF and RDF levels the maximum TSS, protein and starch content recorded in treatment 125% GRDF followed by 100% GRDF as compared to lowest in 75% GRDF and RDF levels during both the years.

Key words : GRDF and RDF levels, Quality parameters, Potato.

Potato (*Solanum tuberosum* L.) is one of the most important non-cereal food crops in the world after wheat, rice and maize. It provides a source of low cost energy to the human diet. It is rich in starch, vitamin especially vitamin C, B1 and minerals. Potato contributes to world food basket just after rice, wheat and maize. It contains 20.6% carbohydrates, 2.1% protein, 0.3% fat, 1.1% crude fibre and 0.9%. It also contains good amount of essential amino acids like leucine, tryptophane and isolucine (Khurana and Naik, 2003). India is largest potato producer in the world and ranks third in area while fourth in production. Potato is grown in an area of 2.09 mha with total production 48.80 mt and productivity 22.9 t ha^{-1} (Anonymous, 2015). In Maharashtra, potato is cultivated on an area of 14000 ha with production 3.21 lakh tonnes and productivity 15.00 t ha^{-1} (Anonymous, 2015). The productivity is extremely low in Maharashtra. One of the reason for such a low productivity is inadequate and unbalanced fertilizer application. Potato is heavy feeder of nutrients because of its shallow and fibrous root system and high fertilizer requirements. Parts of semi arid zone of Maharashtra are well suited for potato cultivation. There is scope for increasing the area under potato crop in soybean -based systems. Diversification of potato in diverse cropping systems is vital to expand area under potato and production of this key food crop in Maharashtra's changing intensive agricultural situation, especially with diminishing arable land. Crop diversification allows for more effective use of limited land resources while maintaining high levels of food production. This is especially significant for potato productivity, which has the greatest potential to generate biomass with a high harvest index per unit time and area. However, there is concern that continual mining of nutrients from the soil as a result of intense farming may make it less fertile Sarkar (2007).

Materials and Methods

The present experiment entitled "Response of nutrient management on productivity and profitability of soybean-based cropping systems" was conducted for two consecutive years *viz*., 2014-15 and 2015-16 at Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri. Geographically, the experimental farm is situated between 190 47' and 190 57' N latitude and between 740 19' and 740 32' E longitude. The altitude varies from 495 to 569 m above the mean sea level. Agro climatically, this area falls in the semi-arid tract with an annual rainfall varying from 307 to 619 mm. The average annual rainfall at Rahuri is 520 mm with 15 to 45 rainy days. The soil in the experimental field was deep (90 cm) and well drained. The topography of the land was fairly leveled (0.6%). The experimental soil was classified as Vertisols with a clay loam in texture. The chemical composition according to criteria laid by Muhr *et al.* (1965) indicates that the soil was low in available nitrogen (207.33 kg ha^{-1}), medium in available phosphorus (15.79 kg ha^{-1}) and very high in potassium content (423.56 kg ha^{-1}).Total soluble salt content was normal (electrical conductivity 0.29 dSm^{-1}). The soil was alkaline in reaction (pH 8.17) and the corresponding numerical values for bulk density, hydraulic conductivity, field capacity and permanent wilting point were 1.31 mg m^{-3}, 1.68 cm hr^{-1}, 34.63 and 18.04%, respectively. Treatments under the present investigation were tested in soybean based cropping system during 2014-15 and 2015-16. The experiment was laid out in split plot design with three replications. Six combinations of two crop sequences (soybean-onion and soybean-potato) and three levels of GRDF *viz*., 75, 100 and 125% were the main plot treatments in kharif season replicated three times in randomized block design. During rabi season each main plot treatments of residual effect of GRDF levels was split into three sub plot treatments with three levels of recommended dose of fertilizer *viz*., 75, 100 and 125% to *rabi* season crops resulting in eighteen treatment combinations replicated three times in split plot design. The quality criteria total soluble solids (%), protein, and starch were evaluated and reported in % using standard methods. With the help of a mortar and pestle, ten randomly selected tubers from five tagged plants from each plot were crushed. The total soluble solids were measured and recorded using a hand refractometer. % the amount of nitrogen in the tuber was determined by multiplying it by 5.88. (Morrison,1956). % Protein = % N x 5.88, and % Starch = % N x 5.88 (percent) The formula for calculating % starch was % Starch = % Glucose x 0.90. (Powell, 1973).The data were statistically analyzed as per the method suggested by Panse and Sukhatme, 1967).

Results and Discussion

Quality studies : The perusal of data pertaining to the influence of residual GRDF levels and RDF levels on quality parameter *viz*., TSS, protein and starch content of potato tuber at harvest are presented in Table 1.

Residual effect of GRDF levels : The quality parameters did not show any significant difference among the GRDF treatments on potato tuber quality at harvest. However, the quality parameters increased with increasing GRDF levels. The quality parameters *viz*., TSS (6.55 and 7.24%), protein (10.1 and 10.3%) and starch (68.7 and 67.1%) of potato was not differed statistically but numerically maximum value observed in residual effect of 125% GRDF applied to kharif crop. The higher availability of nutrients in soil under 125% GRDF might have improved the physiological and metabolic activities in potato crop leading to improve the quality parameters. These results of quality are in close compliance with those of Gaud (2004).

Table 1. Quality parameter of potato tubers as influenced by different treatments at harvest

Treatments	TSS (%)		Protein (%)		Starch (%)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
A. Residual effect of GRDF levels (*kharif* soybean)						
G_1 : 75%	6.02	6.24	9.86	9.91	63.81	63.93
G_2 : 100%	6.19	6.28	10.07	10.18	66.62	67.72
G_3 : 125%	6.55	7.24	10.10	10.31	67.13	68.66
SEm±	0.39	0.24	0.51	0.36	1.15	1.59
CD at 5%	NS	NS	NS	NS	NS	NS
B. Direct effect of RDF levels (*rabi* potato)						
F_1 : 75%	6.19	6.47	9.91	10.10	64.70	65.68
F_2 : 100%	6.27	6.53	9.97	10.12	65.97	66.93
F_3 : 125%	6.29	6.77	10.15	10.19	66.93	67.69
SEm±	0.22	0.24	0.32	0.34	0.79	0.72
CD at 5%	NS	NS	NS	NS	NS	NS
Interaction A x B						
SEm±	0.36	0.41	0.38	0.39	0.66	0.58
CD at 5%	NS	NS	NS	NS	NS	NS
Mean	6.25	6.59	10.01	10.14	65.86	66.76

Direct effect of RDF levels : The maximum TSS, protein and starch content were observed in treatment 125% RDF levels and followed by 100% RDF level but did not show any significant differences among them. The quality parameters *viz*., TSS (6.3 and 6.8%), protein (10.2 and 10.2%), and starch (67.7 and 66.9%) per cent of potato was recorded first rank by 125% RDF levels followed by 100% RDF level. This might be due to higher N content in tubers might be increasing levels of RDF. Similar results were reported by, Islam *et al.* (2013), Jat *et al.* (2013) Sandhu *et al*. (2014).

Interaction : The interaction between residual GRDF and RDF levels found non-significant in respect of quality parameters during both the years respectively.

Conclusion

Based on the findings of this study, it can be stated that the residual impact of 125% GRDF levels and the direct effect of 125% RDF on rabi potato provide the highest value of quality parameters when compared to lower levels. The quality of tuber was improved with introduction of 125% GRDF levels and 125% RDF levels. So, in order to sustain better quality, addition of FYM with RDF is Beneficial.

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Impact of MGNREGA on Rural Women Empowerment in Hisar, Haryana

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Abstract

The study has analyzed income and employment generation by the rural women in Haryana through MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act, 2005) popularly known as NREGA. Which was aimed to ensure legal right to work of 100 days to poor rural households whoever is willing to work at a minimum wage rate. In India, labour force participation rate of women is 52.46percent which is higher than man i.e. 47.54 percent. While in Haryana and Hisar under MGNREGA among the labour force, the participation of women is 41.71 and 43.96 percent, respectively. In Haryana, MGNREGA was launched in 2008 in all the districts. The involvement of rural women for wage earning through MGNREGA showed an increasing trend up to the first five years of implementation of the scheme in the district (i.e. 2008-13) and fluctuated slightly in the consecutive years up to 2019-20. Again, it showed a steep increase in the women involvement under MGNREGA due to unavailability of other employment sources due to COVID-19. As under this scheme the work is provided within the village periphery so being easier for women to work. Wages are paid on the basis of work measurement and there is no time boundattendance on worksite which facilitates the rural women to work according to their suitability during lean hours in a day and days unemployed elsewhere in a year accordingly. In this way MGNREGA not only provided employment to unskilled rural women but also it has wide impact on the enhancement of wage earning of rural women. Which leads to strengthening of their resource-base and makes them financially self-dependent and providing them security against social & family exploitation. MGNREGA is very much helpful in rural women empowerment and ultimately increasing their socio- economic status in long -run. This especial feature of this employment scheme remained best-suited government scheme during the COVID-19 pandemic in the rural areas of not only in Hisar district but also proved life saving tool in all over the country. In this way, we can say that MGNREGA has positive impact on empowerment and employment pattern of women in recent years.

Key words : MGNREGA, Rural Women Empowerment, Socio-Economics, Wages.

Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) initially named as NREGA was notified on 7th September 2005 and came into force from 2nd Feb. 2006. In state of Haryana it was implemented from 1st April, 2008 in all the districts. The prime focus of the scheme is to provide 100 days of wage employment to every rural household who wishes to work and asks for unskilled manual work. It aims at creating sustainable rural livelihood through regeneration of the natural resources. Gram Panchayats are involved in the planning and execution of the scheme and creation of durable assets for development of rural areas. Job cards are issued to all workers seeking employment and unemployment allowance is to be paid if work is not provided within 15 days of their application for work. Use of Machinery is not allowed. The scheme provisions such as priority for women in the ratio of one-third of total workforce, equal wages for both man and woman, crèches for children of women workers had been very effective. Wages are paid on the basis of measurement of work done. Payment to workers through bank account has given much exposure to women.

Under this employment scheme, one household can work and earn wage up to 100-

man days and there is no time bound attendance on worksite which is helpful feature and great advantage especially for women which may work on MGNREGA site in a day when they are free from their other daily works. However, work for all in the non-farm work days is available under the MGNREGA.

In a country like India where 60 percent of population living in about 6.25 lakh villages and mainly depends upon agriculture, MGNREGA provided additional work and wages for rural small farmers, agricultural laborer's especially working in farms and housewives also. The World Bank has suggested that empowerment of women could be a key aspect of all social development programs (World Bank 2001).

MGNREGA provided advantages to all the rural women in shape of economic empowerment through improved standard of living, self-confidence, enhancement of awareness, increased social interaction, increased participation level in Gram Sabha meeting decision making capacity in family & community.

One of the major planks of rapid poverty reduction in the Eleventh Five Year Plan was the successful implementation of MGNREGA in all the states of India. This scheme is also an important strategy in all economic contexts. Fiscal policy that provides more income directly to unskilled workers in the rural areas is likely to bemuch more effective in increasing aggregate income than other forms of public spending (Panwar *et al*., 2011 and Shah *et al*., 2010).

The MGNREGA is completely different in concept from earlier employment schemes since it treats employment as a right and programme is initiated to be demand driven. This scheme has potential to transform rural economy and social relations at many levels. Wage earners are main focus of the scheme and it has enormous potential to uplift the socio-economic status of rural women who are mainly landless agricultural laborer's and family members of marginal and small farmers. In this way increased income through wages earned in MGNREGA leads to better socio-economic status as well as poverty reduction of rural women. Keeping all this into account, present study was carried out with specific objective;To analyze the impact of the MGNREGA in rural women empowerment.

Methodology

The study has been conducted in Hisar district of Haryana. Hisar was the best performing district of Haryana in terms of wages and person days generated. The present study is based on secondary data for the time period from 2008-09 to 2019-20 and has been considered for analyzing the impact of the MGNREGA in rural women empowerment in the district. The data were collected from the Statistical Abstracts of Haryana, nrega.nic.in and other published sources. The trends were observed by calculating compound growth rates, simple averages and percentages to see the impact of MGNREGA on income and economic empowerment of rural women of the study area.

Compound Growth Rate (CGR): To work out the compound growth the log-linear function in the following form was fitted.

$Y= ab^t$

The log form of the equation is:

Log y = Log a + t Log b

Where, Y= Variable for which the growth rates are calculated, a = Constant, b = Regression coefficient and t = Time variable in years

The CGR in terms of percentage was obtained by using the following formula

CGR= [antilog b-1] × 100

Profile of the Study Area

A research study requires the knowledge of the area in which an investigation is to be carried out.

Hisar : Hisar district is situated in south-west part of the state. The main cropping patterns followed by the farmer are cotton-wheat and paddy-wheat. Hisar is having Coolest & Hottest in winter & summer. Average rainfall is also available during the year.

Table 1. Population composition of Hisar district

Particulars	Population	Rural	Urban
Total Population	1743931	1190443	553488
Male	931562	634139	297423
Female	812369	556304	256065

Population : The district has an area of 3983 km2 and population 1743931 in 2011. The population of Hisar district increased by 13.45 percent from 2001 to 2011, however male: female ratio is 1000: 872. Hisar District consist of 9 Blocks i.e. Hisar-I, Hisar-II, Hansi-I, Hansi-II, Narnaund, Barwala, Uklana, Agroha, Adampur. The total villages in Hisar District are 281.

Results and discussion

The summary of progress of this employment scheme in the state of Haryana (Table 2) reveals that employment provided to the household's16.69 percent of state employment of MGNREGS and number of person days generated 22.77percent in Hisar district. It is clear from the table that percentage of person days generated by the women in Hisar district 43.96 is higher than 41.71 of the whole state. The other indicators like no. of total works taken up, no. of works completed, no. of works in progress also showed a significant level of performance in the district.

Social categories of registered workers under MGNREGA : In the registered workers under MGNREGA in the district 43.96 percent were women. The percentage of SC households was 66.90 percent, that of ST householdsare nil and 33.09percent were others.Compound growth rate of workers employment generated block wise in Hisar district of Haryana depicts in (table 3) reveals that the employment has increased at compound growth rate of 9.66, 8.57, 10.92, 13.17, 11.29, 10.85, 7.99, 18.12 and 11.08 percent for Adampur, Agroha, Barwala, Hansi - I, Hansi - II, Hisar - I, Hisar - II, Narnaund and Uklana respectively. The

Table 2. Summary of MGNREGA progress in the study area (2020-21)

Particulars	Haryana state	Hisar District	% of the total
Employment provided to households: (in Lakhs)	3.24465	0.54138	16.69
Total Person days (in Lakh):	117.66	26.79	22.77
SCs	56.97 (48.42%)	17.93(66.90%)	31.47
STs	0.01(0%)	0.00(0.00%)	0.00
Other	60.68 (51.57%)	8.87(33.09%)	14.62
Women	49.07 (41.71%)	11.78 (43.96%)	24.01
Total fund released (in lakh rupees)	27352.85	1982.84	7.25
Expenditure (in lakh rupees)	19,282.6	1894.95	9.83
No. of total works taken up	26086	4330	16.60
No. of works completed	8476	1771	20.89
No. of works in progress	17610	2559	14.53

Note: Figures within the parentheses indicate percentage to total. Source: www.nrega.nic.in

employment in MGNREGAof the district has increased at a compound growth rate by 11.55 percent during 2008-09 to 2019-20.

Compound growth rate of women employment generated block wise in Hisar district of Haryana given in (table 4) reveals that maximum growth rate is attained in block Hansi-I is 20.84percent and minimum in Uklana is 13.11percent. The growth rate of the district has increased by 12.97percent during 2008-09 to 2019-20.

As (Table 5) shows the village with highest and lowest participation of women in all block of district Hisar. At block level higher participation of women was observed in Adampur block i.e. 63.77 among all nine blocks of Hisar district while among villages, Nalwa of Hisar-I block showed highest i.e.91.33 percent participation of women in district and village Dhani Brahmnan of Narnaund showed lowest participation i.e. 17.39 percent.

Income generated by women through

Table 3. Block-wise compound growth rate of workers employment generated in different financial year in Hisar district (Person days)

Year	Adampur	Agroha	Barwala	Hansi-I	Hansi-II	Hisar-I	Hisar-II	Narnaund	Uklana	Total
2008-09	23712	21317	26306	20376	15830	36066	31896	23215	27274	225992
2009-10	57339	18760	45662	43414	20184	65213	54799	55334	68498	429203
2010-11	160727	78652	113967	135045	51100	182197	179692	130861	120110	1152351
2011-12	130300	101570	135714	184027	73926	147800	144998	133448	108778	1160561
2013-14	277025	292365	305176	332699	95620	359205	228191	364466	240507	2495254
2014-15	68398	116456	206008	199773	72446	98962	108714	255207	217959	1343923
2015-16	68918	86762	139522	143875	34440	72256	90487	94536	147337	878133
2016-17	109609	132582	203907	249817	85417	194747	182000	201784	158948	1518811
2017-18	80908	106059	173660	97778	61600	113741	104037	212579	139079	1089441
2018-19	45409	57043	68191	55697	21718	60689	61239	125857	52467	548310
2019-20	71736	57173	91199	89889	57172	124107	80265	171203	96220	838964
CAGR	9.66	8.57	10.92	13.17	11.29	10.85	7.99	18.12	11.08	11.55

Table 4. Block-wise compound growth rate of women employment generated in different financial year in Hisar district (Person days)

Year	Adampur	Agroha	Barwala	Hansi-I	Hansi-II	Hisar-I	Hisar-II	Narnaund	Uklana	Total
2008-09	8118	5648	6934	5846	5737	15397	10974	7281	11929	77864
2009-10	23198	6070	14453	15782	7294	29056	21600	19531	30672	167656
2010-11	57910	27070	36790	52110	18564	75216	65013	48180	47862	428715
2011-12	53622	40937	50384	69884	26752	56549	56703	51588	45809	452228
2013-14	134106	149114	138770	157917	40443	164328	99370	150391	110505	1144944
2014-15	35165	60903	94789	88253	31628	46797	48531	110862	99537	616465
2015-16	38073	46816	67676	69112	15113	34894	39880	40315	68829	420708
2016-17	59860	71147	102263	125277	40189	97859	88227	85565	71882	742269
2017-18	47591	59678	93170	55572	31771	62901	56495	104565	69064	580807
2018-19	28369	34167	40997	32344	12426	37161	37657	65405	29195	317721
2019-20	45747	33058	53880	56695	33782	76078	48766	93002	52308	493316
CAGR	15.50	15.86	18.63	20.84	15.92	14.24	13.23	23.65	13.11	16.63

Table 5. Women participation under MGNREGSin different blocks of Hisar district (2019-20)

Blocks	Participation of women (percentage)	Village with highest participation of women (percentage)		Village with lowest participation of women (percentage)	
Adampur	63.77	Mandi Adampur	86.31	Bagla	18.18
Agroha	57.82	Mirpur	85.47	Sandol	24.51
Barwala	59.08	Behbalpur	77.61	Biana Khera	23.08
Hansi - I	63.07	Jamawari	80.97	Kutabpur	20.56
Hansi - II	59.08	Singhwa Khass	83.89	Jeetpura	31.70
Hisar - I	61.30	Nalwa	91.33	Khokha	30.46
Hisar - II	60.75	Muklan	79.69	Bandaheri	24.28
Narnaund	54.32	Koth Kalan	64.52	Dhani Brahmnan	17.39
Uklana	54.36	Bithmera	68.39	Faridpur	49.20

Table 6. Income generated by women through MGNREGS in Hisar district

Year	No. of person days generated by women	Income generated (in rupees)	Wage rate
2008-09	77864	10667368	137
2009-10	167656	25316056	151
2010-11	428715	71595405	167
2011-12	452228	80948812	179
2013-14	1144944	245018016	214
2014-15	616465	145485740	236
2015-16	420708	105597708	251
2016-17	742269	192247671	259
2017-18	580807	160883539	277
2018-19	317721	89279601	281
2019-20	493316	140101744	281
CAGR	16.63	23.94	6.17

MGNREGA in Hisar district in (Table 5) presented that significant increase in income generated by women during all the financial years with the increase of wage rate as well as person days and participation of women which leads to rural women empowerment.

Conclusions

The study has revealed that the number of households who have been provided employment under MGNREGA has increased rapidly in 2008-09 to 2019-20, in the study area. The other important point to be noticed in the district is increasing participation of the women per household. In Haryana the participation of women under MGNREGA is 49.07 percent w hile in Hisar district it is 11.78 percent. Women and worker employment have increased significantly in all blocks of the district. Compound growth rate of workers employment under MGNREGA is 11.55 percent while in case of women is 16.63 percent in the district. As under this employment scheme the work is provided within the village periphery it is easier for women to work. Wages are paid on the basis of work measurement and there is no time bound attendance on the worksite. The scheme also has the income effect where an increase in the paid income of women worker consequently increases her ability to choose her consumption. The MGNREGA helps them to meet the everyday needs of household in the short run and their strategic needs in the long run. It has reduced the dependence on male family members and freed them from subordination and subjugation. Today women don't want to be left alone; beside she wants to be economically productive having a tangible contribution to her family as well as society also. All these indicates that substantial income is being provided to the household especially women working under the

scheme. Financially sound position of women had better control over family expenditure, saving and social participation and participated more in household management decisions and financial management decisions. It indicates that MGNREGA has enhanced the empowerment of women.

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Progress and Impact of MGNREGA in Rural Tamilnadu - an Economic Analysis

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Abstract

Among the various poverty alleviation programmes implemented in the country, MGNREGA has much importance due to its impact in rural community in terms of income generation and poverty alleviation. Most of the families are benefitted only through MGNREGA in the study area and plays a vital role in the upliftment of the women in the rural areas, through its impact on social protection, livelihood security and democratic empowerment. Hence, this study was undertaken to assess the progress of MGNREGA and it's impact on the socio - economic profile of the beneficiaries in the study area. A multistage stratified random sampling technique was adopted in the study. Composite index of standard of living was computed using a scoring technique and a multiple linear regression model was employed to identify the factors influencing the level of participation in MGNREGA scheme. The logit model was also used to estimate the determinants for the respondent's decision to continue employment in MGNREGA scheme. The study concluded that the composite index of standard of living has been more pronounced in post- MGNREGA situation. It is also inferred that, in general, this scheme had succeeded in raising the socio-economic status of the respondents, by generating additional employment to the beneficiaries. The results revealed that the beneficiaries of MGNREGA faced many problems in getting the wages and were not satisfied with the present wages received under the scheme. However, with the limited availability of non-farm employment and the fact that the farm sector cannot provide gainful employment throughout the year, the MGNREGA has the potential for uplifting the conditions of the rural poor to some extent.

Key words : MGNREGA, Rural Development.

For policy makers, rural development has become a planning concern and it has become increasingly clear that apart from an effort to increase agricultural and industrial production, it is also necessary to address directly the problems of poverty in rural areas. The increasing interest in rural development is a result of the realization that a systematic effort is necessary to create better living conditions in the rural areas, where the vast majority of populations reside. Among the various poverty alleviation programmes implemented in the country, MGNREGA has much importance due to its impact in rural community in terms of income generation and poverty alleviation and received more financial allotment in union budget.

Most of the families in the study area are benefitted only through MGNREGA, which is the largest ever rural development programme of its type. The MGNREGA, by providing legal guarantee to work, marks a paradigm shift from all earlier wage employment programmes. It is an inclusive programme covering all the disadvantaged sections of the society and plays a vital role in the upliftment of the women in the rural areas, through its impact on social protection, livelihood security and democratic empowerment. It also aims at generating productive assets, protecting the environment, empowering rural women, arresting rural-urban migration. With this backdrop, this study was undertaken to assess the progress of MGNREGA and it's impact on the socio -

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economic profile of the beneficiaries in the study area.

Materials and Methods

A multistage stratified random sampling technique with Tamil Nadu state as the universe, the districts as the first stage unit, the blocks in the districts as the second stage unit, the villages in the blocks as the third stage unit and the households as the fourth and ultimate unit of sampling, was adopted in this study.

Out of the 32 districts in Tamil Nadu, by considering the agricultural labourers population, the first two districts namely, Villupuram and Cuddalore were selected for the study. From each district, first two blocks were selected based on agricultural labourers population. Four villages were selected randomly from each of the selected four blocks. The ultimate sample size was fixed as 240 and was distributed at the rate of 15 households per village.

A well-structured and pre-tested interview schedule was used to collect the primary data from the sample households. All the required primary data were collected from the sample respondents during the months of October - December, 2018 and the data collected is pertained to the agriculture year 2017-18. The data collected from the published sources pertained to the latest year of availability of data.

Tools of Analysis

Descriptive analysis : Descriptive statistical analysis was undertaken using percentage, mean etc. to study the socio-economic characteristics of sample beneficiaries of MGNREGA in the study area.

Composite index of standard of living: Composite index of standard of living was computed for each household combining the social and economic indicators using the scoring technique of

Devi (2005). The social indicators included respondents exudes confidence, cooperation from family members, confidently faces financial crisis, helps neighbours, communication skills, freedom to spend and save the earnings, access to medical facilities, sanitation facilities within house and access to safe drinking water. The economic indicators included the value of assets, income, savings and consumption pattern.

Index of Social Indicators of h^{th} household (Sh) is given by

$$\Sigma S_i / \Sigma S_{i\,(max)}$$

Index of Economic Indicators of h^{th} household (Eh) is given by

$$\Sigma E_j / \Sigma E_{j\,(max)}$$

Composite Index of Standard of Living of h^{th} household (CISLh) is given by

$$W_1 S_h + w_2 E_h$$

Where, S_i and E_j represent ith social and j^{th} economic indicators, respectively. $S_{i\,(max)}$ and $E_{j\,(max)}$ are the maximum scores for ith social indicators and jth economic indicators. Weight w_1 is given by $\Sigma S_{i\,(max)} / (\Sigma S_{i\,(max)} + \Sigma E_{j\,(max)})$ and w_2 is equal to $1 - w_1$.

Determinants of Level of Participation in MGNREGA Scheme

A multiple linear regression model was employed to identify the factors influencing the level of participation in MGNREGA scheme. The empirical model used for estimation was given by;

$$Y_t = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \mu$$

Where, Y_t = Number of days the

beneficiaries worked under MGNREGA, α = Constant, X_1 = Age (years), X_2 = Gender (1 for female, 0 for male), X_3 = Literacy level (years of schooling), X_4 = Family size (in numbers), X_5 = Size of landholdings (in acres) and β_i's = Parameters to be estimated and μ_i = error term.

Determinants for Choice of Continuation in MGNREGA Scheme

The logit model was used to estimate the determinants for the respondent's decision to continue employment in MGNREGA scheme. The index variable indicates whether the beneficiary decides to continue working under MGNREGA or not.

$$Li = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \mu$$

Where, α = Constant, X_1 = Age (years), X_2 = Gender (1 for female, 0 for male), X_3 = Literacy level (years of schooling), X_4 = Family size (numbers), X_5 = Man days availed by the beneficiary (numbers), X_6 = Problems in receiving wages (1 for yes, otherwise takes 0), X_7 = Justification of wages, given the work (1 for yes, otherwise takes 0), X_8 = Irregular work (1 for yes, otherwise takes 0), i's = Parameters to be estimated and μ = error term

Garrett Ranking Technique

In this study, Garrett ranking technique was used to rank the constraints faced by the beneficiaries of MGNREGA scheme.

As a first step, the per cent position of each rank was found out by the following formula:

$$\text{Per cent position} = 100 (R_{ij} - 0.5)) / N_j$$

Where, R_{ij} = Rank given to the ith item by the j^{th} individual and N_j = Number of items ranked by the jth individual

The per cent position of each rank, thus, obtained was then converted into scores by referring to the Table given by Garrett in 1959. The respondents were requested to rank the opinions / reasons relevant to them according to the degree of importance. The rank given by each of the respondent was converted into scores. Then for each reason, the scores of individual respondents were added together and divided by the total number of respondents. These mean scores for all the reasons were arranged in the descending order and ranks were given. By this method, the accuracy in determining the preference was obtained.

Results and Discussion

Progress of MGNREGA in the Study Area : The physical and financial progress of the scheme in the study area is presented in Table 1 and 2.

It could be understood from Table 1 that the SC and ST workers constituted around 35 per cent of the active workers in the study area, as against the state figure of 29 per cent. In contrary, the percentage of women person days out of the total person days generated was around 77 per cent in the study districts in 2017-18, whereas, it was high at the state level, i.e., 86 per cent. It could also be seen that the percentage of women days increased over the years in the state, but it was almost maintained at the same level in the study area i.e., at 77 per cent.

The average wage rate per day per person varies widely between the state and the districts over years. It was Rs. 123 and Rs. 111 in Tamil Nadu and in the study districts, respectively, in 2013-14. However, it has increased to Rs. 152 and Rs.138, respectively, for the state as well as in the districts in 2017-18. Also, the average days of employment provided per household in the state was 41.08 in 2017-18, which was comparatively lesser than the previous periods (63.87 per cent). The same pattern is observed

in the district also, where the average rate of employment per household was only 28.34 in 2017-18, as against 53.03 in the previous year. Similarly, the total number of households completed 100 days of employment has an increasing trend up to 2016-17 and then declined in 2017-18. The same trend has been observed in the total households and the total individuals worked under the scheme.

It could be seen from Table 2 that out of the total expenditure incurred on this scheme, the material cost accounted for 13.13 per cent in Tamil Nadu and 12.19 per cent in the study area in 2017-18. The average cost spent per day per person has increased from Rs. 141.20 to Rs.192.41 between 2013-14 and 2017-18 and the same has increased from Rs.124.81 to Rs.178.27 in the sample districts.

Table 1. Physical progress of MGNREGA scheme in the study area, 2014-15 to 2017-18

Physical Progress	Tamil Nadu				Study Area			
	2014 -15	2015 -16	2016 -17	2017 -18	2014 -15	2015 -16	2016 -17	2017 -18
Person days generated (in Lakhs)	2679.65	3686.42	3999.42	2,388.81	306.74	513.66	538.21	251.32
SC person days percentage as of total person days	28.94	28.28	28.42	29.42	35.57	34.63	34.62	34.95
ST person days percentage as of total person days	1.12	1.21	1.11	1.11	1.10	1.11	0.97	1.07
Women person days out of total (%)	53.36	85.20	85.68	85.68	76.54	77.35	76.77	76.80
Average days of employment provided per household	47.36	60.90	63.87	41.08	33.72	52.80	53.03	28.34
Average wage rate per day person (Rs)	122.95	133.45	140.46	152.01	111.12	120.41	130.16	137.98
Total number of households completed 100 days of wage employment	3,33,005	8,46,347	13,20,733	1,50,236	19,062	88,972	1,05,111	4,968
Total households worked (in Lakhs)	56.58	60.53	62.62	58.15	9.21	9.70	10.09	10.59
Total individual worked (in Lakhs)	69.13	74.13	76.16	68.29	13.15	13.90	14.60	12.26
Differently abled persons worked	65,374	65,206	66,320	60,889	11,248	10,666	10,750	9,550

Source: MGNREGA at a Glance, 2017-18

Table 2. Financial progress of MGNREGA scheme in the study area, 2014-15 to 2017-18

Financial progress	Tamil Nadu				Study Area			
	2014-15	2015-16	2016-17	2017-18	2014-15	2015-16	2016-17	2017-18
Total expenditure (Rs. in Lakhs)	3,62,398.57	6,02,754.30	5,67,399.35	6,35,315.34	34,692.39	73,907.54	70,789.01	67,359.05
Wages (Rs. in Lakhs)	3,12,030.52	4,63,337.07	4,45,037.64	5,33,758.28	30,518.90	59,442.80	56,080.31	56,768.58
Material and skilled wages (Rs. in Lakhs)	31,006.54	1,16,175.58	1,01,430.98	80,656.28	1,984.48	11,484.07	12,002.87	7,769.61
Material (percentage)	9.04	20.05	18.56	13.13	6.42	16.99	16.95	12.19
Average cost per day per person (in Rs)	141.20	169.62	170.24	192.41	124.81	146.97	156.03	178.27
Percentage of total expenditure through EFMS	88.22	78.95	80.60	99.60	88.37	82.17	81.10	99.67
Percentage of payments generated within 15 days	27.43	31.97	9.16	99.28	10.24	18.35	6.12	99.63

Source: MGNREGA at a Glance, 2017-18

It was also noted that the percentage of payments generated within 15 days was very less in Tamil Nadu during 2013-14, which was accounted to 27.43 per cent and it has increased and reached 100 per cent in 2017-18. So also, in the study area, only 10.24 per cent of the payments were generated within 15 days in 2013-14 and it reached to 99 per cent in 2017-18. The total expenditure under the scheme has also increased over the years. The above results revealed that there was a slowdown in the progress both in terms of physical and financial, during 2017-18, as compared to the previous years.

Job Cards Position of MGNREGA Beneficiaries : The information on job cards position in the study area is presented in Table 3.

It could be observed from Table 3 that in Tamil Nadu, the total number of job cards issued to the beneficiaries was 81.54 lakhs. Of which, only 85.52 per cent of cards are active. Out of the total workers in the scheme, the numbers of active workers constituted 73.31 per cent and the average days of employment provided per household was 41.08. A look at the table would also show that the 92.52 per cent of the total job cards are active in the study districts. The total active workers constituted 77.74 per cent of the total workers under this scheme.

Average Wage Rate Earned : The information on nature of work and corresponding average wage rate earned by the sample households in the study area were collected for comparison and are presented in Table 4.

It could be seen from Table 4 that average wage rate offered for construction work in the study area was Rs.550, which is comparatively higher than the wages given for other works. The agricultural labourers got an average wage rate of Rs.190, while male labourers received Rs. 220 per day and female labourers received Rs.160 per day, respectively. As compared to the wages earned by the respondents from other works, the wage rate offered for MGNREGA work was very less. Even then, rural poor highly depend on these employment days for their livelihoods.

Economic Impact of MGNREGA : The economic impact of MGNREGA scheme, in terms of employment generation, income levels, assets position, savings pattern and consumption pattern of the beneficiaries in both pre- and post- situations were analysed and results are presented in Table 5 under pre- and post-MGNREGA.

It could be seen from Table 5 that the average employment level of the beneficiaries in pre-MGNREGA situation was 325 man days and it has been increased to 391 man days in

Table 3. Job cards position of MGNREGA in the study area, 2017-18 (in Lakhs)

Particulars	Tamil Nadu	Study Area
Total number of job cards issued	81.54	11.37
Total number of active job cards	69.73 (85.52)	10.52 (92.52)
Total number of workers	118.83	20.17
Total number of active workers	87.11 (73.31)	15.68 (77.74)

Table 4. Average wage rates earned by the sample households

Nature of work	Wage rate day^{-1} (in Rs.)
Agricultural labourers	190
Construction work	550
Shop salesman	160
Milk vendor	150
Technical labour	330
Supervisor	400
Driving	350
MGNREGA work	100

post-MGNREGA and the increment in employment level constituted 20.31 per cent. It could also be seen that the increment in employment was more pronounced in the non-farm sector (24.53 per cent). i.e., it increased from 159 to 198 man days. Also, the additional employment generated in the on-farm and off-farm activities were 13 days and 14 days, respectively.

The results also revealed that the beneficiaries of MGNREGA, earned an average income of Rs.75,300 from sources like on-farm, off-farm and non-farm activities, and they derived an additional income of Rs. 11,520 due to the employment generation from the scheme. The net change in the income from non-farm sources constituted 100.82 per cent. This might be due to the consequent increase in the employment days from MGNREGA scheme, which in turn, could have contributed more income to the households.

It is also observed that on an average MGNREGA beneficiary households possessed assets worth of Rs.15,030 in the pre-MGNREGA situation, while it was Rs. 20,310 in the post-MGNREGA situation. The increment in the asset position constituted 35.13 per cent. Among the different types of assets, the increment in consumer durables accounted a major share, followed by livestock and conventional implements in the post-MGNREGA situation. The pattern of asset holdings changed in favour of livestock and consumer durables in post-MGNREGA situation. The concentration of assets in the form of livestock might have been due to their income generating nature and easy liquidity position offered by them to rural poor.

A further look at the table revealed that on an average, the beneficiary households had saved only Rs.6,140 and Rs.13,820 in the pre- and post-MGNREGA situations, respectively.

Table 5. Economic impact of MGNREGA on the beneficiaries

Particulars	Pre-MGN-REGA	Post-MGN-REGA	Incre-ment
Employment Generation (in man days)			
On-farm	68 (20.92)	81 (20.72)	13 (19.12)
Off-farm	98 (30.15)	112 (28.64)	14 (14.29)
Non-farm	159 (48.93)	198 (50.64)	39 (24.53)
Total	325 (100.00)	391 (100.00)	66 (20.31)
Income Level (in Rupees)			
On-farm	39,870 (62.51)	41,860 (55.59)	1,990 (4.99)
Off-farm	12,980 (20.35)	11,490 (15.26)	-1,490 (-11.48)
Non-farm	10,930 (17.14)	21,950 (29.15)	11,020 (100.82)
Total	63,780 (100.00)	75,300 (100.00)	11,520 (18.06)
Asset Position (in Rupees)			
Conventional implements	8,470 (56.35)	10,570 (52.04)	2,100 (24.79)
Livestock	3,100 (20.63)	4,270 (21.02)	1,170 (37.74)
Consumer durables	3,460 (23.02)	5,470 (26.94)	2,010 (58.09)
Total	15,030 (100.00)	20,310 (100.00)	5,280 (35.13)
Savings Pattern (in Rupees)			
Banks	2,540 (41.37)	6,680 (48.33)	4,140 (163)
Post office	1,220 (19.87)	2,660 (19.25)	1,440 (118.03)
SHGs	1,530 (24.92)	2,830 (20.48)	1,300 (84.97)
Others	850 (13.84)	1,650 (11.94)	800 (94.12)
Total	6,140 (100.00)	13,820 (100.00)	7,680 (125.08)
Consumption Pattern (in Rupees)			
Food	42,070 (77.61)	51,850 (77.58)	9,780 (23,25)
Non-food	12,140 (22.39)	14,980 (22.42)	2,840 (23.40)
Total	54,210 (100.00)	66,830 (100.00)	12,620 (23.28)

The percentage increase in the amount saved through banks, post office, SHGs and others had increased drastically, after the respondents have become the beneficiaries of the MGNREGA. Hence, it could be inferred that the MGNREGA have helped the beneficiaries to develop the habit of thrift through the additional income generated from additional employment.

It is also observed that the annual consumption expenditure of the beneficiary households has been increased to a tune of Rs.12620 (23.28 per cent) between the pre- and post-MGNREGA situation, which might be due to the increase in the income levels of the respondents. The amount spent on food and non food items has increased from Rs.42,070 to Rs.51,850 and Rs.12140 to Rs. 14,980, respectively, in the post-MGNREGA situation. The increase in the amount spent by the consumption might due to the increase in income of the MGNREGA beneficiaries.

Social Impact of MGNREGA : A study of Table 6 would show that the social impact of MGNREGA was found to be high in the post-MGNREGA situation. The sample respondents felt their communication skills and freedom to spend and save the earnings improved vastly after they became the beneficiaries of the MGNREGA.

After becoming MGNREGA beneficiaries, the sample respondents were able to interact and communicate with others confidently and they were also able to face and solve their financial and social problems independently. As the beneficiaries of MGNREGA, they were helping others too in their developmental activities which, earlier they were not allowed to do even though they were willing to help others.

The MGNREGA beneficiaries were not only interested in their own personal development, but involved in social development also.

Table 6. Social impact of MGNREGA (Percentage)

Particulars	Pre-MGN-REGA	Post-MGN-REGA
Respondents exudes confidence	62	87
Co-operation from family members	58	76
Confidently faces financial crisis	46	79
Helps neighbours	74	80
Communication skills	31	90
Freedom to spend and save the earnings	42	93
Access to medical facilities	64	86
Sanitation facilities within house	36	67
Access to safe drinking water	69	82

Awareness about good health and sanitation was created among the residents. The beneficiaries have attributed all these positive aspects in their social behavior.

Composite Index of Standard of Living: The findings of the study discussed in the earlier subheads quantified the impact of MGNREGA on different economic and social aspects separately for the MGNREGA beneficiaries. An aggregate measure of the overall impact of MGNREGA on the standard of living of beneficiaries, encompassing social as well as economic aspects, i.e., composite index has been worked out using the scoring technique.

It could be seen from Table 7 that the estimated average value of index of standard of living was 28 during pre- MGNREGA situation, while it was 47 during post- MGNREGA situation, thus recording an increase of 19 percentage points.

The disaggregated analysis had shown that the index based on social indicators raised from 39 to 53 between pre- and post- MGNREGA situations, whereas the economic index increased from 31 to 42 during this period. This indicated that the impact of MGNREGA was more pronounced in social aspects than the economic aspects of the respondents.

Table 7. Distribution of beneficiaries based on the composite Index of standard of living (Percentage)

Index	Social index		Economic index		Composite index	
	Pre-MGNREGA	Post-MGNREGA	Pre-MGNREGA	Post-MGNREGA	Pre-MGNREGA	Post-MGNREGA
Up to 20	-	-	37.78	24.01	26.71	-
20 to 40	41.18	12.76	45.49	34.71	24.37	22.46
40 to 60	39.46	37.49	16.73	41.28	29.41	35.18
60 to 80	19.36	49.75	-	-	19.51	42.36
80 to 100	-	-	-	-	-	-
Total	100	100	100	100	100	100
Average index	39	53	31	42	28	47

The distribution of households according to the value of composite index clearly brought out the shift in the distribution of respondents towards higher level of index in the post-MGNREGA situation. It could be noted that nearly 50 per cent of the respondents, who were in the average composite index of below 40 in the pre-MGNREGA situation had been shifted to the average index of 60. Thus, it could be concluded that the composite index of standard of living has been more pronounced in post- MGNREGA situation. It is also inferred that, in general, this scheme had succeeded in raising the socio-economic status of the respondents, by generating additional employment to the beneficiaries.

Determinants of Level of Participation under MGNREGA Scheme : The number of days, the beneficiaries worked under MGNREGA programme was regressed on the factors like age, gender, literacy level, family size and size of land holding of the respondents to find out the relationship between the number of days that the beneficiaries worked under the programme and the contributing factors. The results are presented in Table 9.

Co-efficient of Multiple determination (R^2 = 0.86) revealed that 86 per cent of variation in the employment days was explained by the included variables on the profile characteristics and the F value indicates the best fit of regression.

The variables, gender and family size, were found to be significant at one per cent and would positively influence the number of employment days under the MGNREGA scheme. The coefficient for the variable gender was 0.034, indicating that if the worker was a female, the number of employment days increased by 0.034 days. So also, the coefficient for the variable, family size, indicated an increase of 0.318 employment days for every one additional person in the family.

Literacy level of the beneficiaries was found to be negative and significant, indicating an inverse relationship between literacy and the work days. As the literacy level increases, the preference for MGNREGA employment decreases. Size of land holding was also a variable with a significantly negative co-efficient

Table 9. Determinants of level of participation under MGNREGA scheme

Variable	Co-efficients	P value
Constant	23.78	0.065
Age (years)	0.197	0.102
Gender (binary)	0.034***	0.005
Literacy level (years of schooling)	-0.423**	0.027
Family size (numbers)	0.318***	0.003
Size of land holding (acres)	-1.786**	0.032
R^2	0.86	
F value	12.46	

(** and *** indicate significance at 5 per cent and 1 percent levels respectively)

(-1.786), implying that for every one acre increase in the size of land holdings, the employment days would decrease by 1.78 days. Workers with more acreage, diverted more time to agriculture and thus were not able to engage in other works.

Determinants for Choice of Continuation of MGNREGA : To identify the factors that might influence the decision of the beneficiaries regarding whether they would continue working under the MGNREGA or not, a binary logit regression model has been constructed. The dichotomous dependent variable takes the value 1, if the beneficiary is not willing to work under the scheme anymore and 0, otherwise. The results are presented in Table 12.

Table 12. Determinants of choice of continuation

Variables	Co-efficients	Odds ratio	P values
Constant	-45.786	0.000	0.062
Age (years)	-0.021	0.979	0.081
Gender (binary)	1.187	3.277	0.075
Literacy level (years of schooling)	-0.127	3.086	0.193
Family size (numbers)	0.471	1.602	0.081
Man days availed by the beneficiary (numbers)	0.015	1.015	0.091
Problems in receiving wages (binary)	1.647**	5.191	0.043
Unsatisfactory wages, given the work (binary)	2.726**	15.272	0.023
Irregular work (binary)	3.486	32.655	0.165
-2 log likelihood	37.846		
R^2	0.79		
Nagelkerke R^2	0.84		

(**indicate significance at 5 percent levels respectively)

It could be seen from Table 12 that the R^2 value implies 79 per cent of the variation in the decision of the respondents was accounted by the variables included in the model. Besides, the Nagelkerke R^2 was 0.84, which imply that the model is a good fit.

The results show that only two independent variables, *viz*., problems in receiving wages and justification for wages given the work had significant influence on the decision of the beneficiary respondents, whether they will continue working under the MGNREGA or find some other job. While the co-efficient of these two variables were significant at 5 per cent, it can be inferred from the results that the perception of the beneficiary respondents that the wage received under the MGNREGA is not justified increases the possibility that they would no longer work under the MGNREGA.

Further, problems faced by the beneficiary respondents while receiving wage earnings under the MGNREGA from banks or post offices, increases the possibility of them not working under the MGNREGA. The main problem faced and reported by the beneficiaries were that the banks and post offices being located at far off places, they had to travel a long distance to receive the wages. Consequently, they had to incur higher transportation cost besides the cost of time. All the other variable were found to be non- significant.

The field level data revealed that the scheme has changed the standard of living of the rural people to some extent, in general, and SC/ST population in particular. It provided a supplementary income to them and the number of job card holders has also significantly increased. However, due to the problems faced by the beneficiaries in getting the payments and the higher wage rates prevailing in the non-farm sector compared to MGNREGA, the rural workforce have been migrating to urban centers.

Constraints Faced by the Beneficiaries of MGNREGA : The constraints faced by the beneficiaries of MGNREGA were ranked and analysed using Garrett Ranking technique and the results are presented in Table 10. This would give a clear picture on the major

constraints faced by them in the implementation of MGNREGA scheme.

It could be seen from Table 78 that hectic process followed in the banks and post offices was ranked first with a mean score of 93.45. Delay in wage payments and using of account by the respondents had been reported as the second major constraint with a mean score of 86.90. Non availability of regular work assumed third rank with a mean score of 79.15. Lack of special provisions for elderly people was reported as fourth rank by the respondents with a mean score of 64.81. Unnecessary intervention made by the Panchayat officials was ranked fifth with a mean score of 59.05. Corruptions in wage transactions were given sixth rank with a mean score of 52.76. Distant work site was reported as seventh rank with a mean score 49.18.

Table 10. Constraints faced by beneficiaries of MGNREGA

Constraints	Mean score	Rank
Hectic process of bank A/c maintenance	93.45	I
Delay in wage payments	86.90	II
Non availability of regular work	79.15	III
No special provisions for elderly persons	64.81	IV
Unnecessary intervention by authorities	59.05	V
Corruption in wage transactions	52.76	VI
Distant work sites	49.18	VII

Conclusion

The results revealed that the beneficiaries of MGNREGA faced many problems in getting the wages and were not satisfied with the present wages received under the scheme. However, with the limited availability of non-farm employment and the fact that the farm sector cannot provide gainful employment throughout the year, the MGNREGA has the potential for uplifting the conditions of the rural poor to some extent. Hence, it is suggested to deliver the desired outcomes of the scheme by way of good governance in the planning, targeting, implementing and monitoring of the scheme. It is also suggested that the scheme may consider various activities, such as agricultural operations during seasonal time, infrastructure development works during non-cropping seasons and watershed development programme during summer seasons, so as to increase the effectiveness of the scheme. Also, the core objective of creating durable assets and strengthening the livelihood resource base of the rural poor could be attained effectively, through the convergence of MGNREGA with other programmes / schemes.

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Pragmatic Identification of Agriculture Field Problems Through Participatory Rural Appraisal

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Abstract

Agriculture is a sin-qua-non for a nation's progress, Often the emphasis is on the productivity element. An indepth study is inevitable in the production process which is plagued by climate vagaries and various anthropogenic factors. A batch of Aggriculture Research Service providers comprising of six Scientists of various disciplines have made and attempt to study the nitty gritties of agriculture employing participatory rural appraisal technique for identification of agricultural field problems. The village selected is Malpur village of Rajasthan. The study was conducted in 2018 during the Field Experience Training as Agriculture Research Service probationers.

Key words : Participatory Rural Appraisal, Field Experience Training, Agriculture

Participatory Rural Appraisal (PRA) is a systematic, semi-structured activity conducted on site, by a multidisciplinary team. It is basically a bottom to top approach of learning rural life forms with and by rural people (8-10). Due to active participation of community members as well as scientists, PRA has become a useful method to focus attention on village people, their livelihood and relationship with social and economic factors (2-4). It is a good technique to help the community members make an appraisal of their livelihoods and issues related to it. Diverse information is collected during PRA using a number of techniques (5-7). This information is verified by triangulation among various key informants (KI`s) in addition to on-site observation by the team members. Keeping this in view the study was undertaken to identify the major problems faced by the villagers with respect to agriculture.

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Materials and Methods

The following steps were followed to apply the preferential ranking technique (Sabarathnam,1988) in carrying out the analysis.

Step (I) Identification of Key informants (KI)

Key informants, who were conversant with the village situations, like the Panchayat president , progressive farmers, local leaders were first identified. They were asked individually to list out the problems faced by the villagers in relation to agriculture. After knowing the loss or, extent of damage due to each and every problem, they were asked to name three such problems in their village.

Step (ii) Identification of farmers

The farmers identified through the KI were also asked to list out the problems faced by them along with their economic importance. Then, they were also asked to list out other three farmers facing such problem. This technique was continued until 30 farmers were identified.

Estimating the extent of loss or damage, is equivalent of making use of the formula (Harish Kumar and Roy, 1990)

Percentage of damage due to the problem = (number of affected units / total number of units) x 100

Step (iii) Quantification of data

The quantification of data was done by first ranking the problems based on the information obtained from the key informants and the farmers and then calculating the Rank Based Quotient (RBQ) (Sabarathnam,1988), which is as follows :

$$RBQ = \frac{\Sigma f_i (n + 1 - i) \times 100}{N \times n}$$

Where, fi = Frequency of farmers for the i th rank of the problem, N = Number of farmers contacted n = Maximum number of ranks given for ranking problems and i = Rank of the problem.

Step (iv) Computation of the rank correlation coefficient (R)

To choose a single RBQ value for each problem, we worked out the rank correlation coefficient (rs) values and to know the degree of association in listing out the farmers and key

Table 1. Problem ranks for Key Informants and their economic importance (sample size 6)

Problem	Rank										Avg. loss (%)
	1	2	3	4	5	6	7	8	9	10	
Water scarcity	4	1	1	0	0	0	0	0	0	0	30
Soil testing	0	2	2	0	0	0	0	2	0	0	20
Availability of seeds and other inputs	0	0	0	0	3	1	0	0	0	2	15
Disease infestation in vegetables	2	0	1	1	0	2	0	0	0	0	25
Finger rot in safed musli	0	0	0	2	2	2	0	0	0	0	20
Lack of transportation facilities	0	0	0	0	0	0	3	1	2	0	10
Lack of agricultural information in the area	0	1	0	0	0	3	0	0	0	2	15
Low milk production	0	0	0	0	0	0	4	0	2	0	15
Weed infestation	0	0	2	0	0	0	0	1	2	1	15
Pest problem in Cereals	0	0	0	0	0	0	0	5	0	1	20

Table 2. Problem Identification and Prioritization in Malpur village; Rank frequency table

Problem	Rank										Total far-mers
	1	2	3	4	5	6	7	8	9	10	
Water scarcity	14	7	3	1	-	4	-	-	-	1	30
Soil testing	5	8	7	3	-	-	5	2	-	-	30
Availability of seeds and other inputs	3	6	7	3	2	-	1	2	6	-	30
Disease infestation in vegetables	8	9	8	5	-	-	-	-	-	-	30
Finger rot in safed musli	-	-	5	8	15	2	-	-	-	-	30
Lack of transportation facilities	-	-	-	-	-	-	6	10	7	7	30
Lack of agricultural information in the area	-	-	-	7	6	10	7	-	-	-	30
Low milk production	-	-	-	-	-	8	4	4	5	9	30
Weed infestation	-	-	-	3	7	2	5	7	6	-	30
Pest problem in cereals	-	-	-	-	-	4	2	5	6	13	30

Table 3. Rank based quotient (R.B.Q)

Problem number	Key informant (Rank)	Farmer (Rank)
1	93.3(1)	85(1)
2	66.67(3)	64.7(3)
3	43(5)	44.7(5)
4	75(2)	65.7(2)
5	60(4)	54.3(4)
6	31.67(9)	25(9)
7	41.67(6)	38(6)
8	33.33(8)	29(8)
9	40(7)	35(7)
10	26.67(10)	22.7(10)

informants problems.

$$rs = \frac{6\sum_{i=1} D^2}{n\,(n^2 - 1)}$$

where di is the difference in the ranks between the key informants and farmers' i^{th} problem.

If the r_s value was significant at 5 per cent level, we take the average R.B.Q. value, else we consider the farmers R.B.Q. value as the final one , Similar steps were followed to work out the final figure of average percentage loss for each problem.

Step (v) The magnitude value of the problem (VBI) was calculated as

V.B. I= R.B.Q. X Average loss in%

Based on the value based index of the problems, the top most problem (possessing the highest V.B.I was identified.

Results and Discussion

This study was conducted as a part of the Field Experience Training (FET) at Malpur village in Udaipur district of Rajasthan. Six key informants and thirty farmers were contacted to identify the technological needs and problems faced by the villagers. Preferential ranking technique was utilized to identify the problems faced by the Malpur villagers and also the loss or extent or damage due to the problems. In particular, ten different problems were identified. They were : (a) Water scarcity, (b) Soil testing (c) Availability of seeds and other inputs (d) Disease infestation in vegetables, (e) Finger rot in safed musli (f) Lack of transportation facilities (g) Lack of agricultural information in the area and (h) Low milk production (i) Weed infestation (j) Pest problem in cereals. The rankings given to these problems by different key informants and the farmers were outlined in Table 1 and Table 2 respectively, along with the corresponding economic importance of the problems. The Rank Based Quotient value is depicted in Table

Table 4. Problems identified in Malpur village with their magnitude

Problem	RBQ	Av. economic loss per annum (%)	VBI	Rank
Water scarcity	85	30	2550	I
Soil testing	64.7	20	1293.3	III
Availability of seeds and other inputs	44.7	15	670	V
Disease infestation in vegetables	65. 7	25	1641.7	II
Finger rot in Safed Musli	54.3	20	1086.7	IV
Lack of transportation facilities	25	10	250	X
Lack of agricultural information in the area	38	15	570	VI
Low milk production	29	15	435	IX
Weed infestation	35	15	525	VII
Pest problem	22. 7	20	453.3	VIII

4. Perusal of these facts indicates that water scarcity was given the top most rank by four key informants and thirteen farmers. Similarly the average loss due to this problem was found to be 30 per cent (in the case of the key informants). Average economic loss reported by key informants and farmers were almost equal percentage. Likewise, disease infestation in vegetables was given the first rank by two key informants and eight farmers, with the average loss of 25 per cent. Based on the ranks given by the key informants and farmers for the different problems, listed out in Table 1 and Table 2, the rank based quotient was calculated for each problem and is presented in Table 3.

It could be inferred that the calculated R.B.Q. values, ranged from 93.03 to 26.67, in the case of key informants, and from 85 to 22.70 in the case of farmers. However, the highest value in both the case correspond to the incidence of water scarcity in the region. In the next stage, in order to arrive at a single R.B.O. value for all the problems, the rank correlation values were worked out and were found to be 0.97 and 0.976, with respect to the listed problems and the average loss due to the problems respectively. As these two rank correlation values were highly significant , the average values of R.B.Q. and average loss due to the different problems were taken as the final R.B.Q. value (Table 4). In the same table, the Value Based Index (V.B.I.) for all the problems were also provided. It may be noticed, that the maximum V.B.I. value (2550) was attributed to the water scarcity problem. Thus, the preferential ranking technique was successfully utilized to identify water scarcity as the top most problem in Malpur Village of Rajasthan.

Conclusion

Participatory Rural Appraisal Technique is an effective method of eliciting the problems faced by farmers. It helps them to identify the major problem amongst umpteen problems. This technique has great scope in identifying significant problems in Agriculture as it follows bottom to top research approach with the participation of farmers.

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Performance of Chopper Harvesters on Quality of Milling Sugarcane and Sugar Recovery

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Abstract

The study was conducted to evaluate performance of sugarcane harvesters in the field and to analyze effect of harvesting method on trash content green tops in sugarcane delivered for milling and sugar recovery. Two chopper harvesters from Case New Holland and Shaktiman were tested for harvesting sugarcane of two varieties CoM0265 and SNK09293 and compared with manual harvesting take as treatments for analysis whereas three plots at different locations were sub treatments. The tests were conducted in the farmer's field near Ugar Sugar Works Ltd. Ugar Khurd, Karnataka., India. Various machine parameters as well as the operating parameters were studied. Their effects on the field capacity, field and fuel efficiency, un-harvested cane, damaged cane, the total trash delivered for milling and the sugar recovery were studied. The results revealed that the sugar recovery of mechanically harvested sugarcane was (11.68 to 12.00 per cent) comparatively less than that of manually harvested sugarcane (12.21 to 12.44). Green top content in mechanically harvested sugarcane was very high (4 to 12 per cent). That would again contribute to reduction in sugar recovery on basis of total weight of raw material fed to crusher. Trash content of the mechanically harvested sugarcane was 2.0 to 8 per cent, much higher than manually harvested sugarcane (1.0 to 1.5 per cent).

Key words : Sugarcane,Chopper Harvester, Milling Quality, Sugar Recovery.

Sugarcane is an important cash crop and cultivated in more than 90 countries of the world. India contributing 19.98 per cent of the total world production is the second largest producer of sugarcane next to Brazil. Major sugarcane producing states are Uttar Pradesh, Maharashtra, Tamilnadu, Karnataka, and Gujarat. (https://www.indiansugar.com)

Harvesting of sugarcane manually is a highly labor-intensive and drudgery prone activity. High stresses on the muscles and joints (Clementson and Hansen, 2008). The mechanical harvesting reduced laborer requirement for harvest as well as the hardship of workers. One hectare of sugarcane could be harvested in 3.0 to 4.5 h using mechanical harvesters, against 850 to 1000 man-h by manual method of harvesting (Yadav *et al.*, 2002). Machine harvesting avoid pre-harvest burning, which in turn reduces air pollution (Braunbeck et al., 1999). Sugarcane harvesters are of two types namely chopper harvesters and whole cane harvesters. A typical whole cane harvester consists of a de-topper, a base cutter, conveying mechanism, and a discharging mechanism. Base cutters cut canes at about 20 to 30 mm above the ground level (Esquivel *et al.*, 2008). The conveying mechanism has rollers to convey the cane stalks to the discharging mechanism. The discharging mechanism then delivers harvested stalks to either a wagon or onto the field. The other type of harvester is the chopper harvester. Essentially a storage vessel on a truck with a mechanical extension, the machine cuts the stalks at the base, strips the leaves off, and then cuts the cane into segments. These are then deposited into either the on-board container, or a separate

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vehicle traveling alongside. Waste material is then ejected back onto the field, where it acts as fertilizer.

Mechanized sugarcane harvesting brings numerous benefits to farmers and sugar industry. For farmers it helps to increase yield, fosters better ratoon rejuvenation, saves additional expenses spent on stubble shaving, Multiple ratooning and better ratoon performance because of effective harvesting as it cut down to the bottom level of the crop and harvesting operation taken up in one stretch. For millers it helps to uninterrupted supply of cane and multiple ratooning ensures the cane availability continuously. But there is some key component in the mechanical harvesting like sett length which affects the processing of raw material, cane deterioration, invisible losses, trash content, green top content, fuel consumption, field efficiency, field capacity, dropping of sett in field etc. The study was conducted to evaluate performance of sugarcane harvesters in the field and to analyze effect of harvesting method on trash content and sugar recovery.

Materials and Methods

Two different chopper harvesters were tested for harvesting sugarcane at three different locations and compared with manual harvesting. Various machine parameters as well as the operating parameters were studied. Their effect on the field capacity, field and fuel efficiency, losses due to un-harvested cane and damaged cane, the total trash delivered for milling and the sugar recovery was studied. The test conditions for each machine were kept uniform as far as possible.

The test conditions for each machine were kept uniform as far as possible at every location. The details of treatment and sub treatments are presented in Table 1 and 2.

Observations were recorded for each test: Plant population, moisture content of soil in field, speed of operation, wheel slippage, height of cut, number of un-harvested canes, time loss for turning, engine speed, area covered, fuel consumption, field efficiency, weight of the sugarcane harvested, dropped canes and trash content, damage percentage, green top.

Table 1. Details of treatment and replications for comparison of sugarcane harvester

Treatment	T1	T2	T3
Harvesting method	CASE New Holland 4000	Shaktiman Tejas 3737	Manual harvesting
Engine power, hp	176	173	Human worker

Table 2. Details of sub treatments for comparison of sugarcane harvester

Sub treatment	t1	t2	t3
Variety	CoM 265	SNK 09293	SNK 9293
Age of crop, months	12	12	12
Length of furrow, m	105	68	60
Crop spacing, ft	3.50	3.50	4.00
Plant population, Plants Sq. m^{-1}	19	16	13
Type of soil	Black Cotton	Black cotton	Black cotton
Soil moisture, % (WB)	16.43	30.60	16.80

Results and Discussion

The tests conducted in different conditions resulted in variation in performance indices and quality of output. The test results of harvesting sugarcane with two harvesters are presented in Table 3 and discussed in details in subsequent sections.

The data presented in table depicts that the field capacity of harvester and weight of harvested sugarcane were functions of harvesting speed for particular harvester as the speed increased from 3.33 km h^{-1} to 4.7 km h^{-1} field capacity increased from 0.25 ha h^{-1} to 0.39 ha h^{-1} and weight of sugarcane increased

Table 3. Datasheet of field tests of sugarcane harvesters

Observations	Unit	T1t1	T2t1	T1t2	T2t2	T1t3	T2t3
Engine speed (No load)	rpm	2500	2400	2500	2400	2500	2400
Engine speed (On load)	rpm	2400	2300	2400	2300	2400	2300
Avg. Width	mm	1150	1150	1150	1150	1150	1150
Average speed	kmph	4.00	4.14	3.33	4.50	4.70	3.70
Duration of test	h	0.25	0.28	0.65	0.27	0.28	0.30
Time loss at head land	h	0.07	0.08	0.23	0.09	0.12	0.12
Theoretical field capacity	ha h^{-1}	0.46	0.48	0.38	0.52	0.54	0.43
Actual Field capacity	ha h^{-1}	0.33	0.34	0.25	0.39	0.31	0.26
Field efficiency	%	72.00	71.43	64.62	68.15	57.14	60.00
Avg. Wheel slippage	%	8.33	13.63	8.33	7.17	8.00	7.47
Avg. Height of cut	mm	68.87	46.20	54.60	36.25	78.00	82.50
Fuel consumed	l	11.00	10.80	16.50	10.80	12.00	9.84
Fuel consumption	l h^{-1}	44.00	38.57	25.38	40.00	42.86	32.80
Fuel consumption	l ha^{-1}	129.41	94.08	101.52	114.29	126.05	102.50
Time required per ha.	h	2.94	2.44	4.00	2.86	2.94	3.13
Weight of sugarcane harvested	MT	3.73	6.22	8.59	6.06	4.51	4.94
Weight of sugarcane harvested	MT h^{-1}	14.92	22.21	13.22	22.44	16.11	16.47
Fuel consumption per ton	l MT^{-1}	2.90	2.06	2.30	2.10	2.60	1.50
Cane Setts dropped during test	kg	95.00	57.00	154.00	72.00	61.00	32.00
Cane Setts dropped	kg MT^{-1}	26.49	10.91	17.92	14.00	13.50	6.47
Green Top	(%)	4.00	6.00	12.00	10.00	4.00	7.60
Sugar recovery	(%)	11.71	12.00	11.96	11.68	11.86	11.98

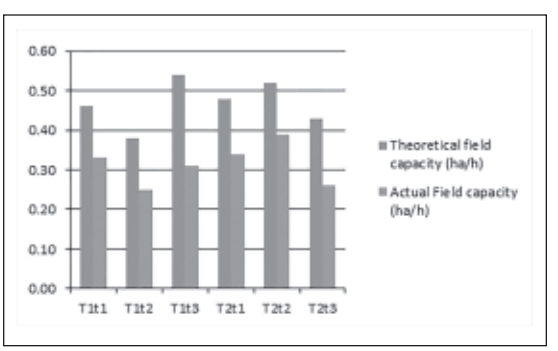

Fig. 1. Comparative field capacities of harvesters.

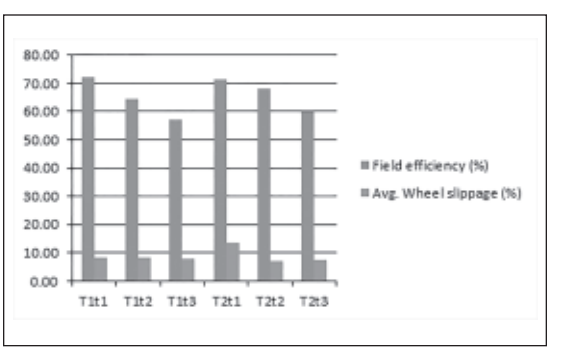

Fig. 2. Comparative field efficiencies and wheel slippage of harvesters.

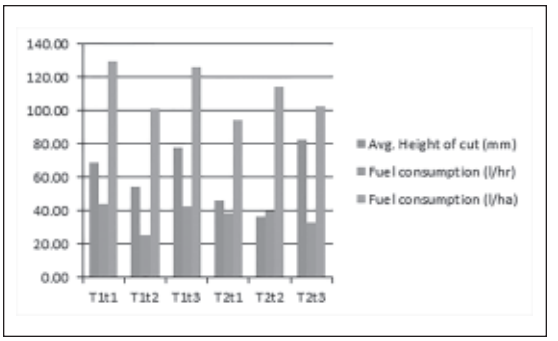

Fig. 3. Comparative height of cut and fuel consumption of sugarcane harvesters.

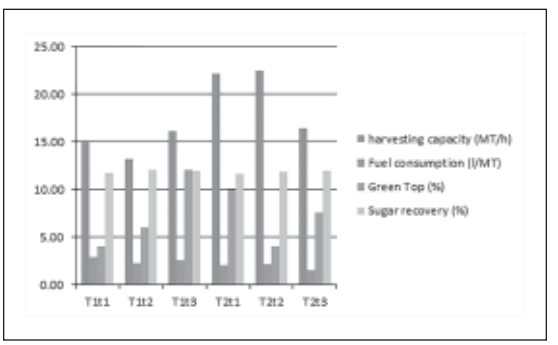

Fig. 4. Comparative harvesting capacity, green tops and sugar recovery.

from 13.22 to 22.44 Mt h^{-1}. Field efficiency was clearly function of machine as well as length of the field. When field length was 60 m field efficiency was 57-60 per cent, which increased to 71-72 per cent for length of 105 m. There was significant increase in fuel consumption with increase in operating speed it was dependant on harvester model also. The dropping of sugarcane setts during operation changed with operating and field conditions.

It is depicted from the figure 1 and 2 that the field capacity and efficiency are function of field size and shape as well as the type of harvester. The harvester 1 was having less slippage as compared to harvester 2.

The harvesters cut the sugarcane at height of 36 to 83 mm above the ground as shown in figure 3.

Average fuel consumption of the harvester was 110 l h^{-1} for harvester 1 and 100 l h^{-1} for harvester 2. But from figure 4 it can be noted that average fuel consumption of harvesters is less than 3 l MT^{-1} of sugarcane.

The green tops content of the mechanically harvested sugarcane ranges from 4 to 11%. Sugar recovery is ot much hampered by the mechanical harvesting.

Conclusions

Field efficiency of sugarcane harvester is higher in 3.5 ft. crop spacing. Sugar recovery of mechanically harvested sugarcane is slightly less than the manually harvested sugarcane. Green top content in mechanically harvested sugarcane is very high.

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Crop Weather Relationships of Fodder Sorghum Varieties under Different Sowing Windows

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Abstract

Field experiment was carried out during summer, 2018 at S.V. Agricultural College, Tirupati, Acharya N. G. Ranga Agricultural University to study the crop weather relationship of fodder sorghum varieties under different times of sowing. The experiment was in four dates of sowing (I FN of January, II FN of January, I FN of February and II FN of February) with varieties (CSV 21 F, CSV 30 F and CSV 32 F). Results are revealed that among the four times of sowing, different meteorological indices GDD, HTU, PTU, and TUE varied across the different growth stages. Early sowing (I FN of January) had favorable agro-climatic conditions particularly temperature, day length and sunshine hours in terms of required accumulation of GDD, PTU and HTU from sowing to harvest compared to other dates of sowing. Total requirement of accumulated GDD, HTU and PTU showed increasing trend with extension of sowing time from I FN of January to II FN of February. The CSV 32 F variety accumulated maximum GDD from sowing to until harvest.

Key words : Times of sowing, GDD, PTU, HTU.

In India, animal husbandry is closely associated with crop production as a complementary enterprise, possessing the largest livestock population of 512 million heads (Livestock census, 2012). The availability of quality feed and fodder has been considered as the major bottleneck in harnessing the potential of the livestock sector in India. Further increasing area under fodder crops is not possible in the country due to lot of demand for food grain to meet the facing hardship for feeding the burgeoning human population. Increasing the fodder yield per unit area is with introduction of high yielding, better quality fodder varieties with suitable location specific agronomic practices. The only way to enhance the fodder production under the existing situation.

Sorghum is an important widely grown forage crop for dairy animals. It is fast growing, quick in recovery after cutting, palatable, nutritious and utilized as silage and hay besides fresh feeding. Sorghum crop is adaptive to vast environmental conditions in India and as well as in Chittoor district. Seasonal variation in production of fodder results in large gap between demand and supply of green fodder during crucial periods of the year such as summer. Development of location specific agrotechniques and identification of good quality genotypes of sorghum offer an excellent opportunity to provide good quality fodder for better nutrition to bovine population.

Among agronomic manipulations, sowing time and suitable cultivars are considered to be important for increased production potentials of fodder sorghum. The sowing time of the sorghum affects the fodder supply to considerable extent and hence, proper sequencing of the sowing time should be done in order to achieve maximum fodder yield along

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with maintaining the regular supply of the green fodder. The identification of genotype for enhanced productivity and quality during summer to mitigate the present shortage of fodder requirement in summer season.

The critical agrometeorological variables associated with agricultural production are precipitation, air temperature and solar radiation (Hoogenboom, 2000). Phenological development of crop closely followed the changes in weather conditions occurring during crop growing period. The variation in planting dates modifies the microclimate to which the plants are exposed and it is responsible for biomass production and ultimately the yield. It is necessary to understand the knowledge of plant environment interaction for increasing yield of crop. The best genotype with suitable sowing time lead to changes in the crop microclimate which has a direct influence on the plant growth and development and resource utilization. Keeping above factors in view, the present experiments were designed to study the crop weather relationships (interactions) in fodder sorghum under different sowing windows and varieties.

Materials and Methods

A field experiment entitled "Optimization of Sowing Window for Summer Fodder Sorghum [*Sorghum bicolor* (L.) Moench] Cultivars" was carried out during summer, 2018 on sandy loam soils of dryland farm of S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University. The experiment was laid out in a split plot design and replicated thrice. The treatments consisted of four times of sowing *viz*., I FN of January, II FN of January, I FN of February and II FN of February assigned to main plots and three fodder sorghum varieties *viz*., CSV 21 F, CSV 30 F and CSV 32 F assigned to subplots.

Agro meteorological indices developed by utilizing various meteorological elements are found in literature to study the crop weather relationships. Agrometeorological indices like Growing Degree Days (GDD), Heliothermal Units (HTU), Photothermal Units (PTU) and Thermal use efficiency (TUE) were computed during different phenophases of sorghum (by adopting the procedure laid out by Rajput (1980).

Growing Degree Days : A degree day is the difference between the mean temperature of the day and base temperature. It is a weather based indicator for assessing crop development. It is a measure of heat accumulation used to predict plant developmental rates such as date that crop reaches maturity. Base temperature of 10°C was used for computation of GDD on daily basis for sorghum (Kumar, 2003).

$$\text{Growing degree days (°C)} = \Sigma \frac{T_{max}+T_{min}}{2} - T_b$$

Where, Tmin = minimum temperature (°C), Tmax= maximum temperature (°C) and T_b = Base temperature = 10°C

Helio Thermal Units : The helio thermal units for a given day represent the product of GDD and the actual hours of bright sun shine for that day. The sum of the HTU for the duration of each phenophase was determined by using the formula.

Accumulated HTU (°C day hour) = GDD x Duration of sunshine hour

Photo Thermal Units : The photo thermal units for each day represent the product of GDD and the day length. The accumulated PTU for each phenophase was determined by the following formula.

Accumulated PTU (°C day hour) = GDD x Day length hour

Thermal Use Efficiency : Thermal Use Efficiency for biomass yield was calculated using the following formula.

TUE (kg ha^{-1} °C day^{-1}) = Biomass yield / GDD

Results and Discussion

Weather parameters : The data pertaining to weather parameters recorded during the crop growth period of fodder sorghum as influenced by times of sowing and varieties are presented in Table 2. The variation in climate is especially related to solar radiation, day length, relative humidity, rainfall and temperature..

The temperature maximum and minimum increased by 4.8 and 5.3°C respectively during the crop growth period of fodder sorghum when sowing was extended from I FN of January to II FN of February. Similarly the morning relative humidity was reduced by 5 per cent when sowing was delayed to II FN of February. Daily evaporation was 5.6 mm during the crop growth period of I FN of January sown crop. It steadily increased with delayed sowing and reached maximum of 6.8 mm when the crop was sown during II FN of February. The duration of sunshine reduced from 8.5 hours day-1 to 7.9 hours day-1 with extended times of sowing from I FN of January to II FN of February. Significant increase or decrease was not observed in other weather parameters.

Growing Degree Days : The crop sown during I FN of January and I FN of February accumulated 104.3 and 102.1 growing degree days respectively for emergence of seedlings. The degree day accumulation was reduced when sowing was delayed and the crop sown very late during II FN of February required 91.6 growing degree days for its emergence. The degree day accumulation from emergence to 4th leaf stage was chiefly influenced by the adopted times of sowing. The crop sown during II FN of February accumulated maximum growing degree days (216.4°C days) followed by II FN of January (190.5°C days). The crop sown during I FN of February (157°C days) and I FN of January (155.3°C days) was exposed to least accumulation of GDD during this corresponding stage. The requirement of accumulated growing degree days to attain subsequent stage of Panicle initiation was gradually increased (187.0 to 331.1°C days) with extended times of sowing from I FN of January to II FN of February and the crop sown during II FN of February accumulated maximum GDD (331.1°C days) for panicle initiation. The trend was continued during the later stage of booting also. The GDD accumulation during 50 per cent flowering was remarkably influenced by the times of sowing and the crop was exposed to maximum of

Table 1. Green fodder yield (t ha^{-1}) and dry fodder yield (t ha^{-1}) of fodder sorghum varieties as influenced by times of sowing

Treatments	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})
Times of sowing		
I FN of January	35	14
II FN of January	33	13
I FN of February	29	12
II FN of February	25	10
SEm±	1.3	0.4
CD (P= 0.05)	4.5	1.4
Varieties		
CSV 21 F	24	10
CSV 30 F	30	12
CSV 32 F	36	14
SEm±	0.9	0.3
CD (P= 0.05)	2.8	0.8
Times of sowing x Varieties		
S at M		
SEm±	1.88	0.53
CD (P= 0.05)	NS	NS
M at S		
SEm±	2.01	0.58
CD (P= 0.05)	NS	NS

224.2 growing degree days when it was sown very late during II FN of February. The accumulation of degree days (151.2°C days) during this corresponding period observed steep reduction with sowing of crop during II FN of January. The total requirement of accumulated growing degree days showed increasing trend (1021.8 to 1359.5°C days) with extension of sowing time from I FN of January to II FN of February. These results are in consonance with the findings of Ahmad *et al*. (2016), Prakash *et al*. (2017).

Among the varieties tested, CSV 21F accumulated maximum growing degree days for emergence. CSV 30 F and CSV 32 F were exposed to maximum growing degree days at 4th leaf and booting stages. The CSV 32 F variety required maximum degree day accumulation during Panicle initiation and 50 percent flowering. However, the variety CSV 30 F required maximum degree day accumulation at panicle initiation under late sown conditions. The total growing degree day accumulation was exceptionally influenced by the tested varieties and CSV 32 F variety recorded maximum growing degree day accumulation from sowing to until harvest. The above results were in conformity with the findings of Hemalatha *et al*. (2013), Prakash *et al*. (2017).

Helio Thermal Units : The crop sown during I FN of January I FN of February and II FN of February required 878.2, 811.6 and 869.2 °C day hours respectively for emergence of seedlings. The HTU requirement was reduced to 603.4 when crop was sown during II FN of January. The HTU requirement from

Table 2. Mean weather parameters recorded during the crop growth period of fodder sorghum as influenced by time of sowing and varieties

	Temperature (°C)			Relative Humidity (%)			Wind velocity KMPH	Bright sun shine	Rain-fall (mm)	Evapo-ration (mm)
	Max.	Min.	Mean	RH I	RH II	Mean				
S1 : I Fortnight of January (12.01.2018)										
V_1	32.1	16.3	24.2	86	37	61	4.6	8.7	28.4	5.6
V_2	32.6	17.2	24.9	86	38	62	4.5	8.4	41.2	5.6
V_3	32.8	17.5	25.1	85	38	61	4.5	8.4	41.2	5.6
Mean	32.5	17.0	24.7	85	37	61	4.5	8.5	36.9	5.6
S2 : II Fortnight of January (27.01.2018)										
V_1	33.4	17.9	25.7	85	35	60	4.4	8.4	41.2	5.9
V_2	33.9	18.9	26.4	84	36	60	4.4	8.3	41.2	6.0
V_3	33.9	19.0	26.5	84	36	60	4.4	8.3	41.2	6.0
Mean	33.7	18.6	26.2	84	36	60	4.4	8.3	41.2	5.9
S3 : I Fortnight of February (10.02.2018)										
V_1	34.7	20.0	27.4	83	36	60	4.3	8.2	0.2	6.3
V_2	35.2	20.8	28.0	82	36	59	4.4	8.3	12.8	6.5
V_3	35.4	21.0	28.2	82	36	59	4.4	8.3	15.0	6.5
Mean	35.1	20.6	27.9	83	36	59	4.4	8.3	9.3	6.4
S4 : II Fortnight of February (26.02.2018)										
V_1	36.5	22.4	29.4	80	35	58	4.2	8.1	15.0	6.8
V_2	36.9	23.1	30.0	80	36	58	4.3	7.8	99.2	6.8
V_3	36.9	22.9	29.9	81	36	58	4.3	7.8	99.2	6.9
Mean	36.8	22.8	29.8	80	36	58	4.3	7.9	71.1	6.8

emergence to 4th leaf stage was chiefly influenced by the adopted times of sowing.

The crop sown during II FN of February required maximum HTU (1637.9 °C day hours) followed by II FN of January (1510.7 °C day hours). The crop sown during I FN January required least accumulation of HTU (1361.8) during this corresponding stage. The accumulated HTU to attain subsequent stage of Panicle initiation was gradually increased with extended times of sowing from I FN of January to II FN of February (1535 to 2467.5°C day hours) and the crop sown during II FN of February accumulated maximum HTU (2467.5°C day hours) for panicle initiation. The crop sown very late during II FN of February was exposed to maximum HTU (4169.7°C day hours) during subsequent stage of booting followed by I FN of February (3672.7°C day hours). The HTU requirement during 50 per cent flowering was remarkably influenced by the times of sowing and the crop sown during I FN of February was exposed to maximum HTU (1764.6°C day hours) followed by II FN of February (1456°C day hours). The accumulation of HTU during this corresponding period observed steep reduction with sowing of crop during II FN of January (1045.6°C day hours). The total requirement of HTU showed decreasing trend with extension of sowing time from I FN of January to II FN of February.

The HTU required for the advancement of the crop through different stages to attain final harvest stage was remarkably influenced by the tested varieties. CSV 21 F required maximum HTU for emergence. CSV 30 F and CSV 32 F were exposed to maximum HTU at 4th leaf and booting stages. The CSV 32 F variety required

Table 3. Agro meteorological indices at different growth stages of fodder sorghum as influenced by time of sowing and varieties

	Sowing to emergence			4th leaf stage			Panicle initiation stage		
	GDD	HTU	PTU	GDD	HTU	PTU	GDD	HTU	PTU
I FN of January									
CSV 21 F	119.2	1012.3	1519.1	149.9	1304.3	1903.7	144.7	1190.9	1821.7
CSV 30 F	96.9	811.1	1235.0	160.6	1390.6	2041.8	186.2	1516.8	2344.1
CSV 32 F	96.9	811.1	1235.0	160.6	1390.6	2041.8	230.2	1900.0	2897.4
Mean	104.3	878.2	1329.7	157.0	1361.8	1995.8	187.0	1535.9	2354.4
II FN of January									
CSV 21 F	109.9	1018.2	1392.2	183.4	1440.4	2306.7	171.5	1088.5	2131.3
CSV 30 F	98.0	905.1	1242.4	195.3	1553.4	2456.5	203.3	1937.8	2522.4
CSV 32 F	87.0	795.1	1103.9	192.9	1538.3	2427.8	232.0	2214.9	2876.2
Mean	98.3	603.4	1246.2	190.5	1510.7	2397.0	202.2	1747.0	2509.9
I FN of February									
CSV 21 F	121.3	988.9	1522.5	156.2	1491.5	1941.1	188.1	1698.1	2309.1
CSV 30 F	92.6	723.0	1165.1	154.9	1497.8	1924.9	255.9	2107.4	3146.2
CSV 32 F	92.6	723.0	1165.1	154.9	1497.8	1924.9	294.9	2368.9	3622.0
Mean	102.1	811.6	1284.3	155.3	1495.7	1930.3	246.3	2058.1	3025.8
II FN of February									
CSV 21 F	107.5	1028.2	1326.7	217.8	1555.9	2667.7	279.2	2132.4	3370.7
CSV 30 F	91.3	865.7	1127.2	217.8	1651.8	2670.7	378.9	2807.8	4558.8
CSV 32 F	76.1	713.7	940.5	213.5	1706.1	2621.0	335.2	2462.4	4043.6
Mean	91.6	869.2	1131.5	216.4	1637.9	2653.1	331.1	2467.5	3991.0

maximum HTU during Panicle initiation and 50 percent flowering. However, the variety CSV 30 F required maximum HTU under late sown conditions. The total HTU requirement was exceptionally influenced by the tested varieties and CSV 32 F variety recorded maximum HTU accumulation from sowing to until harvest. However, the variety CSV 30 F required maximum HTU under late sown conditions. This investigation corroborates with the findings of Thavaprakash *et al*. (2007), Prakash *et al*. (2017).

Photo Thermal Units : The crop sown during I FN of January and I FN of February required 1329.7, and 1284.3 PTU respectively for emergence of seedlings. The PTU requirement was reduced to 1131.5 °C day hours when crop was sown very late during II FN of February. The PTU requirement from emergence to 4th leaf stage was chiefly influenced by the adopted times of sowing. The crop sown during II FN of February required maximum PTU (2653.1°C day hours) followed by II FN of January (2397°C day hours). The crop sown during I FN February required least accumulation of PTU (1930.3 °C day hours) during this corresponding stage.The accumulated PTU to attain subsequent stage of Panicle initiation was gradually increased with extended times of sowing from I FN of January to II FN of February (2354.4-3991.0 °C day hours) and the crop sown during II FN of February accumulated maximum PTU (3991.0 °C day hours) for panicle initiation. The crop was exposed to maximum PTU during the subsequent stage of booting when sowing was delayed to I and II FN of February. The PTU requirement during 50 per cent flowering was remarkably influenced by the times of sowing

Table 3. Contd.

	Booting stage			50 per cent flowering stage			Total		
	GDD	**HTU**	**PTU**	**GDD**	**HTU**	**PTU**	**GDD**	**HTU**	**PTU**
I FN of January									
CSV 21 F	323.9	3000.6	4024.0	323.9	3000.6	4024.0	323.9	3000.6	4024.0
CSV 30 F	403.5	3713.7	4992.2	403.5	3713.7	4992.2	403.5	3713.7	4992.2
CSV 32 F	377.5	3416.8	4661.4	377.5	3416.8	4661.4	377.5	3416.8	4661.4
Mean	368.3	3377.0	4559.2	368.3	3377.0	4559.2	368.3	3377.0	4559.2
II FN of January									
CSV 21 F	354.4	1111.7	4331.2	120.1	639.8	1451.5	939.2	7772.6	11612.9
CSV 30 F	485.5	3734.3	5909.7	167.7	1211.5	1996.6	1149.6	9342.2	14127.6
CSV 32 F	513.2	3850.8	6237.9	166.0	1285.5	1971.9	1190.1	9684.6	14617.7
Mean	451.0	2899.0	5492.9	151.2	1045.6	1806.7	1093.0	8933.1	13452.7
I FN of February									
CSV 21 F	412.4	2885.5	4983.6	164.6	1362.7	1955.2	1042.4	8426.8	12490.5
CSV 30 F	519.8	3920.2	6244.8	215.7	1974.1	2545.9	1238.6	10222.4	15062.9
CSV 32 F	541.3	4212.3	6489.1	224.8	1957.1	2641.7	1308.4	10759.1	15842.8
Mean	491.1	3672.7	5905.8	201.7	1764.6	2380.9	1196.5	9802.8	14465.4
II FN of February									
CSV 21 F	401.0	3433.7	4747.7	161.5	1193.6	1888.5	1165.8	9343.9	14001.2
CSV 30 F	546.7	4613.6	6431.9	245.0	1519.8	2825.6	1479.5	11458.1	17699.8
CSV 32 F	542.2	4461.7	6396.1	266.2	1654.5	3077.0	1433.1	10998.3	17147.3
Mean	496.6	4169.7	5858.6	224.2	1456.0	2597.0	1359.5	10600.1	16282.8

and the crop sown during II FN of February was exposed to maximum PTU (2597.0 °C day hours) followed by I FN of January (2405.4 °C day hours). The accumulation of PTU (1806.4) during this corresponding period observed steep reduction with sowing of crop during II FN of January. The total requirement of PTU showed increasing trend with extension of sowing time from I FN of January to II FN of February (12733-16282.8 °C day hours). These results are in line with the earlier findings as reported Thavaprakash *et al*. (2007), Maurya *et al*. (2015).

The PTU required for the advancement of the crop through different stages to attain final harvest stage was remarkably influenced by the tested varieties. CSV 21 F required maximum PTU for emergence. CSV 30 F and CSV 32 F were exposed to maximum PTU at 4th leaf and booting stages. CSV 21 F required maximum PTU (2621.0) leaf at 4th leaf stage under delayed sown conditions. The CSV 32 F variety required maximum PTU during Panicle initiation and 50 percent flowering. The total PTU requirement was exceptionally influenced by the tested varieties and CSV 32 F variety recorded maximum PTU accumulation from sowing to until harvest. However, the variety CSV 30 F required maximum PTU (4558.8) under late sown conditions. This investigation corroborates with the findings of Prakash *et al*. (2017).

Thermal Use Efficiency : Variation in thermal use efficiency was significant during all the dates of sampling due to adopted times of sowing. The crop sown early during I FN of January recorded maximum thermal use efficiency (1.27 g m-2 °C day-1) than the crop sown at later dates. The thermal use efficiency was progressively and significantly reduced with extended date of sowing from I FN of January to II FN of February (1.27- 0.71 g m^{-2} °C day^{-1}) where as lowest values of thermal use efficiency (0.71 g m^{-2} °C day^{-1}) were registered when sowing of the crop was delayed to II FN of February.

Among the fodder sorghum varieties tried, the highest thermal use efficiency was recorded by CSV 32 F which superior over rest of varieties. The variety CSV 21 F recorded the lower values of thermal use efficiency.

Fodder yield : The data on green and dry fodder yield presented in Table 1 indicated that crop sown during I fortnight of January recorded the maximum green and dry fodder yield which was comparable with crop sown on II fortnight of January. Sowing of the crop at later dates recorded the lower green fodder yields.

Optimum temperature and shorter day length resulted in higher dry fodder yield via optimum metabolic activities and thereby the early sown plants of all varieties had been recorded higher thermal use efficiency. Whereas higher temperatures, lower relative humidity and higher evaporation rates hampered the normal metabolic activities resulting in lower fodder yield as well as lower thermal use efficiency in late sown crop. Among the varieties, irrespective of sowing date CSV 32 F recorded maximum thermal use efficiency than rest of the varieties. It might be attributed to accumulation of more drymatter production due to long duration. (Leelarani *et al*. 2012).

Conclusions

It can be concluded that early sowing (I FN of January) had favorable agro-climatic conditions particularly temperature, day length and sunshine hours interms of required accumulation of GDD, PTU and HTU from sowing to harvest compared to other dates of sowing. Estimation of growing degree days, helio thermal units, photo thermal units, thermal use efficiency and radiation use efficiencies indicated that the I FN of January is more suitable for sowing of the fodder sorghum to

explore full benefits of favourable weather conditions for best economic output.

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Variability Studies for Quality Traits in F_4 Segregating Population of Rice (*Oryza sativa* L)

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Abstract

This study was conducted with the major objectives of analysis of variability for quality characters based on GCV, PCV, heritability and genetic advance, it was understood that the progenies of Pusa Basmati x BPT 5204 would be more useful for improving quality characters. The experiment was conducted with thirty segregating F4 lines of rice, along with their parents Pusa Basmati 1, BPT 5204 and three checkvarieties vizKarjat-4, Karjat-8 and TrombayKarjat Kolam in Kharif 2019 in randomize block design.Wide range of variability was observed in the F4 lines of rice under study. The range of GCV and PCV was 2.56% to 11.89% and 5.44% to 12.87% respectively. The estimates of phenotypic, genotypic, and environmental variances revealed that phenotypic variances were higher in magnitude over the respective genotypic variances for all the characters under study. PCV and GCV were high for amylose content (%) and alkali spreading value. The broad sense heritability ranged from 20 % to 93%. High estimates of broad sense heritability were observed for, grain elongation before cooking, alkali spreading value and amylose content (%). The genetic advance and genetic advance as per cent of mean was ranged from 0.60% to 8.62% and 2.40% to 22.84% respectively. Heritability along with genetic advance is more useful for selection than the heritability alone.

Key words : Rice, GCV, PCV, heritability, genetic advance, quality characters.

Rice is the life and the prince among cereals as this unique grain helps to sustain two thirds of the world's population. Asia is the biggest rice producer, accounting for 90 per cent of the world's production and consumption of rice. It is considered as the main staple food for more than 65 per cent of the world's population. Among the rice growing countries of the world, India ranks first in area and second in production. Rice is grown in 114 countries across the world. The United State Department of Agriculture (USDA 2020) estimated that the world rice production was 497.7 million metric tons of global rice during (2019-20) and constituting the world's cultivated land more than 90 % of the world's rice is produced and consumed in Asia where it is an integral part of culture and tradition. It is one of the oldest and second most intensively grown cereals crop. During 2019-20 rice production of India was around 118.87 million metric tonsfrom an area of 43.66 million hectares. In Maharashtra, rice is the second important food crop next to sorghum, ranks thirteenth in productionis cultivated over an area of 15.39 lakh hectares with an annual production of 29.53 lakh tons with an average productivity of 1.92 tons per hectare in 2019-20. (Anonymous 2020). In the peri urban areas of Maharashtra now a days, there is an increasing demand of fine quality rice, but the quality parameter should be intermediate amylose content (%), soft gel consistency (mm), medium alkali spreading value, high head rice recovery (%) and grain elongation after cookingwith this view cross was made between Pusa Basmati 1 and BPT 5204 which are leading varieties known for quality grain.

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Materials and Methods

Materials and methods The experiment was conducted at the Research Farm of Regional Agricultural Research Station, Karjat under Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharastra, India during Kharif, 2019. The experimental material for the present study consisted of thirty segregating F_4 lines, along with their parents Pusa Basmati 1, BPT 5204 and three check *viz.*, Karjat-4, Karjat-8 and TrombayKarjat Kolam. The present investigation was carried out by adopting Randomized Block Design with three replications. Twenty-nine days old seedlings were transplanted with 20 cm distance between rows and 15 cm distance between plants within rows. All the recommended package of practices was followed along with necessary prophylactic plant protection measure raise a good crop. Observations were recorded and the data was subjected to statistical analysis. The variability was estimated as per procedure for analysis of variation suggested by Panse and Sukhatme (1967). PCV and GCV were calculated by the given formula by Burton and De Vane (1953), broad sense heritability (h^2b) by Lush (1949) and genetic advance i.e., the expected genetics were calculated by using the procedure given by Johnson *et al.* (1955).

Results and Discussion

In the present investigation Pusa Basmati 1 x BPT 5204showed variation in the segregating population,it was partitioned into phenotypic, genotypic and environmental variance. The phenotypic, genotypic, and environmental variances for various quality characters ranged from 0.09 to 27.75, 0.09 to 22.06 and 0.006 to 10.01, respectively. In general, the magnitudes of phenotypic variances were greater than genotypic variances. The phenotypic variance was maximum for gel consistency (27.75) followed by head rice recovery (12.65) and amylose content (8.44). The genotypic variance was maximum for gel consistency (22.06) followed by amylose content (7.21), head rice recovery (2.61%), Alkali spreading value (0.19) grain elongation after cooking (0.17) and Grain elongation before cooking (0.09). The environmental variances were lower than the genotypic variances for all the characters, similar results were observed by Binodh *et al*. (2006), Vanaja and Babu (2006), Bhadru *et al.* (2012) and Dhanwani *et al.* (2013), Dhurai *et al.* (2014), Sahu *et al*. (2015) and Devi *et al*. (2016).

The phenotypic coefficients of variationwere greater in magnitude than the respective genotypic coefficients of variation. The magnitude of phenotypic and genotypic coefficient of variation was highest for amylose content (12.87), (11.89) followed by alkali spreading value (12.07), (11.31) gel consistency (7.47), (6.66) and grain elongation after cooking (6.56) (5.50) respectively, Devi *et al.* (2016), Bhadru *et al*. (2012), Dhanwani *et al*. (2013) and Dhurai *et al*. (2014) observed similar results.

Table 1. Estimates of genetic parameters for qualitative characters in F_4 generation of rice

Parameter	σ2p	σ2g	σ2e	PCV (%)	GCV (%)	H^2b (%)	GA (%)	GAM
Amylose content (%)	8.44	7.21	1.23	12.87	11.89	85	5.11	22.84
Head rice recovery (%)	12.65	2.61	10.01	5.63	2.56	20	1.51	2.40
Gel consistency (mm)	27.75	22.06	5.68	7.47	6.66	79	8.62	12.24
Alkali spreading value	0.22	0.19	0.02	12.07	11.31	87	0.84	21.83
Grain elongation before cooking	0.09	0.09	0.006	5.44	5.26	93	0.60	10.49
Grain elongation after cooking	0.23	0.17	0.06	6.56	5.60	72	0.73	9.86

These estimates revealed that the heritability in broad sense ranged from 20 per cent for head rice recovery to 93 per cent for grain elongation before cooking, indicating high heritability for different yield attributing characters.High estimate of genetic advance was recorded gelconsistency (8.62) followed by Amylose content (5.11), Head rice recovery (1.51). High estimate of genetic advance as per cent meanwas observed for amylose content (22.84%) followed by alkali spreading value (21.83), gel consistency (12.24%), grain elongation before cooking (10.49%) Sahu *et al*. (2015), Devi *et al*. (2016),Bhadru *et al*. (2012) Dhanwani *et al*. (2013)and Dhurai *et al*. (2014) observed similar results.

Conclusion

It is concluded that quality charactersare controlled by both GCV and PCV also to use appropriate selection procedure for improvement of these characters in general and since high heritability coupled with high genetic advance reveals the presence of lesser environmental influence and prevalence of additive gene action in their expression. High heritability with low genetic advance indicated the influence of nonadditive gene action. The heritability provides the information on the magnitude of inheritance for quantitative characters, but it does not indicate the magnitude of genetic gain obtained by selection of best individual from the best population. So, heritability along with genetic advance is more useful for selection than the heritability alone.

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Forecasting of Weekly Rainfall using ARIMA Models in Ghod Catchment of Pune District (M.S.)

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Abstract

The agricultural practices and crop yields of India are heavily dependent on the climatic factors like rainfall. Therefore, more accurate prediction of rainfall could provide better information for planning and devising agricultural strategies. Forecasting of rainfall has been attempted by various research groups using different techniques. In this study, Autoregressive Integrated Moving Average (ARIMA) class models of single orders have been used for forecasting rainfall. The methodology developed by Box-Jenkins (1994) has been used to build ARIMA models for weekly rainfall values from eight rainguage stations viz. Belwandi (1971-2008), Chandoh (1971-2008), Kurwandi (1954-2009), Pimpalwandi (1978-2009), Pabal (1971-2008), Ranjangaon (1954-2009), Shirur (1998-2009) and Supa (1967-2009) in Ghod catchment at Pune district of Maharashtra state. For Belwandi, Chandoh and Pabal rainguage stations the rainfall series of 36 years, for Kurwandi and Ranjangaon stations 54 years, for Pimpalwandi station 31 years, for Shirur station 12 years and for Supa station 41 years rainfall series were used for the model development and validation. Statistical indices such as root mean square error (RMSE), correlation coefficient (R2), mean standard deviation, skewness and kurtosis were used for the goodness of fit the models. The best models with lowest RMSE, highest R^2 value and minimum number of parameters in the models were used for forecasting of weekly rainfall values for the above stations. Eight ARIMA models were developed for the above stations as follows: Belwandi and Pimpalwandi rainguage stations **ARIMA $(1,1,1)(1,1,1)_{52}$** model was finalized with RMSE values 5.01, 0.317 and R2 values 0.312, 0.278 respectively. Chandoh, Kurwandi and Pabal rainguage stations **ARIMA $(1,0,0)(1,0,1)_{52}$** with 2.27, 3.55 and 2.78 RMSE values and 0.175, 0.172 and 0.070 R2 values respectively. Ranjangan, Shirur and Supa rainguage stations ARIMA $(1,1,1)(0,1,1)_{52}$ with 2.58, 0.50 and 2.86 RMSE values and 0.202, 0.199 and 0.336 R^2 values respectively. The performance of the resulting successful ARIMA models was evaluated using the last year data. These models were used to forecast the weekly rainfall data for one year ahead.

Key words : Time series, weekly rainfall forecasting, ARIMA model.

The agricultural practices and crop yields of India are heavily dependent on the climatic factors like rainfall. Out of 142 million ha cultivated land in India, 92 million ha (i.e. about 65%) are under the influence of rainfed agriculture. The monsoon season is the principle rain bearing season and more than 75 % of rainfall occurs during the monsoon season. However, monsoon rainfall is uneven in space and time. The rainfall variability is very high in Maharashtra state and it affects the agricultural production and the economy of the state. Even if annual rainfall is normal, the delay in monsoon and the unusual monsoon causes severe disruption of agricultural activities. Therefore, farmers need the time specific information about the monsoon behaviour. Hence, forecasting of rainfall is very necessary in the field of agriculture. Several stochastic models were developed in past (Box and Jenkins 1994) for modelling of hydrological time series like rainfall, runoff and evaporation. Mahsin *et al.*, (2012), Zakaria *et al*., (2012), Abdul-Aziz *et al.*, (2013) Kaushik and Sabitasing, 2008 examined the

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applicability of ARIMA models forecasting the hydrological parameters like rainfall, maximum, minimum temperature. Rajakumar and Kuamr (2007) examined the autoregressive (AR) and autoregressive moving average models (ARMA) for daily rainfall forecasting using second orders. Very few attempts have been made on the stochastic modeling of rainfall due its erratic nature. The models developed so far indicate that mostly ARMA or ARIMA classes of first order use for rainfall forecasting. Therefore, in this study the applicability the seasonal ARIMA model of single order are proposed for forecasting of weekly rainfall of eight rain gauge stations in Ghod catchment of Pune district (MS).

Materials and Methods

Study Area : The eight rainfall station of Ghod catchment falls under Pune and Ahmednagar districts of Maharashtra which is characterized by semi arid climate where rainfall totals are low and uneven distribution. The area of Ghod catchment is 2860 km^2. An altitude ranges from 500 to 580 m above MSL (Mean Sea Level). The latitude and longitude of the study area are 18.40° to 19.25°N and 73.30° to 74.40°E, respectively. The mean annual rainfall of the catchment is about 513 mm. The average maximum temperature is 41.1°C and average minimum temperature is 22.5°C.

Data Acquisition : The data of these stations, fluctuate greatly with wide variation where its value may ranged between zero to maximum value (more than 100 mm) in addition the maximum value rarely repeated, so it is not easy to find suitable ARIMA models to represent them unless enough trials have been applied. The historical rainfall data of eight rain gauge stations *viz*., Belwandi (1971-2008), Chandoh (1971-2008), Kurwandi (1954-2009), Pabal (1971-2008), Pimpalwandi (1978-2009), Ranjangaon (1954-2009), Shirur (1998-2009) and Supa (1967-2009) were collected from State Data Storage Center, Hydrology Project (Surface Water), Jal Vidnyan Bhavan, Nasik were used for developing the appropriate stochastic ARIMA model.

Methodology

Model description : The acronym ARIMA stands for "Auto-Regressive Integrated Moving Average." ARIMA class of models is the most general class of models for forecasting a time series which can be stationarized by transformations such as differencing and logging. An autoregressive integrated moving average (ARIMA) model is a generalization of an autoregressive moving average (ARMA) model. These models are fitted to time series data either to better understand the data or to predict future points in the series (forecasting). The general form of seasonal ARIMA model is ARIMA (p, d, q) (P, D, Q)s with p-non-seasonal AR orders; d- non-seasonal differencing; q- non-seasonal MA orders; P-seasonal AR orders; D-seasonal differencing; Q-seasonal MA orders and s-time span of the repeating seasonal pattern.

A time series involving seasonal data has relations at a specific lag 's' which depends on the nature of the data, e.g. for monthly data s = 12 and weekly data s = 52. Such series can be successfully modeled only if the model includes the connections with the seasonal lag as well. Such models are known as multiplicative or seasonal ARIMA models. The general multiplicative seasonal ARIMA (p, d, q) (P, D, Q)s model has the following form.

$$\phi_p(B)\Phi_p(B^s)(1-B)^d(1-B^s)^D x_1 = c + \theta_q(B)\Theta_Q(B^s)e_t \qquad (1)$$

Where, c = constant, B = a backshift

operator, d = order of non seasonal difference operator, D = order of the seasonal difference operator, p = order of non seasonal AR operator, P = order of seasonal AR operator, q = order of non seasonal MA operator, Q = order of seasonal MA operator, s = seasonal length or lag (equal to 52 week values), t = discrete time step equal to one month, ϕ = non seasonal AR parameter, Φ = seasonal AR parameter,θ = non seasonal MA parameter and Θ = seasonal MA parameter

$$\phi_p(B) = 1 - \phi_1 B - \phi_2 B^2 - \ldots - \phi_p B^p$$
$$\Phi_p(B^s) = 1 - \Phi_1 B^s - \Phi_2 B^{2s} - \ldots - \Phi_p B^{ps}$$
$$\theta_q(B) = 1 - \theta_1 B - \theta_2 B^{2s} - \ldots - \theta_q B^q$$
$$\Theta_Q(B^s) = 1 - \Theta_1 B^s - \Theta_2 B^{2s} - \ldots - \Theta_Q B^{Qs}$$

The time series was divided into two data sets the first data set where the data were used to analyze the characteristics of the rainfall and selecting the most appropriate rainfall forecast models. The second dats set i.e. validation or testing data set is the last year that was used for evaluating the performance of the selected models for each rain gauge station.

Modelling process : The following modeling process developed by Box and Jenkins (1994) and Hipel and McLeod (1994) were used to fit the stochastic models. Steps used in modelling process as below:

1. Standardization and normalization of time series variables
2. Identification of the model
3. Determination of the parameters of selected model
4. Diagnostic checking
5. Selection of the model.

The most important analytical tool used with time series analysis and forecasting are the autocorrelation function (ACF) and the partial autocorrelation function (PACF).

Standardization and normalization of time series variables : The first step in time series modelling is to standardize and transform the time series. This process is required to ensure normalcy of data sequence and residuals. In general the standardization is performed by normalizing the series as follows:

$$Y_{i,t} = \frac{X_{i,t} - \overline{X}_t}{\sigma_t} \quad (2)$$

Where, $Y_{i,j}$ = Stationary stochastic component in the mean and variance, $X_{i,j}$ = Weekly rainfall in the month of the year j, $\overline{X}_t$ = Weekly mean and σ_t= Weekly standard deviation

Identification of model : For identifying the models of autoregressive integrated moving average class, it is necessary to identify the orders of autoregressive and moving average parameters. One of the basic conditions for applying the ARIMA model on a particular time series is its stationarity. A time series with seasonal variation may be considered stationary if the theoretical autocorrelation function ρ_k and theoretical partial autocorrelation function ρ_{kk} are zero after a lag k = 2s + 2 (where, 's' is the seasonal periods; in this study, for weekly s = 52). The estimate of theoretical autocorrelation function (rm) i.e. rm was obtained by equation. The autocorrelation functions vary between -1 and +1, with values near ±1 indicating stronger correlation.

$$r_m = \frac{\sum_{i=1}^{n-m}\left(x_i - \bar{x}\right)\left(x_{i+m} - \bar{x}\right)}{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} \quad (3)$$

Where, n = number of observations, x = average of the observations and r_m = autocorrelation function at lag m

The estimate of partial autocorrelation function ρ_{kk} i.e. rmm was obtained by the equation (4). The partial autocorrelation function was varying between -1 and +1, with values near

±1 indicating stronger correlation. The partial autocorrelation function (PACF) removes the effect of shorter lag autocorrelation from the correlation estimate at longer lags.

$$\Phi_{mm} = \frac{r_m - \sum_{j-1}^{m-1} \Phi_{m-1,j} r_{m-1}}{1 - \sum_{j-1}^{m-1} \Phi_{m-1,j} r_j} \quad (4)$$

Where, Φ_{mm} = Partial autocorrelation function at lag m

It is considered that ρ_k and ρ_{kk} equals zero if (Maier and Dandy, 1995).

$$\rho_k = 0 \quad ako \setminus r_k \setminus \leq 2/(T)^{0.5} \quad (5)$$

$$\rho_{kk} = 0 \quad ako \setminus r_{kk} \setminus \leq 2/(T)^{0.5} \quad (6)$$

Where, r_k= sample autocorrelation at lag k, r_{kk} = sample partial autocorrelation at lag k and T = number of observations

If the sample autocorrelation function (ACF) of analysed series does not meet the above condition, the time series needs to be transformed into a stationary one using different differencing schemes. For example, (d = 0, D = 1, s = 12) according to the expression given by equation (7)

$$y_t = (1-B)^d (1-B^s)^D x_t = (1-B^{12}) X_t \quad (7)$$

The time series y_t is stationary if the ACF and PACF cut off at lags less than k=2s + 2 seasonal periods. Thus, it is necessary to test the stationary of the transformed time series obtained by differencing the original times series according to single orders of differencing (non seasonal and seasonal). The differenced series that pass the stationarity series needs to be considered for further analysis.

The following guidelines are used for selecting the orders of AR and MA terms (Gorantiwar, 1984):

- If the autocorrelation function cuts off, fit ARIMA (0,d,q) x $(0, 1,Q)_{52}$ model to the data, where q is the lag after which the autocorrelation function first cuts off, and Q is the lag after which seasonal ACF cuts off.
- If the autocorrelation function cuts off, fit ARIMA (p,d,0) x $(P,1,0)_{52}$ model to the data, where p is the lag after which the partial autocorrelation function first cuts off, and P is the lag after which seasonal PACF cuts off.
- If neither the autocorrelation or partial autocorrelation functions cut off, fit the ARIMA (p, d, q) x $(P, 1, Q)_{52}$ model for a grid of values of p, P, q, and Q.

Thus on basis of information obtained from the ACF and PACF, several forms of the ARIMA model need to be identified tentatively.

Parameter estimation : After identifying models, we need to obtain efficient estimates of the parameters. Several methods are available for estimating parameters including maximum likelihood, conditional least squares, unconditional least squares and minimum least square method. Among these methods, maximum likelihood seems to be the best. Therefore in this study, the maximum likelihood method was used for the estimation of parameters.

Diagnostic checking : Once a model has been selected and parameters calculated, the adequacy of the model has to be checked. This process is called diagnostic checking. There are number of diagnostic checking methods to test the suitability of the estimated model. These include Box-Pierce method; Portmanteau lack-of-fit test and t-statistics, standard error of the model parameters, observing ACF and PACF of the residuals, Akaike Information Criteria (AIC) (Akaike, 1974) and Bayesian information criteria (BIC). However in this study following three tests were used.

Examination of standard error: A high standard error in comparison with the parameter values points out a higher uncertainty in parameter estimation which questions the stability of the model. The model is adequate if it meets the following condition.

$$t = cv/se > 2 \quad (8)$$

Where, cv = parameter value and se = standard error

ACF and PACF of residuals : If the model is adequate at describing behaviour of rainfall time series, the residuals of model should not be correlated i.e. all ACF and PACF should lie within the limits calculated by equations (3) and (4) after lag k = 2s + 2, where s = number of periods.

Akaike Information Criteria (AIC) : AIC (Akaike, 1974) is computed by equation (9). The lower values of AIC are desirable.

$$AIC = 2k + \left[\ln\left(\frac{2\pi v_r}{T} \right) + 1 \right] T \quad (9)$$

Where, AIC = Akaike information criteria, K = Number of model parameters, V_r = Residual variance and T = Total number of observations

Selection of the model or goodness of fit tests : To enable comparison of the performance of models, the results were evaluated quantitatively using Root mean square error (RMSE) and correlation coefficient (R^2). RMSE and R^2 were used for selecting the ARIMA models amongst all the models that passed the adequacy test or diagnostic checking.

$$\text{Correlation coeifficent } R^2 = \sqrt{1 - \frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n} O_i^2 - \frac{\sum_{i=1}^{n} P_i^2}{n}}}$$

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)^2}$$

Where, n = Total number of observations used for computing, O_i = Actual value of variable, P_i = Forecast value of variable.

Results and Discussion

Model implementation and analysis : The implementation of the ARIMA models evaluated was based on the Box and Jenkins (1976) methodology. The weekly rainfall values generated by the ARIMA model for different evaluation period were compared with actual evaporation values.

Identification of model : The ACF and PACF of weekly rainfall time series were estimated for different lags. ACF and PACF patterns of original rainfall series (d=0, D=0) are shown in Fig.1. It is seen from Fig. 1 that ACF

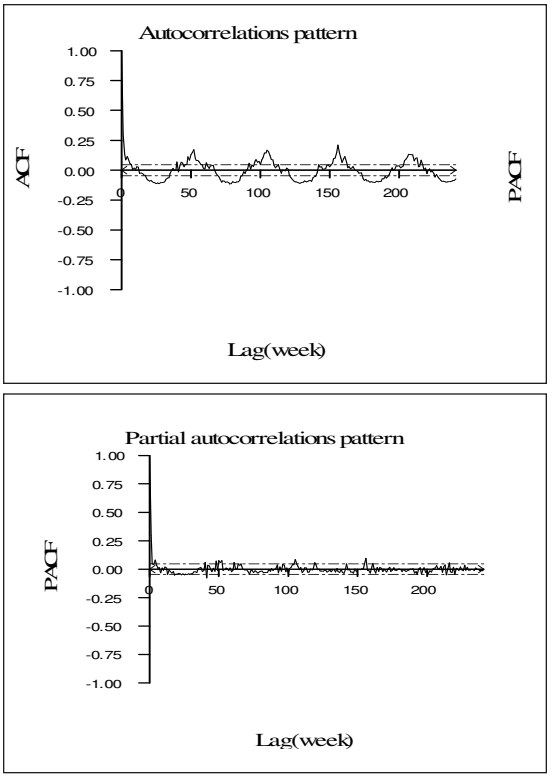


Fig. 1. Autocorrelation and partial autocorrelation patterns of original rainfall series (d=0, D=0)

lies outside limits after lag k = 2s + 2 i.e. 106. Thus, ARIMA model cannot be applied the original time series of rainfall. Therefore, the time series were transformed by using differencing schemes d=1, D= 0; d=0, D=1; d=1, D=1 and d=0, D= 0. The ACF and PACF along with upper and lower limits were estimated by equation (3) and (4). It was observed that ACF of d = 0, D = 0 and d = 1, D = 1 lie within the limits of range specified by equation (3) and (4) after lag 106. Hence, these differencing schemes were used for developing ARIMA models for weekly rainfall time series of different rainguage stations.

On the basis of information obtained from ACF and PACF the orders of autoregressive (AR) and moving average (MA) terms were identified as one. Based on this, 36 forms of ARIMA models were identified and parameters were computed for each rainguage station.

Determination of parameters and diagnostic checking : Following parameters of the selected models were calculated by maximum likelihood method.

1. ϕ_1 (AR) 2. θ_1 (MA) 3. Φ_1 (AR) 4. Θ_1 (MA)

Out of the 36 possibilities, the 7 ARIMA models that satisfied the tests are selected for all rainguage stations, which further used for the ACF and PACF test.

Residual of ACF and PACF : For model to be consider as adequate at all behavior of time series the residuals of model should be correlated, i.e. all ACF and PACF should lie within the limits calculated by equation (3) and (4) after lag k = 2s + 2, where, s = number of period such as s = 52 or s = 12 for this case s = 52 and the value of k = 106 computed. ACF and PACF residual series plot of several models are laid within the prescribed limits.

Out of the 7 ARIMA models, 3 ARIMA models that satisfied the residual of ACF and PACF were selected. The 3 models ARIMA $(1,0,0)(1,1,1)_{52}$ ARIMA $(1,1,1)(0,1,1)_{52}$ and ARIMA $(1,1,1)(1,1,1)_{52}$ with less AIC that satisfy standard error, ACF and PACF of residuals criteria were finally used. The ACF and PACF plots of ARIMA $(1,0,0)(1,0,1)52$, ARIMA $(1,1,1)(0,1,1)_{52}$ and ARIMA $(1,1,1)(1,1,1)_{52}$ models are shown in Fig.2, Fig.3 and Fig.4 respectively.

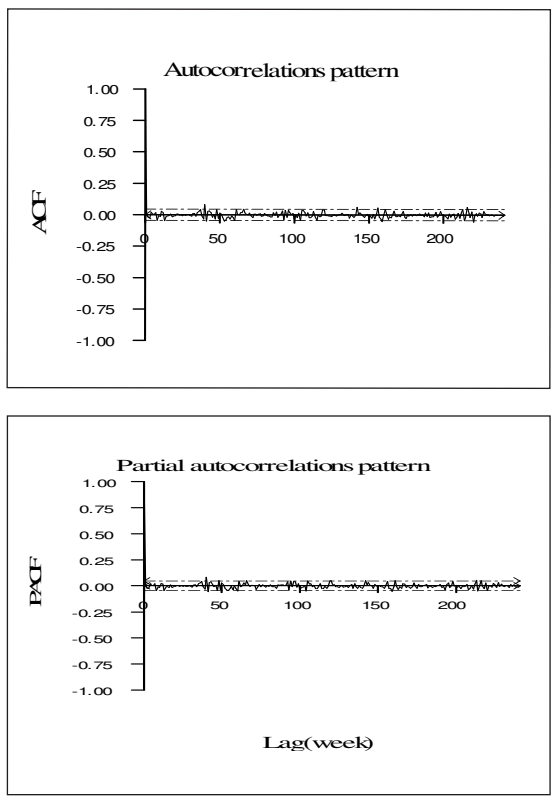


Fig. 2. Autocorrelation and Partial autocorrelation pattern of rainfall time series for ARIMA $(1,0,0)(1,1,1)_{52}$

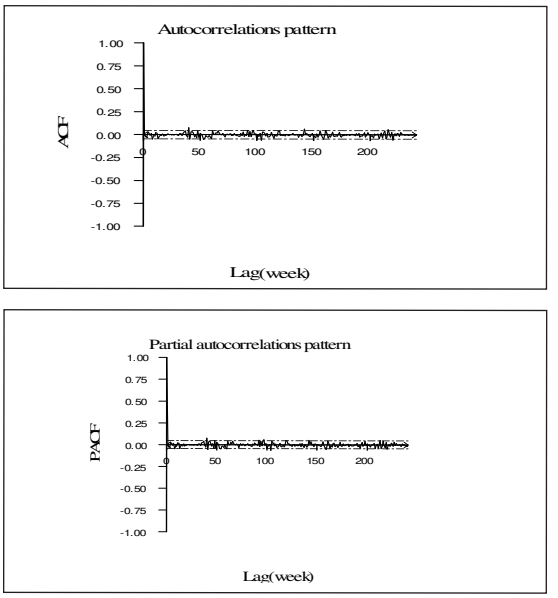


Fig. 3. Autocorrelation and Partial autocorrelation pattern of rainfall time series for ARIMA $(1,1,1)(0,1,1)_{52}$

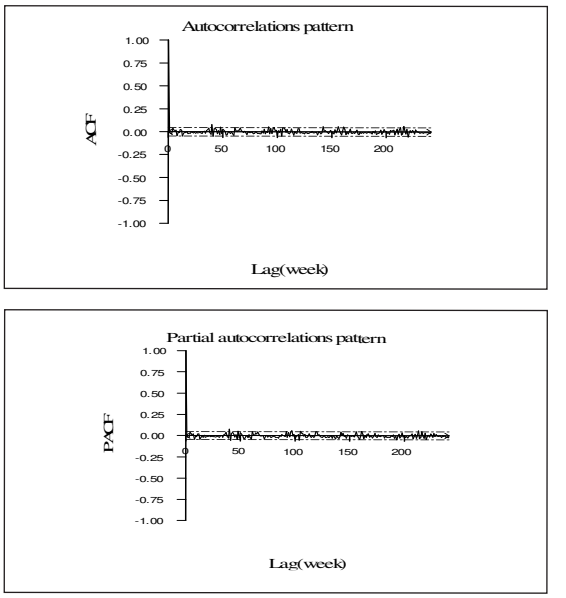


Fig. 4. Autocorrelation and Partial autocorrelation pattern of rainfall time series of for ARIMA $(1,1,1)(1,1,1)_{52}$

Selection of the best model : The models with less AIC and that satisfy standard error, ACF and PACF of residuals criteria were finally used for generation of weekly rainfall values. For this purpose rainfall values were forecasted for one year with help of identified ARIMA models. These values were compared with actual values for one year by calculating the root means square error (RMSE) and R^2 values between them. The RMSE and R^2 values of these three models are given in Table.1. From Table.1 ARIMA $(1,1,1)(1,1,1)_{52}$ model was selected for forecasting of rainfall of Belwandi and Pimpalwandi rainguage station, ARIMA $(1,0,0)(1,0,1)_{52}$ model was selected for Chandoh, Kurwandi and Pabal stations, ARIMA $(1,1,1)(0,1,1)_{52}$ model was selected for Ranjangaon, Shirur and Supa stations. The parameters of finally selected ARIMA models for all rainguage stations are given in Table.2.

Table 1. RMSE and R^2 values of ARIMA models of all rainguage stations

	ARIMA $(1,0,0)(1,0,1)_{52}$		**ARIMA $(1,1,1)(0,1,1)_{52}$**		**ARIMA $(1,1,1)(1,1,1)_{52}$**	
	RMSE value	**R^2 value**	**RMSE value**	**R^2 value**	**RMSE value**	**R^2 value**
Belwandi	5.16	0.292	5.06	0.277	5.01	0.312
Chandoh	2.27	0.175	2.41	0.164	2.45	0.137
Kurwandi	3.55	0.172	4.01	0.178	3.98	0.176
Pabal	2.78	0.070	2.93	0.069	2.92	0.060
Pimpalwandi	0.318	0.266	0.319	0.266	0.317	0.278
Ranjangaon	2.69	0.172	2.58	0.202	2.53	0.180
Shirur	0.51	0.197	0.50	0.199	0.51	0.183
Supa	3.01	0.341	2.86	0.336	2.87	0.331

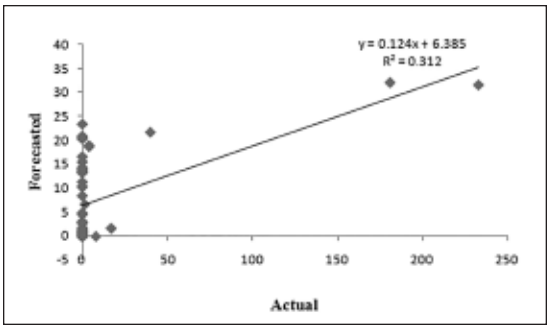
Table 2. Parameter estimate, standard error, corresponding t value and AIC values of selected ARIMA models from graph for all rainguage stations

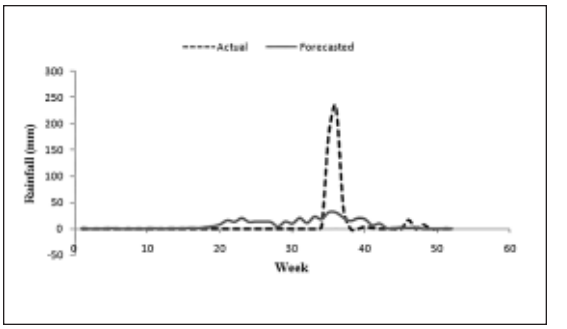
Belwandi, ARIMA (1,1,1)(1,1,1)$_{52}$						**Chandoh, ARIMA (1,0,0)(1,0,1)$_{52}$**					
Parameter	C	ϕ1	θ1	Φ1	Θ1	Parameter	C	ϕ1	θ1	Φ1	Θ1
Estimate	0	0.18	1	0.02	0.93	Estimate	7.98	0.21		0.98	0.91
Standard Error	0	0.02	0	0.03	0.01	Standard Error	1.39	0.02		0.01	0.02
t-value	0.07	7.95	350.01	0.84	66.78	t-value	5.73	9.31		81.66	45.86
AIC	17328.88					AIC	17176.79				
Kurwandi , ARIMA (1,0,0)(1,0,1)$_{52}$						**Pabal, ARIMA (1,0,0)(1,0,1)$_{52}$**					
Parameter	C	ϕ1	θ1	Φ1	Θ1	Parameter	C	ϕ1	θ1	Φ1	Θ1
Estimate	7.98	0.21		0.98	0.91	Estimate	7.98	0.21		0.98	0.91
Standard Error	1.39	0.02		0.01	0.02	Standard Error	1.39	0.02		0.01	0.02
t-value	5.73	9.31		81.66	45.86	t-value	5.73	9.31		81.66	45.86
AIC	28395.91	AIC	17865.85								
Pimpalwandi, ARIMA (1,1,1)(1,1,1)$_{52}$						**Ranjangaon, ARIMA (1,1,1)(0,1,1)$_{52}$**					
Parameter	C	ϕ1	θ1	Φ1	Θ1	Parameter	C	ϕ1	θ1	Φ1	Θ1
Estimate	0	0.12	0.98	0.06	0.92	Estimate	0	0.18	1		0.92
Standard Error	0	0.03	0	0.03	0.02	Standard Error	0	0.02	0		0.01
t-value	0.21	4.48	189.14	1.93	56.17	t-value	0.1	8.01	351.86		74.04
AIC	8132.299	AIC	26629.87								
Shirur, ARIMA (1,1,1)(0,1,1)$_{52}$						**Supa, ARIMA (1,1,1)(0,1,1)$_{52}$**					
Parameter	C	ϕ1	θ1	Φ1	Θ1	Parameter	C	ϕ1	θ1	Φ1	Θ1
Estimate	0	0.14	1		0.86	Estimate	0.00	0.18	1.00		0.92
Standard Error	0	0.04	0.01		0.04	Standard Error	0.00	0.02	0.00		0.01
t-value	1.07	3.23	90.09		20.93	t-value	0.10	8.01	351.86		74.04
AIC	2901.94	AIC	19677.20								

Note: ϕ = non seasonal AR parameter, Φ = seasonal AR parameter, θ = non seasonal MA parameter, Θ = seasonal MA parameter

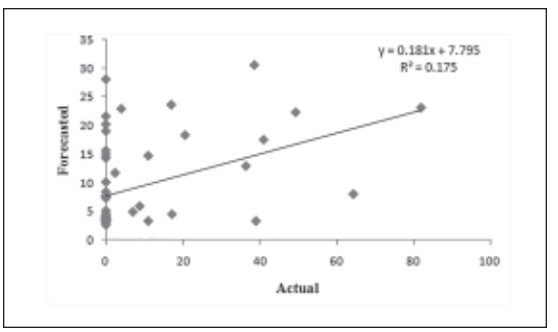
Table 3. The mean, standard deviation, skewness and kurtosis values of actual and forecasted rainfall values for all rainguage stations

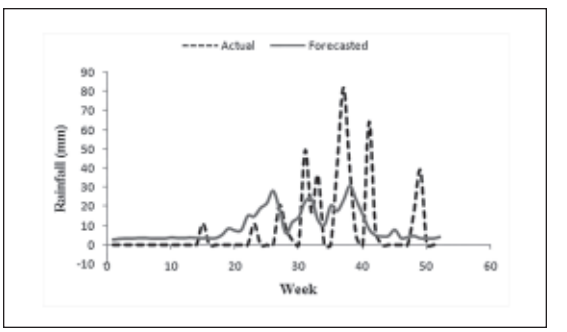
	Rainfall models	**Mean deviation**	**Standard**	**Skewness**	**Kurtosis**
Belwandi	Forecasted	7.552	9.041	1.019	0.097
	Actual	9.394	40.692	4.911	23.912
Chandoh	Forecasted	9.363	7.856	1.113	0.006
	Actual	8.650	18.170	2.464	5.909
Kurwandi	Forecasted	18.008	18.897	1.348	0.767
	Actual	11.669	26.069	2.619	6.699
Pabal	Forecasted	11.656	10.630	1.042	0.257
	Actual	7.008	19.609	3.262	10.427
Pimpalwandi	Forecasted	1.414	1.642	1.135	-0.023
	Actual	1.265	2.698	2.584	6.305
Ranjangaon	Forecasted	11.019	10.481	0.640	-0.975
	Actual	9.458	21.758	2.822	7.970
Shirur	Forecasted	1.581	1.882	1.332	0.647
	Actual	1.500	4.076	4.083	17.788
Supa	Forecasted	11.369	11.109	1.386	1.098
	Actual	14.288	24.974	1.759	2.300



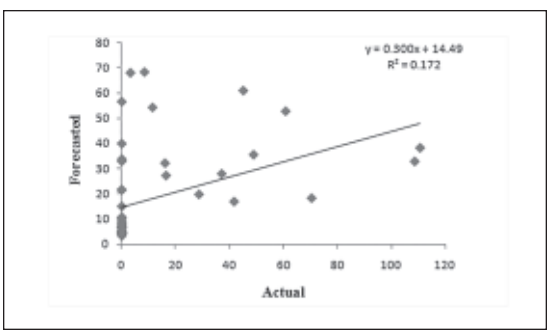


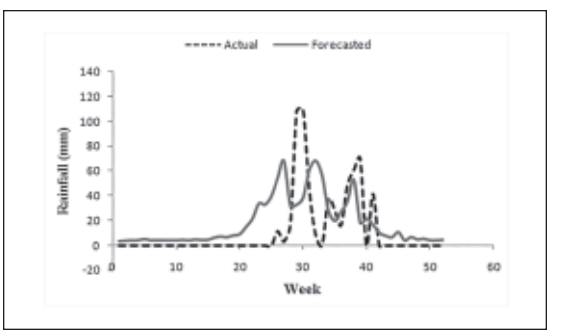
(a) ARIMA $(1,1,0)(1,1,1)_{52}$ model of Belwandi rainguage station



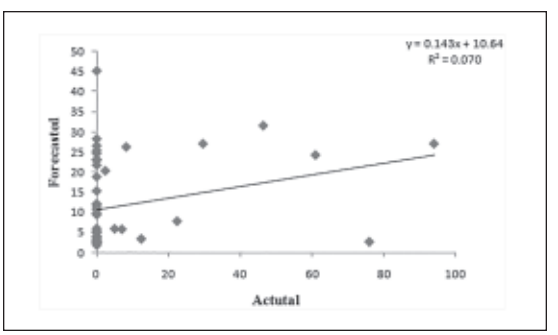


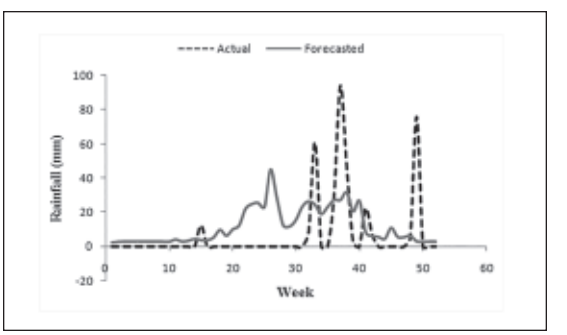
(b) ARIMA $(1,0,0)(1,0,1)_{52}$ model of Chandoh rainguage station



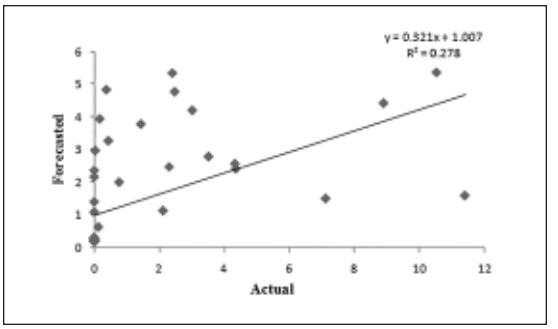


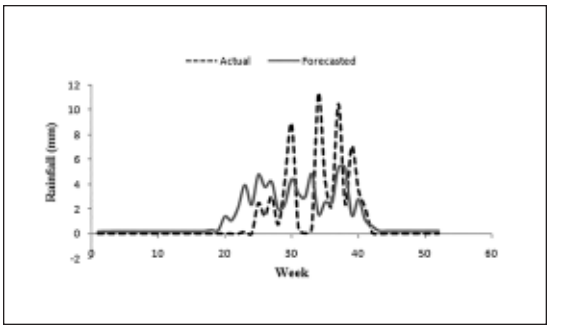
(c) ARIMA $(1,0,0)(1,0,1)_{52}$ model of Kurwandi rainguage station



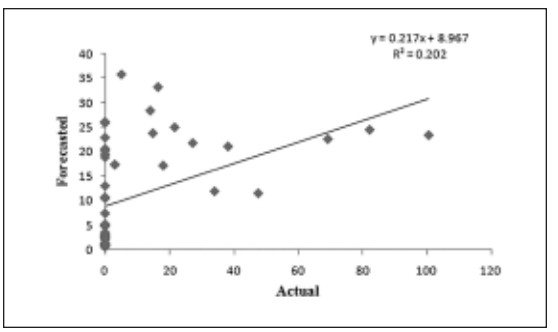


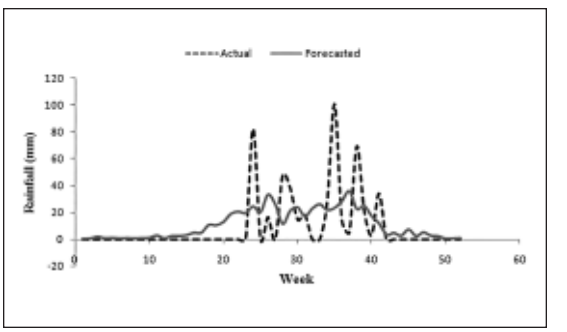
(d) ARIMA $(1,0,0)(1,0,1)_{52}$ model of Pabal rainguage station



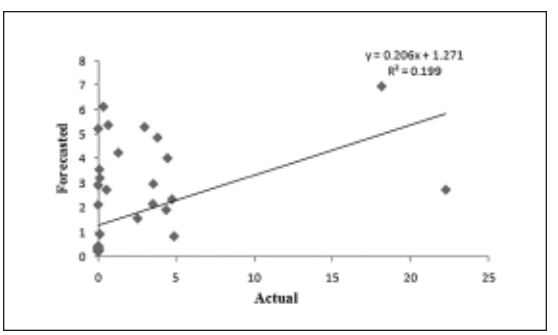


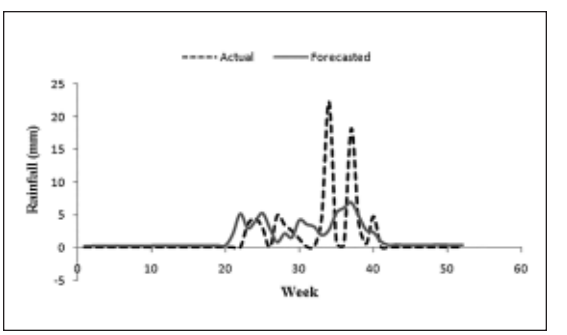
(e) ARIMA $(1,1,1)(1,1,1)_{52}$ model of Pimpalwandi rainguage station



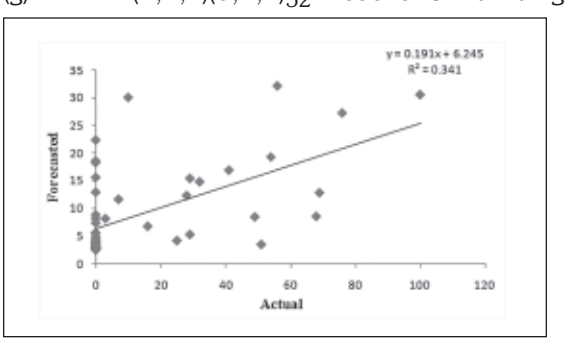


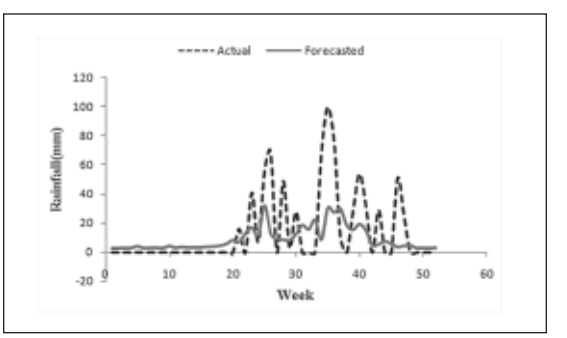
(f) ARIMA $(1,1,1)(0,1,1)_{52}$ model of Ranjangaon rainguage station





(g) ARIMA $(1,1,1)(0,1,1)_{52}$ model of Shirur rainguage station





(h) ARIMA $(1,0,0)(1,0,1)_{52}$ model of Supa rainguage station

Fig. 4 (a to h) Comparison of forecasted and actual rainfall of all rainguage stations by selected ARIMA model

Comparison of forecast and actual values : The statistical values obtained by the forecasted model and the actual rainfall for all rainguage stations are given in Table.3. The scatter plot and graph of forecasted and actual rainfall values from the best stochastic ARIMA models that passes the all diagnostic checking test for all rain gauge station is shown in Fig.4.

Conclusion

The study indicates that the multiplicative ARIMA model as a tool for forecasting the rainfall has been demonstrated for 8 rainguage stations in Ghod catchment of Pune district (M.S.). For Belwandi and Pimpalwandi rainguage stations ARIMA (1,1,1) $(1,1,1)_{52}$ gave lowest RMSE values (i.e. 5.01 and 0.317) and highest R^2 values (0.312 and 0.278) respectively. Hence, it is best stochastic model for forecasting weekly rainfall values. Similarly for Chandoh, Kurwandi and Pabal ARIMA (1,0,0) $(1,0,1)_{52}$ model with lower RMSE values (i.e. 2.27, 3.55 and 2.78) and highest R^2 values (0.175, 0.172 and 0.07) respectively and hence, it is best stochastic model for forecasting weekly rainfall values. For Ranjangaon, Shirur and Supa ARIMA (1,1,1) $(0,1,1)_{52}$ model with lower RMSE values (i.e. 2.58, 0.50 and 2.86) and highest R^2 values (0.202, 0.199 and 0.336) respectively and hence, it is best stochastic model for forecasting weekly rainfall values for Ranjangaon and Shirur rainguage station. It is concluded that ARIMA model can be successfully used for forecasting of weekly rainfall.

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Effect of Drip Fertigation on Yield and Water Use of Onion Crop in Inceptisols

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Abstract

The experiment was conducted at Instructional Farm of PGI, MPKV, Rahuri, (MS) during Summer 2016 and 2017 on Onion in relation to nutrients management with Water Soluble Fertilizers (WSF) through drip fertigation in RBD replicated thrice with nine treatments *viz*.; T_1 - DI (Drip Irrigation)-Absolute control (no fertilizers),T2-SI (Surface Irrigation)100 % RD of CF (urea, SSP & MOP), 50% N in two splits at 30 & 45 DAP, T_3 - SI 100 % RD of CF (urea, 24:24:0 & MOP), 50% N in two splits at 30 and 45 DAP, T_4 - DI 100% RDF fertigation through WSF 24:24:0 + Urea and SOP up to 91 DAP, T_5 - DI 100% RDF fertigation through WSF 24:24:0 + Urea and SOP up to 77DAP, T_6 - DI 100% RDF fertigation through WSF 24:24:0 + Urea and SOP up to 63DAP, T_7 - DI 80% RDF fertigation through WSF 24:24:00 + Urea and SOP up to 91DAP, T_8 - DI 80% RDF fertigation through WSF 19:19:19 + Urea and SOP up to 91 DAP, T9- DI 80% RDF fertigation through WSF 12:61:00 + Urea and SOP up to 91 DAP. The recommended packages of practices were adopted. The pooled data showed that, all growth and yield contributing parameters, yield, NPK availability and uptake and nutrient use efficiency, water productivity etc of onion were influenced significantly due to different fertigation The drip irrigation resulted into lowest water use (399.65 mm) compared to surface irrigation (705.00 mm) with 43.47% water saving. The treatment T_4 resulted into 82.53 % increase in yield and maximum water use efficiency (WUE) of 161.62 q ha^{-1} mm followed by T_5 (154.75 q ha^{-1} mm) and T_6 (148.31 q ha^{-1} mm) compared to surface irrigation, where it was minimum (49.43 q ha^{-1} mm). The treatment T_7 resulted in 43.47% water and 20% fertilizer saving with 50.29% increase in yield. The NPK availability in soil and uptake by onion was improved significantly with drip fertigation over surface irrigation (SI) with conventional fertilizer (CF) at harvest. The significantly maximum NPK availability (172.3, 17.20, 333.5 and uptake of 123.6, 56.57 and 112.80 kg ha^{-1} respectively), nutrient use efficiency (NUE) (172.8 kg yield kg^{-1} nutrient applied) with water productivity of Rs. 646 ha^{-1} cm of water was observed in treatment T_4 at harvest. However, it was followed by and remained at par with T_5 and T_6 and (160.80 kg yield kg^{-1} nutrient), (Rs.599) and T_6 (Rs. 565), T_7 (Rs. 480) ha^{-1} cm of water, whereas SI with CF (T_2) resulted into Rs.173 ha^{-1} cm of water. The lowest NUE (27.88 kg yield kg^{-1} nutrient) was observed in T_2 followed by T_3 (48.93 kg yield kg^{-1} nutrient). The significantly maximum average weight of onion bulbs (92.09 g), twin bulbs (2.62%) , onion bulbs yield (63.14 t ha^{-1}) at harvest was obtained in treatment T_4, but it was at par with treatment T_5 (60.74 t ha^{-1}) and T_6 (58.23 t ha^{-1}) and T_7 (51.25 t ha^{-1}) in respect of onion yield. The bigger size of bulbs attributed to increase in weight due to the combined effect of water and fertilizers used judiciously in drip fertigation as compared with surface irrigation with conventional fertilizer. It is concluded from the above results that, the drip irrigation with 100% RD of WSF using 24:24:00 Urea and SOP for 91 days resulted into higher net seasonal income, net extra income and water productivity over control, with highest B:C ratio (3.73) as compared to other treatments.

Key words : Onion, Drip Fertigation, Water productivity, Water use efficiency,Water Soluble Fertilizers.

Onion (*Allium cepa* L.) is one of the most important vegetable grown and widely used in Indian diet in the form of salads, pickles, chutney etc. and as flavoring agent in several processed edible products, as dehydrated flakes and powder. It is valued for its distinct pungent flavour which is due to volatile oil known as "Allyl-propyl-disulphide". The bulbs are used in soups, sauces, condiments, spices and medicines

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(Jones and Mann, 1963). It is indispensable item in every kitchen and it adds flavour to various vegetable preparations hence, it is called as the "Queen of kitchen" (Selvaraj, 1976). Medicinal properties of onion have been dealt in 'Charak Samhita' and recent reports suggest that onion plays important role in preventing heart diseases and is useful against malaria, night blindness, lower blood pressure and reduce blood glucose level (Augusti, 1990).

India is the second largest producer in the world with an area of 834.20 thousand hectare and production of 217 lakh t and productivity of 21.26 mt ha^{-1} (Anonymous, 2017). Onion ranks first in the export of fresh vegetable and gained importance as cash crop, thus, we have enormous scope for increasing production of onion to double our production. In India the crop is cultivated all over the country. Though the country is leading in onion production in the world, the average yield is very low, because most of the cultivators follow conventional method of irrigation.

Maharashtra is the largest producer of onion in the country with an output of 6773.08 thousand metric tons production from 471.66 thousand hectare area. Productivity of onion is 16.73 metric tons ha^{-1} (Anonymous, 2017).The major onion growing districts are Nasik, Ahmednagar, Pune and Satara. This crop has wide range of adaptability. It is grown on variety of soil in mild climate without extremes of high or low temperature even though it can be grown under wide range of climatic conditions. Although the different varieties of onion are grown in Maharashtra for *rabi* and summer seasons and for different colours (dark red, light red and white etc.). At present in Maharashtra, only 18 per cent of the total cultivable area is under irrigation having an ultimate potential of 50 per cent. To bridge this vast gap, it is necessary to manage the available water efficiently for maximum crop production. In coming years, only the agriculture sector would have to share water with other sector. Under such dwindling supplies of water day-by-day, there is increased needs for more efficient use of water. The low yield of such a valued crop should be enhanced to meet the production and demand gap (Lawande, 2003).

Surface irrigation (SI) methods are predominantly adopted by the farmers which results in poor yield and the available water is not only utilized judiciously ultimately results in reducing the productivity of cultivated land. The application of excess water through SI not only causes reduction in yield. Micro irrigation is the method of precisely and frequently watering crops which is not subjected to water stress and proper aeration in the root zone is maintained and overcomes the drawback of surface irrigation. High water and fertilizers use efficiency can be obtained through micro irrigation (Gorantiwar *et al*., 1987). Drip irrigation is one of the effective methods which minimize conveyance, deep percolation, run-off and soil water evaporation losses and increase the crop yield to 25-30 per cent with 40-60 per cent saving of irrigation water (Sivanappan, 1979). Onion crop is sensitive to irrigation, since it has got relatively shallow root zone and hence requires more irrigations compared to other vegetables crops. The use of appropriate quantity of irrigation at proper time plays a vital role in enhancing the productivity of onion. Micro irrigation methods are recently innovated promising system for economizing the use of irrigation water and is a solution on problems of water scarcity and poor quality. Water saving in micro irrigation system is achieved mainly due to irrigation of smaller portion of the soil volume, decreased surface evaporation and runoff and deep percolation losses and salinity hazards to crops, improved fertilizers and chemical application, limited weed infection and ultimately increases crop production. Today, when we are shifting from conventional methods

to the pressurized irrigation i.e. drip, mini sprinkler and micro sprinkler, rain port sprinkler, overhead sprinkler irrigation, it is essential to adopt suitable to management practices. However, micro irrigation system require precise design consideration to meet the requirement of crop to be irrigated and prevailing physical and chemical properties of soil. Review of research studies in respect of Drip irrigation and fertigation through Drip on onion production indicates that there is a scope to study the production potential of onion by using strategy 'more crops, per drop' with precise fertilizer application through fertigation. In view of this, the present study was undertaken

Material and Methods

The experiment was conducted at Instructional Farm of PGI, MPKV, Rahuri, (MS) during summer 2016 and 2017 in relation to nutrients management with Water Soluble Fertilizers (WSF) through drip fertigation to onion variety N-2-4-1 (Phule Samarth) in RBD replicated thrice with nine treatments. The land was prepared by ploughing and followed by two harrowing. The stubbles, debris and weed from previous crop were collected and removed from the plot. The plot size was 7.0 x 4.80 m, at 0.15 x 0.075 m spacing (6 lines per BBF of 0.90 m top and 1.20 m bottom),with RDF 100:50:50 NPK kg ha^{-1} through Urea, Single Super Phosphate and Muriate of Potash on Medium deep soil, Initial soil status :172.5:16.2:328.0 kg ha^{-1} NPK, Planting was done on 04.01.2016 and 30.12.2016 and harvesting on 09.05.2016 , 08.05.2017.

Geographically, the research farm is situated in between 19° 47' and 19° 57' North latitude and between 74° 82' and 74° 19' East longitude. The altitude is about 500 m above MSL. This area falls under semi arid and sub-tropical zone. The soil of experimental site was uniform, leveled and well drained clay loam with 45 cm depth. Composite representative soil sample was analyzed in laboratory.

The layout of drip irrigation system The single lateral was laid at 1.20 m and the emitter were spaced apart 0.5 m 16 mm lateral with inline build dripper were used for study. The operating pressure for the system was maintained at 1 kg cm^{-2}. The emission uniformity of drip irrigation system was estimated as 90 per cent. The crop water requirement was worked out by formula laid by Allen *et al*., (1998). Irrigation scheduling as per treatments based on cumulative pan evaporation. All the recommended agronomical practices were followed. Care of pest and diseases was taken by spraying recommended pesticides as and when required.

Soil moisture was measured by gravimetric method from the soil layers at 15 and 30 cm depth before irrigation. The data was utilized for estimating the soil moisture depletion curve. The soil moisture content were determined using standard methodology i.e., oven dry method. The various biometric observations were recorded by adopting standard sampling technique on five randomly selected onion plants from each treatment and replication. The sample plants were identified by fixing bamboo pegs near the plants.

Climatologically, the research farm falls under semi arid zone with annual rainfall varying from 307 to 619 mm. The annual average rainfall is 520 mm, which is mostly received during the monsoon months from June to September. The rainfall is erratic and unevenly distributed in 15 to 45 rainy days. The tract is the rain shadow area lying on eastern side of Western Ghat. The area chronically comes under drought prone having continuous famine conditions at least once in three years. Therefore, irrigation facilities are needed even in rainy season.

The statistical analysis of the data of each parameter was done by the statistical method known as "Analysis of variance" (ANOVA) appropriate for randomized block design (Panse and Sukhatme, 1967). The 'F'- test of significance was used for testing the null hypothesis and appropriate standard error (S.E. +). Treatment effect was worked out on the basis of critical difference (C.D) at 5 per cent probability level.

Fertigation schedule

Percent nutrients to be applied in 13 splits (91 days)

Days after planting	% Nutrients		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
01-21 (3 weeks)	25	20	10
22-42 (3 weeks)	35	40	20
43-70 (4 weeks)	25	30	40
71-91 (3 weeks)	15	10	30
Total	100	100	100

Percent nutrients to be applied in 11 equal splits (77 days)

Days after planting	% Nutrients		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
01-21 (3 weeks)	40	40	10
22-42 (3 weeks)	30	30	30
43-63 (3 weeks)	25	30	40
64-77 (2 weeks)	05	-	20
Total	100	100	100

Percent nutrients to be applied in 9 splits (63 days)

Days after planting	% Nutrients		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
01-21 (3 weeks)	40	40	20
22-42 (3 weeks)	35	30	45
43-63 (3 weeks)	25	30	35
Total	100	100	100

Results and Discussions

Growth contributing characters : The data pooled over two years (2016-17) revealed that, amongst the different treatments, 100% RD of WSF through 24:24:00, Urea and SOP up to 77 DAP (T5) recorded significantly maximum values of plant height (84.56 cm), No. of leaves plant^{-1} (12.44) and neck thickness (1.26 cm). However, it was at par with T_4 (81.71 cm) and T_6 (81.15 cm) respectively in respect of plant height, T_6 (11.75) and T_4 (11.24) in respect of number of leaves plant^{-1} and with all other treatments except T_1 and T_2 in respect of neck thickness (Table 1).

Post harvest observations :

Per cent twin bulb : The percent twin bulbs differed significantly due to different fertigation treatments. The significantly maximum twin bulbs (2.62%) were recorded in treatment of 100% of RD of WSF through 24:24:00 for 91 days (T_4) over the other treatments, however it was at par with treatments T_5 and T_6 (Table 2). The production of twin bulbs might be due to activation of multiple growth centres in the basal plate of the bulbs and producing more No. of smaller plants.

Polar and Equatorial diameter : The significantly maximum polar (6.0 cm) and equatorial diameter (6.90 cm) was recorded in treatment of 100% RD of WSF through 24:24:00 for 77 days (T_5) over other treatments at harvest. However, it was at par with treatments T_4 and T_6. The bigger size of bulbs attributed to increase in weight due to the combined effect of water and fertilizers used judiciously in drip fertigation as compared to surface irrigation with conventional fertilizer (Table 2).

Yield contributing characters :

Average bulb weight : The average weight of onion bulbs (Table 3) was influenced

significantly due to different treatments at harvest. The maximum average weight bulbs (92.09 g) was obtained in treatment T_4 (100% RD of WSF through 24:24:00 for 91days) which was significantly higher than all other treatments.

Yield of onion and onion leaves : The yield of onion and onion leaves (Table 3) influenced significantly due to different fertigation doses. The treatment T_4 i.e. drip irrigation with 100% RD of WSF through 24:24:00, Urea and SOP for 91 days recorded

Table 1. Growth and yield contributing characters of onion as influenced by different treatments (Pooled mean of 2 years)

Treatments	Plant height (cm)			No. of leaves plant^{-1}			Neck thickness of onion (cm)		
	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1 : Absolute control	57.9	59.80	58.85	7.0	8.13	7.57	0.72	0.50	0.61
T_2 : SI with 100 % RD of CF	73.1	63.10	68.10	8.0	9.17	8.59	0.79	0.57	0.68
T_3 : SI with 100 % RD of CF (24:24:0)	77.3	65.50	71.40	8.3	9.60	8.95	0.88	0.95	0.91
T_4 : 100% RDF thro 24:24:00 for 91 days	82.2	81.23	81.71	10.5	11.98	11.24	1.08	1.25	1.17
T_5 : 100% RDF thro 24:24:00 for 77 days	86.0	83.12	84.56	12.0	12.88	12.44	1.20	1.31	1.26
T_6 : 100% RDF thro 24:24:00 for 63 days	83.8	78.50	81.15	11.7	11.79	11.75	1.10	1.20	1.15
T_7 : 80% RDF thro 24:24:00 for 91 days	81.8	73.12	77.46	10.3	11.36	10.83	0.96	1.10	1.03
T_8 : 80% RDF thro 19:19:19 for 91 days	79.3	70.50	74.90	9.0	11.64	10.32	0.92	1.00	0.96
T_9 : 80% RDF thro 12:61:00 for 91 days	78.3	69.50	73.90	8.6	10.00	9.30	0.90	0.97	0.94
SE±	1.43	1.24	1.34	0.60	0.42	0.52	0.04	0.14	0.13
CD at 5%	4.30	3.73	3.85	1.80	1.27	1.49	0.12	0.42	0.39

Table 2. Yield and yield contributing characters of onion as influenced by different treatments (Pooled mean of 2 years)

Treat-ments	% Twin bulbs of onion			Polar diameter (cm)			Equatorial diameter (cm)			Yield of leaves (t ha-1)			Bulb to leaves ratio		
	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1	1.75	1.90	1.83	4.80	5.12	4.96	5.00	5.40	5.20	4.98	5.50	5.24	5.37	5.57	5.47
T_2	2.20	2.40	2.30	5.00	5.40	5.20	5.20	5.85	5.53	5.34	5.88	5.61	5.68	6.00	5.84
T_3	2.25	2.47	2.36	5.15	5.39	5.27	5.90	5.97	5.94	5.44	7.00	6.22	5.97	6.40	6.19
T_4	2.35	2.88	2.62	5.60	6.09	5.85	6.45	6.90	6.68	8.10	9.13	8.62	6.06	7.75	6.91
T_5	2.32	2.85	2.59	5.90	6.09	6.00	6.70	7.10	6.90	8.83	9.40	9.12	6.17	7.88	7.03
T_6	2.34	2.75	2.55	5.75	5.94	5.85	6.50	6.50	6.50	8.65	8.88	8.76	6.10	7.40	6.75
T_7	2.25	2.70	2.48	5.50	5.89	5.69	6.25	6.13	6.19	7.68	8.40	8.04	6.03	7.00	6.52
T_8	2.10	2.60	2.35	5.40	5.75	5.58	6.15	6.00	6.08	7.33	8.13	7.73	6.02	6.98	6.50
T_9	2.00	2.05	2.03	5.25	5.63	5.44	6.05	5.99	6.02	7.11	7.80	7.46	6.00	6.75	6.38
SE±	0.03	0.48	0.03	0.11	0.07	0.09	0.09	0.79	0.09	0.40	0.51	0.46	0.04	1.02	0.04
CD at 5%	0.10	NS	0.09	0.32	0.21	0.27	0.22	0.98	0.27	1.19	1.53	1.32	0.12	0.32	0.12

T_1 : Absolute control, T_2 : SI with 100 % RD of CF, T_3 : SI with 100 % RD of CF(24:24:0), T_4 : 100% RDF thro 24:24:00 for 91 days, T_5 : 100% RDF thro 24:24:00 for 77 days, T_6 : 100% RDF thro 24:24:00 for 63 days, T_7 : 80% RDF thro 24:24:00 for 91 days, T_8 : 80% RDF thro 19:19:19 for 91 days, T_9 : 80% RDF thro 12:61:00 for 91 days

significantly maximum onion bulbs yield (63.14 t ha^{-1}) but it was at par with treatment T_5 i.e. drip irrigation with 100% RD of WSF using 24:24:0 for 77 days (60.74 t ha^{-1}) and T_6 i.e. drip irrigation with 100% RD of WSF using 24:24:0 for 63 days (58.23 t ha^{-1}) and T_7 i.e. drip irrigation with 80% RD of WSF using 24:24:0 for 91days (51.25 t ha^{-1}).

The maximum yield of onion leaves (9.12 t ha^{-1}) was obtained in treatment T_5 (100% RD of WSF through 24:24:00 for 77 days) was significantly higher than all other treatments except T_6, T_4 and T_7 which were at par. It indicated that fertigation using WSF can save fertilizers dose up to 20% with increase in yield (Table 2).

Bulbs to leaves ratio : The significantly maximum bulb to leaves ratio (7.03) was obtained in T5 treatment (100% RD of WSF through 24:24:00 for 77 days) and was at par with treatment T_4 (Table 2).

Water Studies :

Water use and water use efficiency : The drip method of irrigation resulted into lowest water use (399.65 mm) as compared to

Table 3. Yield and yield contributing characters of onion as influenced by different treatments (Pooled mean of 2 years)

Treatments	Av. weight of onion (g)			Yield (t ha^{-1})			% increase in yield over T_2		
	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1 : Absolute control	59.20	68.13	65.99	26.78	30.38	28.58	-	-	-
T_2 : SI with 100 % RD of CF	68.60	72.40	71.49	30.36	37.95	34.16	-	-	-
T_3 : SI with 100 % RD of CF (24:24:0)	71.40	75.37	74.42	32.44	44.29	38.36	6.85	16.71	11.78
T_4 : 100% RDF thro 24:24:00 for 91 days	88.80	93.13	92.09	49.11	77.16	63.14	61.76	103.3	82.53
T_5 : 100% RDF thro 24:24:00 for 77 days	83.40	90.12	88.51	54.50	66.98	60.74	79.51	76.50	78.00
T_6 : 100% RDF thro 24:24:00 for 63 days	85.40	89.80	88.75	52.80	63.65	58.23	73.91	67.72	70.82
T_7 : 80% RDF thro 24:24:00 for 91 days	77.80	81.12	80.33	46.33	56.16	51.25	52.60	47.98	50.29
T_8 : 80% RDF thro 19:19:19 for 91 days	75.40	80.50	79.28	44.15	45.16	44.66	45.42	19.00	32.21
T_9 : 80% RDF thro 12:61:00 for 91 days	73.20	78.80	77.46	42.66	43.96	43.31	40.51	15.84	28.18
SE±	1.80	1.01	0.88	1.13	4.42	4.40	-	-	-
CD at 5%	5.42	3.04	2.64	3.38	13.25	14.34	-	-	-

Table 4. Water use of onion as influenced different treatments (Pooled mean of 2 years)

Treatments	Effective rainfall (mm)			Water applied (mm)			Total water use (mm)		
	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1 : Absolute control	00	10	10	410	379.3	394.65	410	389.3	399.65
T_2 : SI with 100 % RD of CF	00	10	10	750	650.0	700.00	750	660.0	705.00
T_3 : SI with 100 % RD of CF (24:24:0)	00	10	10	750	650.0	700.00	750	660.0	705.00
T_4 : 100% RDF thro 24:24:00 for 91 days	00	10	10	410	379.3	394.65	410	389.3	399.65
T_5 : 100% RDF thro 24:24:00 for 77 days	00	10	10	410	379.3	394.65	410	389.3	399.65
T_6 : 100% RDF thro 24:24:00 for 63 days	00	10	10	410	379.3	394.65	410	389.3	399.65
T_7 : 80% RDF thro 24:24:00 for 91 days	00	10	10	410	379.3	394.65	410	389.3	399.65
T_8 : 80% RDF thro 19:19:19 for 91 days	00	10	10	410	379.3	394.65	410	389.3	399.65
T_9 : 80% RDF thro 12:61:00 for 91 days	00	10	10	410	379.3	394.65	410	389.3	399.65

surface method of irrigation (705.00 mm) and thus resulted into 43.47% water saving. The 100% RD of WSF using 24:24:00, Urea and SOP 91 days through drip method of irrigation (T4) resulted into 82.53% increase in yield with 43.47% water saving as compared to surface irrigation. The drip irrigation with 80% RD of fertigation for 91 days (T_7) resulted in 43.47% water saving, 20% fertilizer saving and 50.29% increase in yield.

The maximum water use efficiency of 161.62 q ha^{-1} mm was obtained in treatment T_4, 100% RD of WSF using 24:24:00, Urea and SOP for 91 days through drip method of irrigation followed by T_5 (154.75 q ha^{-1} mm) and T_6 (148.31 q ha^{-1} mm). The surface method of irrigation resulted into minimum water use efficiency of 49.43 q ha^{-1} mm (Table 4).

Nutrient availability and uptake : The NPK availability and uptake was found to be influenced significantly due to different

Table 4. Contd…

Treatments	WUE (kg ha^{-1}-mm)			Water saving (%)			Increase in yield (%)		
	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1 : Absolute control	65.32	80.09	72.71	45.3	41.0	43.15	-	-	-
T_2 : SI with 100 % RD of CF	40.48	58.38	49.43	-	-	-	-	-	-
T_3 : SI with 100 % RD of CF (24:24:0)	43.25	68.13	55.69	-	-	-	6.85	16.71	11.78
T_4 : 100% RDF thro 24:24:00 for 91 days	119.8	203.43	161.62	45.3	41.64	43.47	61.76	103.3	82.53
T_5 : 100% RDF thro 24:24:00 for 77 days	132.9	176.59	154.75	45.3	41.64	43.47	79.51	76.50	78.01
T_6 : 100% RDF thro 24:24:00 for 63 days	128.8	167.81	148.31	45.3	41.64	43.47	73.91	67.72	70.82
T_7 : 80% RDF thro 24:24:00 for 91 days	113.0	148.06	130.53	45.3	41.64	43.47	52.60	47.98	50.29
T_8 : 80% RDF thro 19:19:19 for 91 days	107.7	119.06	113.38	45.3	41.64	43.47	45.42	19.00	32.21
T_9 : 80% RDF thro 12:61:00 for 91 days	104.0	115.90	109.95	45.3	41.64	43.47	40.51	15.84	28.18

Table 5. Nutrient availability in soil at harvest of onion as influenced by different treatments (Pooled mean of 2 years)

Treatments	N availability (kg ha^{-1})			P availability (kg ha^{-1})			K availability (kg ha^{-1})		
	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1 : Absolute control	157.4	150.3	153.8	13.1	10.2	11.65	318.0	309.2	313.6
T_2 : SI with 100 % RD of CF	167.2	165.3	166.3	15.0	14.8	14.90	320.0	318.4	319.2
T_3 : SI with 100 % RD of CF (24:24:0)	168.4	166.4	167.4	15.4	15.2	15.30	325.0	323.2	324.1
T_4 : 100% RDF thro 24:24:00 for 91 days	174.4	170.1	172.3	17.7	16.7	17.20	336.0	331.0	333.5
T_5 : 100% RDF thro 24:24:00 for 77 days	172.2	168.2	170.2	17.2	16.3	16.75	332.0	331.8	331.9
T_6 : 100% RDF thro 24:24:00 for 63 days	170.1	167.5	169.8	16.4	16.0	16.20	330.0	330.5	330.3
T_7 : 80% RDF thro 24:24:00 for 91 days	169.4	166.5	167.9	15.8	15.3	15.55	328.0	326.4	327.2
T_8 : 80% RDF thro 19:19:19 for 91 days	165.2	164.3	164.8	14.8	14.4	14.60	320.0	318.2	319.1
T_9 : 80% RDF thro 12:61:00 for 91 days	163.1	162.2	162.7	14.6	14.3	14.45	319.0	317.4	318.2
SE±	1.67	0.41	1.10	0.63	0.27	0.28	2.67	1.70	1.17
CD at 5%	5.00	1.24	3.30	1.90	0.83	0.85	8.00	5.10	3.50

Table 6. Nutrient uptake by onion as influenced by different treatments (Pooled mean of 2 years)

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1 : Absolute control	52.22	59.24	55.74	24.10	27.34	25.72	46.61	52.86	49.75
T_2 : SI with 100 % RD of CF	59.10	73.62	66.52	27.21	34.10	30.75	52.80	66.80	59.80
T_3 : SI with 100 % RD of CF (24:24:0)	62.87	85.90	75.88	28.95	37.90	33.44	56.21	78.40	67.31
T_4 : 100% RDF thro 24:24:00 for 91 days	96.74	150.4	123.6	44.49	68.67	56.57	87.24	137.50	112.8
T_5 : 100% RDF thro 24:24:00 for 77 days	104.86	129.9	119.76	48.22	60.28	55.47	93.68	118.60	108.27
T_6 : 100% RDF thro 24:24:00 for 63 days	109.63	123.5	114.18	50.66	57.29	52.77	97.93	113.3	103.60
T_7 : 80% RDF thro 24:24:00 for 91 days	90.45	109.5	100.6	41.60	49.98	45.82	81.29	99.40	90.35
T_8 : 80% RDF thro 19:19:19 for 91 days	86.23	87.16	86.72	39.67	40.80	40.25	77.50	81.30	79.60
T_9 : 80% RDF thro 12:61:00 for 91 days	82.76	77.12	79.94	38.40	39.40	35.90	74.94	70.72	72.75
SE±	1.73	0.35	1.25	1.18	0.40	1.23	1.41	2.17	1.57
CD at 5%	5.18	1.05	3.75	3.53	1.21	3.70	4.23	6.50	4.70

treatments (Table 5).The treatment T_4 (100% RD of WSF through 24:24:00 for 91 days) recorded significantly maximum availability of NPK (172.3, 17.20 and 333.5 kg ha^{-1}, respectively) in soil at harvest with significantly maximum uptake of N, P and K (123.6, 56.57 and 112.80 kg ha^{-1} respectively) by onion crop. However, it was at par with T_5 (119.76, 55.47 and 108.27 kg ha^{-1} respectively) for N and K availability however it was at par with T_5 (100% RD of 24:24:00 for 77 days) and T_6 (100% RD of 24:24:00 for 63 days) for P availability in soil of onion over other treatments N, P and K uptake was improved significantly in drip fertigation treatments over surface irrigation with conventional fertilizer (Table 6).

Nutrient use efficiency : The pooled data of nutrient use efficiency was found to be influenced due to different treatments (Table 7). The maximum nutrient use efficiency (172.8 kg yield kg^{-1} nutrient applied) was observed in treatment T_4 (100% RD of WSF, 24:24:00 for 91 days) followed by T_5 (160.80 kg yield kg^{-1} nutrient). The lowest nutrient use efficiency (27.88 kg yield kg^{-1} nutrient) was observed in T_2 followed by T_3 (48.93 kg yield kg^{-1} nutrient).

Cost economics :

Seasonal cost of cultivation : The seasonal cost of cultivation was maximum (Rs.

Table 7. Nutrient use efficiency of onion as influenced by different treatments (Pooled mean of 2 years)

Treatments	Nutrient use efficiency (kg yield kg^{-1} nutrient applied)		
	2016	2017	Pooled mean
T_1	-	-	-
T_2	17.9	37.85	27.88
T_3	28.3	69.55	48.93
T_4	111.7	233.9	172.80
T_5	130.1	183.0	160.80
T_6	138.6	166.35	148.23
T_7	122.2	161.13	141.67
T_8	108.6	92.38	100.50
T_9	99.3	59.88	79.60

T_1 : Absolute control, T_2 : SI with 100 % RD of CF, T_3 : SI with 100 % RD of CF (24:24:0), T_4 : 100% RDF thro 24:24:00 for 91 days, T_5 : 100% RDF thro 24:24:00 for 77 days, T_6 : 100% RDF thro 24:24:00 for 63 days, T_7 : 80% RDF thro 24:24:00 for 91 days, T_8 : 80% RDF thro 19:19:19 for 91 days, T_9 : 80% RDF thro 12:61:00 for 91 days

94,679) in treatment T_4 to T_6 followed T_8 and T_7 (Rs. 92,730 and 89,932) and T_9 (Rs. 87,042). The lowest seasonal cost of cultivation of Rs. 65,905 was obtained for SI with 100% RD of CF (Table 8).

Net Seasonal Income : The maximum net seasonal income of Rs. 2,58,092 was obtained in treatment T_4 (100% RD of WSF using 24:24:00, Urea and SOP for 91 days) over other treatments followed by T_5 (Rs. 2,39,392) and T_6 (Rs. 2,25,587) (Table 8).

B : C ratio : The significantly maximum B: C ratio of 3.73 was observed in T_4 (DI with 100% RD of WSF using 24:24:00, Urea and SOP for 91 days) over other treatments; followed by T_5 (3.53), T_6 (3.38) and T_7 (3.13).

Net extra income over control and Water productivity : The drip irrigation with 100% RD of WSF using 24:24:00, Urea and SOP for 91 days (T4) recorded maximum net extra income Rs. 136117 ha^{-1} over surface irrigation with 100% RD of conventional

Table 8. Seasonal cost of cultivation and net seasonal income of onion (Pooled mean of 2 years)

Treatments	Seasonal cost of cultivation (Rs. ha^{-1})			Net seasonal income (Rs.)		
	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1 : Absolute control	68,449	75,998	70,838	65,451	1,06,282	86,353
T_2 : SI with 100 % RD of CF	61,918	69,812	65,905	89,882	1,57,888	1,21,975
T_3 : SI with 100 % RD of CF (24:24:0)	64,312	72,206	68,299	97,888	1,93,534	1,42,681
T_4 : 100% RDF thro 24:24:00 for 91 days	92,290	99,839	94,679	1,53,260	3,63,121	2,58,092
T_5 : 100% RDF thro 24:24:00 for 77 days	92,290	99,839	94,679	1,80,210	3,02,041	2,39,392
T_6 : 100% RDF thro 24:24:00 for 63 days	92,290	99,839	94,679	1,71,710	2,82,061	2,25,587
T_7 : 80% RDF thro 24:24:00 for 91 days	87,564	95,071	89,932	1,44,086	2,41,889	1,91,944
T_8 : 80% RDF thro 19:19:19 for 91 days	87,041	1,01,190	92,730	1,33,709	1,69,770	1,52,901
T_9 : 80% RDF thro 12:61:00 for 91 days	84,653	92,202	87,042	1,28,647	171,558	1,51,164

Price - 2016 : Rs. 5000 t and 2017: Rs. 6000 t

Table 9. Net extra income, water productivity and B:C ratio of Onion (Pooled mean of 2 years)

Treatments	Net extra income over control (Rs. ha^{-1})			Net profit mm-1 use of water			B:C ratio		
	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
T_1 : Absolute control	0	0	0	160	273	216	1.96	2.40	2.22
T_2 : SI with 100 % RD of CF	0	0	0	120	239	173	2.45	3.26	2.85
T_3 : SI with 100 % RD of CF (24:24:0)	8,006	35,646	20,706	131	293	202	2.52	3.68	3.09
T_4 : 100% RDF thro 24:24:00 for 91 days	63,378	2,05,233	1,36,117	374	933	646	2.66	4.64	3.73
T_5 : 100% RDF thro 24:24:00 for 77 days	90,328	1,44,153	1,17,417	440	776	599	2.95	4.03	3.53
T_6 : 100% RDF thro 24:24:00 for 63 days	81,828	1,24,173	1,03,612	419	725	565	2.86	3.83	3.38
T_7 : 80% RDF thro 24:24:00 for 91 days	54,204	84,001	69,969	351	621	480	2.65	3.54	3.13
T_8 : 80% RDF thro 19:19:19 for 91 days	43,827	11,882	30,926	326	436	383	2.54	2.68	2.65
T_9 : 80% RDF thro 12:61:00 for 91 days	38,765	13,670	29,189	314	441	378	2.52	2.86	2.74

fertilizer (Table 9) with maximum water productivity of Rs. 646 ha^{-1} cm over other treatments and followed by treatments T_5 (Rs. 599), T_6 (Rs. 565), T_7 (Rs. 480) ha^{-1} cm of water, whereas surface irrigation with conventional fertilizer (T_2) resulted into Rs. 173 ha^{-1} cm of water.

The no fertilizer treatment (T_1) produced lowest values in respect of plant height (58.85 cm), leaves $plant^{-1}$ (7.57), neck thickness (0.61cm) , twin bulbs (1.83%), the polar (4.96 cm) as well as equatorial diameter (5.20 cm). Average weight of onion bulbs (65.99 g) , yield of onion 28.58 t ha^{-1} and onion leaves (5.24 t ha^{-1}) was observed, bulbs to leaves ratio (5.47), NPK availability (153.8, 11.65 and 313.6 kg ha^{-1}, respectively) and uptake (55.74, 25.72 and 49.75 kg ha^{-1}, respectively) with minimum net seasonal income of Rs. 86,353 and lowest B: C ratio were obtained under T_1 (Absolute control treatment) of 2.22.

Conclusions

All the growth and yield contributing characters were maximum and significantly superior incase of 100% RD of WSF using 24:24:00; Urea and SOP for 77 days (T_5) however, it was at par with T_4 and T_6.

The significantly maximum yield of onion bulbs (63.14 t ha^{-1}) (82.53% increase in yield) with 43.47% water saving as compared to surface irrigation, as well as higher net seasonal income, net extra income and water productivity over control, with highest B:C ratio (3.73) was obtained in treatment T_4 (100% RD of WSF, 24:24:00 Urea and SOP for 91 days but it was at par with treatment T_5, T_6 and T_7. The nutrient availability and uptake was found to be improved under drip irrigation as compared to SI with conventional fertilizer.

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Analysis of the Carbon Sequestration Potential of Multi-Varietal and Mono-Varietal Mango Orchards in Semi-Arid Monsoonal Climate with Distinct Seasons

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Abstract

This study tested the hypothesis that multi-varietal mango orchards sequester more carbon (C) than mono-varietal mango orchards. We estimated the C sequestration potential of multi-varietal and mono-varietal mango orchards in Chittoor district of Andhra Pradesh, India, a center of mango diversity in semi-arid monsoonal climate with distinct summer, winter and rainy season. Fifteen multi-varietal mango orchards and six mono-varietal mango orchards were selected for this study. The total C sequestered per tree was higher in multi-varietal mango orchards (138.9 kg tree^{-1}) as compared to mono-varietal mango orchards (113.78 kg tree^{-1}). Whereas, weeds and litter which represent the floor level C sequestration was lower in multi-varietal mango orchards than mono-varietal mango orchards. In multi-varietal mango orchards and mono-varietal mango orchards, the floor C represent 8.44% and 10.47% of the total C sequestered, respectively. The soil C stocks in both mono-varietal mango orchards (63.6 t ha^{-1}) and multi-varietal mango orchards (64.0 t ha^{-1}) were fairly uniform. The mean total C sequestered in mono-varietal orchards varied from 67.31 to 81.35 t ha^{-1} with a mean of 76.2 t ha^{-1} and in multi-varietal orchards, it ranged from 71.45 to 86.22 t ha^{-1} with a mean of 78.55 t ha^{-1}. The lack of differences in total C sequestered between mono-varietal and multi-varietal mango orchards demonstrated that varieties did not influence the C sequestration potential of the crop. Our data also indicated that both mono-varietal mango orchards and multi-varietal mango orchards have similar kind of huge potential in greenhouse gas (GHG) mitigation through C sequestration while providing sustainable economic income to the farmers.

Key words : Carbon sequestration; allometric equation; grafted mango; mango varieties; mono-varietal mango; multi-varietal mango orchard.

The most dreaded problem of the new millennium is the global warming. The route cause for this is supposedly the greenhouse gas (GHG) emissions. One of the options for reducing the rise of GHG concentration in the atmosphere and thus possible climate change is to increase the amount of carbon (C) removed by and stored in plants. Trees are the large reservoirs of C as well as potential C sink and sources to the atmosphere. In tropical countries like India, Csinks in forests and fruit orchards but due to large scale industrialization and increased population, the forest area is declining. However, fruit orchards area is on the increase. Perennial fruit trees like cashew, mango and guava have similar potential like forest trees to sink atmospheric C. of them, mango is the major fruit crop of India and it is an evergreen tree. Mango is native to India and Southeast Asia (Mukherjee, 1953) where it has been cultivated for over 4000 years for the quality fruits. Mango is known as 'the king offruits' as it is the most popular fruit in tropical regions. It is the national fruit of India (Usman *et al*. 2001).

In India, mango is grown in seasonally moist tropical climate having a distinct dry and wet season. There is a strong seasonality of photosynthetically active radiation (PAR) usually being much larger in late wet season than in the

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dry season. The seasonally moist tropical fruit trees have evolved adaptive mechanisms to maximize C uptake in an environment with large seasonal variation of light and water. One adaptive mechanism is that perennial fruit trees have deep roots (1.0 m and deeper) for getting access to water in deep soil during dry season. Two types of mango population occur in India, the wild polyembryonicmangoes and the cultivated grafted mangoes. Estimates of the population and area occupied by wild polyembryonic mango are not available but surely are a sizeable area as India is the origin of mangoes. Cultivated grafted mango occupied an area of 25,16,000 hectare (ha) and has great potential for C sequestration (NHB, 2015).

There are about 1500 varieties of mangoes grown including 1000 commercial varieties. However, only following varieties are grown in large area in different states: Alphonso, Bangalora,Banganapalli, Bombai, Bombay Green, Dashehari, Fazli, Fernandin, Himsagar, Amrapali, Kesar, KishenBhog,Langra, Mallika, Mankhurd, Mulgoa, Neelum, Raspuri, Samarbehist, Chausa, Suvarnarekha, Totapuri, Vanaraj and Zardalu. Single selected variety orchards are more common than multiple variety orchards. However, multiple varietal orchards have several advantages over mono-varietal orchards including ecosystem services like C sequestration, length of pollen availability, extended marketing period etc..

Our hypothesis is that multi-varietal mango orchards sequester more C than mono-varietal mango orchards as there is differential growth habit, spread of canopy, length of fruiting season, period of fruiting season etc. This was examined in a major mango belt of Chittoor district of Andhra Pradesh, India.

Materials and Methods

Study location : Chittoor district (Fig. 1) is one among 13 districts of Andhra Pradesh State in Southern India. It is Located between 12°37' - 14°8' north latitudes and 78°3' - 79°55' east longitudes, 30% of the total land area is covered by forests in the district.Chittoor experiences semi-arid monsoonic climate with distinct summer, winter and rainy seasons. It is hot in summer. The summer highest day temperature is in between 31°C to 42°C. Average temperatures during mango fruiting is: December 20°C, January 24°C, February 24°C, March 27°C, April 31°C, May 34°C. The region has 57% of the area under red loamy, 34% red sandy and 9% covered by black clay. The average annual rainfall of the area is 934 mm. Out of this, for south west monsoon period is 438 mm and that for north east monsoon period is 396 mm. The rainfall received during winter and summer is negligible. The mean annual soil temperature is 31.9°C with mean summer and winter soil temperatures of 32.1°C and 27.8°C, respectively. The area qualifies for iso-hyperthermic temperature regime. Mango is one of the major fruit crops of the Chittoor district,a center of mango diversity and occupied an area 23839 hawith a production of 2.14 lakh tonnes per annum(Kumar and Subramanyachari, 2015).

Selection of orchards : Based on the diversity of mango varieties, 21 farmers'orchardsall in the age group of 20 to 22 years were selected consisting of 15 multi-

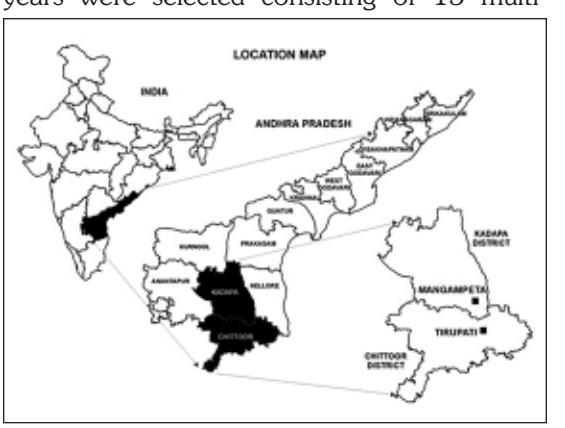

Fig. 1. Location map of the study area

Table 1. Mono-varietal mango orchards selected for the study

Site	Area (ha)	Mango variety
1.	2.0	Benisha
2.	2.0	Totapuri
3.	4.0	Totapuri
4.	6.0	Totapuri
5.	10.0	Neelum
6.	7.0	Rumani

varietal and 6mono-varietal orchards for this study. The orchard size varied from 4 hato 30ha. The multiple variety orchards contained minimum 7 varieties and maximum 16 varieties. Mono-varietal orchards selected were 3Totapuri orchards and one each of Benisha, Neelum and Rumani variety. The details of the mono-varietal and multi-varietal orchards selected for the study are presented in Table 1 and 2. Since the area under each farmer and under each type varied we earmarked uniformly 2 ha area under each category for sampling based on tree uniformity and even distribution of varieties.

Computation of tree biomass : All the orchards selected contained only grafted treeshence there was no scope for recording the diameter at breast height(DBH), a parameter necessary for using general allometric equation for estimating the tree biomass. We followed the allometric equation developed by Ganeshamurthy *et al*. (2016) for grafted mangoes for estimating the tree above ground biomass (AGB) and below ground biomass (BGB). The measurement included the number of primary branches and diameter of the primary

Table 2. Multi-varietal mango orchards selected for the study

Site	Area (ha)	Mango variety
1.	20	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum,Reddypasand, Kalepadu, Himamipasand and Gadhamar.
2.	15	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Dilpasand, Kalepadu, Rajapasand, Gadiyaram, Mallika, Royalpasand and Naativarieties.
3.	30	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Reddypasand, Kalepadu, Himamipasand and Gadhamar.
4.	25	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Athimaduram, Manoranjitham, Dilpasand, Reddypasand, Kalepadu, Himamipasand, Punasa, Gadhamar and Naati varieties.
5.	4	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Kalepadu and Naati varieties.
6.	4	Totapuri, Kadhar, Rumani, Neelum, Kalepadu, Benisha and Naati varieties.
7.	4	Totapuri, Kadhar, Pulura, Benisha, Chekeraguttulu, Mulgoa, Rumani, Neelum, Kalepadu and Naati varieties.
8.	10	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Kalepadu and Naati varieties.
9.	5	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Kalepadu, Gadhamar and Naati varieties.
10.	30	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Dilipasand, Kalepadu, Gadiyaram, Mallika, Athimaduram, Gadhamar and Naati varieties.
11.	25	Totapuri, Kadhar, Pulura, Benisha, Lalbaba, Dilpasand, Kudadath, Mittagiri, Athimaduram, Mulgoa, Rumani, Neelum, Kalepadu, Gadhamar and Naati varieties.
12.	30	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Athimaduram, Dilipasand, Reddypasand, Kalepadu, Lalbaba, Gadhamar, Himamipasand, Bogamrangasani, Chittithota and Naati varieties.
13.	15	Totapuri, Kadhar, Pulura, Benisha, Athimaduram, Mulgoa, Rumani, Himamipasand, Gadhamar, Neelum, Kalepadu and Naati varieties.
14.	18	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Dilipasand, Kalepadu, Himamipasand and Naati varieties.
15.	10	Totapuri, Kadhar, Pulura, Benisha, Mulgoa, Rumani, Neelum, Reddypasand, Kalepadu, Himamipasand, Gadhamar and Naati varieties.

branches. For this purpose, we measured the allometric parameters of all the trees available with individual farmers ranging from 113 trees to 660 trees. For BGB estimation we followed the ratio of 1:0.29 as suggested by Ganeshamurthy *et al*. (2016).

Tree sampling : Matured leaves were collected from 20 random trees from each orchard and from each variety for estimation of C content. These samples were pooled variety wise, washed and dried at 65°C till constant weight.The samples were powdered for C estimation.Similarly samples of twigs representing tertiary branches and other smaller branches were also selected and processed for C estimation.The bark and wood samples were collected from selected trees by using a tree drill and processed for C estimation.

Carbon estimation

Mango tree samples : The C content of the plant samples were estimated by using a CHNS analyser (Elementar) and expressed as per cent C in the sample.

Weeds and litter : The litter and weed biomass were collected by demarcating a 2 square meter area below the canopy of sampled trees in each orchard and periodically the litter were collected, dried and weighed for commuting the annual litter biomass of the orchards. The litter samples were analysed for their C content using a CHNS analyser (Elementar) and expressed as percent C in the sample.

Soil carbon stock: Representative four pedon samples (0-15, 15-30, 30-60 and 60-100 cm) were collected from each mango orchard and total C stock was estimated in the soils. Soil samples were collected randomly from ten spots at each depth and mixed thoroughly, and a composite sample was drawn. The samples were air-dried, sieved using a 2 mm sieve and analysed for total soil organic carbon by Walkleyand Black method (Nelson and Sommers, 1996). The bulk density of soil was determined following core sampling method. Soil bulk density was expressed as the ratio of oven-dry weight of soil core (dried at 105°C for 24 h) and its total volume.

Carbon stock was then calculated as (TOC x Ds x e)/10.

Where, TOC is the total organic carbon at a given soil depth (thickness of the layer); Ds is the soil bulk density at a given soil depth (thickness of the layer) and eis the thickness of the layer.

Mango allometric parameters and Carbon capture: Carbon (C) storage from mango tree is estimated based on dry matter and C content of the tree parts. For the purpose of C sequestration we recorded the allometric parameters from each of the trees in the entire orchards ranging from 154 trees in Benishato 504 in Totapuri in mono-varietalmangoorchards and from 113 trees in orchard 13 to 660 trees in orchard 15 in multi-varietal mango orchards. The average number of primary branches were 3.19 in mono-varietal orchards as against 2.84 in multi- varietal orchards (Table 5 and 6). The mean diameters of primary branches were 18.36 cm in mono-varietal orchards and 21.9 cm in multi-varietal orchards. Utilizing these two tree parameters, the AGB of mango trees were estimated following the allometric equation developed for grafted mangoes by Ganeshamurthy *et al*. (2016).

$$Y = 2.886X^{1.039}$$

Where Y is AGB and X is the product of mean number of primary branches and mean diameter of primary branches

Results and Discussion

Chittoor in Andhra Pradesh is one of the regions wherein commercial cultivation of many

varieties like Totapuri, Neelum, Banganapalli, Alphonso, Kalepaduetc.is being taken up. Due to overemphasis on the cultivation of certain varieties *viz*., Totapuri, which has demand from the processing industry, local indigenous varieties meant for table, pickling, juice or for other products are becoming extinct. In this study, we tested the hypothesis that multi-varietal mango orchards sequester more C than mono-varietal mango orchards.

The soils belong to Typic Ustifluvents and the soil moisture control section remains dry for more than 90 cumulative days or 45 consecutive days in four months following summer solstice and it qualifies for ustic soil moisture regime. The soils were sandy-loam to clay-loam and poorly to excessively drained. The solum depth varied from deep to very deep. The soils were calcareous, near neutral to alkalinewith pH ranged between 7.42 to 7.85 in mono-varietal orchards and 7.40 to 7.81 in multi-varietal mango orchards. Both the orchards had free $CaCO_3$ of about 4.5 per cent. Soils at both sites were low in available N and were well supplied with P and K. The soils were not compact with the bulk density of 1.397 g cc^{-1} in mono-varietal orchards and 1.387 g cc^{-1} in multi-varietal orchards having about 30 per cent water holding capacity (Table 3 and 4).

Use of height-diameter relationships is very common in most allometric equations and in dicotyledonous tree species. These are quite similar and have a slope very close to unity and may differ most among larger trees. This is true with mangoes grown from seeds but not so in case of commercially grown grafted trees for fruit purpose as measurement of diameter at breast height, the basic parameter required for using such allometric equations is not possible. Hence we used the allometric equation developed exclusively for grafted mangoes for estimation of C stocks of the mango trees (Ganeshamurthy *et al.*, 2016).

On per tree basis, the mean AGB was more in multi-varietal orchards (218.5 kg $tree^{-1}$) than in mono-varietal orchards (176.12 kg $tree^{-1}$). This is partly attributed to synergistic growth performance of mango in mixed orchards compared to monocrops as there is scope for better light penetration, better root spread and synergistic effects of one variety over the other varieties. The results obtained donot match with the biomass produced by wild mangos which have straight trunk and grow taller than grafted mangos and produce larger biomass. Hence these two distinct mango types cannot be compared. (Eneji *et al*., 2014; Selvaraj *et al*., 2016). The BGB also followed the similar trend of AGB with a mean BGB of 71.94 kg $tree^{-1}$ in mono-varietal orchards and 89.3 kg $tree^{-1}$ in multi-varietal orchards. The AGB to BGB ratio generally used in literature for trees is 0.26. On the other hand,Ganeshamurthy *et al*. (2016)

Table 3. Selected soil properties of mono-varietal mango orchards

Site	pH (H_2O)	Organic carbon (%)	N-available (mg kg^{-1})	P-available (mg kg^{-1})	K-available (mg kg^{-1})	$CaCO_3$ (%)	Moisture (%)	Bulk density (g cc^{-1})
1.	7.61	0.39	71.43	5.16	75.89	4.4	33	1.376
2.	7.68	0.43	73.25	5.10	88.66	3.8	28	1.410
3.	7.70	0.40	68.12	4.94	86.50	4.0	30	1.409
4.	7.78	0.40	67.55	4.81	87.34	3.9	29	1.414
5.	7.85	0.41	75.00	5.04	85.71	4.2	30	1.370
6.	7.42	0.45	73.21	4.82	77.68	3.8	34	1.381
Mean	7.53	0.40	67.86	4.79	83.93	4.5	30	1.397

reported a ratio of 0.29 for grafted mangoes and mentioned that the discrepancy is due to a greater recovery of roots in their estimates. Hence we used the ratio reported by this group.

Utilizing the mean C content of the AGB and BGB, the total above ground and below ground C sequestered by grafted mangoes were estimated. The computed mean total C sequestered per tree was 113.78 kg tree-1 in mono-varietal mango orchards and 138.9 kg tree^{-1} in multiple variety mango orchards. This showed that the trees in multi-varietalmango orchards were relatively more robust than mono-varietal orchards. The mean tree C capture is again far below the values reported for polyembryonic wild mango trees (Eneji *et al*., 2014) as the grafted mangoes are very dwarf, planted very close and pruned regularly to maintain the short stature of the tree for management convenience. Further, the wood density of wild mangoes were relatively higher (Wood database, 2018) than cultivated mangoes. On area basis, the mango trees (100 trees ha^{-1}) sequestered 11.38 t ha^{-1} and 13.90 t ha^{-1} in mono-varietal orchards and multi-varietal orchards, respectively.

Carbon capture from weed and litter biomass : Mono-varietal orchards had higher weed biomass (581.8 kg tree^{-1}), hence captured higher C (265.3 kg tree^{-1}) than multi-varietal orchards. This is perhaps because of uniform canopy the weeds were exposed to better light in these orchards than multiple variety orchards and could grow faster. However, the litter biomass was higher in multi-varietal orchards (1361 kg tree^{-1}) than mono-varietal orchards (1218.1 kg tree^{-1}) (Table 7 and 8). The proportion of this fraction of weeds and litter in total C sequestration is very low. In multi-varietal and mono-varietal mango orchards, the floor C represent 8.44% and 10.47% of the total C sequestered, respectively. Weed and litter biomass depended more on the tree growth and the fruiting behavior.Multi-varietal orchards produced differential litter fall because of varietal behavior where the flower to fruit set and

Table 4. Selected soil properties of multi-varietal mango orchards

Site	pH (H_2O)	Organic carbon (%)	N-available (mg kg^{-1})	P-available (mg kg^{-1})	K-available (mg kg^{-1})	$CaCO_3$ (%)	Moisture (%)	Bulk density (g cc^{-1})
1.	7.55	0.44	66.07	4.21	83.93	4.6	34	1.361
2.	7.43	0.38	63.39	4.61	87.50	4.0	28	1.408
3.	7.52	0.43	64.29	4.64	81.25	4.1	35	1.358
4.	7.40	0.42	66.07	4.79	85.71	4.8	34	1.366
5.	7.70	0.40	62.50	4.63	84.82	4.1	32	1.380
6.	7.81	0.40	62.50	4.73	82.14	4.0	34	1.380
7.	7.52	0.41	63.39	4.95	83.93	4.4	30	1.388
8.	7.65	0.42	64.29	4.78	83.04	4.6	34	1.403
9.	7.60	0.38	62.50	4.31	77.68	4.0	31	1.400
10.	7.77	0.38	65.18	4.63	71.43	4.0	30	1.388
11.	7.54	0.41	67.41	4.70	78.57	4.4	34	1.382
12.	7.59	0.42	71.43	5.00	75.89	4.7	33	1.388
13.	7.54	0.41	66.07	4.75	81.25	4.4	31	1.404
14.	7.72	0.40	70.54	4.70	86.61	4.1	32	1.394
15.	7.60	0.43	71.43	4.55	81.25	4.4	34	1.402
Mean	7.60	0.41	65.80	4.67	81.67	4.3	32	1.387

retention differed with varieties. The quantum of nutrient absorbed and the light capture varied with varieties and this had its impact on the litter fall.

Soil C stocks : The soil C stocks in both mono-varietal orchards and multi-varietal orchards were fairly uniform in all the orchards and the mean soil organic carbon stocks (SOC) were 63.6 t ha^{-1} in mono-varietal orchards and 64.0 t ha^{-1} in multi-varietal orchards (Table 9). Soil system attains a quasi-equilibrium stage after accumulation of dry matter and loss of SOC over time depending on land use systems. Thus SOC levels often show tooth-like cycles of accumulation and loss. After each change in land use system, a period of constant management is required to reach a new quasi-

Table 5. Allometric characters and tree biomass C in mono-varietal mango orchards

Variety	No. of trees	No. of primary branches	Girth of primary branches (cm)	AGB (kg $tree^{-1}$)	AGB C content (kg $tree^{-1}$) a	BGB (kg $tree^{-1}$)	BGB C content (kg $tree^{-1}$) b	Total content (kg $tree^{-1}$) a+b	Total C content (t ha^{-1*})
Totapuri	504	3.23	18.50	191.82	86.32	78.35	37.61	123.93	12.39
Benisha	154	3.01	24.14	247.25	111.26	100.99	48.48	159.74	15.97
Neelum	290	2.12	24.35	173.88	78.25	71.02	34.09	112.34	11.23
Rumani	164	4.40	6.43	91.51	41.18	37.38	17.94	59.12	5.91
Mean	279	3.19	18.36	176.12	79.25	71.94	34.53	113.78	11.38

* 100 trees per hectare

Table 6. Allometric characters and tree biomass C in multi-varietal mango orchards

Site	No. of trees	No. of primary branches	Girth of primary branches (cm)	AGB (kg $tree^{-1}$)	AGB C content (kg $tree^{-1}$) a	BGB (kg $tree^{-1}$)	BGB C content (kg $tree^{-1}$) b	Total content (kg $tree^{-1}$) a+b	Total C content (t ha^{-1*})
1.	337	2.45	30.79	278.29	125.23	113.67	54.56	179.79	17.98
2.	323	2.73	21.19	203.60	91.62	83.16	39.92	131.54	13.15
3.	562	2.45	16.03	127.54	57.39	52.09	25.01	82.4	8.24
4.	506	2.98	34.38	353.59	159.11	144.42	69.32	228.44	22.84
5.	307	4.03	10.37	158.48	71.32	64.73	31.07	102.39	10.24
6.	118	2.27	10.37	158.48	71.32	64.73	31.07	102.39	10.24
7.	152	3.34	26.15	293.81	132.21	120.01	57.6	189.82	18.98
8.	203	2.49	21.23	177.72	79.97	72.59	34.84	114.82	11.48
9.	314	1.74	4.35	30.21	13.59	12.34	5.92	19.52	1.95
10.	260	2.63	36.99	341.61	153.73	139.53	66.98	220.70	22.07
11.	259	2.30	39.05	321.25	144.56	131.22	62.98	207.55	20.76
12.	502	4.27	9.42	130.80	58.86	53.43	25.64	84.50	8.45
13.	113	3.27	26.54	301.12	135.51	122.99	59.04	194.54	19.45
14.	263	2.82	24.65	226.69	102.01	92.59	44.44	146.46	14.65
15.	660	2.79	17.25	174.58	78.56	71.31	34.23	78.56	7.86
Mean	323	2.84	21.9	218.5	98.3	89.3	42.8	138.9	13.9

* 100 trees per hectare

equilibrium value (QEV). In this way, the SOC is stabilized to other new QEV of the changed situation in terms of new land use pattern, vegetation cover and management practices. The SOC tends to attain QEV with varying duration of 500-1000 years in a forest system, 30-50 years in agricultural systems after forest cutting, 20-50 years under different agricultural systems and 30 years for horticultural system (Chhabra *et al*., 2012). It has been shown that horticultural systems under these tropical land use attains QEV in 25 years (Ganeshamurthy, 2012). Mango is grown in Chittoor region of Andhra Pradesh in India since about 100 years. Hence the soils under these mango orchards have attained the quasi-equilibrium stage after accumulation of dry matter and loss of SOC over time.

Total C sequestration by mango orchards: The C pool compartment of mango orchards is given in Table 10 and 11. The mean total C

Table 7. Litter and weed biomass C in mono-varietal mango orchards

Mango variety	Weed bio-mass (kg ha^{-1})	% Mean C content	Weed C content (kg ha^{-1}) a	Litter bio-mass (kg ha^{-1})	% Mean litter C content	Litter C (kg ha^{-1}) b	Total C content (kg ha^{-1}) a+b
Totapuri	492.0	45.8	225.33	1360.0	46.3	629.6	855.0
Benisha	476.1	46.5	221.34	1304.0	45.7	595.9	817.2
Neelum	524.5	44.3	232.13	1266.0	47.2	578.6	810.8
Rumani	835.0	45.8	382.43	943.0	44.6	420.5	803.0
Mean	581.8	45.6	265.3	1218.1	46.0	556.2	821.5

Table 8. Litter and weed biomass C in multi-varietal mango orchards

Site	Weed bio-mass (kg ha^{-1})	% Mean C content	Weed C content (kg ha^{-1}) a	Litter bio-mass (kg ha^{-1})	% Mean litter C content	Litter C (kg ha^{-1}) b	Total C content (kg ha^{-1}) a+b
1.	356	46.3	164.83	1485	45.1	669.74	834.56
2.	388	47.1	182.75	1312	46.3	607.46	790.20
3.	619	46.5	287.84	948	46.8	443.66	731.50
4.	372	45.8	170.38	1762	46.0	810.52	980.90
5.	583	45.3	264.10	1080	45.6	492.48	756.58
6.	541	46.8	253.19	1116	45.6	508.90	762.08
7.	412	44.8	184.58	1294	46.1	596.53	781.11
8.	475	45.5	216.13	1042	46.3	482.45	698.57
9.	324	45.8	148.39	1654	45.2	747.61	896.00
10.	381	46.7	177.93	1832	45.4	831.73	1009.66
11.	369	46.3	170.85	1657	45.6	755.59	926.44
12.	607	45.1	273.76	892	46.5	414.78	688.54
13.	376	45.8	172.21	1740	46.2	803.88	976.09
14.	435	45.0	195.75	1369	46.6	637.95	833.70
15.	548	46.8	256.46	1246	45.4	565.68	822.15
Mean	452	45.9	207.94	1361	45.91	624.60	832.54

sequestered in both mono-varietal mango orchards and multi-varietal mango orchards were fairly similar with only a marginal difference between the two groups. The mean C sequestered in mono-varietal orchards varied from 67.31 t ha^{-1} to 81.35 t ha^{-1} with a mean of 76.20 t ha^{-1} and in multi-varietal orchards ranged from 71.45 t ha^{-1} to 86.22 t ha^{-1} with a mean of 78.55 t ha^{-1}. The results convinced that the C sequestration by mango was fairly similar over different varieties and both mono-varietal and multi-varietal mango orchards sequester similar amounts of C. The overall C sequestered by these cultivated mango orchards was very low compared to wild polyembryonic mango trees grown from seeds for the obvious reason that the growth of seedling raised trees are generally robust and produce more biomass. This was due to the reasons that wild mango trees may reach 40 m or more in height and live for several hundred years as against 8-10 meters height and life of 40 to 50 years in cultivated grafted mangoes. Wild mangoes are fast growing erect trees with slender to broad and rounded upright canopy. On the other hand the grafted mangoes were dwarf statured, relatively slow growth and branched at surface. The wild mango trees were long lived with some still producing fruits at 300 years old, whereas the grafted mango trees generally decline after 30 years. The wood density of wild mangoes were relatively higher (Specific gravity 0.68) (Wood database, 2018) than commercially cultivated grafted mangoes (Specific gravity 0.52-0.55). The wild mango tree is anchored by a long unbranched taproot and can descend to greater depth plus a mass of feeder roots as against a narrow root volume of grafted mangoes. The feeder roots of wild mangoes send down anchor roots which penetrate the soil to a depth of 1.2 m and spread lateral as far as 7.5 m as against less than one meter depth and a spread of 2 to 3 meters in grafted mangoes. All these parameters showed that the biomass productivity of grafted mangoes was far lower than the cultivated grafted mangoes in the orchards. Hence grafted cultivated mangoes were not as competitive as wild mangoes for C capture.

Table 9. Soil organic C in multi-varietal mango orchards and mono-varietalmango orchards

Site/Multi-varietal mango orchard	Soil C (t ha-1)	S. No.	Mono-varietal mango orchard	Soil C (t ha-1)
1	63.8	1.	Totapuri	65.8
2	64.5	2.	Benisha	65.0
3	60.5	3.	Neelum	64.5
4.	62.4	4.	Rumani	60.6
5	65.8			
6	61.3			
7.	62.9			
8	66.0			
9	64.6			
10.	62.8			
11.	61.4			
12.	65.8			
13.	64.3			
14.	62.8			
15.	61.6			
Mean	63.6			64.0

Conclusions

Our study demonstrated that themango orchards sequestered 76.2 t ha^{-1} C in mono-varietal mango orchards as against 78.55 t ha^{-1} in multi-varietal mango orchards.This small difference is attributed mainly to similar growth pattern of the varieties examined in this study. This shows that within the scope of the varieties covered in this study both multi-varietal mango orchards and mono-varietal mango orchards sequester similar quantities of C. From this study, it can be stated that mono-varietal mango orchards follows a pattern similar to that observed in multi-varietal mango orchards for mitigation of negative impact ofclimate change.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Dominant Weed Flora of Soybean and Cotton in Vidharbha Region of Maharashtra

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Abstract

A survey of weed flora of soybean and cotton in south-east districts of vidharbha region of Maharashtra revealed that a total of 13, 12 and 9 weed species were dominant in soybean, cotton and non cropped area of these districts of south west vidharbha region of M.S. Among grasses cynadon dectalon and Euphorbhia geneculata among broad leaved was dominant in soybean and cotton, where as in non cropped area cassia Lora was dominant. In soybean 2 grasses, 1 sedge and 10 broad leaved weed, In cotton 2 grasses, 1 sedge and 12 BL weeds and in non cropped areas 9 weeds were found dominant.

Key words : Soybean, cotton, Weed Flora.

Soybean and cotton are main cash crops grown in south east districts of vidharbha region of M.S. These crops are grown in *kharif* on assured rainfall received during this season. Yield reduction due to uncontrolled weeds and duration of Infestation (Yaduraju and Sreekumar, 2002). Cotton is grown at wider row spacing and with slow initial plant growth faces heavy competition with weed leads to drastic yield reduction in unweeded fields. Yield losses due to weed competition in cotton are estimated to 70 -75 %. (Shelke,1995).

The weed intensity and infestation varies with the environmental factors in addition to soil type, crop grown and season (saavendraet. Al. 1980). As weed species changes with place to place and crop grown, it is very effective to control weeds by adopting proper management practices based on information available on crop weed association and location specific weed infestation. The present survey was made to collect the most accurate information on weed infestation in soybean and cotton grown on large area in these districts.

Materials and Methods

Weed survey of soybean and cotton was conducted in three districts of vidharbha region of M.S. namely Nagpur, Wardha and Yoetmal during July-Aug 2010, as this period gives most appropriate representation of the weed species of the region. Survey route was followed with easy approach and can cover representative area of the region. During survey at every 10 km distance a site was selected for weed count by using a quadrate of 0.5 x 0.5 m^2 size and each spot 100 meter deep inside the fields, as suggested by Raju (1977). The values of Relative density (%). Relative frequency were calculated and these values were used to calculated IVI values for each weed species with formula as follow.

Relative density (%) = a / b where a = Number of individual of a species in all quadrate

$$\text{Relative frequency (\%)} = \frac{\text{Frequency of species A}}{\text{Sum frequency of all species}} \times 100$$

IVI (Importance value index) = RD + RF

Results and Discussion

Weed flora of soybean : Total thirteen weed species were found to infest soybean fields, among these two species were grasses, one sedge and ten belonged to broadleaved weeds. In all districts cynadon dectyalon, *Cyperus rotundus, Parthenium hysterophorus, Euphorbia geneculata* and *Ergotis minor* were most dominant weeds. The relative density of these weeds varied from 8.32 to 28.05, 3.56 to 12.79, 12.88 to 25.22, 13.78 to 24.25 and 1.40 to 6.20 (Table 1) respectively. *Euphorbia geneculata* alone having IVI va lue of 26.31 in Wardha to 51.00 in Nagpur.

On the basis of IVI values in all the districts, *Euphorbia geneculata, Parthenium hysterophorus* and *Cynadon dectyalon* were the most dominant weeds in soybean which needs to be controlled at proper time with priority. *Cyperus rotundus* and *Celocia argentia* were observed in all these districts. Abitulon indicum and Dignera arvensis were important weed with higher IVI value in Yoetmal and Bracheriaeruciformis in Nagpur respectively.

Weed flora of cotton : In all the sites surveyed, cotton was infested with 12 weed species including 2 grasses, one sedge and 9 broadleaf weeds. *Cynadon dectalon* was the dominant grassy weed, in sedges *Cyperus rotundus* where as in broad leaf *Dignera arvensis, Euphorbhia geneculata* and *Parthenium hysterophorus* was dominant in cotton in all districts.

In Nagpur *Cynadon dectalon* (53.32 IVI), in Wardha *Amaranthus polygamous* (30.36 IVI) and in Yoetmal *Celocia argentia* (33.80 IVI) were dominant weed species may be due to medium to light textured soil type commonly observed in these districts. (Table 2). *Commelina benghalensis* was dominant in Nagpur as well as Wardha .Similar weed species in cotton were also reported by Shelke and Bhosale (1990) from Parbhani.

Cynadon dectalon was the dominant grassy weed in all districts followed by *Cyperus rotundus*, the other weed species commonly observed in all districts were *Parthenium*

Table 1. Domain weed flora of soybean in S-E districts of vidharbha region of M.S.

Name of weed	Nagpur			Wardha			Yoetmal		
	RD	RF	IVI	RD	RF	IVI	RD	RF	IVI
Grassy weeds									
Cynadondectalon	28.05	18.22	46.27	18.56	12.77	31.33	8.32	10.80	19.12
Bracheriaeruciformis	22.15	18.57	40.72				6.81	10.31	17.12
Sedge Cyperusrotundus	3.56	8.79	12.35	12.79	12.43	25.22	7.82	9.68	17.50
Broad leaved weeds									
Partheniumhysterophorus	25.22	18.17	43.39	18.34	12.71	31.05	12.8	10.2	22.90
Digneraarvensis	2.29	2.23	4.67	-	-	-	16.8	10.81	27.62
Euphorbhia geneculata	24.25	26.75	51.00	13.18	12.53	26.3	16.6	10.66	27.26
Abitulonindicum	6.22	8.17	14.39	-	-	-	14.2	10.81	24.92
Commilinabenghalensis	2.78	4.52	7.30	16.80	14.62	31.42	-	-	-
Celociaargentia	1.23	5.17	6.40	8.41	7.12	15.53	18.4	14.40	3.28
Ergotis minor	1.40	7.46	8.86	4.70	7.63	12.33	6.20	8.45	14.65
Phyllanthusniruri	5.60	12.80	18.40	3.12	6.64	9.60	-	-	-
Solanumnigrum	7.14	4.32	11.46	-	-	-	3.68	8.14	11.42
Amaranthus polygamous	-	-	-	4.16	10.11	14.27	8.26	6.24	14.50

hysterophorus, Dignera arvensis and *Commelina benghalensis*.

Non cropped area : In non cropped area from these districts, nine weed species were observed among which *Parthenium hysterophorus, Althernethra sessilis, Cassia tora, Tridex procumbens* and *Euphorbia hirta* were dominant. (Table 3). In Nagpur, *Parthenium hysterophorus* (54.82 IVI) was most dominant weed species, where as *Cassia tora* in Wardha (48.36 WI) and Yoetmal (51.97 IVI) districts. Other weed species important in Nagpur, Wardha and Yoetmal were *Cassia tora, Althernethra sessilis* and *Lantana camera* respectively. *Achyrantus aspera* was observed in Wardha and Yoetmal where as *Abitulon indicum* was observed in Nagpur and Wardha district.

With the information generated through an extensive weed survey, it becomes easier to

Table 2. Dominant weed flora of cotton in S-E districts of vidharbha region of M.S.

Name of weed	Nagpur			Wardha			Yoetmal		
	RD	RF	IVI	RD	RF	IVI	RD	RF	IVI
Grassy weeds									
Cynadondectalon	26.75	26.57	53.32	9.63	19.10	28.73	24.8	18.40	43.26
Bracheriaeruciformis	-	-	-	14.89	11.61	26.50	12.3	12.20	24.23
Sedge1.72									
Cyperusrotundus	1.72	12.60	29.83	8.53	8.74	17.27	18.8	14.41	33.29
Broad leaved weeds									
Partheniumhysterophorus	8.10	16.34	23.35	10.78	15.16	25.94	8.60	5.86	14.46
Digneraarvensis	18.73	10.77	29.50	6.16	6.74	12.93	9.80	10.48	20.29
Euphorbhia geneculata	19.70	19.31	38.84	13.18	13.81	27.05	6.88	8.22	18.09
Abitulonindicum	20.13	10.34	30.40	17.52	18.41	30.94	8.90	8.84	17.74
Commilinabenghalensis	-	-	-	5.93	7.41	13.41	-	-	-
Argimonemexicana	-	-	-	17.46	12.94	30.36	-	-	-
Phyllanthusmedrapetensis	-	-	-	-	-	-	9.08	10.38	19.96
Celociaargentia	-	-	-	-	-	-	15.6	18.12	33.80
Convolvulus	-	-	-	-	-	-	4.06	6.18	10.24

Table 3. Domain weed flora of Non cropped area in of Vidharbha region of M.S.

Name of weed	Nagpur			Wardha			Yoetmal		
	RD	RF	IVI	RD	RF	IVI	RD	RF	IVI
Partheniumhysterophorus	33.62	22.20	54.82	22.40	16.88	39.28	12.4	22.80	35.61
Althernethrasessilis	22.46	24.33	46.69	25.95	20.81	46.76	20.8	18.72	39.52
Cynadondectalon	20.93	20.16	40.58	-	-	-	-	-	-
Cassia tora	23.78	18.81	42.54	25.80	22.56	48.36	30.8	18.30	51.97
Abitulonindicum	12.29	14.44	26.73	5.88	8.26	14.14	-	-	-
Achyaranthusaspara	-	-	-	18.12	19.78	37.90	8.85	5.41	14.26
Lantana camera	-	-	-	-	-	-	18.0	25.81	43.81
Tridexprocumbens	3.34	7.64	10.98	10.18	8.68	18.46	4.64	5.52	10.16
Euphorbia hirta	2.82	4.13	6.95	3.65	8.98	10.63	7.32	8.12	5.44

adopt proper weed management techniques in each crop and district based on dominant weeds observed so that, the yields of these crops can be maintained to a desired level.

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Studies on Pathogens Associated With Leaf Spot of Sorghum (*Sorghum bicolour*)

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Abstract

Isolations made from the diseased leaf samples of sorghum showing typical red and blighted spots yielded four type of growth i.e. growth of four different organisms. On the basis of morphological characters and symptoms developed the organisms were identified as *Colletotrichum sublineolum, Drechslera sorghicola, Alternara spp* and *Curvularia sp*. The sorghum leaf agar, Richard's agar, sorghum grain agar and potato dextrose agar were the good media for growth of *C. sublineolum* and *D. sorghicola*. The non synthetic media recorded maximum growth compared to synthetic media. The fungicides, propiconazole (0.05%) and hexaconazol +mancozeb (0.2+0.4%) were found to be most effective against *C. sublineolum* whereas, carbendazim (0.1%), propiconazole (0. l%), propineb (0.25%), benomyl (0.1%), carbendazim + mancozeb (0.1+0.1), benomyl + maneozeb (0.2+0.4%) and hexaconazol + mancozeb (0.2+0.4%) were most effective against *D. sorghicola* at half and full dose of recommended concentration.

Key word : Sorghum, leaf spots, leaf blight.

Sorghum (*Sorghum bicolour* (Linn) Moneach) is one of the most important cereal crops grown all over the world and stand fifth amongst the world's cereals. Due to various advantages offered by the crop as food as well as forage, the crop has been grown on a wide range of area. In India area under sorghum crop is 63.2 lakh ha. with total production of 60.10 lakh MT. India ranks second in production of sorghum next after Nigeria (69.0 lakh MT). (www.faostat.fao.org.2013) and in India, Maharashtra ranks first in area and production. It is being cultivated in Maharashtra for dual purpose i.e. for grain as well as fodder. With the extensive cultivation of crop, problems of diseases and pest have cropped up and resulted

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in considerable losses in yield. The Crop suffers many more fungal, bacterial and viral diseases.

Materials and methods:

Sorghum leaves showing typical leaf spot symptoms were collected from sorghum field and isolation was done by following standard tissue isolation technique on potato dextrose agar. The pure culture of the isolated organisms were made and identified under microscope. The pathogenicity of isolated organisms was proved by using microdroplet inoculation technique i.e. MDIT (Nakamura *et al*., 1985, Munaut *et al.*, 1997, Mathur and Totla, 2001). The healthy plants of highly susceptible var. RSV 458 was used for pathogenicity test. Experiment was conducted in glass house under controlled condition.

The morphological characters viz. mycelium, conidiophores, conidia, acervuli, setae, appressoria were observed. The microscopic measurements based on 50 observations for each structure were recorded from five different slides. The growth and cultural study of the' pathogens was carried out on five synthetic (Richard's agar, Czapek's agar, Elliott's agar, Sabouraud's agar and Tochinial's agar) and five non-synthetic (Potato dextrose agar, Host leaf extract agar, host seed agar, corn meal agar & Malt extract agar) media.

***In-vitro* evaluation of fungicides :** Twelve fungicides were evaluated using two different concentrations, i.e. half and full dose of recommended concentration, in the laboratory. The poisoned food technique was followed as described by Gene and Thapliyal (2002) to evaluate the efficacy of fungicides in inhibiting the mycelial growth of *C. sublineolum* and *D. sorghicola*. The pathogens were grown on PDA medium for 12 days prior to setting up the experiment. The PDA medium was prepared and melted. The fungicidal suspension was added to the melted medium to obtain the required concentrations on commercial formulation basis of the fungicide. Twenty ml of poisoned medium was poured in each sterilized Petri plates. Suitable check was maintained without addition of fungicide. Mycelial disc of 5 mm was taken from the periphery of 1 2 days old colony and placed in the centre of Petriplates and incubated at 27 ± 1° C tor 12 days. Three replications were maintained for each treatment. The diameter of the colony was measured in two directions and av. was worked out. Per cent inhibition of mycelial growth of the fungus was calculated by using the formula by Vincent (1947).

***In-vitro* evaluation of bio-control agents.**

$$I = \frac{(C-T)}{C} \times 100$$

Where, I = Per cent growth inhibition, C - Radial growth in control and T = Radial growth in treatment (fungicide/bio agents). In-biro evaluation of biocontrol agents

***In-vitro* evaluation of bio-control agents :** Species of' *Trichoderma bioagents viz*., *hamtum, konigii harzianuni viride* and *P. fluroscence* were tested for their bioefficasy against *C. sublineoluru* and *D. sorghicola*. An *in vitro* trial was laid out in Petri plates by dual inoculation technique (Brodbent *et al.*1971).

The pure culture of bio agents were grown on PDA for 7 days until the Petri plates were fully covered. The discs of 0.5 cm diameter of pathogen and bio agents each were cut with sterile cork borer from the peripheral growth zone and transferred aseptically on PDA in Petri plate. The fungal discs were placed in plate in such a manner so that the pathogen and bio-control agent get equal opportunity for growth. The streaking of *Pseudomonas* spp. around pathogen was done squarely in and percent

inhibition were recorded using following formula.

Colony growth in control plate = (Colony growth in treatment plate Per cent growth Inhibition) / (Colony growth in control plate) x 100

Results and discussion

Isolations made from the diseased leaf samples showing typical red and blighted spots yielded four type of growth i.e. growth of four different organisms. The pure culture of these organisms was obtained by single spore isolation method and maintained on PDA slants for further study. These organisms were inoculated on healthy sorghum seedling of susceptible var. RSV 458 to prove the pathogenicity. On fifth day of inoculation some small yellow to brown pin point spots appeared and developed into typical spots on leaves within 14 to 15 days. The well developed spots were circular to oval in shape with reddish brown margin with ashy center. These spots enlarged in size causing complete drying and blighting of leaves. These spots matched with the spots caused by Colletotrichum sublineolum. The pathogenicity test carried out in the present investigation in respect of *C. sublineolum* (= *C. graminicola*) is totally in agreement with the findings of Ali and Warren (1987) and Mathur and Totla (2001). They successfully proved the pathogenicity of C. grâminicola in sorghum by using Microdroplet inoculation technique. The other small isolated spots with pale yellow to light brown in colour with concentric area at the center were observed within 10 to 12 days after inoculation. Finally these spots turned to light brown with brightened patch. These symptoms were matched with the leaf spot symptoms developed by the infection of *Drechsiera sorghicola*. The other two organisms *Alternaria sp.* and *Curvularia sp*. not developed any type of symptoms on sorghum leaves. On the basis of morphological characters and symptoms developed the organisms were identified as *Colletotrichum sublineolum, Drechslera sorghicola, Alternara sp.* and *Curvularia sp.*

Setae were irregularly arranged throughout the acervulus in culture as well as on infected lesions. In culture, they were dark brown, septate (0-4 septa), straight or slightly bending, tapering and pointed at apex while bulbus at base. The average number of setae per acervulus was 2.7(2-4 setae per acervulus). They were measured 89.37 µm (69.78- '125.14 µm) in length, while 4.72 µm (4.10-5.70 µm), 3.80 µm (2.80-4.67 µm) and 2.50 µm (1.70-3.18 µm) in width at base, middle and top, respectively. The colour and irregular shape of acervulus as observed by Hande (2001) and Gaikwad (2002) in *C. gloeosporides* are also tallying with the present results. However, the acervulus measurements recorded by these scientists are not tallying with present findings.

On host, setae were dark brown to black in colour, straight or slightly bending, septate (0-4), less pointed at apex and bulbous at base. The ay.number of setae per acervulus were 5.67 (4-7). They measured 75.60 µm (51.30-109.20 µm) in length while, in width they were 5.35 µm (3.39-7.85 µm), 3.92 p.m (2.70-5.96 µm) and 2.62 µm (1.52-3.86 µm) at base, middle and top, respectively. The general characters of the setae are in conformity with findings of Rajasab and Ramlingam (1981).

Conidiophores : The conidiophores arose in cluster those were short, simple, thickly arranged and hyaline in acervulus. They measured 14.12 µm (10.6-18.24 µm) in length and 1.46 µm (0.90-2.4 µm) in width. The length: width ratio was 9.6

Conidia : Conidia born singly on conidiophores, which were curved, mostly sickle or falcate or spindle in shape with tapering ends. They were single celled, hyaline and contained

with Ito 4 vacuoles/globules. Length of conidium was found more in culture [22.02 µm (18.1-25.6 µm) than on host [18.60 µm (12.40-23.70 µm)]. While, the conidial width measurement was recorded as 3.74 µm (x.34-4.9 µm) and 1.96 µm (1.48-2.33 µm) at centre and extreme ends, respectively, with length: width ratio of 5.88. These width measurement were comparatively less as that of host wherein, these measurements were 3.99 µm (3.39-4.45 µm)

Table 1. The morphological and cultural characters of *C. sublineolum* and *D. sorghicola*

Name of media	Colony Diameter (mm)		Growth characters		Sporulation	
	C. Sublin-eolum	***D. Sorgh-icola***	***C. Sublineolum***	***D. soghicola***	***C. sublin-eolum***	***D. sorgh-icola***
Elliott's	83.16	69.33	Moderately growth, white mycelia with regular smooth margin	Moderately growth, white mycelia with regular smooth margin	++	++
Sabouraud's	86.50	63.67	Moderate growth, white cottony Mycelium with irregular margin	Moderate growth. Dark black mycelium with regular margin	++	++
Czapek's	85.00	84.33	Moderate, pinkish white raised mycelia 84.33 with regular margin	Good growth, blackish mycelia with regular margin	++	++
Richard's	89.50	82.67	Good growth, dull white mycelium with irregular margin	Good growth, blackish mycelium with irregular margin	++	++
Tochnical	82.66	86.33	Moderate growth, white cottony mycelium with irregular margin	Good growth, dark blackish cottony mycelium with irregular margin	++	++
PDA	88.33	88.00	Good growth, Ashy white mycelia with regular margin	Excellent growth, Dark black in colour. raised mycelia at centre with regular margin	+++	+++
Malt extract	87.66	58.67	Moderate, dirty white mycelium with irregular margin	Poor growth ashy black mycelium with regular margin.	++	++
Sorghum Seed	88.66	89.67	Good growth, pinkish white cottony mycelium with regular margin	Excellent growth Blackish mycelium with regular margin	++++	++++
Sorghum leaf	89.66	90.00	Good growth, Blackish white Mycelium with regular margin	Excellent growth, Blackish mycelium with regular margin	++++	++++
Corn meal	65.83	79.67	Poor growth, dirty white mycelium with irregular margin	Good growth, ashy mycelium with irregular margin	-	-
Mean	84.70	79.23				
SEm ±	0.621	0.444				
C.D. at 5 %	1.833	1.310				

Sporulation : Abundant=++++ Good=+++ Moderate=++ Poor=+ No sporulation= -

and 2.08 µm (1.48-2.55 µm) and 2.01 µm (1.48-2.55 µm) at centre and ends, respectively. while the length: width ratio of 4.62 was less in host due to the more width of conidium on it.

Chlamydospore : The chiamydospores were formed in the old culture of *C. sublineolum*. The, were both intercalary and terminal, thick walled, round to oval in shape, light brown in colour and measured 11.31 µm (6.85-16.9 µm) in diameter.

Appressoria : Appressoria were formed abundantly in old culture of fungus. They were of various shape like oval, clavate, elongated, lobate or irregular and light brown to dark brown in colour, thick walled with or without distinct pore at centre and measured 17.98 µm (8.9-24.2 µm) x 10.75 µm (6.28-13.80 µm) in size. The length: width ratio was 1.67. The observations regarding appressorial pores are in consonance with the finding of Gaikwad et. al. (2002). They also noticed single pore in the appressorium of *C. gloesporiodes* causing fruit rot of custard apple.

Morphology of *D. sorghicola* : The morphological characters of *D. sorghicola* in respect of conidia, conidiophores and mycelium were studied from the eight days old culture grown on patato dextrose agar.

Table 2. Effect of different fungicides on growth *C. sublineolum* and *D. sorghicola* under *in vitro*.

Fungicide	**Conc. %**	***C. Sublineolum***		***D. sorghicola***	
		Mean colony dia (mm)	**% inhibition**	**Mean colony**	**% inhibition**
Copper oxychloride	0.25	12.65	95.93	22.33	75.18
	0.125	25.00	72.22	28.00	68.89
Carbendazim	0.1	0.00	100	35.33	60.74
	0.05	0.00	100	50.00	44.44
Bordeaux mixture	1.0	15.66	82.59	35.33	60.74
	0.50	24.67	72.59	58.00	35.56
Captan	0.25	12.33	86.30	19.67	78.14
	0.125	18.00	80	34.33	61.85
Mancozeb	0.25	20.66	77.04	0.00	100
	0.125	42.33	52.96	13.67	84.81
Propiconazole	0.1	0.00	100	0.00	100
	0.05	0.00	100	0.00	100
Propinzeb	0.25	0.00	100	6.33	92.96
	0.125	22.33	75.19	19.33	78.52
Benomyl	0.1	0.00	100	25.33	71.85
	0.05	0.00	100	46.67	48.15
Chlorothalonil	0.25	28.00	68.88	28.00	68.88
	0.125	29.00	67.78	40.33	55.19
Carbendazim + Mancozeb	0.1+0.25	15.00	83.33	15.00	83.33
	0.1+0.125	0.00	100	27.67	69.26
Benomyi + Mancozeb	0.1+0.25	0.00	100	0.00	100
	0.05+0.125	0.00	100	20.00	77.78
Control	-	90.00	0	90	
		For half dose	**For half dose**		
S.E. (Mean)		0.226	0.392		
C.D. at 5 %		0.658	1.140		

Mycelium : The mycelium was irregularly branched, septate, light brown in colour and measured 7.87 µm (6.87-8.50 µm) in width.

Conidiophores : The conidiophores were simple straight or slightly bend at tips, rigid and hat to dark brown in colour. The conidia were born either singly or in group of 3 to 10 on the tip of conidiophores.

Conidia : Conidia were thick walled, wider at middle and tapering towards both the ends. The spores were brown to huffy brown in colour with 4 to 9 septa. Conidia measured 77.40 µm (62.52 to 92.20 µm) in length and 18.42 µm (15.30 to 23.25 µm) in width. The length width ratio was 4.20.

Cultural characteristics of *C. sublineolum* on different solid media

Diversity in cultural and morphological characters of *C. sublineolum* were studied in five non synthetic and live synthetic media at room temperature 27 ± 10°C as described in "Materials and Methods" and the results obtained are presented in Table 1. The radial growth, colony characters and sporulation of the fungi were recorded, when the maximum growth was attained on any one of the tested media. The effect of different culture media on .the growth of the pathogen differed significantly. Maximum radial growth of *C. sublineoium* was recorded on sorghum leaf agar, Richard's agar, sorghum grain agar and potato dextrose agar with colony diameter of 89.66. 89, 5, 88.66 and 88.33 mm, respectively, which were at par with each other, The media *viz*., Malt extract, Sabouraud's agar. Czapek's agar, Elliott's agar and Tochinal's agar recorded moderate colony diameter of 87.66, 86.5, 85.00, 83.16 and 82.66 in, respectively. While, the lowest growth (65,83 mm diam) was recorded in corn meal agar medium. Potato dextrose agar as good medium forgrowth and sporulation in foregoing studies is in consonance with findings of Ekbote et al. (1997) and Kanhed and Gaikwad (2008).

The non synthetic media recorded maximum growth compared to synthetic media. Mycelium colour varied from white to dirty white. The growth varied from flat, raised fluffy to sparse. Pigmentation in the media also varied from pinkish white to blackish and light pink to orange.

Sporulation also showed greater variation in different media, (Table 1) ranging from abundant (excellent) to poor sporulation, Abundant sporulation was recorded on potato dextrose agar, sorghum leaf agar, sorghum grain agar and moderate sporulation in Richard's agar, Malt extract, Sabouraud's agar, Czapek's agar and Poor sporulation \r% as recorded in Corn meal agar, Tochinal's agar and Elliott's agar.

Cultural characteristics of *D. sorghicola* on different solid media

Diversity in cultural and morphological characters of *D. sorghicola* were studied in five non synthetic and five synthetic media at room temperature 27 ± 1° C. and the results obtained are presented in Table 1. The radial growth, colony characters and sporulation of the pathogen was recorded, when the maximum growth was attained on any one of the tested media. The effect of different culture media on the growth of fungi differed significantly. Maximum radial growth of *D. sorghicola* was recorded on sorghum leaf agar, sorghum grain agar and FDA, with colony diameter of 90, 00, 89.66 and 88.00 mm. respectively which were at par with each other. Elliott's agar and Sabouraud's agar media recorded moderate colony diameter of 69.33 and 63.67 mm,, respectively. While, Malt extract medium showed the least colony diameter of 58.67 mm.

The non synthetic media recorded maximum growth compared to synthetic media. Mycelium

colour varied from dark back to whitish black. The growth varied from flat, raised fluffy to sparse. pigmentation in the media also varied from black to Ashy black.

Sporulation also showed greater variation in different media (Table 1). Abundant (excellent) sporulation was recorded on PDA, sorghum leaf agar. sorghum grain agar and moderate sporulation in Richard's agar, Malt extract, Sabouraud's agar, Capek's agar and poor sporulation was recorded in Corn meal agar, Tochinal's agar and Elliott's agar.

***In-vitro* efficacy of fungicides against *C. sublineolum* :** Twelve fungicides were screened in the laboratory for their efficacy against *C. sublineolum* by poisoned food technique. The data revealed that. (Table 2) the effect of different fungicides with half and full dose of their concentration on checking the growth of *C. sublineolum* was significant. Among 12 fungicides carbendazim (0.1%), propiconazole (0.1%). propineb (0.25%). benomyl (0.1%), carbendazim + mancozeb (0.1+0.1). benomyl + mancozeb (0.2+0.4%) and hexaconazol + mancozeb (0.2+0.4%) were found to be most effective which inhibited 100 per cent growth of the fungus at half and full dose of recommended concentration.

***In vitro* efficacy of fungicides against *D. sorghicola* :** Among twelve fungicides screened in the laboratory for their efficacy against *D. sorghicola*.by poisoned food technique, mancozeb (0.25%), propiconazole (0.1%), benomyi + mancozeb (0.2+0.4%) and hexaconazol + mancozeb (0.2+0.4%) were found to be most effective which inhibited 100 per cent growth of the fungus at recommended concentration. Among 12 fungicides, propiconazole (0.05%) and hexaconazol + mancozeb (0.2+0.4%) were found to be most effective which inhibited 100 per cent growth of the fungus at half dose of recommended concentration.

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Mineral Profile in Relation of Animals, Soil, Feed and Fodder in Sindhudurg of Maharashtra

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Abstract

The present investigation on Mineral profile in relation of animals, soil, feed and fodder was carried out in selected block in Sindhudurg of Maharashtra to identify the macro and micro-minerals. The samples were analyzed and results compared with the critical level for particulars minerals level and percentages of samples which contain micro and micro-minerals. In non-irrigated and irrigated region the average Ca and P was found deficient in soil whereas Cu, Fe, Mg and Zn was found adequate. The Ca, P, Mg and Zn were observes deficient in feed and fodder. However, Cu, Fe, were observed adequate in this region. The Ca, P, Mg and Zn were seen adequate in the blood serum of the cattle and buffaloes whereas Cu, Fe, Zn were seen adequatein the blood serum oflarge ruminants in the district.

Key words : Macro and Micro-mineral, Soil, Feed, Fodder.

The status of mineral in animal body is the mirror image of health, growth and production ability of livestock. Prolong consumption of mineral deficient diets (feed and fodders) certainly causes mineral deficiency diseases. Mineral deficiencies or imbalance of mineral in soil and forages are one of the factors responsible for low productivity and reproductive problems among growing cattle in tropics.

Minerals are required by the body for optimum growth and proper muscle and nerve functions. In addition they are essential components of body enzymes, hormones and cells. Providing adequate amount of essential minerals to meet animal requirement is important for maximizing productivity and health of animals. Dietary factors usually affect mineral requirement by altering absorption of mineral from the gut.

The presence of major minerals and trace minerals in the fodders mainly depend on their level in the soil on which the fodders are grown (Singh 1985). However other factors like soil type, pH of soil, species of plants. Keeping this fact in view, the present investigation was undertaken to study the minerals status of soil, feeds / fodders grown on that soil and blood serum content of the cattle and buffaloes from selected representative locations in Sindhudurg district of Maharashtra.

Materials and Methods

The present investigation was undertaken during three seasons (Summer, Winter Rainy) of the year. Total three talukas viz. Dodarnarg, Vengurla and Vibhawadi were randomly selected for the study. In each talukas two villages based on irrigated and non-irrigated type were randomly selected. From each village three representative farmers having ten animals as cattle or buffalo were used for collection of soils, feed and fodders and blood samples presented in Table. 1

Soil : The 78 representative soil samples were collected either from cultivated or grazing

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land during summer and winter seasons. One sample from each farmer in village was used for mineral analysis.

Feed and Fodders : The total 386 representative samples of different types of concentrate mixtures, about 250 g each and roughage 500 g used by each farmer for feeding animals was collected during three season (Summer. Rainy and Winter). The samples were sun dried finely ground and then stored in small plastic bags for the analysis minerals.

Blood Serum : The 540 blood samples were collected from three animals (Cattle or buffalo) from each of the selected farmer's families during three seasons (Summer, Rainy and Winter About 15-20 ml of blood was collected from jugular vein of animals in clean and sterilized test tubes without anticoagulant and serum was separated. The serum samples were stored in deep freezer at - 20° C for further mineral analysis.

Mineral estimation : The collected samples were analyzed to study the important minerals in soil, plant and animals existing in the agro-climatic conditions. Minerals *viz*., Ca,P, Mg, Cu, Fe and Zn were estimated from all the samples (soil, feed and fodders and blood serum.) 1 the minerals except Phosphorus were estimated by Atomic Absorption Spectrophotometer (AAS, Perkin Elener, Model A Analyst 200) as per Kolmer *et al*. (1951) Phosphorus was estimated by U.V. molybdate method as per Yee (1968).

Results and Discussion

A sample survey was conducted in sindhudurg district of south Konkan region to study the mineral profile in relation of animals, soil, feed and fodders in Maharashtra for improving livestock production potential. The data pertaining to average initial mineral content of soil, feed and fodders and blood serum is presented in Table 2.

A) Macro mineral content in soil:

Calcium (Ca) : The average initial Ca content of soil of non-irrigated and irrigated condition in Sindhudurg district was 63.94 and 64.25 ppm, respectively. The present observed values compared with critical level suggested by Mc-Dowell *et al*. (1984) were found below the critical level in the districts. Prabowo et al. (1990) reported higher concentration of calcium than those observed study was due to seasonal effect i.e. in rainy season calcium was higher due to higher soluble salts. The observed value of Ca content in soil was higher than those quoted by Gowda *et al*. (2002).

Phosphorus (P) : The average initial P content of soil during non-irrigated and irrigated condition was 6.91 and 7.78 ppm respectively. The observed values compared with critical level suggested by Mc-Dowel *et al.* (1984) were found below the critical level. Kalita et al. (2003) aslo reported that P was below the critical level due to various factors like low pH (5.6-6.2) and their ionic acidity of soil which induces formation of complex with Fe.

Table 1. Total number of samples collected during three years of Sindhudurg district

Season	2010-11			2011-12			2013-14			Total samples		
	Ser-ums	Soil	Feed/ fodder	Ser-ums	Soil	Feed/ fodder	Ser-ums	Soil	Feed/ fodder	Ser-ums	Soil	Feed/ fodder
Summer	-	-	-	40	-	36	20	36	72	160	36	108
Rainy	-	-	-	120	-	76	120	-	108	240	-	184
Winter	20	6	18	120	36	76	-	-	-	140	42	94
Total	20	6	18	280	36	188	240	36	180	540	78	386

Magnesium (Mg) : The average initial Mg content of soil of non-irrigated and irrigated condition was 16.89 and 16.14 ppm, respectively. The magnesium content in all soil samples compared with critical level was found above the critical level. Gowda et al. (2001) reported higher Mg content for soil of Mandira district of Assam (42.14 ppm)

B) Micro mineral content of soil:

Copper (Cu) : The average initial Cu content of soil during non-irrigated and irrigated condition of the district was 0.54 and 0.47 ppm, respectively. It was found that copper content of irrigated and non-irrigated soil was below the critical level.

Iron (Fe) : The average initial Fe content of soil or non-irrigated and irrigated conditions was 53.38 and 63.16 ppm, respectively. The present observed values compared with critical level suggested by McDowell *et al*. (1984) was above the critical level.

Zinc (Zn) : The average Zn content of soil of non-irrigated and irrigated condition of the district values was 1.95 and 2.22 rc ppm respectively, The present finding compared with the critical level (1.5 ppm) were found above the critical level.

A) Micro mineral content of feed and fodder :

The data pertaining to average initial mineral content of feed and fodder from Sindhudurg district during the year 2010-2012 is given in Table 2

Calcium (Ca) : The average Ca content of feed and fodder of non-irrigated and irrigated land of sindhudurg district were 0.264 and 0.249 per cent, respectively. However, the average Ca content when compared with critical level was below the observed level in the district. The present findings also corroborated with the repot from Garg *et al*. (2003). They reported Ca content was higher than the present findings.

Phosphorus (P) ; The average P content of feed and fodder of non-irrigated and irrigated soil of the district were 0.138 and 0.169 per cent, respectively. The present finding compared with critical level (0.25%) were found lower in the district. The present finding of deficient levels of P in the feed and fodder were in line with the report of Gerg *et al.* (2005).

Magnesium (Mg) : The average Mg content of feed and fodder of non-irrigated and irrigated condition of Sindhudurg district were 0.089 and 0.102 per cent, respectively. The

Table 2. Average initial mineral content of soil, feed and fodders and blood serum

Minerals	Soil			Field and fodder			Blood serum		
	Critical limit (ppm)	Non-irrigated (ppm)	Irrigated (ppm)	Critical limit (ppm)	Non-irrigated (ppm)	Irrigated (ppm)	Critical limit (ppm)	Non-irrigated (ppm)	Irrigated (ppm)
Macro minerals									
Ca	71.0	63:94	64.25	0.300	0.264	0.249	8.00	5.87	6.14
P	10.0	6.91	7.78	0.250	0.138	0.169	4.50	2.64	2.65
Mg	9.1	16.89	16.14	0.200	0.089	0.102	2.00	1.83	1.67
Micro minerals									
Fe (ppm)	19.0	56.38	63.46	50.00	93.96	85.56	1.00	3.18	2.87
Cu (ppm)	0.6	0.54	0.47	8.00	11.74	11.45	0.65	0.89	0.97
Zn (ppm)	1.5	1.95	2.22	30.00	19.82	16.85	0.50	1.14	1.15

present findings when compared with critical level of 0.200 per cent suggested by McDowell *et al*. (1985) were found below the critical level. The results were also in agreement with the report of Gerg *et al*. (2003).

Copper (Cu) : The average Cu content in feed and fodder of non-irrigated and irrigated condition of Sindhudurg district were 11.74 and 11.45 ppm, respectively. The results compared with critical level of 8.00 ppm as suggested by (MC Dowell et al., 1985) were found above the critical level. Gowda *et al*. (20015) for GNC reported lower content of copperthan present finding. Similarly Garg *et al*. (2003) also reported lower copper content of wheat bran of Kota district of Rajasthan.

Iron (Fe) : The average Fe content of feed and fodder of non-irrigated and irrigated condition were 93.96 and 85.56 ppm, respectively. The present findings compared with the critical level 50.00 ppm suggested by McDowell, (1985) were found above the critical level. Garg *et al*. (2003) reported higher content of Fe in Rewari district of Haryana and Pancharnahal district of Gujarat state. Also, higher levels of Fe (480 ppm) in paddy straw, bajra kutti, and wheat straw was reported by Gowda *et al.* (2002) at Central Dry Zone of Karnataka.

Zinc (Zn) : The average zinc content in feed and fodder of non-irrigated and irrigated condition was 19.82 and 16.85 ppm, respectively in Sindhudurg district. The results compared with critical level suggested by McDowell, (1985)was found below the critical level.

A) Macro mineral content of blood scrum:

The data pertaining to average initial mineral content of blood serum from Sindhdurg district during the year 2010-2012 is presented in Table 2.

Calcium (Ca) : The average calcium content in blood serumof non-irrigated and irrigated condition was 5.87 and 6.14 mg dl^{-1}, respectively. The present results in the district compared with critical level suggested by McDowell et al. (1984) found below the critical level. Prabowo *et al*. (1990) reported higher Ca content than observed value, was due to seasonal effect. Similarly. Mondal *et al*. (2003) reported which values varied for calcium, due to age and physiological state of lactating animals.

Phosphous (P) : The average phosphorus content in blood serum of non-irrigated and irrigated condition was 2.64and2.65 mg dl^{-1}, respectively. The present results were compared with critical level suggested by McDowell (1984) was observed below the critical level. Modal *et al.* (2003) reported higher 4.53 to 4.67 per cent phosphorus.

Magnesium (Mg) : The average Mg content of blood serum of non-irrigated and irrigated condition was 1.83 and 1.67 mg/dl, respectively. The present findings were compared with critical level suggested by McDowell *et al.* (1984) was found below the critical level.

B) Micro mineral content of blood scrum:

Copper (Cu) : The average serum copper content in non-irrigated and irrigated condition was 0.89 and 0.97ppm, respectively. The results compared with critical level suggested by (Mcdowell *et al*. (1984) was found above the critical level. The findings indicating adequated serum copper level corroborated with the findings of Rajora and Pachauri (1993) in Tarai region.

Iron (Fe) : The average serum iron content in non-irrigated and irrigated conditions was 3.18 and 2.87 ppm, respectively. The results compared with critical level suggested by (McDowell *et al*. (1984) was found above the

critical level. The findings indicating adequate i.e. more than critical level.

Zinc (Zn) : The average Zinc content in serum of non-irrigation and irrigated condition was 1.14 and 1.15 ppm, respectively. It was found that Zn was above the critical level. The results are in agreement with the report of Kawitak (2005) in Marathwada region of Maharashtra.

Conclusion

I was concluded that the average initial content of Ca and P were found deficient in soil, feed and fodder and blood serum of cattle and buffaloes of the district whereas Cu, Fe, was found adequate. Mg and Zn, was found adequate in soil but deficient in feed and fodder of the region. The average Mg was deficient in blood serum of cattle and buffaloes of the districts whereas Zn was seen adequate in blood serum of large ruminants in the district.

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Correlation and Path Analysis in Groundnut (*Arachis hypogaea* L.) Under Stress Condition

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Abstract

Thirty genotypes of groundnut including release varieties and germplasms were used to assess the correlation and contribution of characters towards yield. The pod yield plant^{-1} showed significant positive relationship with proline content followed by branches plant^{-1}, pods plant^{-1}, days to 50 per cent flowering and days to maturity. The character proline content showed positive direct effect on pod yield plant^{-1} followed by pod plant^{-1}, 100 kernel weight, days to 50 per cent flowering, SCMR reading, harvest index and plant height. Thus for improvement of groundnut under stress condition due weightage should be given to these characters. The 30 genotypes were groped in eight clusters. Cluster I contained 8 genotypes followed by cluster III which contained 6 genotypes, cluster IV and cluster V each contained 5 genotypes, cluster II contained 3 genotypes, while cluster VI, VII and VIII were mono-genotypic. Proline content contributed highest towards divergence. Based on diversity studies the genotypes that can be used for further breeding programme for improvement of groundnut under stress condition are KDG-128 (Phule Warna), RG-532, CGMG-2010-11, GSP-64, LGN-163, JSP-60, KDG-197, ICGV-13229, ICGV-00348 and RTNG-53.

Key words : Groundnut, Stress, SCMR, SLA, Proline content.

Groundnut/peanut (*Arachis hypogaea* L.) is an important food and oilseed crop in Asia and Africa. Groundnut oil is considered healthier than saturated oils and is resistant to rancidity, because of its high monosaturated content. Groundnut kernels are the rich source of edible oil (40-55%) and proteins (22-28%) along with Ca, P, Fe, Zn and B. Its cake is used as feed or for making other food products and haulms provide quality fodder.

Groundnut is cultivated predominantly in the tropics and subtropics, where the availability of water is a major constraint on yield (Viramani and Singh, 1986). Groundnut yield in rainfed areas is limited by drought stress because pod yield and yield attributing parameters have been severely affected (Pimratch *et al*., 2008,). During the entire season, the crop is subjected to water deficit stress at one stage or another leading to drastic reduction in productivity. This necessitates development of cultivars which can withstand water stress and still can be productive. Reduction in peanut yield resulting from drought has been well documented (Nageswara Rao *et al*., 1989 and Reddy *et al*., 2003). Drought during the pod and seed forming stages has been shown to reduce pod yield of peanut by 56-85% (Nageswara Rao *et al*., 1989).

Photosynthesis is generally correlated with chlorophyll content per unit leaf area; SCMR gives actual potential and photosynthetic capacity of leaf (Nageshwar Rao *et al*., 2001). Proline accumulation is often considered to be involved in stress resistance mechanisms (Ramanjulu and Sudhakar, 2000). Alves, (2016) revealed that, proline is the most appropriate descriptor for selecting genotypes tolerant to water stress. The physiological parameter for drought tolerance of groundnut genotypes differed much in SLA value in water stress and normal condition. SLA was negatively correlated

with water use efficiency in turn pod yield [Basu and Nautiyal (2004), Thakur *et al*., (2013)]. Study of correlation among various characters under drought situation is the prime importance in developing an efficient breeding programme. The correlation studies provide information about the relationship between any two characters. The path coefficient analysis provides the partitioning of correlation into direct and indirect effects giving the relative importance of each of the casual factors. The present study was undertaken to determine the association of various traits and direct indirect effects towards pod yield under stress condition.

Materials and Methods

Thirty genotypes of groundnut including release varieties and germplasms were evaluated under controlled drought condition during *kharif* (July to October) 2017 at Agricultural Botany Farm, College of Agriculture, Pune, Maharashtra, India. Irrigation were given only twice throughout the experiment, i.e. first at sowing and second at pegging stage, it means two stress periods, i.e. before pegging and after pegging stage. The experiment was laid out in Randomized Block Design (RBD) with three replications. Each entry was sown in a row of 2 m length with spacing of 45 x 10 cm. The observations on different quantitative traits, SCMR reading were recorded at flowering stage, leaf samples for proline content and SLA were obtained at 45th day after the irrigation at pegging stage (i.e. 85th day after sowing).

Proline accumulation was determined as described by Bates *et al*. (1973). SCMR values were recorded using the SPAD-502 (Soil Plant Analytical Development) meter from fully expanded third leaf from top. SLA is expressed as the ratio between leaf area to leaf dry weight. Leaf area was estimated using leaf area meter (Li-COR model LI 3000) and expressed as cm^2 and weight of leaves taken after oven drying and expressed as gram (g). The data was subjected to correlation (Johnson *et al*.,1955) and path analysis (Dewey and Lu, 1959).

Results and Discussion

The pod yield plant^{-1} showed significant positive relationship with proline content (0.933)

Table 1. Genotypic correlation of 11 characters in 30 genotypes of groundnut under stress condition

Observations	Days to maturity (No.)	Plant height (cm)	Branches plant^{-1} (No.)	100 Kernel weight (g)	Shelling %	Harvest index %	Pod plant^{-1} (No.)	SLA (cm^2 g^{-1})	SCMR reading	Proline content (mg g^{-1})	Pod yield plant^{-1} (g)
Days to 50% flowering (No.)	0.189	0.081	0.621**	-0.145	-0.006	-0.284**	0.536**	0.232*	-0.051	0.555**	0.653**
Days to maturity (No.)		0.118	0.352**	-0.493**	-0.559**	-0.390**	0.464**	0.256*	-0.349**	0.219*	0.264*
Plant height (cm)			-0.103	0.125	0.231*	-0.248*	-0.072	0.02	0.169	-0.046	0.045
Branches plant^{-1} (No.)				-0.075	-0.156	-0.116	0.425**	-0.156	0.205	0.697**	0.752**
100 Kernel weight (g)					0.843**	0.341**	-0.241*	-0.183	0.504**	0.258*	0.193
Shelling %						0.518**	-0.163	-0.131	0.572**	0.176	0.163
Harvest Index (%)							-0.026	-0.084	0.337**	0.150	0.123
Pod plant^{-1} (No.)								0.453**	-0.465**	0.603**	0.709**
SLA (cm^2 g^{-1})									-0.513**	0.223*	0.134
SCMR reading										0.030	0.086
Proline content (mg g^{-1})											0.933**

followed by branches plant^{-1} (0.752), pods plant^{-1} (0.709), days to 50 per cent flowering (0.653) and days to maturity (0.264) (Table 1). The characters plant height, 100 kernel weight, shelling per cent, harvest index, specific leaf area and SCMR reading were positive but non-significantly associated with the pod yield. Days to maturity showed significant negative association with 100 kernel weight, shelling per cent, harvest index and SCMR reading; while with rest of two characters, its association was significant and positive except plant height and days to 50 per cent flowering. Whereas 100 kernel weight showed significant positive association with shelling per cent, harvest index, SCMR reading and proline content while with days to maturity and pod plant^{-1}, its association was significant and negative. Pods plant^{-1} showed significant and positive association with days to 50 per cent flowering, days to maturity, branches plant^{-1}, specific leaf area and proline content, but its association was negative and significant with 100 kernel weight and SCMR reading. SCMR reading recorded significant positive association with 100 kernel weight, shelling per cent, harvest index and proline content, while its association was significant and negative with days to maturity, pod plant^{-1} and SCMR reading. Proline content recorded significant and positive association with days to 50 per cent flowering, days to maturity, branches plant^{-1}, 100 kernel weight, pod plant^{-1} and specific leaf area.

The SLA had significant inverse relationship with SPAD chlorophyll meter reading (SCMR) and total chlorophyll content. Asalatha *et al.* (1999) reported that SLA had significant positive relationship with pod yield and negatively related with transpiration efficiency. Positive relationship of SLA with pod yield means that the genotypes with low SLA are poor in partitioning.

The character Proline content showed

Table 2. Direct (diagonal) and Indirect (above and below diagonal) path effects of different characters towards Pod Yield at genotypic level in groundnut under stress condition

Character	Days to 50% flowering (No.)	Days to maturity (No.)	Plant height (cm)	Branches plant^{-1} (No.)	100 Kernel weight (g)	Shelling %	Harvest index %	Pod plant^{-1} (No.)	SLA (cm^2 g^{-1})	SCMR reading	Proline content (mg g^{-1})	Pod yield plant^{-1} (g)
Days to 50% flowering (No.)	0.267	0.000	0.011	-0.038	-0.047	0.003	-0.047	0.246	-0.030	-0.012	0.300	0.653**
Days to maturity (No.)	0.051	-0.001	0.016	-0.022	-0.162	0.228	-0.064	0.214	-0.033	-0.082	0.118	0.264*
Plant height (cm)	0.022	0.000	0.132	0.007	0.041	-0.094	-0.041	-0.033	-0.003	0.040	-0.025	0.045
Branches plant^{-1} (No.)	0.166	0.000	-0.014	-0.061	-0.025	0.064	-0.019	0.195	0.020	0.048	0.377	0.752**
100 Kernel weight (g)	-0.039	0.001	0.017	0.005	0.328	-0.344	0.056	-0.111	0.024	0.118	0.140	0.193
Shelling %	-0.002	0.001	0.030	0.010	0.276	-0.408	0.085	-0.075	0.017	0.134	0.095	0.163
Harvest index (%)	-0.076	0.000	-0.033	0.007	0.112	-0.211	0.164	-0.012	0.011	0.079	0.081	0.123
Pod plant^{-1} (No.)	0.143	-0.001	-0.010	-0.026	-0.079	0.066	-0.004	0.460	-0.058	-0.109	0.326	0.709**
SLA (cm^2 g^{-1})	0.062	0.000	0.003	0.010	-0.060	0.054	-0.014	0.208	-0.129	-0.120	0.121	0.134
SCMR reading	-0.014	0.000	0.022	-0.013	0.165	-0.233	0.055	-0.214	0.066	0.234	0.016	0.086
Proline content (mg g^{-1})	0.148	0.000	-0.006	-0.042	0.085	-0.072	0.025	0.277	-0.029	0.007	0.541	0.933**

positive direct effect (0.541) on pod yield plant^{-1} followed by pod plant^{-1} (0.460), 100 kernel weight (0.328), days to 50 per cent flowering (0.267), SCMR reading (0.324), harvest index (0.164) and plant height (0.132) (Table 2). Plant height and harvest index had low positive direct effect on pod yield plant^{-1}. The character shelling per cent had high negative direct effect, while, the character days to maturity, branches plant^{-1} and specific leaf area had low direct effect with negative magnitude on pod yield plant^{-1}. Under stress condition 100 kernel weight, pod plant^{-1}, SCMR reading contributed indirectly towards yield.

Genetic divergence in 30 genotypes of the groundnut was measured following Mahalanobis's (1936) D^2 statistics. These 30 genotypes were grouped into different clusters following Tocher's method as described by Rao (1952). The genotypes were groped in eight clusters (Table-3). Cluster I contained 8 genotypes followed by cluster III which contained 6 genotypes, cluster IV and cluster V each contained 5 genotypes, cluster II contained 3 genotypes, while cluster VI, VII and VIII were mono-genotypic. Proline content contributed highest towards divergence. It was followed by 100 kernel weight, harvest index, days to

Table 3. Distribution of 30 genotypes of groundnut into different clusters under stress condition

Clusters	No. of genotypes included	Genotypes
I	8	AK 159, MABC 2016-18, TKG Bold, RG 595, RHRG 1305, R 2001-2, JL 977, RHRG 1308.
II	3	ICGV 13220, ICGV 13229, ICGV 14415.
III	6	KDG 160, JL 776, LGN 163, RHRG 1135, GSP 64, JL 501
IV	5	ICGV 14410, GPBD 4, ICGV 13200, KDG 187, AK 359
V	5	CGMG 2010-11, RTNG 53, KDG 197, RG 532, JSP 60.
VI	1	RTNG 29
VII	1	ICGV 00348
VIII	1	KDG 128 (Phule Warna)

Table 4. Average intra and inter cluster D^2 and D (in parenthesis) values in groundnut under stress condition

Cluster	I	II	III	IV	V	VI	VII	VIII
I	26.73 (5.17)	34.57 (5.88)	75.52 (8.69)	54.17 (7.36)	131.56 (11.47)	146.89 (12.12)	63.52 (7.97)	179.56 (13.40)
II		13.03 (3.61)	117.72 (10.85)	81.90 (9.05)	131.79 (11.48)	213.45 (14.61)	44.35 (6.66)	250.91 (15.84)
III			39.06 (6.25)	107.74 (10.38)	94.67 (9.73)	215.79 (14.69)	116.64 (10.80)	59.44 (7.71)
IV				25.10 (5.01)	244.61 (15.64)	66.91 (8.18)	128.37 (11.33)	225.60 (15.02)
V					36.00 (6.00)	441.00 (21.00)	108.16 (10.40)	116.42 (10.79)
VI						0.00 (0.00)	310.11 (17.61)	345.96 (18.60)
VII							0.00 (0.00)	206.20 (14.36)
VIII								0.00 (0.00)

maturity and pod plant^{-1}. The remaining characters contribute very little to divergence.

The highest intra-cluster distances were observed for cluster III (39.06) followed by cluster V (36.00), cluster I (26.73), cluster IV (25.10), and cluster II (13.03). The clusters VI, VII and VIII showed no intra cluster distances being mono-genotypic (Table 4). The maximum inter cluster distance observed between cluster V and VI (441.00) followed by clusters VI and VIII (345.96), clusters VI and VII (310.11), cluster II and VIII (250.91). The minimum inter cluster distances observed between cluster I and II (34.57), cluster II and VII (44.35), cluster I and IV (54.17) indicating proximity with each other. The cluster I was the most distant from cluster VIII (179.56) followed by cluster VI (146.89), cluster V (131.56), cluster III (75.52), cluster VII (63.52), cluster IV (54.17) and cluster II (34.57). The cluster II was the most distant from cluster VIII (250.91) followed by cluster VI (213.45), cluster V (131.79), cluster III (117.72), cluster IV (81.90) and cluster VII (44.35). D^2 values between cluster III and cluster VI was the highest (215.79) followed by cluster VII (116.64), cluster IV (107.74), cluster V (94.67) and cluster VIII (59.44). Cluster IV was the most distant from cluster V (244.61), followed by cluster VIII (225.60), cluster VII (128.37) and cluster VI (66.91). Cluster V had maximum D2 distance with cluster VI (441.00) followed by cluster VIII (116.42) and cluster VII (108.16). Cluster VI had maximum D^2 distance with cluster V (441.00) followed by cluster VIII (345.96) and cluster VII (310.11). Cluster VII had maximum D2 distance with cluster VIII (206.20).

Potential parents were identified by using the procedure given by Arunachalam and Bandopadhyay (1984). Based on this the potential parents (genotypes) that can be used for further breeding programme for improvement of groundnut under stress condition are KDG-128 (Phule Warna), RG-532, CGMG-2010-11, GSP-64, LGN-163, JSP-60, KDG-197, ICGV-13229, ICGV-00348 and RTNG-53.

Based on the present studies it can be concluded that the traits 100 kernel weight, pods plant^{-1}, proline content and SCMR reading should be considered for improvement of groundnut under stress condition.

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