

Influence of Fertigation Levels and Microbial Consortia on Broccoli Productivity and Profitability under Drip Irrigation

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(Received : 01.03.2026 Accepted : 18.07.2026)

Abstract

The experiment entitled "Effect of different fertigation levels and microbial consortia on yield and economics of broccoli (*Brassica oleracea* L. var. *italica*) under drip irrigation" was conducted during the rabi season of 2023-24 at the Interfaculty Department of Irrigation Water Management, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar (Maharashtra). The study aimed to evaluate the effect of fertigation levels and microbial consortia on the growth and yield of broccoli. The experimental field had well-drained clay loam soil (45 cm depth) with low available nitrogen (258.4 kg ha⁻¹), medium phosphorus (19.80 kg ha⁻¹), and very high potassium (395.1 kg ha⁻¹), slightly alkaline in reaction (pH 7.91) and electrical conductivity of 0.38 dS m⁻¹. The experiment was laid out in a split-plot design with three replications. The main plots comprised three fertigation levels: 50% RDF (F₁), 75% RDF (F₂), and 100% RDF (F₃). Five microbial consortia were allotted to subplots: control (C₀), MPKV consortium (C₁), VNMKV Biomix (C₂), Arka microbial consortium (C₃), and IFFCO NPK liquid biofertilizer consortium (C₄). Biofertigation was applied at transplanting and at 15, 30, and 45 days after transplanting. The application of 100% RDF fertigation resulted in the highest curd yields across all harvesting intervals: 19.47 q ha⁻¹ (first harvest), 20.88 q ha⁻¹ (second), 22.21 q ha⁻¹ (third) and 20.39 q ha⁻¹ (fourth), culminating in the maximum total curd yield of 82.95 q ha⁻¹. This was at par with the 75% RDF fertigation level, which yielded 79.05 q ha⁻¹. Fertigation at the 100% RDF level resulted in significantly maximum gross monetary returns (Rs. 4,97,680 ha⁻¹) and net monetary returns (Rs. 3,42,778 ha⁻¹) compared to other fertigation treatments. However, these economic gains were statistically at par with those observed under the 75% RDF fertigation level. Biofertigation schedule involving the MPKV Consortium demonstrated a significant positive effect on curd yield of broccoli across all harvest intervals: first harvest (25.00 q ha⁻¹), second harvest (24.30 q ha⁻¹), third harvest (30.07 q ha⁻¹), fourth harvest (24.70 q ha⁻¹) and a total curd yield of 104.07 q ha⁻¹. In case of economic studies MPKV Consortium was found superior in terms of gross monetary returns (Rs. 5,46,167 ha⁻¹) and net monetary returns (Rs. 3,96,880 ha⁻¹) than rest of biofertigation schedule.

Key words : Broccoli, Fertigation levels, Microbial consortium, Drip irrigation, Yield, Growth parameters.

Broccoli (*Brassica oleracea* L. var. *italica*) is a widely cultivated cole vegetable of the family Cruciferae, bearing close similarity to cauliflower but characterized by its green, compact edible heads formed on both terminal and lateral shoots. The crop is nutritionally rich, containing substantial amounts of vitamins A and C, minerals, dietary fiber, and antioxidant compounds. In India, broccoli cultivation is gaining popularity owing to rising consumer awareness and its adaptability to varied agro-climatic regions, especially in states such as

Maharashtra, Himachal Pradesh, Uttarakhand, and Tamil Nadu. Fertigation, which involves the application of fertilizers through drip irrigation, allows accurate and efficient placement of nutrients in the root zone. This practice enhances nutrient absorption, improves water and fertilizer use efficiency, and consequently leads to better crop growth, yield, and quality (Bar-Yosef, 1999; Solaimalai *et al.*, 2005). Previous research has indicated that fertigation can result in fertilizer savings of 20–60 percent along with yield improvements ranging from 8

to 41 percent in various vegetable crops (Jucilene *et al.*, 2009; Singh *et al.*, 2010). Apart from fertigation, microbial consortia contribute significantly to sustainable nutrient management in crops. Beneficial microorganisms such as *Azotobacter*, phosphate-solubilizing bacteria (PSB), *Trichoderma*, and potassium-solubilizing bacteria (KSB) improve nutrient availability by transforming nutrients into plant-available forms, thereby enhancing plant growth and soil health (Selim *et al.*, 2009). The application of these beneficial microbes through irrigation water, known as biofertigation, provides an environmentally friendly and economically viable strategy for integrated nutrient management (INM). In view of the limited research on fertigation and biofertigation practices for broccoli under Indian agro-climatic conditions, the present study entitled “Response of Broccoli (*Brassica oleracea* L. var. *italica*) to different fertigation levels and microbial consortia under drip irrigation” was conducted to evaluate their effects on growth and yield.

Materials and Methods

The experiment was carried out at the Instructional Farm of the Inter-Faculty Department of Irrigation Water Management, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, during the rabi season of 2023–24. The experimental soil was well-drained with a clay loam texture. It was low in available nitrogen (258.4 kg ha⁻¹), medium in available phosphorus (19.8 kg ha⁻¹), and high in available potassium (395.1 kg ha⁻¹). The soil reaction was slightly alkaline, with a pH of 7.91, and it contained 0.51 percent organic carbon. The electrical conductivity of the soil was 0.38 dS m⁻¹ at 24 °C. The field capacity and permanent wilting point were 38.11 percent and 19.90 percent, respectively, while the bulk density was 1.11 g cm⁻³. The experimental site falls under the agro-climatic scarcity zone of

Maharashtra and is characterized as drought-prone. The study involved three fertigation levels assigned to the main plots: F₁ (50% of the recommended dose of fertilizers), F₂ (75% RDF), and F₃ (100% RDF). The subplot treatments comprised five microbial consortia, namely C₀ (control), C₁ (MPKV consortium), C₂ (VNMKV Biomix), C₃ (Arka microbial consortium), and C₄ (IFFCO NPK liquid biofertilizer consortium). Biofertigation was applied at transplanting and subsequently at 15, 30, and 45 days after transplanting (DAT). The broccoli variety ‘Saki’ was used for the experiment. Seedlings were transplanted on December 5, 2024, at a spacing of 45-75 cm × 45 cm in paired rows.

Results and Discussion

Yield Attributes and Yield Studies

Table 1. Yield attributing characters and total yield of broccoli as influenced by different treatments

Treatment	Yield attributing characters		
	Dia-meter of curd (cm)	Wt. of curd plant ⁻¹ (g)	Total yield (q ha ⁻¹)
I. Fertigation Levels			
F ₁ - 50% RDF	17.10	1737	64.06
F ₂ - 75% RDF	18.92	1900	79.05
F ₃ - 100% RDF	20.23	1907	82.95
S.E.(m) ±	0.78	14.89	1.09
C.D at 5 %	3.04	58.48	4.30
II. Microbial Consortia			
C ₀ - Control	14.75	1702	65.09
C ₁ - MPKV Consortium	23.56	2009	91.03
C ₂ - VNMKV Biomix	20.25	1913	79.31
C ₃ - Arka Microbial Consortium	18.62	1814	71.85
C ₄ - IFFCO NPK Liquid Biofertilizer Consortium	16.58	1802	69.48
S.E.(m) ±	1.43	32.94	3.03
C.D at 5 %	3.66	96.17	11.72
III. Interaction			
A × B	N.S.	Sig.	Sig.
General mean	18.75	1848	75.35

Diameter of Curd : Data pertaining that different fertigation levels significantly influenced the diameter of curd of broccoli. Application of fertigation at 100% RDF attained the maximum average diameter of curd (20.23 cm) as compared to rest of fertigation levels. This is followed by 75% RDF fertigation level the average diameter of curd (18.92 cm). The findings are comparable to those reported by Chand *et al.* (2017). The microbial consortium of MPKV Consortium registered the maximum diameter of curd (23.56 cm) among all the microbial consortium. The lower curd diameter as determined by the control. The results are in conformity with the findings Pawde *et al.* (2019), Kumar *et al.* (2017) and Singh *et al.* (2014).

Weight of curd plant-1 : Application of fertigation at 100% RDF exhibited the

maximum and significantly highest average weight of curd; (1907 g) as compared to rest of fertigation levels. Because the average weight of curd plant-1 was positively connected to the amount of fertigation used, the crop satisfied the nutrient demand throughout the crop growth period at 100% RDF fertigation, which improved vegetative growth, curd diameter and girth, resulting in an increase in curd weight. It was at par with 75% RDF, average weight of curd (1900 g). Similar findings have been reported by Tumbare (2013), Chand and Singh (2017) and Singh *et al.* (2017). Microbial consortium of MPKV Consortium among all the consortium, had the greatest average curd weight (2009 g). Whereas, the control observed minimum average curd weight plant⁻¹. Nutrient application with extended splits increases curd diameter which ultimately increases curd weight plant⁻¹. These findings are consistent with those

Yield

Table 2. Curd yield of broccoli as influenced by different treatments

Treatment	Curd yield (q ha ⁻¹)				
	First harvest	Second harvest	Third harvest	Fourth harvest	Total yield
I. Fertigation Levels					
F ₁ - 50% RDF	16.03	17.67	16.82	13.53	64.06
F ₂ - 75% RDF	19.11	19.63	20.60	19.51	79.05
F ₃ - 100% RDF	19.47	20.88	22.21	20.39	82.95
S.E.(m) ±	0.68	0.34	0.79	0.41	1.09
C.D at 5 %	2.66	1.33	3.11	1.62	4.30
II. Microbial Consortia					
C ₀ - Control	15.60	17.22	16.69	15.58	65.09
C ₁ - MPKV Consortium	21.62	21.96	26.59	20.87	91.03
C ₂ - VNMKV Biomix	19.17	20.87	20.24	19.03	79.31
C ₃ - Arka Microbial Consortium	17.46	19.20	18.14	17.04	71.84
C ₄ - IFFCO NPK Liquid Biofertilizer Consortium	17.17	18.07	17.71	16.53	69.48
S.E.(m) ±	0.84	0.41	1.16	0.64	3.03
C.D at 5 %	2.45	1.18	3.39	1.88	11.72
III. Interaction					
A x B	Sig.	Sig.	Sig.	Sig.	Sig.
General mean	18.20	19.46	19.87	17.81	75.35

reported by Pawde *et al.* (2019), Kumar *et al.* (2017) and Singh *et al.* (2014).

The application of 100% RDF fertigation resulted in the highest values of curd yields across all harvesting intervals that is 19.47 q ha⁻¹ (first), 20.88 q ha⁻¹ (second), 22.21 q ha⁻¹ (third) and 20.39 q ha⁻¹ (fourth), culminating in the maximum total curd yield of 82.95 q ha⁻¹. This was at par with the 75% RDF fertigation level, which yielded first harvest (19.11 q ha⁻¹), second harvest (19.63 q ha⁻¹), third harvest (20.60 q ha⁻¹), fourth harvest (19.51 q ha⁻¹) and 79.05 q ha⁻¹. In contrast, the lowest yield components and total production were recorded under the 50% RDF fertigation treatment. These findings align with reports by Chand and Singh (2017), Sharma *et al.* (2017), Biradar *et al.* (2018), Sohail *et al.* (2018) and Tumbare *et al.* (2013). The MPKV Consortium resulted in the

highest curd yields across all harvest intervals first harvest (21.62 q ha⁻¹), second (21.96 q ha⁻¹), third (26.59 q ha⁻¹) and fourth (20.87 q ha⁻¹), culminating in the highest total curd yield of 91.03 q ha⁻¹. while VNMKV Biomix application was found at par with MPKV Consortia with yield of 79.31 q ha⁻¹ this results are in consistent with Pawde *et al.* (2019), Kumar *et al.* (2017) and Singh (2014).

Gross Monetary Returns : The gross monetary returns of broccoli were significantly influenced by fertigation levels. Among the fertigation treatments, the highest gross return (Rs. 4,97,680 ha⁻¹) was recorded with F₃ (100% RDF), which was statistically at par with F₂ (75% RDF) (Rs. 4,74,320 ha⁻¹). Regarding microbial treatments, the application of C₁ (MPKV Consortium) produced the highest gross return of Rs. 5,46,167 ha⁻¹, significantly superior to

Economic Studies

Table 3. Economics of broccoli as influenced by different treatments

Treatment	Cost of cultivation (Rs. ha ⁻¹)	Gross monetary returns (Rs. ha ⁻¹)	Net monetary returns (Rs. ha ⁻¹)	B:C ratio
I. Fertigation Levels				
F ₁ - 50% RDF	144183	384340	240157	2.66
F ₂ - 75% RDF	149766	474320	324554	3.16
F ₃ - 100% RDF	154901	497680	342778	3.21
S.E.(m) ±	-	6569	6569	-
C.D at 5 %	-	25793.1	25793.1	-
II. Microbial Consortia				
C ₀ - Control	148697	390533	241470	2.62
C ₁ - MPKV Consortium	149287	546167	396880	3.65
C ₂ - VNMKV Biomix	150183	475867	325684	3.16
C ₃ - Arka Microbial Consortium	150855	431100	280245	2.85
C ₄ - IFFCO NPK Liquid Biofertilizer Consortium	149063	416900	268203	2.79
S.E.(m) ±	-	11816.5	11816.5	-
C.D at 5 %	-	34489.8	34489.8	-
III. Interaction				
A x B	-	Sig.	Sig.	-
General mean	-	452113.4	302498	3.01

other consortia and control. This indicates that higher nutrient availability through fertigation positively impacted broccoli productivity, translating to higher gross income.

Cost of Cultivation : Highest cost of cultivation was recorded with application of 100% RDF (Rs. 1,54,901 ha⁻¹), followed by 75% RDF (Rs. 1,49,766 ha⁻¹). Among microbial treatments, the cost of cultivation was highest in C₃ (Arka Microbial Consortium) at Rs. 1,50,855 ha⁻¹, followed by C₂ (VNMKV Biomix) at Rs. 1,50,183 ha⁻¹. The lowest cultivation cost (Rs. 1,48,697 ha⁻¹) was observed under C₀ (control).

Net Monetary Returns : Application of fertigation with 100% RDF fertigation level was obtained significantly higher net monetary returns of Rs. 3,42,778 ha⁻¹ than rest of fertigation level. Whereas, significantly It was at par with 75% RDF fertigation level, net monetary returns Rs. 3,24,554 ha⁻¹. Application of microbial consortia showed significant effect on net monetary returns highest returns were recorded with application of MPKV consortia (Rs. 3,96,880 ha⁻¹) whereas lowest returns were obtained with control (Rs. 2,41,470 ha⁻¹) that is no any application of microbial consortia. These results were due to greater yield obtained with the use of MPKV consortia reflected in good net monetary returns. These findings are in accordance with the results of Tumbare (2013).

Benefit: Cost ratio : Among the fertigation treatments, the highest B:C ratio (3.21) was recorded in F₃ (100% RDF), followed very closely by F₂ (75% RDF) with a B:C ratio of 3.10. Among microbial treatments, the MPKV Consortium (C1) recorded the highest B:C ratio of 3.65, indicating the best return per rupee invested.

Conclusion

The combination of 100% RDF

fertigation and MPKV Consortium resulted in the highest yield. This could be due to application of required quantity of nutrients directly in the vicinity of root zone. Also, all macro and micro nutrient are easily available to plant. The plant grows without any deficiency with high leaf area. Which increase in luxurious crop development throughout the growing season by increasing the water usage efficiency of applied water. It creates a conducive environment for promoting physiological processes like as photosynthesis, which resulted in increased curd width and average weight of curd plant⁻¹, resulting in increased curd yield along with extended activities of microorganisms helps to make unavailable nutrients in available form, which met the crop's nutrient requirements. Above mentioned treatment was found to be at par with 75% RDF along with MPKV Consortia which is comparatively equally beneficial under drip irrigation systems. This highlights the potential of combined fertigation and biofertigation in optimizing water usage. On the basis of results obtained after one year of experimentation it is concluded that, application of fertilizer at 75% recommended dose (97.5:15:22.5 N:P2O5:K2O kg ha⁻¹) coupled with biofertilizer MPKV Consortium through fertigation found suitable to broccoli for maximum growth, yield attributes, curd yield, quality and monetary returns.

Reference

- Bar-Yosef B. 1999. Advances in fertigation. *Advances in Agronomy* 65(1) : 1-77.
- Biradar, M. S., Mantur, S. M. and Dhotre, M. 2018. Influence of fertigation on growth and yield of broccoli and red cabbage under nethouse conditions. *Acta Horticultrae* 1227: 485-490.
- Chand, T. and Singh, M. K. 2017. Effect of different doses of NPK and boron application on growth and yield of Broccoli (*Brassica oleracea* L. var. *italica*) under western Uttar Pradesh India. *Bulletin of Environment. Pharmacol and Life Science* 7(1) : 69-74.
- Jucilene, A. S. andrade, A. P. and Azevedo, C. A. V. 2009. Characteristics of bell pepper fruits cultivated in

- greenhouse under doses of nitrogen via fertigation. *Journal of the Brazilian Association of Agricultural Engineering* 13(2):152-157.
- Kumar, P., Kumar, S., Kumar, M. R., Kumar R. and Rawat R. 2017. Efficacy of biofertilizers on growth, yield and quality of sprouting broccoli (*Brassica oleracea* var. *italica*), cv. pusa broccoli kts-1. *Plant Archives* 17(2): 1647-1650.
- Pawde, M. V., Bhosale, A. M. and Syed, S. J. 2019. Effect of Liquid Biofertilizers and Inorganic Fertilizers on Yield and Quality Attributes of Broccoli (*Brassica oleracea* L. var. *italica*) *International Journal of Current Microbiology and Applied Sciences* 8(10): 374-379.
- Selim, E. M., El-Fattah, A. A., Abouel-Magd, M. M. and Khalafallah, M. A. 2009. Efficiency of bio-fertigation on nutrients uptake by broccoli and soil microbial biomass under sandy soil conditions. *Journal of Agricultural and Environmental Science* 6(3): 280-286.
- Sharma, S. K., Singh, A. and Chopra, R. 2017. Effect of drip fertigation scheduling on yield and economics of cauliflower (*Brassica oleracea* var. *botrytis*) and chili (*Capsicum annum* L.). *Annals of Plant and Soil Research* 19(2): 137-142.
- Singh, A. K. 2014. Effect of nitrogen and phosphorus on growth and yield of cauliflower var. Snowball-16 under Cold Arid Region of Ladakh. *Haryana Journal of Horticultural Science* 33(2): 127-129.
- Singh, B., Pathak, K., Boopathi, T. and Deka, B. 2010. Vermicompost and NPK fertilizer effects on morpho-physiological traits of plants, yield and quality of tomato fruits (*Solanum lycopersicum* L.). *Vegetable Crops Research Bulletin* 73(1):77-86.
- Sohail, K., Nangial, K., Ullah, Z., Ahmad, J., Abdullah, K., Nawaz, F. and Khan, Riaz. 2018. Effect of deficit irrigation and nitrogen levels on growth and yield of cauliflower under drip irrigation. *Pure and Applied Biology* 7(2): 910-921.
- Solaimalai, A., Baskar, M., Sadasakthi, A. and Subburamu, K. 2005. Fertigation in high value crops. *Agricultural Reviews* 26(1): 1-33.
- Tumbare, A. D., Tekale, C. D., Tekale, G. S., Danawale, N. J. and Tambe, S. T. 2014. Effect of different fertigation levels and schedules on growth and yield of cucumber under polyhouse condition. *International Journal of Current Research* 6(7): 7353-7355.
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