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Effect of Different Fertigation Levels and Microbial Consortia on Yield and Economics of Broccoli (*Brassica oleracea* L. var. *italica*) Under Drip Irrigation and Plastic Mulch"

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Abstract

The present investigation entitled " Effect of different fertigation levels and microbial consortia on yield and economics of broccoli (*Brassica oleracea* L. var. *italica*) under drip irrigation and plastic mulch" was conducted on the farm of Interfaculty Department of Irrigation Water Management, Post Graduate Institute, MPKV, Rahuri, Dist. Ahmednagar (Maharashtra) with a view to study the yield potential and economics of broccoli during *rabi* season, 2022-23. The present investigation was laid out in split plot design with three replications. The three main plot treatments comprised of three fertigation levels *viz*., F_1 : 50% RDF, F_2 : 75% RDF and F_3 : 100% RDF whereas sub plot treatments comprised of five microbial consortium *viz*., C_0 : Control, C_1 : MPKV Consortium (*Azotobacter* + PSB + KSB + *Trichoderma*), C_2 : VNMKV Biomix, C_3 : Arka microbial consortium, C_4 : IFFCO NPK Liquid Biofertilizer Consortium. Biofertigation of microbial consortium was done at transplanting, 15 DAT, 30 DAT and 45 DAT. Application of fertigation at 100% RDF fertigation level registered significantly higher yield attributing characters *viz*., diameter of curd (19.99 cm), weight of curd plant^{-1} (2023 g) and total curd yield (74.62 t ha^{-1}). It was at par with 75% RDF fertigation level. The minimum values of all the yield attributes were registered at 50% RDF fertigation level. The significantly higher gross monetary returns (Rs. 4,01,160 ha-1), cost of cultivation (Rs. 1,06,431) net monetary returns (Rs. 2,94,729 ha^{-1}) and B:C ratio (3.76) was obtained with application of fertigation with 100% RDF fertigation level. It was at par with 75% RDF fertigation level. The minimum values of all the economic attributes were registered at 50% RDF fertigation level. Scheduling of biofertigation of microbial consortium of MPKV Consortium (*Azotobacter* + PSB + KSB + *Trichoderma*) obtained significantly higher yield attributing characters of broccoli *viz*., diameter of curd (23.06 cm), weight of curd plant^{-1} (19.83 g) and total curd yield (75.73 t ha^{-1}). The biofertigation of MPKV Consortium (*Azotobacter* + PSB + KSB + *Trichoderma*) was found superior in terms gross monetary returns (Rs. 3,91,200 ha^{-1}), cost of cultivation (Rs. 1,06,427), net monetary returns (Rs. 2,84,773 ha^{-1}) and B:C ratio (4.09) than rest of biofertigation schedule.

Key words : Broccoli, Fertigation levels, Microbial consortium, Azotobactor, economics.

Broccoli (*Brassica oleracea* L. var. *italica*) is an important vegetable among the cole crop belongs to the family Brassicaceae or Cruciferacea and originated from the Mediterranean region. Sprouting broccoli with a kind of terminal head consisting of green buds and thick fleshy flower stalks morphologically resembles the cauliflower except secondary heads, which develop in the axil of leaves and may contribute up to 50 per cent of the total yield. The name broccoli is derived from the Latin word "brachium" which means arm or branch.

Broccoli is known as the Crown of jewel nutrition" as it is a rich source of many minerals, vitamins such as vitamin A and C, carotenoids, fiber, calcium and folic acid besides its antioxidant and anti-carcinogenic properties. It also contains a few important phytochemicals, sulphoraphane, betacarotene, indole-3-carbinol, glucosinolates which help to fight against many cancers (Aires *et al*., 2006). Nowadays, more attention to broccoli is due to its multifarious use

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and great nutritional value (Talalay and Fahey, 2001; Rangkadilok *et al*., 2000). Broccoli is a highly versatile green vegetable present in many of the world's most iconic cuisines. However, even though many of the world's countries use and enjoy broccoli, actual broccoli production can vary greatly from one nation and region to another. The United States is the largest producer of sprouting broccoli followed by India. Broccoli is cultivated in hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri Hills and Northern plains of India. On average, the total global amount of broccoli and cauliflower produced is around 25.5 million tons. Gujarat is known as a significant contributor to the nation's overall broccoli production. The major broccoli producing cities in India are Ahmedabad and Rajkot. The famous districts in Tamil Nadu for production are Coimbatore, Madurai, and Salem.

Fertigation provides a variety of benefits to the users like high crop productivity, quality, resource use efficiency, and environmental safety, flexibility in field operations, effective weed management and successful crop cultivation in fields with undulating topography. Regular and unbalanced use of chemical fertilizers leads in the end to a decrease in the base saturation and to acidification of soil (Roe, 1998). Fertigation facilitates the enhanced mobility, availability and uptake of applied nutrients because of higher soil moisture content (Silber, 2008) and more frequent application of fertilizers, corresponding to quantitative and timely demand by the crops (Srivastava, 2005). Therefore, fertigation can potentially reduce the transport of nutrients away from the root zone. This remarkably increases fertilizer and water-use efficiency, which reduces production costs (Bar-Yosef, 1999; Solaimalai *et al*., 2005). In this context, fertigation, where water-soluble solid fertilizers or liquid fertilizers are applied through a drip irrigation system, can be a logical approach. Previous studies have reported significant fertilizer savings of 20-60% along with 8-41% increases in yields of horticultural and vegetable crops as a result of fertigation (Jucilene *et al*., 2009; Singh *et al*., 2010).

In addition, microbial consortia has a positive role in helping the plants through contain of microorganisms, which are capable of mobilizing nutrient elements from unavailable form to available form through different biological processes. Also, microbial consortia offer an economically attractive and ecologically sound means of reducing external inputs and improving quality and quantity of vegetable produce. The fertilization boosted the output of cruciferous vegetables like broccoli, according to many researchers who reported and approved this finding (Selim *et al*., 2009). Biofertilizers can serve as alternative to mineral fertilizers for improving soil structure and microbial biomass for sustainable increased production. Azotobacter and Phosphorus Solubilizing Bacteria (PSB) are the biofertilizers which nourish the crops and soil by liberating the growth promoting substances and vitamins. Azotobacter fixes atmospheric nitrogen in the root zone of the plants where as PSB solubilises unsoluble fixed phosphates already present in the soils. These biofertilizers are organic and thus absolutely safe and provide mechanical support, vigor and health to the seedlings. Therefore, the application of biofertilizers are economical, eco-friendly (pollution free) and are based on renewable energy sources and provide sustainability to the farming system.

Material and Methods

The present field experiment entitled, "Response of Broccoli (*Brassica oleracea* L. var. *italica*) to different fertigation levels and microbial consortia under drip irrigation and plastic mulch." was carried out at Instructional farm of Inter-Faculty Department of Irrigation Water Management, Post Graduate Institute,

Mahatma Phule Krishi Vidyapeeth, Rahuri during rabi season, 2022-23. Geographically, the Instructional Farm of Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri is situated between 190 47' and 190 57' North latitude and between 740 19' and 740 32' East longitude. The altitude is 495 to 569 m above from sea level. The soil of experimental field was well drained clay loam in texture and low in available nitrogen (185.10 kg ha^{-1}), medium in available phosphorus (17.80 kg ha^{-1}) and high in available potassium (365.45 kg ha^{-1}) content. The soil was slightly alkaline in reaction (pH 7.51) with 0.61% organic carbon. The electrical conductivity of soil was 0.33 dSm^{-1} at 24 °C. The field capacity and permanent wilting point was 38.11 and 19.90%, respectively. The bulk density of soil was 1.11 g cm^{-3}. Agro climatically the region located in scarcity zone of Maharashtra (drought prone area). The mean maximum temperature during experimentation period was ranging from 31.0°C to 36.6°C, while mean minimum temperature was ranging from 9.7 °C to 17.9 °C. The three main plot treatments comprised of three fertigation levels *viz*., F_1 : 50% RDF, F_2 : 75% RDF and F_3 : 100% RDF whereas sub plot treatments comprised of five microbial consortium *viz*., C_0 : Control, C_1 : MPKV Consortium (*Azotobacter* + PSB + KSB + *Trichoderma*), C_2 : VNMKV Biomix, C_3 : Arka microbial consortium, C_4 : IFFCO NPK Liquid Biofertilizer Consortium. Biofertigation of microbial consortium was done at transplanting, 15 DAT, 30 DAT and 45 DAT. The seedlings of broccoli, variety Saki was obtained from Vishwa Hightek Nursery, Virgaon, Akole. Dist. Ahmednagar. The transplanting of seedling was done at a spacing of 45-75 cm x 45 cm in paired row on 11th January 2023. Curds were harvested in four intervals according to treatment and physiological development. First harvesting was done on 19th March 2023, followed by 23th, 25th and 29th March 2023.

Results and Discussion

1. Yield characters : The data pertaining to yield parameters affected by different fertigation levels are presented in Table 1. The mean diameter of curd, weight of curd and curd yield (18.26 cm, 1845 g and 61.07 t ha^{-1}, respectively) of broccoli was obtained during investigation.

The yield attributing characters viz., diameter of curd (19.99 cm), weight of curd $plant^{-1}$ (2023 g), and total curd yield (74.62 t ha^{-1}) was maximum and significantly higher in application of fertigation at 100% RDF fertigation level. However, 75% RDF fertigation level was at par (18.82 cm, 1896 g, 69.38 t ha^{-1}) with it. Whereas the significantly minimum diameter of curd (15.97 cm), weight of curd $plant^{-1}$ (1626 g), and total curd yield (61.47 t ha^{-1}) were registered at 50% RDF fertigation level This could be due to a higher amount of nutrients being applied; the cell dividation increases and the cell elongation process accelerates, resulted in a increase in diameter of curd, weight of curd and curd yield. Due to application of all macro and micro nutrients in required quantity directly in the vicinity of root zone, they are easily available to plant. Then 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. Similar findings have been reported by Chand and Singh (2017), Singh *et al*. (2017), Biradar *et al*. (2018), Sohail *et al*. (2018) and Yanglem and Tumbare (2014), Chand *et al*. (2017).

Scheduling of biofertigation of microbial consortium of MPKV Consortium (*Azotobacter*

+ PSB + KSB + *Trichoderma*) obtained significantly higher yield attributing characters of broccoli *viz*., diameter of curd (23.06 cm) and weight of curd plant^{-1} (1983 g) and total curd yield (75.73 t ha^{-1}) was noticed due to scheduling of biofertigation of microbial consortium of MPKV Consortium (*Azotobacter* + PSB + KSB + *Trichoderma*). Whereas the significantly minimum diameter of curd (14.40 cm), weight of curd plant^{-1} (1677 g), and total curd yield (56.57 t ha^{-1}) were registered with control. This could be due to extended activities of microorganisms helps to make unavailable nutrients in available form, which met the crop's nutrient requirements, the vegetative growth and biomass production increased, resulting in a higher curd output. Significantly lower curd yield was observed with control. Significantly lower diameter of curd, weight of curd and curd yield was observed with control These findings are consistent with those reported by Pawde *et al*. (2019), Kumar *et al*. (2017) and Singh *et al*. (2014).

2. Economic Studies : The economics of broccoli was assessed in terms of gross monetary returns, cost of cultivation, net monetary returns and benefit cost ratio and presented in table 2. The mean gross monetary returns, cost of cultivation, net monetary returns and B:C ratio were (Rs. 3,80,947 ha^{-1}, Rs. 1,05,996, (Rs. 3,02,692 ha^{-1} and 3.83, respectively).

The data in respect of gross monetary returns, cost of cultivation, net monetary returns and benefit cost ratio was influenced significantly due to different fertigation levels. Application of fertigation with 100 % RDF fertigation level was obtained significantly higher gross monetary returns of (Rs. 4,01,160 ha^{-1}), cost of cultivation (Rs. 1,06,431 ha^{-1}), net monetary returns (Rs. 2,94,729 ha^{-1}) and B:C ratio (3.76). However,

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

Treatment	Yield attributing characters		
	Diameter of curd (cm)	Weight of curd plant^{-1} (g)	Total yield (t ha^{-1})
A. Fertigation Levels			
F_1 : 50% RDF	15.97	1626	61.47
F_2 : 75% RDF	18.82	1896	69.38
F_3 : 100% RDF	19.99	2023	74.62
S.Em.±	0.70	32.77	1.77
C.D. (P = 0.05)	2.76	128.69	6.94
B. Microbial Consortium			
C_0 : Control	14.40	1677	56.57
C_1 : MPKV Consortium (*Azotobacter* + PSB + KSB + *Trichoderma*)	23.06	1983	75.73
C_2 : VNMKV Biomix	18.92	1898	61.06
C_3 : Arka Microbial Consortium	17.97	1787	58.83
C_4 : IFFCO NPK Liquid Biofertilizer Consortium	16.96	1778	57.96
S.Em. ±	1.03	26.83	1.05
C.D. (P = 0.05)	3.00	78.31	3.06
C. Interaction			
A x B	N.S.	Sig.	Sig.
General mean	18.26	18.45	61.07

Table 2. 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
A. Fertigation Levels				
F_1 : 50 % RDF	105996	322720	216724	3.04
F_2 : 75 % RDF	106113	380773	274660	3.58
F_3 : 100 % RDF	106431	401160	294729	3.76
S.Em. ±	-	5192	5192	-
C.D. (P = 0.05)	-	20388	20388	-
B. Microbial Consortium				
C_0 : Control	105191	370867	265676	3.50
C_1 : MPKV Consortium (Azotobacter + PSB + KSB + Trichoderma)	106427	391200	284773	4.09
C_2 : VNMKV Biomix	106132	387533	281401	3.94
C_3 : Arka Microbial Consortium	105531	379200	273669	3.75
C_4 : IFFCO NPK Liquid Biofertilizer Consortium	104951	375933	270982	3.45
S.Em. ±	-	7954	7954	-
C.D. (P = 0.05)	-	23218	23218	-
C. Interaction				
A x B	-	Sig.	Sig.	Sig.
General mean	105996	380947	302692	3.83

the 75% RDF fertigation level was at par (Rs. 3,80,773, Rs. 1,06,113, Rs. 2,74,660 and 3.58) with it. Whereas the significantly minimum gross monetary returns of (Rs. 3,22,720 ha^{-1}), cost of cultivation (Rs. 1,05,996 ha^{-1}), net monetary returns (Rs. 2,16,724 ha^{-1}) and B:C ratio (3.04) were registered at 50% RDF fertigation level. Similar results were also reported by Doltra *et al*. (2006) and Brahma *et al*. (2005).

The biofertigation of MPKV Consortium (*Azotobacter* + PSB + KSB + *Trichoderma*) was found superior in terms gross monetary returns (Rs. 3,91,200 ha^{-1}), cost of cultivation (Rs. 1,06,427 ha^{-1}), net monetary returns (Rs. 2,84,773 ha^{-1}) and B:C ratio (4.09) than rest of biofertigation schedule. Whereas the significantly minimum gross monetary returns (Rs. 3,70,867 ha^{-1}), cost of cultivation (Rs. 1,05,191 ha^{-1}), net monetary returns (Rs. 2,65, 676 ha^{-1}) and B:C ratio (3.50) obtained with control. Similar results were also reported by Srichandan *et al*. (2015) and Lal *et al*. (2019).

Conclusion

It could be concluded that, application of fertigation at 75% RDF fertigation level coupled with biofertigation of MPKV Consortium (Azotobacter + PSB + KSB + Trichoderma) found suitable to broccoli for maximum yield attributes and economic returns.

References

Aires, A., Fernandes, C., Carvalho, R., Bennett, R. N., Saavedra, M. J. and Rosa, E. A. 2006. Seasonal effects on bioactive compounds and antioxidant capacity of six economically important Brassica vegetables. Molecules 16(8): 6816-6832.

Bar-Yosef, B. 1999. Advances in fertigation. Advances in Agronomy 65: 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

Hoticulturae 1227.1261.

Chand, P., Mukherjee, S. and Kumar, V. 2017. Effect of various levels of drip irrigation on growth and yield attributes of sprouting broccoli (*Brassica oleracea* var. *italica*) Cultivar Fiesta. International Journal of Pure and Applied Bioscience 5(4): 139-143.

Chand, T. and Singh, M. K. 2017. Effect of different does 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. 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.

Lal, S., Singh, S. P., Yadav, T. V. and Meena, A. K. 2015. Effect of bio-fertilizers and zinc on growth, yield and qualityof sprouting broccoli (*Brassica oleraceae* var. *italica*). Progressive Horticulture 47(1).

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.

Rangkadilok, N., Nicolas, M. E., Bennett, R. N., Premier, R. R., Eagling, D. R. and Taylor, P. W. 2000. Determination of sinigrin and glucoraphanin in Brassica species using a simple extraction method combined with ion-pair HPLC analysis. Scientia Horticulturae 96(14): 27-41.

Roe, N. E. 1998. Compost utilization for vegetable and fruit crops. Horticultural Science 33(6): 934-944.

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.

Silber, A. 2008. High frequency irrigations as means for enhancement of nutrient use effiency- soilless grown bell pepper as a model plant. Acta Horticulturae, International Society for Horticultural Science 779: 281-288.

Singh, A., Sharma, S.K. and Chopra, R. 2017. Effect of drip fertigation scheduling on yield and economics of cauliflower (*Brassica oleracea* var. *botrytis*) and chili (*Capsicum annum* L.). Annuals of Plant and Soil Research 19(2): 137-142.

Singh, B., Pathak, K., Boopathi, T., and Deka, B. 2014. 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(77).

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: 1-33.

Srichandan, S., Mangaraj, A., Behera, K. K., Panda, A. K., Das and Rout, M. 2015. Growth, yield and economics of broccoli (*Brassica oleracea* var. *italica*) as influenced by organic and inorganic nutrients. International Journal of Agriculture, Environment and Biotechnology 8(4): 965-970.

Srivastava, S. 2005. Crop coefficients and water quality for watermelon and bell pepper under drip and seepage irrigation. Meng thesis 12(3): 34-58.

Talalay, P. and Fahey, J. W. 2001. Phytochemicals from Cruciferous plants protect against cancer by modulating carcinogen metabolism. Journal of Nutrition 13(1): 3027-3033.

Yanglem, S. D. and Tumbare, A. D. 2014. Influence of irrigation regimes and fertigation levels on yield and physiological parameters in cauliflower. The Bioscan. 9(2): 589-594.