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Effect of fertilizers, biofertilizers and micronutrients on yield and quality of brinjal (*Solanum melongena* L.) in Alfisols of Konkan

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Abstract
The field experiment was laid out in Factorial Randomized Block Design during *rabi* season of 2017-18 at Research Farm of the Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri Maharashtra. The four levels of N and P application viz. F_1- RDF (150:50:50 Kg NPK ha^{-1}), F_2-75% RDN + Full dose of P & K + N-Fixer (*Azotobacter chroococcum)*, F_3-75% RDP + Full dose of N & K +P-Solublizer (*Aspergillus niger*) and F_4-75% RDN+ 75% RDP+ Full dose of K+ N-Fixer + P-Solubilizer were added as a factor-1 and four foliar applications of micronutrients as a factor-2 replicated thrice. Foliar application of micronutrients S_1- Control (Water Spray), S_2- Foliar spray of Zinc ($ZnSO_4$@0.5%) and S_3- Foliar spray of Boron (Borax @0.2%) and S_4- Foliar spray of Zinc and Boron ($ZnSO_4$@0.5%) + (Borax @0.2%)Soil application of fertilizers and bio fertilizers with foliar spray of zinc and boron was showed significant result with respect to yield. The treatment receiving F_4S_4 (75% RDN+ 75% RDP+ Full dose of K+ N-Fixer + P-Solubilizer and foliar spray of $ZnSO_4$@ 0.5% + Borax @0.2%) showed highest yield (27.21 t ha^{-1}) which was found significantly superior over rest of the treatments except F_4S_3 treatment combination. Interaction effect of application of fertilizers along with biofertilizers and foliar spray of micronutrients found highest anthocyanin content (14.83 mg $100g^{-1}$) and total phenol content (24.95 mg $100g^{-1}$) of brinjal fruit significantly increased due to application of 75% RDN + Full dose of P & K + N-Fixer and foliar spray of Zinc and Boron.

Keywords: Fertilizers, biofertilizers and micronutrients, yield, brinjal, *Solanum melongena* L.

Introduction
Brinjal (*Solanum melongena* L.) belongs to family solanaceace, which of Indian origin. It is one of the common and popular vegetable crops grown and is occupying a pride of place in every day food of all people. It is an economically important vegetable crop in tropics and subtropics. Brinjal is perennial but cultivated on commercial level as an annual crop. Plant is herbaceous, annual with erect or semi-spreading in nature. The fruits have high nutritive value and a good source of vitamins and iron. Brinjal is quite rich in certain nutrients which include Carbohydrates (4.0%), Protein (2.0%), fat (1.0%), Vitamin C (3.5%), Vitamin K (3.0%), Calcium (1.0%), Copper (9%), iron (3.0%), manganese (11.0%) and Zinc (1.0%). (Anonymous, USDA National Nutrient data base). In our country, brinjal cultivation shares the total production of about 8%. In India, brinjal is cultivated on an area of 662.5 thousand hectare with total production of 12,515.2 thousand MT and average productivity is 18.9 MT ha^{-1}. While in Maharashtra, it is cultivated on an area of 21,090 hectare with total production 407,640 MT and productivity is 19.33 MT ha^{-1} in 2015-16 (Anonymous, 2017) [2]. In recent years chemical fertilizers have played a significant role in providing nutrients for intensive crop production. But increased use of chemical fertilizers in an imbalanced manner has created problem of multiple nutrient deficiencies, diminishing soil fertility with decreased crop yields and uneconomic returns.

Nowadays, there is essentiality of integrated production and protection technology for enhancing the quality as well as production of crops and to reduce the cost of production. So along with high production of crops, good quality is also required to fetch high price and to ensure the supply of crops. The yearly application of organic manures and biofertilizers in conjunction with NPK fertilizers has a pronounced effect in enhancing the efficiency of chemical fertilizers. This has also led to improve crop productivity by 16 – 44 percent in various soil groups (Thakur *et al*. 2012) [13].

To overcome the deficit in nutrient supply and to overcome the adverse effects of fertilizers it is suggested that the efforts should be made to exploit all the available resources of nutrients under the theme of integrated nutrient management. Under this approach the best available option lies in the complementary use of bio fertilizers and/ or organic manures in suitable combinations with chemical fertilizers. The integrated approach of nutrient management ensures the good soil quality. Bio fertilizers are efficient, eco-friendly, environmentally safe, cost effective, economically viable and ecologically sound. Bio fertilizers are essential component of this approach which is being promoted to harvest the naturally available biological system of nutrient mobilization. Besides the major nutrients and biofertilizers, micronutrients also have a good role in plant growth. Micronutrients like Iron, Zinc and Boron are necessary for plant development and metabolism. Hence, their foliar sprays of micronutrients facilitate efficiency consumption of nutrients straight through leaves, the effect of which can show its importance soon (Tawab *et al.* 2015). The fertilizers not only in short supply, but they are expensive in developing countries like India. Morever, continuous use of chemical fertilizers affects the soil health and lead to the environmental hazards. Therefore by using the biofertilizers to supplement part of the nutrient need of the plant, but also the environmental hazards associated with chemical fertilizers can be avoided. Our intention of using biofertilizers is to achieve the objective of higher productivity and better use efficiency of fertilizers to reduce the cost of fertilizers and sustain the health of soil and productivity of brinjal (*Solanum melongena* L.).

Material and Methods

The experiment was conducted in the Department of Agronomy, at the College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra) during *rabi* season (2017-18). Brinjal (Swarna Pratibha) was taken as a test crop for experiment. The field experiment was laid out in factorial randomized block design (FRBD) comprising of sixteen treatment combinations replicated thrice.

Treatment Details

Factor I : Levels of Fertilizers and Biofertilizers (F)		
F_1	:	RDF(150:50:50 Kg NPK ha^{-1})
F_2	:	75% RDN + Full dose of P & K + N-Fixer (*Azotobacter chroococcum)*
F_3	:	75% RDP + Full dose of N & K +P-Solublizer (*Aspergillus niger*)
F_4	:	75% RDN+ 75% RDP+ Full dose of K+ N-Fixer + P-Solubilizer
Factor II : Micronutrient Sprays (S)		
S_1	:	Control (Water Spray)
S_2	:	Foliar spray of Zinc ($ZnSO_4$@0.5%)
S_3	:	Foliar spray of Boron (Borax @0.2%)
S_4	:	Foliar spray of Zinc and Boron ($ZnSO_4$@0.5%) + (Borax @ 0.2%)

FYM were applied 15 days before transplanting of the crop in single dose. Similarly, treatment wise fertilizers were applied in respective treatments. Nitrogen was applied in three splits, 50% N was applied as basal while 25% N was applied thirty days after transplanting of a crop and 25% N was applied 60 days after transplanting. The phosphorus and potassium were applied as basal dose before transplanting of a crop. The cultures of *Azotobacter chroococcum* and *Aspergillus niger* were prepared separately in water @ 250 g / 3 liter each and one was prepared by mixing both cultures in water @ 250 g / 3 liter. The brinjal seedlings (root dipping) were dipped for a period of 30 minutes in the slurry and then used for transplanting according to the respective treatment. The foliar applications of micronutrients i.e. zinc and boron was sprayed @ concentrations of 0.5% and 0.2% respectively. Sprays were taken up at 30 and 60 days after transplanting.

The various pre and post cultural operations were carried out as per the recommended package of practices given by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for brinjal. Harvesting of brinjal fruits was carried out as per harvesting indices. Full grown but tender fruits were harvested at an interval of 7 days between each picking. The mature brinjal fruits were collected after each picking and weighed immediately from each plot. Sum of weight of brinjal fruits after all pickings were recorded and expressed as yield of brinjal in Kg per net plot. In addition to this brinjal yield in t ha^{-1} was also calculated. Fruit samples were collected and analyzed for different quality parameters by following the standard analytical methods. The fruit samples were analyzed for phenol by Follin-ciocalteau reagent method (Sadasivam and Manickam, 1996) [11] and Anthocyanin by Ethanolic HCl method (Ranganna, 1986). The data have been subjected to appropriate method of statistical analysis as described by Panse and Sukhatme (1967).

Result and Discussion

Effect of fertilizers, biofertilizers and micronutrients on yield of brinjal

The data pertaining to the effect of fertilizers with and without bio fertilizers and foliar spray of micronutrients on fruit yield of brinjal is presented in Table 1 and Fig.1

Data revealed that the highest fruit yield (25.92 t ha^{-1}) were recorded by the treatment F_4 receiving 75% recommended dose of nitrogen plus 75% recommended dose of phosphorous with full dose of potassium and inoculation of biofertilizers nitrogen fixer and phosphorus solubilizer which was found significantly superior over rest of the treatments. However minimum yield (14.94 t ha^{-1}) was registered in the treatment F_1 receiving recommended dose of fertilizer.

Table 1: Effect of fertilizers, biofertilizers and micronutrients on yield (t ha^{-1}) at harvest.

F \ S	Yield (t ha^{-1})				
	S_1	**S_2**	**S_3**	**S_4**	**Mean**
F_1	13.23	14.03	15.95	16.55	14.94
F_2	16.98	17.92	18.51	18.74	18.04
F_3	20.73	20.63	23.56	22.90	21.96
F_4	24.58	25.42	26.44	27.21	25.92
Mean	18.89	19.51	21.12	21.35	20.22
	F		S		F × S
S.E. (m) ±	0.157		0.157		0.314
C.D.(P=0.05)	0.453		0.453		0.905

With respect to foliar spray of micronutrient, it was observed that the maximum yield of brinjal fruits (21.35 t ha^{-1}) were obtained in the S_4 treatment receiving $ZnSO_4$ @0.5% + Borax @ 0.2% foliar application which was found at par with treatment S_3 in which 0.5% $ZnSO_4$ was applied. The interaction effect between soil application of fertilizers and bio fertilizers with foliar spray of zinc and boron was also showed significant result with respect to yield of brinjal fruits. It was observed that the treatment receiving F_4S_4 (75% RDN+

75% RDP+ Full dose of K+ N-Fixer + P-Solubilizer and foliar spray of $ZnSO_4$ @ 0.5% + Borax @0.2% showed highest yield (27.21 t ha^{-1}) which was found significantly superior over rest of the treatments except F_4S_3 treatment combination.

From the foregoing result and discussion on the yield of brinjal, it is concluded that the use of lower level of fertilizers and inoculation of nitrogenous and phosphatic biofertilizers with foliar spray of micronutrient Zn and B exhibited favorable effect on the yield of brinjal. The reason for obtaining higher yield of fruits is beneficial interaction between major nutrients with biofertilizers and foliar spray of Zn and B. The possible reasons for increased yield per plant could be attributed to the increase in the vegetative growth, better performance of yield attributes which might have promoted greater yield (Mujawar, 2012) [8]. Similar results were also obtained by Anburani and Manivannan (2002), Aryal (2016) [1], Natesh *et al.*, (2005) [10], Naidu *et al.* (2002) [9] and Shahi *et al.* (2002) [12].

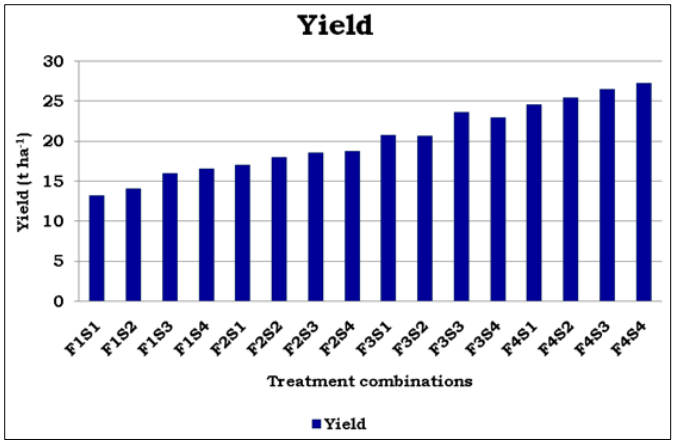

Fig 1: Effect of fertilizers, biofertilizers and micronutrients on Yield of brinjal Effect of fertilizers, biofertilizers and micronutrients on quality parameters

Anthocyanin content

The data pertaining to the effect of fertilizers with and without bio fertilizers and foliar spray micronutrients on anthocyanin content in brinjal fruits is presented in Table 2 and Fig. 2

Table 2: Effect of fertilizers, biofertilizers and micronutrients on anthocyanin content of the fruits at harvest

F \ S	Anthocyanin (mg 100g^{-1})				
	S_1	S_2	S_3	S_4	Mean
F_1	12.93	14.19	12.27	13.58	13.24
F_2	13.82	12.29	14.47	14.83	13.85
F_3	12.88	13.05	13.60	13.51	13.26
F_4	13.63	12.99	14.67	14.77	14.00
Mean	13.32	13.13	13.74	14.17	13.59
	F	S	F × S		
S.E. (m) ±	0.068	0.068	0.136		
C.D.(P=0.05)	0.196	0.196	0.393		

From the data it is seen that application of fertilizers with bio fertilizers recorded highest anthocyanin content (14.00 mg 100g^{-1}) of brinjal fruit significantly increased due to application of 75% of RDN and 75% RDP along with combination of N fixer and P-solubilizer over rest of the treatment which was also found at par with F_2. In case of foliar spray of micronutrients recorded highest anthocyanin content (14.17 mg 100 g^{-1}) of brinjal fruit significantly increase due to foliar spray of $ZnSO_4$ @0.5% and Borax @0.2% over rest of the treatments.

Interaction effect of application of fertilizers along with bio fertilizers and foliar spray of micronutrients found highest anthocyanin content (14.83 mg 100g^{-1}) of brinjal fruit significantly increased due to application of 75% RDN + Full dose of P & K + N-Fixer and foliar spray of Zinc and Boron which was also found at par with F_2S_3, F_4S_3 and F_4S_4. Similar findings i.e. decreasing levels of phosphorus result in increasing amounts of anthocyanin content have been reported by Marie *et al.* (2008) [6].

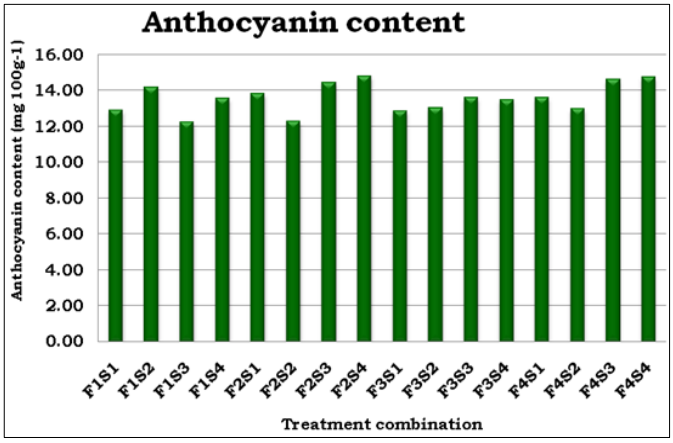

Fig 2: Effect of fertilizers, biofertilizers and micronutrients on anthocyanin content of the fruits at harvest

The significant increase in anthocyanin content in the brinjal fruits as a result of the different treatment combinations might be attributed to the application of fertilizers with bioferilizers to the crop. Potash plays important role in activation of several enzymes which promotes the anthocyanin pigmentation (Tisdale *et al.*, 1993) [14]. Similar, findings were also reported by Mohan (2016) [17], Kadlag *et al.* (2007) [4] Tripathi *et al.* (2014) [15].

Total phenol content

The data pertaining to the effect of fertilizers with and without bio fertilizers and foliar spray micronutrients on total phenol content in brinjal fruits is presented in Table 3 and Fig. 3.

From the data it is seen that application of fertilizers with bio fertilizers recorded highest total phenol content (19.59 mg 100g^{-1}) of brinjal fruit significantly increased due to application of 75% of RDN and 75% RDP along with combination of N fixer and P-solubilizer over rest of the treatment. In case of foliar spray of micronutrients recorded highest total phenol content (23.75 mg 100g^{-1}) of brinjal fruit significantly increase due to foliar spray of $ZnSO_4$@0.5% and Borax @0.2% over rest of the treatments.

Table 3: Effect of fertilizers, biofertilizers and micronutrients on total phenol content of the fruits at harvest

F \ S	Total phenols (mg 100g^{-1})				
	S_1	S_2	S_3	S_4	Mean
F_1	11.73	20.29	14.07	23.32	17.35
F_2	15.46	18.46	16.72	22.02	18.17
F_3	11.49	18.97	14.59	24.71	17.44
F_4	14.61	20.04	18.73	24.95	19.59
Mean	13.33	19.44	16.03	23.75	18.14
	F	S	F × S		
S.E. (m) ±	0.264	0.264	0.528		
C.D.(P=0.05)	0.763	0.763	1.525		

Interaction effect of application of fertilizers along with bio fertilizers and foliar spray of micronutrients found highest total phenol content (24.95 mg $100g^{-1}$) of brinjal fruit significantly increased due to application of 75% RDN and 75% RDP along with combination of N-Fixer and P-solubilizer and foliar spray of Zinc and Boron which was also found at par with F_3S_4. Similar findings have been reported by Tripathi *et al.* (2014) [15] and Judita *et al.* (2015).

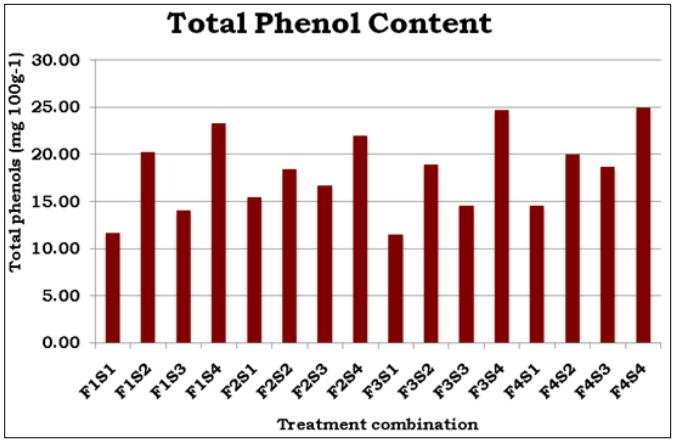

Fig 3: Effect of fertilizers, biofertilizers and micronutrients on

Total phenol content of the fruits at harvest

Higher total phenol was increased in the combination of fertilizers and foliar spray of micronutrients. It might be due to physiological influence of organic and inorganic sources of nutrients on the activity of number of enzymes. It might be also due to more energy and food material available to the brinjal fruit as a result of the vegetative growth (Mujawar, 2012) [8]. Similar findings were also reported by Latha *et al.* (2014) [5]. Uthumporn *et al.* (2016) [16].

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