Research Article

Effect of Bio-fertilizers on Growth, Yield and Quality of Brinjal (*Solanum melongena* L.) cv. Kashi Uttam

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Abstract

The present experiment was carried out during September 2017 to April 2018 at Main Experimental Field, Department of Horticulture, SHUATS, Prayagraj, (U.P.) - 211007. The experiment was conducted in Randomized Block Design (RBD), with ten treatments and each replicated thrice. The treatments were T_0 (Control (RDF)), T_1 (RDF + VAM @ 100%), T_2 (RDF + PSB @ 100%), T_3 (RDF + AZ @ 100%), T_4 (RDF + VAM @ 50% + AZ @ 50%), T_5 (RDF + VAM @ 50% +PSB @ 50%), T_6 (RDF + PSB @ 50% + AZ @ 50%), T_7 (RDF + VAM @ 50% + PSB @ 25% AZ @ 25%), T_8 (RDF + VAM @ 25% + PSB @ 25% + AZ @ 50%) and T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%). The observations were recorded on growth, yield and quality traits of Brinjal and subjected to statistical analysis. From the present investigation it is found that the treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) is proved as a best combination of biofertilizers along with inorganic fertilizer for the improvement of Brinjal cultivation through organically; where treatment T_9 significantly enhances the growth, yield and quality traits of Brinjal and also recorded maximum Benefit per ha.

Keywords: Brinjal, Biofertilizers, Vermicompost, PSB and Azolla

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Introduction

Vegetables are the important components in the diet of Indian people as majority of the Indians are vegetarian. Vegetables are the rich source of carbohydrates, protein, vitamins, minerals, fat, crude fiber and elemental salts. Besides, vegetables also enhance the test, colour and texture of the diet. India occupies prime position in the world in production of vegetable crops ranking 2nd next to China and producing about 162.89 million tones from an area of 9.72 million hectares [1]. However, it is not sufficient to meet the requirement of the present population. India will require about 160 million tones of vegetables annually by the year 2020 AD**.** [2]. Among vegetables, brinjal is one of the most common and principle vegetable grown in India and other parts of the world, however, higher altitudes are not suitable for its cultivation. There are a large number of cultivars which are being grown throughout the country depending upon yield and consumers preference. It belongs to the family "Solanaceae" and botanically it is also known as (*Solanum melongena* L.), some other names are Eggplant and Aubergine etc.

The brinjal is much more important in the warm areas, being grown extensively in India, Bangladesh, Pakistan, China, Philippines. Besides, France, Italy and United State are popular country for its cultivation. Brinjal is also famous as a poor man's crop because it finds the place among the vegetables, where higher production of vegetables is an important observation. The brinjal is staple vegetable in almost all tropical countries in the world and liked by both poor and rich consumers. Since there is a common belief that brinjal is not much valuable vegetable for health. However, it is quite high in nutritive value and can be compared with tomato [3].

Generally, solanaceous vegetables require large quantity of major nutrients like nitrogen, phosphorus and potassium, in addition to secondary nutrients such as calcium and sulphur for better growth, fruit and seed yield. The cost of inorganic fertilizer has been enormously increasing to an extent that they are out of reach of the small and marginal farmers and also it is continuously harming the ecological niche. The use of biofertilizers in such situation is therefore a practically paying proposal. Biological activity in soil is an important index of soil fertility which can be improved by the application of biofertilizers [4]. A Bio-fertilizer (also bio-fertilizer) is a substance which contains living microorganisms which, when applied to seeds, plant surfaces, or soil. Such bio-fertilizer that can be used in horticultural crops is Azospirillum, mycorrhizae fungi and phosphate solubilizer.

Vesicular arbuscular mycorrhiza (VAM) forms symbiotic relation with 83% of the dicotyledones and 79% of the monocotyledons; only a few field crops are not able to accept mycorrhizal symbiosis [5]. Mycorrhiza fungi are also helpful to improve soil texture, water holding capacity, biological control of root pathogens, resistance to biotic and abiotic stress, help in better plant growth and increase fruit production. They also improve uptake of minor elements, produce plant hormone and increase the activity of nitrogen- fixing organisms in root zone.

Phosphate solubilizing bacteria (PSB) are a group of beneficial bacteria capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds. It is generally accepted that the mechanism of mineral phosphate solubilisation by PSB strains is associated with the release of low molecular weight organic acids. Azospirillum is one of very well-studied plant growth-promoting rhizobacteria, at lab scale to field. It is a heterotrophic nitrogen fixing organism, has been reported to be beneficial and economical on several crops. They improve growth, yield, quality as well as productivity of crops.

Materials and Methods

The details of the various materials used and methods adopted to lay out the experiment are presented below:

Experimental site

The experiment was carried out at Main Experimental Field, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The area of Allahabad district comes under subtropical belt in the South East of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46^{o}C – 48^{o}C and seldom falls as low as 4^{o}C – 5^{o}C. The relative humidity ranged between 20 – 94 percent. The average rainfall in this area is around 1013.4mm annually. However, occasional precipitation is also not uncommon during winter months.

Experimental details

The brinjal crop with Kashi Uttam variety was grown in Randomized Block Design with 10 treatments and each replicated thrice. Treatment details were T_0 (Control - RDF), T_1 (RDF + VAM @ 100%), T_2 (RDF + PSB @ 100%), T_3 (RDF + AZ @ 100%), T_4 (RDF + VAM @ 50% + AZ @ 50%), T_5 (RDF + VAM @ 50% +PSB @ 50%), T_6 (RDF + PSB @ 50% + AZ @ 50%), T_7 (RDF + VAM @ 50% + PSB @ 25% AZ @ 25%), T_8 (RDF + VAM @ 25% + PSB @ 25% + AZ @ 50%), T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%). Each plot comprised of 4m^2 with a spacing of 60cm row to row and 60cm plant to plant and each treatment carrying 9 plants per plot. The observations were recorded on vegetative growth, yield and quality parameters of brinjal as Plant height (cm), Plant spread (cm^2), Number of branches per plant, Days to first flowering, First fruit initiation (days), Fruit length (cm), Fruit width (cm), Total no. of fruits per plant, Average fruit weight (gm), Yield per plant (g), Yield per plot (Kg.), Yield per hectare (q/ha), TSS (ºBrix) and Ascorbic acid (mg/100g fruit pulp). Total soluble solids (TSS) were recorded with the help of hand refractometer. The data were collected from five randomly selected plants of each treatment and analysis of variance technique was used to analyse the recorded data followed the procedure of [6].

Ascorbic acid content was estimated by grinding 5 gram fruit pulp with 30 per cent metaphosphoric acid as buffer. The extract was filtered with muslin cloth and appropriate volume was made. A suitable aliquot was titrated against 2-6. dichlorophenol dye solution till light pink colour appeared. The result were calculated with help of following formula and expressed as milligram ascorbic acid per 100 gram of fruit pulp [7].

$$\text{Ascorbic acid} = \frac{\text{Titer value} \times \text{dye factor} \times \text{volume made up} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{volume of sample taken for estimation}}$$

Results and Discussion

The present investigation entitled ‘Effect of bio-fertilizers on growth, yield and quality of brinjal (*Solanum melongena* L.) cv. Kashi Uttam’ was carried out during September, 2017 to April, 2018 at Main Experimental Field, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.) India. The results of the present investigation have been discussed and interpreted in the light of previous research work done in India and abroad. The results of the experiment are summarized below:

Growth Parameters

At 30 days after transplanting the maximum plant height was recorded in T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) which is (26.33cm) followed by T_8 and T_6 which were at par to each other while the minimum plant height was recorded in the treatment T_0 (RDF (120:60:60 NPK) is (18.14 cm). At 60 days after transplanting the maximum plant height was recorded statistically significant in T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) is (38.04cm) which was par with T_8 and T_7 while the minimum plant height was recorded in the treatment T_0 (RDF (120:60:60 NPK) which is (28.07cm). At 90 days after transplanting the maximum plant height was recorded statistically significant in T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) which is (52.89cm) which is at par with T_8 and T_7 while the minimum plant height was recorded in T_0 (RDF (120:60:60 NPK) which is (41.00cm) as presented in table 1. This might be due to fact that RDF + VAM @ 25% + PSB @ 50% + AZ @ 25% act as a nutrilink to plants, increases hormonal, nutritional condition and contributed to a considerable extent for better plant height. Similar results were reported by Kiran [8]; Solanki [9] and Doifode [10].

Plant spread was maximum in T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) (67.51cm^2) followed by T_8 and T_7 while the minimum is found in T_0 (RDF + (120:60:60 NPK) which is (56.47cm^2). Similar results were also reported by Devi [11]. While Number of Branches was found maximum in treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) with (4.10) followed by T_1 and T_8, while the minimum is found in T_0 (RDF + (120:60:60 NPK) which is (3.04) as shown in table 1. This might be due to fact that RDF + VAM @ 25% + PSB @ 50% + AZ @ 25% enhanced the microbial activity into the soil and supplied required nutrient demand of plants to contribute considerable extent for Better plant spread and more Branches. Similar results were also reported by Anburani [12] and Solanki [9].

The data mentioned in table 1 showed that Days to first flowering is recorded minimum in Treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) with (41.11days), which positively resulted in earlier initiation of first fruit (50.60days) followed by T_7 and T_5 while the maximum is found in T_0 (RDF + (120:60:60 NPK) which is (49.45days) and (58.20days) respectively. This might be due to fact that RDF + VAM @ 25% + PSB @ 50% + AZ @ 25% act as a nutrilink to plants and increases hormonal, nutritional condition and contribute considerable extent for earliness in flowering and fruiting as reported by Devi [11].

Fruit Length and Fruit width was recorded maximum in treatment T_8 (RDF + VAM @ 25% + PSB @ 25% + AZ @ 50%) which is (9.40cm) and (10.50cm) respectively as presented in table 1, and significantly superior over all other treatments. The next better treatment for fruit length is followed in T_5 and T_9, while for fruit width followed by treatment T_9 and T_7. The statistically lowest fruit length was observed in the treatment T_1 (RDF + VAM @ 100%) (6.90cm) and lowest fruit width in T_0 (RDF + (120:60:60 NPK) (8.10cm). Fruit development is highly affected by auxin formation in the growing seeds and other parts of the fruit to supply food reserves in order to increase fruit development. Moreover, microorganisms that produce auxin are VAM and Azosprillium sp. as microbe, which attaches nitrogen and plays as growth regulator. These results are in close conformity with Gargi [13] and Yadav [14].

Yield Parameters

Total number of fruits per plant as presented in table 1, found maximum in treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) with (23.98) number of fruits, followed by treatment T_3 and T_5 which is which is significantly superior over all the treatments. The statistically lowest total number of fruit per plant is observed in Treatment T_2 (RDF + PSB @ 100%) which is (16.20). Fruit development is highly affected by auxin formation in the growing seeds and other parts of the fruit to supply food reserves in order to increase fruit development. Moreover, microorganisms that produce auxin are VAM and Azosprillium sp. as microbe, which attaches nitrogen and plays as growth regulator. Similar results were reported by Suryanto [15]; Nanthankumar [16] and Kiran [8].

The data regarding yield parameters are presented in table 2. The maximum average Fruit weight was recorded in treatment T_4 (RDF + VAM @ 50% +AZ @ 50%) with (237.62g) average fruit weight followed by T_8 and T_7 which is significantly superior over all other treatments. The statistically lowest average fruit weight is observed in Treatment T_0 (RDF) which is (181.45g). Furthermore, the application of biofertilizer may increase fresh weight of eggplant 50.32 %. It was due to the content level of nitrogen, phosphor, and potassium in RDF + VAM @ 50% +AZ @ 50% have higher nutrients than other treatments. Similar results were reported by Kumaran [17]; Suryanto [15] and Solanki [9].

Fruit yield/plant and yield/plot (kg) was found maximum in treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) which is (3.74kg) and (10.43kg) followed by treatment T_5 which is significantly superior over all other treatments. The statistically lowest fruit yield/plant and yield/plot was recorded in Treatment T_0 (RDF) which is (2.52kg) and (7.29kg). Mirzakhani [18] mentioned that the nitrogen availability in soil would be improved by

azospirillum, which might have increased the yield. Similar results were recorded by Muhammad [19] and Doifode [10] in brinjal.

Yield/hectare was recorded maximum in treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) which is (234.68q/ha) followed by treatment T_5 and T_7 and the lowest fruit yield per hectare is found in treatment T_0 (RDF) which is (104.03q/ha). The above result corroborates with Devi [11]; Choudhury [20] and Kiran [8], who recorded maximum yield with phosphorous solubalizing bacteria (PSB) and Azotobacter application.

Table 1 Effect of Bio-fertilizers on Plant height (cm), Plant Spread (cm^2), Number of branches/plant, Days to first fruit initiation, Days to first flowering, Length and width of Fruit (cm) and Number of Fruits/Plant of Brinjal.

Treatment Symbol	Treatment Details	Plant Height (cm)			Plant spread (cm^2)	Number of branches per plant	Days to first fruit initiation	Days to first flowering	Length of fruit (cm)	Width of fruit (cm)	Number of fruit/ plant
		30 DAS	60 DAS	90 DAS							
T_0	RDF (120:60:60 NPK)	18.14	28.07	41.00	56.47	3.04	58.20	49.45	7.50	8.10	17.34
T_1	RDF + VAM @ 100%	21.09	30.12	43.41	59.54	3.80	55.09	48.00	6.90	8.70	17.86
T_2	RDF + PSB @ 100%	22.14	30.86	46.97	58.32	3.21	54.51	46.05	7.10	8.60	16.20
T_3	RDF + AZ @ 100%	19.96	29.24	45.09	57.05	3.43	57.01	47.66	8.20	8.90	22.68
T_4	RDF + VAM @ 50% + AZ @ 50%	22.70	32.45	46.14	60.08	3.26	53.00	43.00	8.50	8.50	21.12
T_5	RDF + VAM @ 50% +PSB @ 50%	23.63	33.34	44.25	61.63	3.11	54.33	42.87	9.10	9.60	21.28
T_6	RDF + PSB @ 50% + AZ @ 50%	24.10	31.47	47.07	60.78	3.68	52.70	45.30	7.80	9.40	18.80
T_7	RDF + VAM @ 50% + PSB @ 25% AZ @ 25%	20.67	34.03	48.54	62.17	3.54	51.12	41.90	7.00	9.70	18.90
T_8	RDF + VAM @ 25% + PSB @ 25% + AZ @ 50%	25.08	36.21	50.01	65.06	3.71	50.89	44.50	9.40	10.50	17.29
T_9	RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%	26.33	38.04	52.89	67.51	4.10	50.60	41.11	8.70	10.10	23.98
F- test		S	S	S	S	S	S	S	S	S	S
C. D. at 5 %		3.30	4.75	5.63	5.81	0.50	4.51	5.06	1.19	1.35	2.91
S. Ed. (±)		1.57	2.26	2.68	2.77	0.24	2.51	2.41	0.56	0.64	1.38

Quality parameters

In terms of Total Soluble Solids (^{o}Brix) was recorded maximum in treatments T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) with (8.83^{o}Brix) which is statistically at par with treatment T_8 and T_4 which is significantly superior over the other treatment. The lowest TSS of fruit was observed in the treatment T_0 (RDF (120:60:60 NPK) which is (5.23 ^{o}Brix) as shown in table 2. Total soluble solids (T.S.S.), quality of solids, dissolved in the liquid part of brinjal were observed to be increased after treatment with Azospirillum. These findings are in close conformity with Solanki [9] and Mishra [21].

Ascorbic acid (mg/100 g) was also recorded maximum in treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) with (15.01mg) which is superior over the other treatments (table 2) like T_4 (14.02mg) and T_3 (13.51mg). The lowest Ascorbic acid found in T_0 (RDF (120:60:60 NPK) which is (11.36mg) as compared to others treatments. These findings are supported by Muhammad [19], Anburani [22] and Unlu [23] who suggested that both bio fertilizers application and humic acid affect the concentration of vitamin C and the amount of antioxidative compounds in solanaceous crops.

Economics

Maximum gross returns, Net Return and Cost Benefit Ratio Rs. 469360.00/ha, Rs. 123680.00/ha and (1:3.69) respectively was recorded in treatment T_9 with RDF + VAM @ 25% + PSB @ 50% + AZ @ 25% and the minimum Gross Return, Net Return and Cost Benefit Ratio (Rs. 208640.00/ha, Rs. 342275.00/ha and 1:2.46) respectively was recorded in treatment T_0 (Control) as presented in table 2. As the economics is the need of the farmers while taking

decision regarding the adoption of the techniques and scientific knowledge Hence, T_9 with RDF + VAM @ 25% + PSB @ 50% + AZ @ 25% gave the highest gross return, net return, and cost benefit is due to higher productivity and enhanced fruit quality, which increase the market value of the fruits. Similar findings were reported by Sharma [24] and Mishra [25] in different crops. The beneficial use of nitrogen fixing microorganism's viz., Azotobacter and phosphate solublizing bacteria (PSBs), as a supplementary source of plant nutrition on agricultural crops is well documented [26]. These non-conventional sources of fertilizers are not only cost effective but simultaneously boost up the productivity of field crops [27].

Table 2 Effect of Bio-fertilizers on Average fruit weight (g), Fruit yield/plant (kg), Fruit Yield/Plot (kg), Fruit Yield q/ha, TSS (^{o}Brix), Ascorbic acid (mg/100 g) and Benefit Cost Ratio of Brinjal.

Treatment Symbol	Treatment Details	Average fruit weight (g)	Fruit yield/ plant (kg)	Fruit yield per plot (kg)	Fruit yield q/ha	TSS (^{o}Brix)	Ascorbic acid (mg/100gm)	Benefit cost ratio
T_0	RDF (120:60:60 NPK)	181.45	2.52	7.29	104.03	5.23	11.36	1:2.46
T_1	RDF + VAM @ 100%	203.84	2.91	9.12	205.20	6.62	11.57	1:3.67
T_2	RDF + PSB @ 100%	209.88	2.72	8.93	200.93	7.11	12.68	1:2.93
T_3	RDF + AZ @ 100%	195.65	3.55	8.17	183.83	5.38	13.51	1:3.08
T_4	RDF + VAM @ 50% + AZ @ 50%	237.62	3.51	8.65	194.63	8.08	14.02	1:3.32
T_5	RDF + VAM @ 50% +PSB @ 50%	212.97	3.63	10.02	225.45	6.13	12.41	1:3.62
T_6	RDF + PSB @ 50% + AZ @ 50%	208.32	3.13	9.08	205.63	6.66	12.11	1:3.17
T_7	RDF + VAM @ 50% + PSB @ 25% AZ @ 25%	231.12	3.49	9.40	211.50	7.54	11.68	1:3.50
T_8	RDF + VAM @ 25% + PSB @ 25% + AZ @ 50%	236.90	3.28	7.93	178.43	8.25	13.22	1:2.89
T_9	RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%	194.97	3.74	10.43	234.68	8.83	15.01	1:3.69
F- test		S	S	S	S	S	S	
C. D. at 5 %		30.76	0.49	1.32	8.55	1.02	1.86	
S. Ed. (±)		14.64	0.23	0.63	4.07	0.49	0.89	

Conclusion

On the basis of present investigation it is concluded that the treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) is proved as a best combination of bio-fertilizers along with inorganic fertilizer for the improvement of brinjal cultivation through organically; where treatment T_9 (RDF + VAM @ 25% + PSB @ 50% + AZ @ 25%) significantly enhances the growth, yield and quality traits of brinjal and also gave maximum return/ha.

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