Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(4): 1579-1583
Received: 14-05-2017
Accepted: 17-06-2017

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Impact of biofertilizers on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill.) cv. Pusa Sheetal

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Abstract
On the basis of overall findings of the present research study it was concluded that there is wide range of variation in tomato for all the characters studied. Tomato fruit yield per plot indicates that 75% RDF + 25% FYM + Azospirillum have very significant role in tomato fruit production, mostly; all the organic manures and bio-fertilizers have yield higher production over the control. Significant responses noticed with the treatment of 50% RDF + 50% FYM + Azospirillum + Azotobacter followed by 50% RDF + 50 VC +PSB. The treatment 75% RDF + 25% FYM + Azospirillum they have maximum yield of tomato fruits per hectare (t/ha) followed by T_5. Vermicompost 100% had recorded a minimum acidity maximum TSS (^{0}Brix) and vitamin-C over the control.

Keywords: Tomato, INM, biofertilizers, azotobactor, growth, yield, quality

Introduction
Tomato (*Lycopersicon esculentum.* Mill) 2n=24, is one of the important vegetable crops which contains some important minerals and vitamins. Tomato, the world's largest grown vegetable crop known as a protective food occupies an important place in the economy of human societies because of its high nutritive value added products and its wide spread production in different agro climatic conditions. It is one of the most important vegetable in world ranking second next to potato in many countries. Tomato occupies the most prestigious berth not only in the sophisticated, ultra-modern kitchen, but also equally nutritious and value added products that can be prepared from it. It is often called poor man's orange because of its high nutritive value and available to masses. It is one of the most popular salad vegetables and taken with great relish. It is widely employed in cannery and made into soups, conserves, pickles, ketchup, sauces, juice etc. Tomato juice has become an exceedingly popular appetizer and beverage. The annual production of tomato in India during was 18227 MT from 880 MH of land and 19402 MT from 1204 MH of land. The leading tomato producing states are Uttar Pradesh, Karnataka, Maharashtra, Haryana, Punjab and Bihar.

Biofertilizer is a natural product carrying living microorganisms derived from the root or cultivated soil. So they don't have any ill effect on soil health and environment. Besides their roll in atmospheric nitrogen fixation and phosphorous solubilisation, these also help in stimulating the plant growth hormone providing better nutrient uptake and increased tolerance towards drought and moisture stress. A small dose of biofertilizer is sufficient to produce desirable results because each gram of carrier of biofertilizers contains at least 10 million viable cells of a specific strain (Anandaraj and Delapierre, 2010) [1].

Azotobactor and Azospirillum are the two most important non-symbiotic N- fixing bacteria in non-leguminous crops. Under appropriate conditions, Azotobactor and Azospirillum can enhance plant development and promote the yield of several agriculture important crops in different soils and climatic regions. These beneficial effects of Azotobactor and Azospirillum on plants are attributed mainly to an improvement in root development, an increase in the rate of water and minerals uptake by roots, displacement of fungi and plant pathogenic bacteria and to a lesser extent, biological nitrogen fixation (Okon and Itzigshohn, 1995) [7]. Besides N_2 fixation, Azotobactor synthesizes and secretes considerable amounts of biologically active substances like vitamins B, nicotinic acid, panthothenic acid, biotin, heteroxins, gibberellins etc. which enhance root growth of plants (Rao, 1986) [10]. Another important characteristic of Azotobactor association with crop improvement is secretion of ammonia into rhizospere in the presence of root exudates, which help in modification of nutrient uptake by the plants (Narula and Guopta, 1986) [5]. The ability of Azospirillum to produce plant growth regulatory substances along with N_2 fixation stimulate plant growth and thereby productivity.

The changes that occur in the plant roots help in transport of minerals and water (Sarig *et al*, 1988) [11]. All these factors combined together produce positive effects on crop yield, especially for vegetables and cereals.

Vermicompost contains most nutrients in plant available forms such as nitrates, phosphates and exchangeable calcium and soluble potassium. There is accumulating scientific evidence that vermicompost can influence the growth and productivity of plants significantly. Therefore, the present study was planned to evaluate the impact of biofertilizer on growth, yield and quality of Tomato cv. Pusa Sheetal under subtropical condition of Lucknow.

Materials and Methods

The field experiment was conducted during Rabi season of 2015-16 at the Horticulture Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow. The seeds of cultivar were obtained from the IARI, New Delhi. The experiment was laid out in Randomized Block Design (RBD) with three replications along with twelve treatments namely Control, RDF 100%, vermicompost 100%, RDF 75% + 25% VC +PSB, 50% RDF +50% VC +PSB, 75% RDF + 25% VC + Azospirillum, 75% RDF + 25% + Azospirillum, F.Y.M. 100%, 75% RDF + 25% FYM + PSB, 50% RDF + 50% FYM + PSB, 75% RDF + 25% FYM + Azospirillum, 50% RDF + 50% FYM + Azospirillum. The seed were sown in nursery beds on 30 October 2015 and seeds were germinated after 5-6 days. Tomato nursery of variety Pusa Sheetal was transplanted on 10 December 2015 in the main field after ploughing, hoeing and well laid out plan. The seedlings were transplanted at a spacing 45 cm x 30 cm in a plot, 16 seedlings of the cultivar were accommodated per plot. Tomato seedlings were transplanted in the field and a light watering was done after transplanting of the seeding Crop was taken due care with respect to weeding, hoeing and other operations. Micro-nutrients as per treatment were calculated and weighed before making the desired solutions. Proper solution of desired doses was applied over the tomato crop. Careful observations were taken with respect to the morphological as well as maturity parameters which plant height (cm), number of branches, number of flower/plant, number of cluster/plant, number of fruits per plant, fruit weight, fruit diameter, plant yield per plant, plot yield, and yield (t/ha), tritable acidity (%) TSS, vitamin-C. Recommended dose of Bio-fertilizers and manures application is given before the transplanting. Seedling treated with Azospirillum and PSB and transplanted. Data collected for various growths and yield at successive stage of plant growth were analysis and the significance and the treatment effect was judged with the help of "F" (variance ratio) test. The data was analysis as per the method given by Panse and Sukhatme, (1967) [8]. Least significant difference at 5% level was used for finding the significant differences among the treatment means.

Results and Discussion

Height of the plant

The Effect of different organic manures and bio-fertilizers on height of the plant from 30 days to 90 days of transplanting has been presented in Table 1. The data clearly marked out that data significantly increased the height of plant as compared to control. The statistical analysis of plant height are the maximum plant height of T_7 (16.32, 26.29 and 30.52) which significant over the control at 30,60 and 90 DAT. Observations pertaining to the height of the plant do not reflect any constant trend. However, it is clear that very slight variance with respect to this character is observed. Table 1 clearly indicated that RDF 50% + 50% VC + PSB had a positive effect on increase in plant height. Application of RDF 50% + 50% VC + PSB had maximum height as compared to control. A maximum plant height of 30.527 cm was recorded under treatment T_7. This increase in height may be due to the fact that PSB promotes vegetative growth by active cell division and elongation, and therefore, the height might have increased. Such results have also been reported by Meena *et al.* (2013) [4] and Yadav and Pandey (2015) [15] in tomato.

Number of branches

The data number of plant branches at 30, 60 and 90 DAT presented in Table 1 revealed that the number of plant branches T_7 (4.40,9.56 and 13.08) were significantly higher as compared to control. Number of branch per plant tomato varied significantly at 30, 60 and 90 DAT due to application on organic manures and bio-fertilizers. The maximum number of branch at 30 DAT (4.40), 60 DAT (9.56), 90 DAT (13.08) was recorded from T_7 treatment application of 75% RDF + 25% FYM + Azospirillum. It was revealed that number of branch per plant tomato increased which the organic manures and bio-fertilizers in tomato, especially *Azospirillum*. Similar result has also been reported by Meena *et al.* (2010) [3] and Paulraj *et al*. (1982) [9] in tomato.

Flowering and Fruit setting

Days to flowering

The number of days to first flowering is depicted in the Table 1. The statistical analysis of days to first flowering are the minimum days of T_7 (41.10) followed by T_{12} (39.42) and T_6 (38.92) which are significant. The data on days to 50% flowering of the plant at DAT are presented in Table 1. The data was recorded and statistical analysis proved that T_7 (49.09) has minimum days to 50% flowering followed by T_{12} (48.07) and T_{11} (47.60) which significant over the control. The data recorded on days to the fruit set of T_{12} (67.39) has minimum days taken to fruit set which is non- treated. Statistical analysis proved that the T_{12} (67.39) has minimum days requirement for fruit setting followed by treatments T_7 (67.35), T_{10} (66.67) and T_{11} (66.45).These findings are in conformity with the reports of Meena *et al.* (2010) [3] and Paulraj *et al*. (1982) [9] in tomato.

Number of flower per plant

The data regarding the number of flowers are presented in Table 1. The data reveals that there had been a significant increase in number of flowers per plant by organic manures and bio-fertilizers treatments. A maximum number of flower per plant (31.43) were recorded at T_7 which was followed by $T_{12,}$ T_{11} and T_6. While the minimum number of flower per plant (22.33) was recorded from control. The above finding leads to supports with the findings of Sendur *et al*. (1998) [12], Meena *et al.* (2010) [3] and in tomato.

Number of flower clusters per plant

The effect of organic manures and bio-fertilizers treatments on number of flower cluster per plant have been presented in Table 1 and the data revealed that there had been a significant increase in number of flower cluster per plant by different treatments. A maximum number of (9.13) clusters per plant were recorded at T_7 which was followed by T_{11}, while the minimum number of cluster per plant (5.14) was recorded from control. This increase may be *Azospirillum* which is

increase flower clusters per plant per plant significantly over the control. Similar findings obtained Terry *et al*. (1995) [13] and Meena *et al.* (2010) [3] in tomato.

Average number of fruits per plant

Fruits are obtained in different dates, as effected by different treatments or organic manures and bio-fertilizers have been presented in Table 2. Statistical analysis proved that the maximum number of fruits was recorded in the case of treatment T_7 (14.01), which is highly significant over other treatments. However, treatment T_{11}, T_{12}, and T_6 increased the number of fruits significantly higher over the control. It is clear that all treatments have significant effect over the control with respect to these characters. 75% RDF + 25% FYM + Azospirillum have produced maximum number of fruits per plant. Such results have been also observed by Meena *et al.* (2010) [3], Paulraj *et al*. (1982) [9] in tomato.

Average fruit weight (gm)

Here, discussed the results on average weight of fruits and has been presented in Table 2. The table indicated that the application of organic manures and bio-fertilizers (75% RDF +25% FYM + Azospirillum) have maximum fruit weight of T_7 (64.94 gm) as compared to the control (37.14 gm). This increase in fruits weight mass be assigned to (75% RDF +25% FYM + Azospirillum +), since by its characteristics virture, it has promoted the growth of all vegetative parts and consequently more food material for such plants fruits with higher weight obtained. This result supported findings of Terry *et al*. (1995) [13] and Meena *et al.* (2013) [4] in tomato.

Fruit diameter (mm)

The results on average fruit diameter (mm) have been presented in Table 2. The data indicated that the application of organic manures and bio-fertilizers increase significant fruit diameters. The maximum fruit diameter are obtained T_7 (63.61) followed by T_5 (60.72), T_{12} (60.68) and T_{10} (59.35) significance over the control. The above finding leads to collaborates the finding of Meena *et al.* (2010) [3] and Wange and Kale (2004) [14], in tomato.

Fruits yield per plant (kg)

Yield of tomatoes per plant was affected by the different combination of treatments in Table 2. The treatment T_7 (75% RDF + 25% FYM + Azospirillum) has given the highest yield per plant T_7 (0.92) which is significantly superior over control. The significant response was followed by T_{11} (0.86) and $T_{12,}$ $T_{6,}$ over the control. Fruits yield per plant depends upon the number of fruits and size of the fruits per plant. There both the characters are higher in treatment of RDF 75% + 25% FYM + Azospirillum. Such result have also been found by Meena *et al.* (2010) [3] and Yadav and Pandey(2015) [15] in tomato.

Fruits yield per plot (kg)

Results of the experiment show the significant role of organic manures and biofertilizer in boosting the yield of fruits in Table 2. It has been noticed that the T_7 (75% RDF + 25% FYM + Azospirillum) treatment has contributed highest yield per plot followed T_{11}. Statistical analysis revealed that maximum fruits yield per plot was counted in the treatment T_7 (14.09 kg) and was highly significant. The treatment T_{11} and $T_{12,}$ T_6 also increased the yield and showed significant effect over the control. Here, it can be said that yield depends on the number of fruits per plant, fruit diameter and weight of tomato fruit. However, in this case these characters have higher values in the treatment of 75% RDF + 25% FYM + Azospirillum of the all treatments. Similar results have also been reported by Gadagi *et al.* (1999) [2] and Meena *et al.* (2013) [4] in tomato.

Yield (q/ha)

Results of the experiment clearly indicates in Table 2 the superiority of the treatment of T_7 (75% RDF + 25% FYM + Azospirillum) over these characters. Here T_7 have yielded highest (370.10q/ha) followed by T_{11} (348.50q/ha) over significant the control. The yield per hectare is ultimate response due to number of branches, number of fruits, yield per plant and such other associated characters. The performance of this treatment is a combined effect of all the positive function of different treatments present individually. This result conformity with the findings has by Wange and Kale (2004) [14], Terry *et al.* (1995) [13] and Meena *et al.* (2010) [3].

Tritable acidity (%)

The data clearly indicates that vermicompost treatments had resulted in decreasing the percentage acidity of tomato. Treatment T_3 recorded a minimum acidity of (0.52) per cent as compared to (0.71) per cent in control.The data were found to be significant in decreasing acidity percentage. Similar result has also been reported by Meena *et al.* (2010) [3] in tomato.

Total soluble solids (TSS) (^{0}Brix)

The data indicates that the treatment T_3 showed maximum TSS (5.27) of fruit. The plants with vermicompost increased the T.S.S. of fruits over the control. Statistical analysis indicates that the treatment T_3 gave highest TSS next T_8, T_{12}, and $T_{10.}$ Such results are with the conformity with Sendur *et al.* (1998) [12] and Yadav and Pandey (2015) [15] in tomato.

Vitamin C (mg /100ml)

The data indicates that the treatment T_7 showed maximum vitamin-C (23.87 mg/100g) of fruit. The plants with increased the vitamin-C of fruits over the control. Statistical analysis indicates that the treatment T_7 gave highest vitamin-C followed by T_5, T_{12}, and $T_{10.}$ Similar results have also been reported by Sendur *et al*. (1998) [12] and Meena *et al*. (2013) [4].

Table 1: Impact of bio-fertilizers on vegetative growth parameters of tomato

Treatment	Plant height (cm) (DAT)			Number of branches /plant (DAT)			Days to first flowering	Days to 50% flowering	Days to fruit set	No. of flower cluster / Plant	No. of flowers / Plant
	30	60	90	30	60	90					
T_1 Control	15.11	17.76	25.52	2.99	5.68	8.50	36.83	40.66	61.59	5.14	22.33
T_2RDF 100%	14.47	18.92	25.33	3.45	6.78	8.52	37.59	41.73	62.81	6.19	25.45
T_3Vermicompost 100%	14.04	19.32	26.09	3.47	6.96	8.61	38.12	42.57	64.32	6.81	25.83
$T_4$75% RDF +25% VC + PSB	14.07	20.08	26.21	3.82	7.31	8.85	38.87	44.29	64.94	7.10	27.35
$T_5$50% RDF + 50% VC + PSB	14.19	20.78	25.54	3.86	7.43	8.77	38.40	43.01	64.58	7.70	28.41
T_6 75% RDF + 25% VC + Azospirillum	14.77	21.37	26.97	3.93	7.67	9.14	38.92	44.97	66.18	7.93	29.16
T_7 75% RDF + 25% FYM + Azospirillum	16.32	26.29	30.52	4.40	9.56	13.08	41.10	49.09	67.35	9.13	31.43
T_8 F.Y.M. 100%	14.72	19.80	26.03	3.22	6.34	8.79	37.68	41.53	65.49	6.67	26.76
T_9 75% RDF + 25% FYM + PSB	15.63	20.36	27.79	3.74	7.13	9.06	38.44	44.50	65.00	7.42	28.01
T_{10} 50% RDF + 50% FYM +PSB	15.16	21.10	28.9	3.70	7.00	9.26	38.02	45.90	66.67	7.11	28.62
T_{11} 50% RDF + 50% VC + Azospirillum	15.77	22.76	27.98	4.07	7.91	10.86	38.43	47.60	66.45	8.12	29.23
T_{12} 50% RDF + 50% FYM + Azospirillum	13.67	21.83	26.10	4.20	7.32	10.62	39.42	48.07	67.39	7.84	29.52
C.D (P=0.05)	0.85	0.96	2.638	0.35	0.61	0.42	1.15	1.40	0.92	0.59	1.51
S.E m(±)	0.29	0.32	0.894	0.12	0.21	0.14	0.39	0.47	0.31	0.20	0.51

Table 2: Impact of bio-fertilizers on fruit, yield and quality of tomato

Treatment	Average no of fruits / plant	Av. fruit Diameter (mm)	Av. fruit weight (g)	Fruit yield/ plant (Kg)	Fruit yield/plot (Kg.)	Yield/ha (q)	Acidity%	T.S.S. ^{0}Brix	Vitamin-C mg /100 ml
T_1 Control	10.35	33.10	37.14	0.47	7.20	294.4	0.71	3.69	21.82
T_2RDF 100%	10.73	42.39	38.90	0.53	8.02	322.0	0.64	3.74	22.21
T_3Vermicompost 100%	11.313	45.56	41.36	0.58	8.45	320.2	0.52	5.27	22.28
$T_4$75% RDF +25% VC + PSB	11.717	49.79	41.31	0.71	10.47	325.5	0.61	4.32	22.60
$T_5$50% RDF + 50% VC + PSB	11.587	60.72	44.99	0.81	11.35	335.8	0.69	4.01	23.04
T_6 75% RDF + 25% VC + Azospirillum	12.243	58.87	48.50	0.85	12.03	344.7	0.62	4.70	22.60
T_7 75% RDF + 25% FYM + Azospirillum	14.007	63.61	64.94	0.92	14.09	370.1	0.67	4.18	23.87
T_8 F.Y.M. 100%	11.753	44.35	45.60	0.77	9.82	314.1	0.60	5.05	21.62
T_9 75% RDF + 25% FYM + PSB	12.223	52.45	47.07	0.82	11.36	324.3	0.63	4.40	22.76
T_{10} 50% RDF + 50% FYM +PSB	12.073	59.35	48.04	0.84	12.02	339.0	0.58	4.88	22.78
T_{11} 50% RDF + 50% VC + Azospirillum	12.927	57.78	55.06	0.86	12.23	348.5	0.59	4.48	22.68
T_{12} 50% RDF + 50% FYM + Azospirillum	12.413	60.68	52.48	0.85	12.04	345.7	0.56	5.02	23.34
C.D (P=0.05)	0.647	1.73	1.37	0.06	0.84	9.8	0.03	0.31	1.16
S.E m(±)	0.219	0.59	0.47	0.02	0.29	3.3	0.01	0.10	0.39

Conclusion

On the basis of overall findings of the present research study it was concluded that there is wide range of variation in tomato for all the characters studied. The treatment combination T_7 (75% RDF + 25% FYM + Azospirillum) is highly significant for morphological as well as maturity parameters which plant height (cm), number of branches, number of flower/plant, number of cluster/plant, number of fruits per plant, fruit weight, fruit diameter, plant yield per plant, plot yield, yield (t/ha), tritable acidity (%), TSS and vitamin-C. However, since this is based on experiment, further trials may be needed to substantiate the results in tomato.

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