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Effect of organic manures, inorganic fertilizers and biofertilizers on growth parameters of guava (*Psidium guajava* L.) cv. Sardar in Mrig Bahar crop of sub humid agro ecological zone of Rajasthan

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Abstract
A field experiment entitled "Effect of organic manures, inorganic fertilizers and biofertilizers on growth, yield and quality of Guava (*Psidium guajava* L.) cv. Sardar in Mrig Bahar Crop" was conducted during the May 2018 to February 2019, at the Fruit Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar. The experiment consisted of sixteen different treatments of organic manures, inorganic fertilizers and biofertilizers was laid out in Randomized Block Design with four replications. The results revealed that the treatment T_{14} (75% RDF + 10 kg Vermicompost + 50 g Azotobacter + 50 g PSB + 5 kg mustard oil cake per plant) was found significantly superior over all other treatments with respect to plant growth characteristics including soil physicochemical properties.

Keywords: Guava, vermicompost, azotobacter, PSB, mustard oil cake and growth

Introduction
Guava (*Psidium guajava* L.) is one of the most important and commercially cultivated fruit crop belonging to the family Myrtaceae. It is one of the privileged fruits liked by the common masses and is aptly known as "apple of the tropics". Guava is said to have originated in Tropical America (Hayes 1953) and it was introduced in India by the Portuguese during 17th century. Guava is classified under genus *Psidium*, which encompasses 150 species but only *Psidium guajava* has been exploited commercially in terms of commercial success. India is the leading producer of guava in the world and it shares about 45 % of total production of guava in the world. The leading guava producing states in India are Madhya Pradesh, Uttar Pradesh, Maharashtra, Bihar, West Bengal, Gujarat and Karnataka (Anonymous, 2016).

In Rajasthan state, guava is mainly grown in the districts of Sawai Madhopur, Kota, Baran, Tonk, Sirohi, Udaipur, Banswara and Jhalawar etc. Sawai-Madhopur is the leading guava producing district of Rajasthan state. The total area, production and productivity of guava in India is about 2.62 lakh hectare, 3648 metric tons and 13.7 metric tons per hectare, respectively. Uttar Pradesh is the leading guava producing state of the country with an area, production and productivity of 41000 hectare, 42.50 metric tons, and 10.37 metric tons per hectare, respectively, Guava fruit is a powerhouse of nutrients. Guava fruit has pleasantly sweet and refreshingly acidic in flavor and emits sweet and strong aroma. The fruit is an excellent source of ascorbic acid and pectin content but has low energy (66 cal/100g), protein (1 %) and has 17 % dry matter and 83 % moisture Since guava fruits possess immense nutritional value, its cultivation is gaining momentum in different parts of Rajasthan state. Guava fruit has earned the popularity because of easy availability to common masses during season at affordable rates in comparison to other fruits. It is predominantly used as dessert fruit and also being used in various processed products being prepared from guava such as jam, jelly, cheese, puree, ice cream, canned fruit and RTS are prepared from ripe fruits of guava. Integration of organic manures with mineral fertilizers has positive effect on the physical, microbiological and chemical properties of soil, which is indirectly responsible for supporting growth and amenable development of plants. (Adak *et al*. 2012) [1].

Materials and methods

The experiment "Effect of Organic manures, Inorganic fertilizers and Biofertilizer on Growth, Yield and Quality of Guava (*Psidium guajava* L.) cv. Sardar in Mrig Bahar Crop" was conducted during the year 2018-19, at the Fruit Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar. The guava orchard was planted during 2008 at 8 x 8 m spacing under square method of planting and soils are black vertisols having predominance of clay with abundant water holding capacity. Guava stands next to Nagpur mandarin as major fruit crop in Jhalawar district.

The treatments combinations applied are given as under:

Treatments notation	Treatment contents
T_0	Control
T_1	100 % RDF (600 g N : 300 g P : 300 g K / tree) + 10 kg Vermicompost
T_2	75 % RDF + 10 kg Vermicompost
T_3	50 % RDF + 10 kg Vermicompost
T_4	100 % RDF + 50g Azotobacter
T_5	75 % RDF + 50g Azotobacter
T_6	50 % RDF + 50g Azotobacter
T_7	100 % RDF + 50g PSB
T_8	75 % RDF + 50g PSB
T_9	50 % RDF + 50g PSB
T_{10}	100 % RDF + 5 kg Mustard oil cake
T_{11}	75 % RDF + 5 kg Mustard oil cake
T_{12}	50 % RDF + 5 kg Mustard oil cake
T_{13}	100 % RDF +10 kg Vermicompost + 50 g Azotobactor + 50 g PSB + 5 kg Mustard oil cake
T_{14}	75 % RDF +10 kg Vermicompost + 50 g Azotobactor + 50 g PSB + 5 kg Mustard oil cake
T_{15}	50 % RDF +10 kg Vermicompost + 50 g Azotobactor + 50 g PSB + 5 kg Mustard oil cake

The tree height of guava was measured using measuring tape from base to the apex of the trees. Trunk girth of guava trees was recorded using Vernier Callipers. Plant orientation EW and NS was measured with the help of measuring tape. Number of branches was counted visually on selected trunk from initiation to termination of experiment.

The experiment was laid down in randomized block design with three replications. Soil physico - chemical parameters includingsoil pH, electrical conductivity (dSm^{-1}), organic carbon (%) and available NPK (kg ha^{-1}) were recorded atinitiation of experiment and after completion of experiment. Soil pH was determined by using glass electrode pH meter (Jackson, 1973) [5], electrical conductivity of soil by using standard precision conductivity bridge (Jackson, 1973) [5], organic carbon content by Walkley and Black (1934) [20] wet digestion method, available Nitrogen (kg/ha) by using alkaline Potassium Permanganate method (Subbiah and Asija, 1956) [19], available soil Phosphorus (kg/ha) by Olsen *et al.*, (1954) [15], available potassium content (kg/ha) by Flame Photometer (Metson, 1956) [14]. The data obtained during the experiment were subjected to statistical analysis using Fisher's analysis of variance technique.

Results and discussion

1. Tree Height (m): The data calculated in table 1 reveals the cumulative increase in tree height of guava plants cv. Sardar under different treatment combinations. Data presented in table1 exhibited that maximum plant height (5.08m) was recorded under T_{14} treatment after 90 days after manuring and it was found highly significant over all other treatments. Minimum tree height (3.37m) was recorded under control. Overall, treatment showed maximum increase in tree height at 30, 60 and 90 days after manuring application. The increase in tree height in response to differential treatments indicates vigour of guava plants.

2. Trunk Girth (cm): The data presented in table 2 indicates the cumulative increase in trunk girth of guava plants cv. Sardar under different treatment combinations during experimental duration. Data exhibited in table 2 revealed that maximum trunk girth (48.98 cm) after 90 days after manuring was measured under T_{14} treatment, it was found at par with T_{15} treatment and was found highly significant over all other treatments, minimum trunk girth (42.93cm) was obtained under control. Overall, treatment T_{14} exhibited maximum increase in trunk girth at 30, 60 and 90 days after manuring. The increase in trunk girth in response to differential treatments indicates accumulation of carbohydrate bio-mass in the trunk girth of guava plants.

3. Tree Canopy Spread East-West (m): The perusal of data in table 3 indicates the cumulative increase in East-West spread (m) of guava plants cv. Sardar in response to application of different treatment. Data presented in table 4 envisaged that maximum E-W spread (4.94 m) was obtained under T_{15} treatment after 90 days after manuring was found at par with T_{14} treatment and was highly significant over all other treatments. Minimum E-W canopy spread (4.15cm) was recorded under control. Overall, treatment T_{15} exhibited maximum increase in E-W canopy spread at 30, 60 and 90 days after manuring. The increase in plant spread in response to differential treatments indicates manifestation of shoot and leaf vigour by nutrient uptake and accelerated photosynthesis under environmental condition.

4. Tree Canopy Spread North-South (m): The data presented in table 4 reveals the cumulative increase in North-South spread (m) of guava plant cv. Sardar in response to application of different treatments. It is obvious from the data in table 4 that maximum N-S spread (4.92m) was measured under T_{15} treatment at 90 days after manuring and it was found at par with T_{11} T_{12} T_{13} and T_{14} treatments. Minimum N-S canopy spread (4.01) was measured under control. Overall, treatment, T_{15} exhibited maximum increase in tree canopy spread (N-S) at 30, 60 and 90 days after manuring. The increase in plant spread in response to differential treatments indicates manifestation of shoot and leaf vigour by nutrient uptake and accelerated photosynthesis under environmental condition.

5. Number of branches: the data calculated in table 5 indicates number of branches of guava cv. Sardar in *Mrig bahar* crop in response to the effect of organic manures, inorganic fertilizers and biofertilizers during experimental duration. Data presented in table 5 reveals that maximum number of branches (13.25) at 90 DAM which was found at par with T_{15} treatment and were found highly significant over all other treatments Minimum number of branches (6.50) were recorded under control at 90 DAM Overall, increase in the number of branches were also estimated in T_{14} treatment at 30, 60 and 90 days after manuring. The data represents numeric variation in number of branches of guava cv. Sardar in response to application of different treatments.

The higher vegetative growth (plant height and diameter of shoots) by *Azotobacter* under T_{14} treatment might be due to the growth promoting substances that improved P and N availability and thereby causing higher protein synthesis which resulted in improved morphological growth. Many plant-associated bacteria have the ability to produce the naturally occurring plant growth regulator indole-3-acetic acid which plays the most important role in plant growth promotion. The increase in vegetative growth could be attributed to the higher amount of nutrient mobilization and multi minerals availability through vermicompost supplementation as well as stimulation of growth stimulating substances excreted by earthworms in their casts. The overall better growth may be attributed to more synthesis of organic matter coupled by biofertilizers application along with incorporation of *Azotobacter*, *PSB*, mustard oil cake and inorganic fertilizers incorporation. This might be attributed as a result of holistic approach under Integrated Nutrient Management which perhaps leads to accentuation in soil microbial activity thereby leading to higher N-fixation and phosphate mobilization. The significantly better plant growth and development attributes obtained under T_{14} treatment could be attributed to the fact that there might be increased uptake of nutrients followed by improved source-sink ratio and concurrent release of nutrients along with plant hormones like auxins, gibberellins and cytokinins in the rhizosphere of guava plants.

Soil parameters

The prime role of Vermicompost as a soil conditioner and PSB application is to improve the soil quality as well as make available phosphorous thereby promoting the plant growth by utilization of sustaining natural resources. The plant growth is most obvious characteristic for evaluation the phenotypic expression in terms of vigour and nutrient uptake index. The results showed the positive influence of combination of Vermicompost, Azotobacter and PSB in enhancement of better plant growth attributes as well as improved available N and K status of canopy rhizosphere soil of guava trees. The data on soil physico-chemical properties in guava cv. L - 49 orchard soils are presented in table 6. The data pertaining to the effect of Vermicompost + PSB treatments on soil physicochemical properties revealed that pH, electrical conductivity (EC) decreased and organic carbon (%), available N, P, K status was increased significantly under T_{14} treatment (75 % RDF +10 kg Vermicompost + 50 g Azotobactor + 50 g PSB + 5 kg Mustard oil cake). PSB in consonance which Vermicompost improved the absorption and use of P by guava plants and contributes plant growth by producing hormones and cytokinins. Vermicompost has very high porosity, aeration, drainage and water holding capacity and strong retention of nutrients. The results of present findings are in accordance with those of Dutta and Kundu 2012 [8] in mango cv. Himsagar, Singha *et al.*, 2014 in mango, Hadole *et al.*, 2015 [12] in Nagpur Mandarin, Dutta *et al.*, 2016 [8] in mango cv. Himsagar, Poonia *et al.*, 2018 in mango cv. Dashehari and Poonia *et al.*, 2018 [16] in mango cv. Kesar.

Table 1: Effect of organic manures, inorganic fertilizers and biofertilizers on tree height (m) of guava (*Psidium guajava* L.) cv. Sardar in *Mrig bahar* crop at the 30, 60 and 90 days intervals.

Treatments		30 DAM	60 DAM	90 DAM
T_0	Control	3.30	3.36	3.37
T_1	100 % RDF (600 g N : 300 g P : 300 g K / tree) + 10 kg Vermicompost	4.11	4.16	4.21
T_2	75 % RDF + 10 kg Vermicompost	4.14	4.21	4.51
T_3	50 % RDF + 10 kg Vermicompost	4.02	4.11	4.24
T_4	100 % RDF + 50g Azotobacter	3.42	3.50	3.54
T_5	75 % RDF + 50g Azotobacter	3.64	3.66	3.70
T_6	50 % RDF + 50g Azotobacter	3.68	3.70	3.74
T_7	100 % RDF + 50g PSB	3.78	3.80	3.83
T_8	75 % RDF + 50g PSB	4.27	4.30	4.34
T_9	50 % RDF + 50g PSB	3.97	3.91	3.95
T_{10}	100 % RDF + 5 kg Mustard oil cake	3.73	3.80	3.96
T_{11}	75 % RDF + 5 kg Mustard oil cake	4.20	4.30	4.42
T_{12}	50 % RDF + 5 kg Mustard oil cake	4.11	4.26	4.33
T_{13}	100 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.35	4.43	4.52
T_{14}	75 % + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.73	4.87	5.08
T_{15}	50 % + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.54	4.66	4.77
SEm (±)		0.09	0.09	0.09
CD (5%)		0.28	0.26	0.27

* DAM = Days after manuring

Table 2: Effect of organic manures, inorganic fertilizers and biofertilizers on trunk girth (cm) of guava (*Psidium guajava* L.) cv. Sardar in *Mrig bahar* crop at the 30, 60 and 90 days intervals.

Treatments		30 DAM	60 DAM	90 DAM
T_0	Control	42.57	42.78	42.93
T_1	100 % RDF (600 g N : 300 g P : 300 g K / tree) + 10 kg Vermicompost	43.25	44.86	45.46
T_2	75 % RDF + 10 kg Vermicompost	43.67	45.07	45.31
T_3	50 % RDF + 10 kg Vermicompost	44.12	45.11	45.62

T_4	100 % RDF + 50g Azotobacter	42.63	43.56	43.76
T_5	75 % RDF + 50g Azotobacter	42.60	43.29	43.66
T_6	50 % RDF + 50g Azotobacter	42.85	43.31	43.58
T_7	100 % RDF + 50g PSB	43.08	43.38	43.65
T_8	75 % RDF + 50g PSB	43.20	44.41	44.76
T_9	50 % RDF + 50g PSB	43.18	44.74	45.38
T_{10}	100 % RDF + 5 kg Mustard oil cake	44.51	45.09	45.61
T_{11}	75 % RDF + 5 kg Mustard oil cake	44.87	45.17	45.55
T_{12}	50 % RDF + 5 kg Mustard oil cake	44.41	45.65	45.20
T_{13}	100 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	45.68	46.82	47.13
T_{14}	75 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	46.07	47.62	48.98
T_{15}	50 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	45.98	47.26	48.58
SEm (±)		0.25	0.24	0.33
CD (5%)		0.73	0.71	0.97

* DAM = Days after manuring

Table 3: Effect of organic manures, inorganic fertilizers and biofertilizers on tree canopy spread E-W (m) of guava (*Psidium guajava* L.) cv. Sardar in *Mrig bahar* crop at the 30, 60 and 90 days intervals.

Treatments		**30 DAM**	**60 DAM**	**90 DAM**
T_0	Control	4.12	4.13	4.15
T_1	100 % RDF (600 g N : 300 g P : 300 g K / tree) + 10 kg Vermicompost	4.61	4.63	4.66
T_2	75 % RDF + 10 kg Vermicompost	4.67	4.70	4.72
T_3	50 % RDF + 10 kg Vermicompost	4.65	4.68	4.71
T_4	100 % RDF + 50g Azotobacter	4.21	4.24	4.26
T_5	75 % RDF + 50g Azotobacter	4.36	4.38	4.42
T_6	50 % RDF + 50g Azotobacter	4.34	4.37	4.40
T_7	100 % RDF + 50g PSB	4.47	4.50	4.53
T_8	75 % RDF + 50g PSB	4.55	4.58	4.61
T_9	50 % RDF + 50g PSB	4.54	4.56	4.58
T_{10}	100 % RDF + 5 kg Mustard oil cake	4.63	4.65	4.68
T_{11}	75 % RDF + 5 kg Mustard oil cake	4.74	4.68	4.81
T_{12}	50 % RDF + 5 kg Mustard oil cake	4.77	4.74	4.75
T_{13}	100 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.62	4.79	4.84
T_{14}	75 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.78	4.96	4.90
T_{15}	50 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.83	4.87	4.94
SEm (±)		0.03	0.10	0.02
CD (5%)		0.10	0.29	0.07

* DAM = Days after manuring

Table 4: Effect of organic manures, inorganic fertilizers and biofertilizers on tree canopy spread N-S (m) of guava (*Psidium guajava* L.) cv. Sardar in *Mrig bahar* crop at the 30, 60 and 90 days intervals.

Treatments		**30 DAM**	**60 DAM**	**90 DAM**
T_0	Control	3.97	3.99	4.01
T_1	100 % RDF (600 g N : 300 g P : 300 g K / tree) + 10 kg Vermicompost	4.54	4.57	4.60
T_2	75 % RDF + 10 kg Vermicompost	4.61	4.64	4.69
T_3	50 % RDF + 10 kg Vermicompost	4.58	4.62	4.67
T_4	100 % RDF + 50g Azotobacter	4.13	4.16	4.19
T_5	75 % RDF + 50g Azotobacter	4.24	4.27	4.31
T_6	50 % RDF + 50g Azotobacter	4.43	4.26	4.29
T_7	100 % RDF + 50g PSB	4.29	4.24	4.35
T_8	75 % RDF + 50g PSB	4.33	4.38	4.42
T_9	50 % RDF + 50g PSB	4.32	4.36	4.40
T_{10}	100 % RDF + 5 kg Mustard oil cake	4.59	4.63	4.68
T_{11}	75 % RDF + 5 kg Mustard oil cake	4.64	4.71	4.77
T_{12}	50 % RDF + 5 kg Mustard oil cake	4.62	4.70	4.76
T_{13}	100 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.69	4.74	4.81
T_{14}	75 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.73	4.79	4.87
T_{15}	50 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	4.76	4.83	4.92
SEm (±)		0.04	0.08	0.06
CD (5%)		0.14	0.24	0.18

* DAM = Days after manuring

Table 5: Effect of organic manures, inorganic fertilizers and biofertilizers on number of branches of guava (*Psidium guajava* L.) cv. Sardar in *Mrig bahar* crop at the 30, 60 and 90 days intervals.

Treatments		30 DAM	60 DAM	90 DAM
T_0	Control	5.75	6.00	6.50
T_1	100 % RDF (600 g N : 300 g P : 300 g K / tree) + 10 kg Vermicompost	7.00	7.50	8.25
T_2	75 % RDF + 10 kg Vermicompost	8.00	9.00	10.00
T_3	50 % RDF + 10 kg Vermicompost	7.50	8.25	9.25
T_4	100 % RDF + 50g Azotobacter	6.50	6.75	7.75
T_5	75 % RDF + 50g Azotobacter	6.25	6.75	8.25
T_6	50 % RDF + 50g Azotobacter	6.25	7.00	8.00
T_7	100 % RDF + 50g PSB	6.75	7.50	8.50
T_8	75 % RDF + 50g PSB	7.25	8.25	9.50
T_9	50 % RDF + 50g PSB	7.00	7.50	9.25
T_{10}	100 % RDF + 5 kg Mustard oil cake	7.50	8.50	9.50
T_{11}	75 % RDF + 5 kg Mustard oil cake	8.25	9.50	10.75
T_{12}	50 % RDF + 5 kg Mustard oil cake	8.00	9.00	9.87
T_{13}	100 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	8.75	10.00	11.25
T_{14}	75 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	9.75	11.25	13.25
T_{15}	50 % RDF + 10 kg Vermicompost + 50 g AZB + 50 g PSB + 5 kg MOC	9.50	10.75	12.25
SEm (±)		0.33	0.39	0.68
CD (5%)		0.97	1.15	1.99

* DAM = Days after manuring

Table 6: Effect of Vermicompost and PSB on soil physico-chemical parameters of *guava* cv. L - 49 at the end of experiment (December 2018).

Treatments	Soil parameters					
	pH	EC (dSm^{-1})	OC (%)	N ($kgha^{-1}$)	P ($kgha^{-1}$)	K ($kgha^{-1}$)
Initial values	7.80	0.63	0.40	321.25	32.10	301.20
T_0	7.60	0.60	0.42	322.10	32.99	302.60
T_1	7.58	0.58	0.44	322.80	33.46	303.70
T_2	7.52	0.57	0.43	322.84	33.61	303.80
T_3	7.53	0.56	0.45	322.91	33.71	303.85
T4	7.48	0.57	0.47	322.97	33.76	304.00
T_5	7.52	0.55	0.45	323.01	34.06	304.80
T_6	7.50	0.52	0.46	323.07	34.16	305.10
T_7	7.49	0.51	0.48	323.12	34.36	305.15
T_8	7.47	0.53	0.47	323.17	34.46	305.25
T_9	7.45	0.50	0.52	323.25	34.66	305.30
T_{10}	7.46	0.48	0.51	323.33	34.82	305.60
T_{11}	7.43	0.52	0.53	323.60	34.87	305.70
T_{12}	7.44	0.47	0.55	324.02	35.36	305.95
T_{13}	7.44	0.45	0.53	324.75	35.46	306.01
T_{14}	7.43	0.46	0.54	324.79	35.56	306.70
T_{15}	7.45	0.44	0.56	325.02	35.67	307.00
T16	7.43	0.42	0.57	325.06	35.72	307.24
T17	7.31	0.38	0.64	327.52	37.07	310.72
T18	7.32	0.39	0.62	326.36	36.64	310.12
T19	7.34	0.40	0.63	326.03	36.46	309.82
SEm (±)	0.04	0.01	0.01	0.64	0.27	0.35
CD (5%)	0.11	0.03	0.02	1.81	0.75	0.99

*Initial values of soil health parameters were recorded at the time of initiation of experiment (July 2018).

Conclusion

The plant growth parameters study of guava cv. Sardar under application of different treatment combinations on Mrig bahar guava trees revealed that application of T_{14} treatment (75 % RDF +10 kg Vermicompost + 50 g Azotobactor + 50 g PSB + 5 kg Mustard oil cake per plant) manifested better results in terms of increment in plant growth parameters particularly plant height, rootstock girth, scion girth, number of shoots/plant, number of nodes/plant and improvement in soil health particularly lowering down soil pH, EC and enhancement of soil organic carbon and available N, P, K status of guava rhizosphere soil as compared to other treatments.

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