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Vijay
Department of Horticulture
CCS Haryana Agricultural University, Hisar, Haryana, India

Jeet Ram Sharma
Department of Horticulture
CCS Haryana Agricultural University, Hisar, Haryana, India

Satpal Baloda
Department of Horticulture
CCS Haryana Agricultural University, Hisar, Haryana, India

Rakesh kumar
Department of Microbiology
CCS Haryana Agricultural University, Hisar, Haryana, India

Vikas Sheoran
Department of Horticulture
CCS Haryana Agricultural University, Hisar, Haryana, India

Vijay
Department of Horticulture
CCS Haryana Agricultural University, Hisar, Haryana, India

Hemant Saini
Department of Horticulture
CCS Haryana Agricultural University, Hisar, Haryana, India

Correspondence
Vijay
Department of Horticulture
CCS Haryana Agricultural University, Hisar, Haryana, India

Response of organic amendments and biofertilizers on growth and yield of guava during rainy season

Sourabh, Jeet Ram Sharma, Satpal Baloda, Rakesh Kumar, Vikas Sheoran, Vijay and Hemant Saini

Abstract
The effect of organic manures and biofertilizers along with inorganic fertilizers on growth and yield of guava cv. Hisar Surkha was studied. Experimental findings revealed that different treatments significantly increased plant height and number of flowers per branch. Vermicompost and FYM were used alone and in combination with biofertilizers at three RDF (recommended dose of fertilizers) levels i.e. 50%, 75% and 100%. *Azotobacter* + PSB inoculation along with 100% RDF + Vermicompost showed maximum plant height, flowers per branch, fruit set, number of fruits, average weight of fruit and yield, however, average plant spread was not significantly affected. The treatment significantly reduced fruit drop.

Keywords: Guava, Hisar Surkha, Azotobacter, PSB, growth, yield, fruit drop

Introduction
Guava (*Psidium guajava* L.), the apple of tropics, is a popular fruit of India which is a good source of vitamin C and pectin. Guava is highly responsive to fertilization. Chemical fertilizers fulfill the major nutrient requirement of the crop but their excessive and unbalanced use may lead to ecological hazards and depletion of physico-chemical properties of the soil and ultimately affect crop yields. Under such circumstances, there is need to consider alternate source of nutrients which may enhance crop yields without having adverse effects on soil properties. Biofertilizers are considered as a cheap and, eco-friendly source for improving soil fertility status. Increasing and extending the role of biofertilizers may reduce the need for chemical fertilizers and decrease the adverse environmental effects (Rafet *et al.*, 2007) [7]. Accordingly, an investigation was undertaken to observe the effect of organic manures and biofertilizers in combination with inorganic fertilizers growth and yield of guava cv. Hisar Surkha under agro-climatic conditions of western Haryana.

Materials and Methods
The present study was conducted at the experimental orchard, Department of Horticulture, CCS, Haryana Agricultural University, Hisar on 4 year old guava plants. Biofertilizers were applied in ring method 75cm away from tree trunk. 100 ml biofertilizer was used to make final volume of 5 litre with water and applied uniformly around tree rhizosphere. The height of the tree was measured with well-marked measuring pole up to the maximum point of height, ignoring the off type shoots and expressed in meter (m). Distance between point to which the branches of the tree had grown in the east-west and north-south direction were measured and average was expressed in meter (m). Three branches were selected in each direction on the tree and number of flowers were counted and average was expressed as number of flowers per branch. The initial fruit set was calculated by subtracting the number of fruits set at initial stage from total number of flowers on tagged branches. The percent initial fruit set was calculated by using the formula given below:

$$\text{Initial fruit set (\%)} = \frac{\text{Initial fruit set}}{\text{Total number of flowers}} \times 100$$

Fruit drop was calculated by subtracting the numbers of fruits retained at maturity from the number of fruits set at initial stage on three tagged branches and the average of three replications was expressed as number of fruit drop. Total number of fruits per tree of three replications was counted at the time of harvesting and average was expressed as number of the help of pan electronic balance.

The average was expressed as average fruit weight in gram (g). Yield was calculated by multiplying total number of fruits with average fruit weight and average has been expressed in kilograms per tree (Kg/tree).

Results and Discussion
Studies on crop growth
Plant height and average plant spread
A perusal of data in table 1 indicates that plant height was significantly affected by various treatments. Maximum plant height of 3.43 m was recorded with T_{16} i.e. RDF 100% + FYM + *Azotobacter* + PSB but found at par with all the treatments comprising 100% RDF (T_{14}, T_{15}, T_{16}) along with T_{10}, T_{11} and T_{12} except T_{13}. Minimum plant height 2.77 m was observed with control. Average plant spread was found non significant. All the 100% treatments proved significantly in increasing growth of guava over control.

The increase in the plant height might be due to the fact that application of NPK and vermicompost along with *Azotobacter* and PSB presides phosphorus mobilization from soil pool to plant system and increased nitrogen availability due to apt nitrogen fertilization and fixation. Timely fulfillment of nutritional requirement led to production of more photosynthates and accelerated metabolic activities resulting in vigorous growth of tree. Similar results were reported in guava by Pilania *et al.* (2010) [4] and Chandra *et al.* (2016) [1].

Number of flowers per branch, initial fruit set and fruit drop
The results presented in table 2, revealed that among all the treatments, maximum number of flowers per branch (21.12) was recorded when the plants were treated with T_{17} (RDF 100 % + Vermicompost + *Azotobacter* + PSB) which was at par with other the treatments of 100 % RDF (T_{16}, T_{18}, T_{15}, T_{14} and T_{13}) whereas minimum number of flowers per branch (16.62) were recorded in control (T_{19}). Maximum fruit set (63.2 %) was recorded with T_{17} (RDF 100 % + Vermicompost + *Azotobacter* + PSB) which was at par with all 100% RDF treatments (T_{13}, T_{14}, T_{15}, T_{16} and T_{18}) and 75% RDF treatments (T_9, T_{10}, T_{11} and T_{12}) whereas minimum fruit set (51.6 %) was recorded in control (T_{19}). Minimum fruit drop (29.8 %) was recorded with T_{17} (RDF 100 % + Vermicompost + *Azotobacter* + PSB) which was at par with all other treatments of 100% RDF (T_{13}, T_{14}, T_{15}, T_{16} and T_{13}) and maximum (41.9 %) was recorded in control (T_{19}).

Table 1: Effect of different organic amendments and biofertilizers on plant height (m) and average tree spread (m) in guava (*Psidium guajava* L.) cv. Hisar Surkha

Treatments	Plant height (m)	Average plant spread (m)
T_1 - RDF 50 %	2.87	3.51
T_2 - RDF 50 % + FYM	2.95	3.56
T_3 - RDF 50 % + Vermicompost	2.86	3.57
T_4 - RDF 50 % + FYM + *Azotobacter* + PSB	2.90	3.62
T_5 - RDF 50 % + Vermicompost + *Azotobacter* + PSB	2.94	3.63
T_6 - RDF 50 % + *Azotobacter* + PSB	2.88	3.65
T_7 - RDF 75 %	2.93	3.64
T_8 - RDF 75 % + FYM	2.97	3.66
T_9 - RDF 75 % + Vermicompost	3.07	3.66
T_{10} - RDF 75 % + FYM + *Azotobacter* + PSB	3.15	3.67
T_{11} - RDF 75 % + Vermicompost + *Azotobacter* + PSB	3.19	3.69
T_{12} - RDF 75 % + *Azotobacter* + PSB	3.11	3.68
T_{13} - RDF 100 %	3.08	3.74
T_{14} - RDF 100 % + FYM	3.19	3.77
T_{15} - RDF 100 % + Vermicompost	3.24	3.79
T_{16} - RDF 100 % + FYM + *Azotobacter* + PSB	3.43	3.85
T_{17} - RDF 100 % + Vermicompost + *Azotobacter* + PSB	3.40	3.88
T_{18} - RDF100 % + *Azotobacter* + PSB	3.26	3.81
T_{19} - Control	2.77	3.50
CD at 5%	0.33	NS

The increase in number of flowers per twig, initial fruit set and reduced number of fruit drop might be attributed to optimum NPK fertilization and increased nutrient availability from *Azotobacter* and PSB which may have increased various endogenous hormonal levels in plant tissue which might be responsible for enhancing flowering pollen germination and pollen tube which might have ultimately increased fruit set and higher fruit retention (Godage *et al.*, 2013) [3].

Table 2: Effect of different organic amendments and biofertilizers on number of flowers per branch, fruit set (%) and fruit drop (%) in guava (*Psidium guajava* L.) cv. Hisar Surkha

Treatments	Number of flowers per branch	Fruit set (%)	Fruit drop (%)
T_1 - RDF 50 %	17.06	53.4	41.1
T_2 - RDF 50 % + FYM	17.42	53.4	40.4
T_3 - RDF 50 % + Vermicompost	17.67	53.9	38.5
T_4 - RDF 50 % + FYM + *Azotobacter* + PSB	17.88	54.8	37.4
T_5 - RDF 50 % + Vermicompost + *Azotobacter* + PSB	18.07	55.3	36.5
T_6 - RDF 50 % + *Azotobacter* + PSB	17.82	56.0	36.9
T_7 - RDF 75 %	18.54	56.5	36.1
T_8 - RDF 75 % + FYM	18.67	56.6	36.0
T_9 - RDF 75 % + Vermicompost	18.74	57.0	35.8
T_{10} - RDF 75 % + FYM + *Azotobacter* + PSB	19.02	58.4	35.1

T_{11} - RDF 75 % + Vermicompost + *Azotobacter* + PSB	19.08	59.5	34.1
T_{12} - RDF 75 % + *Azotobacter* + PSB	18.83	58.8	34.3
T_{13} - RDF 100 %	19.52	59.3	32.9
T_{14} - RDF 100 % + FYM	19.56	60.0	32.2
T_{15} - RDF 100 % + Vermicompost	20.17	60.5	31.8
T_{16} - RDF 100 % + FYM + *Azotobacter* + PSB	20.94	63.0	30.2
T_{17} - RDF 100 % + Vermicompost + *Azotobacter* + PSB	21.12	63.2	29.8
T_{18} - RDF100 % + *Azotobacter* + PSB	19.97	61.3	31.4
T_{19} - Control	16.62	51.6	41.9
CD at 5%	2.01	6.17	3.8

Fruit yield and yield parameters

Number of fruits per tree, average fruit weight and fruit yield

The data in table 3 reveal that different biofertilizer treatments significantly influenced number of fruits per tree. The maximum number of fruits per tree (158.7) in rainy season were recorded with T_{17} (RDF 100 % + Vermicompost + *Azotobacter* + PSB) which was at par with the treatments T_{18} and T_{16} and minimum (118.8) was recorded in control (T_{19}). Maximum fruit weight (137.0 g) was recorded when the plants were supplied with T_{17} (RDF 100 % + Vermicompost + *Azotobacter* + PSB) which was at par with 100% RDF treatments incorporated with organic manures and biofertilizers (T_{16}, T_{18}, T_{15}, T_{14} and T_{13}) and minimum (112.7 g) was recorded in control (T_{19}).

Fruit yield of guava was significantly influenced by different biofertilizer treatments at 75% and 100% RDF levels. The highest fruit yield (21.74 kg/tree) was achieved from trees which were supplied with 100 % RDF along with vermicompost, *Azotobacter* and PSB (T_{17}), which is statistically at par with treatments comprising 100% RDF (T_{14}, T_{15}, T_{16} and T_{18}) except T_{13}. The lowest fruit yield (13.38 kg/tree) was recorded from control (T_{19}), which was closely followed by T_1, T_2 and T_3.

Table 3: Effect of different organic amendments and biofertilizers on number of flowers per branch, fruit set (%) and fruit drop (%) in guava (*Psidium guajava* L.) cv. Hisar Surkha

Treatments	Number of fruits per tree	Average fruit weight (g)	Yield (Kg/tree)
T_1 - RDF 50 %	125.6	115.1	14.46
T_2 - RDF 50 % + FYM	127.5	115.7	14.75
T_3 - RDF 50 % + Vermicompost	127.3	117.5	14.96
T_4 - RDF 50 % + FYM + *Azotobacter* + PSB	129.2	120.8	15.61
T_5 - RDF 50 % + Vermicompost + *Azotobacter* + PSB	130.9	119.8	15.68
T_6 - RDF 50 % + *Azotobacter* + PSB	128.4	118.3	15.19
T_7 - RDF 75 %	134.8	123.8	16.69
T_8 - RDF 75 % + FYM	138.1	124.4	17.17
T_9 - RDF 75 % + Vermicompost	140.6	124.9	17.56
T_{10} - RDF 75 % + FYM + *Azotobacter* + PSB	144.5	127.4	18.41
T_{11} - RDF 75 % + Vermicompost + *Azotobacter* + PSB	146.4	129.6	18.98
T_{12} - RDF 75 % + *Azotobacter* + PSB	138.7	128.2	17.78
T_{13} - RDF 100 %	151.2	131.0	19.81
T_{14} - RDF 100 % + FYM	152.9	133.5	20.41
T_{15} - RDF 100 % + Vermicompost	153.7	134.2	20.62
T_{16} - RDF 100 % + FYM + *Azotobacter* + PSB	155.3	135.9	21.11
T_{17} - RDF 100 % + Vermicompost + *Azotobacter* + PSB	158.7	137.0	21.74
T_{18} - RDF100 % + *Azotobacter* + PSB	155.4	134.4	20.89
T_{19} - Control	118.8	112.7	13.38
CD at 5%	4.1	3.7	1.91

Higher number of fruits per tree and yield is the culmination and result of improved number of flowers, fruit set, retention and reduced fruit drop as evident from the present study. Improved bacterial population in rhizosphere is the evidence of improved nutritional status resulting in improved fruit length, breadth, number of fruits per tree and yield. Moreover, these microbes are known for their role in improving plant immunity and act as anti-pathogen. Dwivedi (2013) [2] reported that the integrated use of 50% NPK (RDF) + 25 kg FYM + 5 kg vermicompost per tree resulted in maximum number of fruits per tree, fruit weight and highest yield per tree. The nitrogen fixers and phosphorus solubilizers might have increased the availability of nitrogen and phosphorus by increasing their translocation from roots to fruit and leaves to fruit (Singh and Singh, 2009) [6]. Biofertilizers may have helped improve the overall plant health and ecosystem, thereby enhancing assimilate portioning.

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