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Effect of chemical fertilizers, bio-fertilizers and organic manure on growth, yield and quality of guava under Prayagraj agro-climatic condition

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Abstract
The present experiment was carried out during December 2018 to March 2019 in Central horticulture research farm of Department of Horticulture, SHUATS, Prayagraj. The experiment was conducted in Randomized Block Design with 12 treatment replicated thrice. The treatments were T_0 (control), T_1 (100% RDF (600:300:300g NPK / Tree), T_2 (75% RDF Cow dung slurry (10L/tree)), T_3 (50% RDF *Azospirillum* (100g / tree)), T_4 (75% RDF VAM (30g/Tree)), T_5 50% RDF Vermicompost (10kg/tree), T_6 (75% RDF Cow dung slurry (10Lt./tree)+ *Azospirillum* (100g / tree)), T_7 (50% RDF VAM (30g/Tree) + *Azospirillum* (100g/Tree)), T_8 (75% RDF Cow dung slurry (10Lt./tree)+ VAM (30g/Tree), T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)), T_{10} (75% RDF VAM (30g/Tree) + Vermicompost (10kg/tree)), T_{11} (*Azospirillum* (100g/Tree) + (50% RDF VAM (30g/Tree)+ Vermicompost (10kg/tree). From the present investigation it is found that treatment T_{11} (*Azospirillum* (100g/Tree) + (50% RDF VAM (30g/Tree) + Vermicompost (10kg/tree) was found superior in terms of Plant height, Crown height, plant girth, no. of flowers, no. of fruit set percentage, no. of fruit, average fruit weight, fruit yield per plant, length of fruit, width of fruit, pulp thickness, T.S.S., Acidity and cost benefit ratio.

Keywords: Cow dung slurry, *Azospirillum*, Vermicompost, VAM (Vesicular arbuscular mycorrhizae)

Introduction
Guava (*Psidium guajava* L.) is one of the most important fruit crops of tropical and sub-tropical regions of India. It can be grown satisfactorily on marginal soils with minimum care and is also called as "Apple of the Tropics". It is the most important member of the Myrtaceae family. In India, it has become an important fruit crop owing to its wider edapho-climatic adaptability, hardy to various biotic and abiotic stresses, precocious and prolific bearing habit and highly remunerative even without much care. It is largely grown in warmer tropical countries of the world. The Portuguese introduced it in India in the 17th century. Guava is classified under genus *Psidium*, which consists of 150 species but only (*Psidium guajava* L.) has been exploited commercially. It is popular in India due to its delightful taste, pleasant flavor, high palatability and digestive value. It is a rich source of ascorbic acid in human diet, content of which is three to five times more than that in fresh orange juice. It also supplies essential dietary minerals like iron, calcium and phosphorous. It also contains substantial quantities of carbohydrates, sugars and pectin. Owing to excellent taste and flavor, high nutritional value and wide r availability at moderate price the fruit is often called as "Poor man's apple". The conventional products of guava are jelly, jam, pulp, concentrate, juice, cheese, toffee, dehydrated guava and canned guava.

The Physico-chemical characteristics of guava vary with varieties, stages of maturity, management practices, agro-climatic situations, season of the crop, etc. The ripe fruit contains approximately 79.50 per cent moisture, 15.25 per cent dry matter, 3.20 per cent crude fiber and little amount of ash. The TSS varies from 8.5-10.5 per cent. Fructose is the principal sugar in green ripe fruit of guava. Several volatile compounds including hydrocarbons, alcohol and carbonyls have been found to be responsible for the characteristic flavor of guava. The decrease in astringency with advancement of maturity is ascribed to polymerization of leuco-anthocyanins.

Today, guava has well established market in more than 60 countries. It is cultivated in India, Mexico, Thailand, Spain, Portugal, Southern France, Israel, Panama, Malaysia, Kenya, USA, New Zealand, Philippines, China, Pakistan, Australia and some African countries. The major producers of guava in the world are India, Brazil and Mexico (Singh, 2009) [27].

Guava is the fourth most important fruit crop in India after Mango, Banana and Citrus (Ray, 2002) [24].

In India, guava occupies an area of 228.5 thousand hectares and production of 2.71 million tones has been achieved during 2011-12 with a productivity of 12.32 metric tones ha^{-1}**.** Its cultivation is common in India, which is concentrated mainly in Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra and Chhattisgarh. Chhattisgarh has covered an area of 15.6 thousand hectares with an annual production of 121300 metric tones and a productivity of 7.78 metric tonnes ha^{-} (Anonymous, 2012) [1]. The low productivity of guava in the state as compared to national productivity may be due to less adoption of improved crop management technology in respect of planting system, nutrition, plant protection and irrigation etc. Among several other factors, probably nutrition is a key factor affecting the productivity of fruit trees. As guava tree removes large amount of nutrients from soil, balanced fertilization seems to be an important factor governing the productivity of guava trees. Imbalance use of chemical fertilizers is a common practice adopted by the farmers. Large scale use of chemical fertilizers causes problem of ground water and environmental pollution through leaching, volatilization, denitrification and wastage of nutrients through costly fertilizers. The disproportionate use of chemical fertilizers has widened soil imbalance in terms of NPK ratio. The occurrence of multi-nutrient deficiencies and overall decline in productive capacity of soil has been widely reported due to non- judicious fertilizer use (Chhonkar, 2008) [8].

The recent concept of integrated nutrient supply involving organic, inorganic and bio -fertilizers has developed to meet the growing need for nutrients under intensive cultivation. In integrated plant nutrition supply system, the basic goal is to maintain or possibly improve the soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner. Guava is very hardy to soil and agro-climatic conditions and gives good response to manuring in terms of increasing fruit production and quality. Fertilizer experiments conducted in India showed that guava has given good response to balanced use of inorganic fertilizers along with organic manures.

Materials and Methods

The Experiment was conducted in Randomized Block Design (RBD) with one control and 11 treatments at the central research farm of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj during 2018-2019. Total no. of treatments were 11 + 1 *viz.* T_0 (control), T_1 (100% RDF (600:300:300g NPK / Tree), T_2 (75% RDF Cow dung slurry (10L/tree)), T_3 (50% RDF *Azospirillum* (100g / tree)), T_4 (75% RDF VAM (30g/Tree)), T_5 50% RDF Vermicompost (10kg/tree), T_6 (75% RDF Cow dung slurry (10Lt./tree)+ *Azospirillum* (100g / tree)), T_7 (50% RDF VAM (30g/Tree) + *Azospirillum* (100g/Tree)), T_8 (75% RDF Cow dung slurry (10Lt./tree)+ VAM (30g/Tree)), T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)), T_{10} (75% RDF VAM (30g/Tree) + Vermicompost (10kg/tree)), T_{11} (*Azospirillum* (100g/Tree) + (50% RDF VAM (30g/Tree)+ Vermicompost (10kg/tree).

Climatic condition in the experimental site

The area of Prayagraj district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 ºC-48 ºC and seldom falls as low as 4 ºC- 5 ºC. The relative humidity ranges between 20 to 94%. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

Results and discussion

The efforts have been made in this chapter to compare and interpret the result of various experiment carried out during the course of investigation with the findings of the other research works. The data recorded on various characters during "Mrig bahar" 2018-19, the course of investigation have been presented in this chapter along with appropriate tables, figures and illustrations**.** The present investigation entitled "Effect of chemical fertilizers, organic manures, and bio-fertilizers on growth, yield and quality of Guava (*Psidium guajava* L.) under Prayagraj agro-climatic conditions."

The experiment was conducted in Randomized Block Design with 1 control + 11 treatments, and three replications.

The results of the experiment are summarized below.

In terms of plant height, the maximum plant height was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree)) with (204.43 cm) followed by T_{10} (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)) with (196.60 cm) and the minimum was recorded in T_0 control with (129.83 cm). This study is supported by the findings of (Atom 2013) [4], (Dutta *et. al.*, 2009) [11], who reported that Azospirillum + VAM (30g) incubation along with 100 Nitrogen + 100% P_2O_5 show maximum increase in plant height.

In terms of crown height, the maximum crown height was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree)) with (199.76 cm) followed by T_{10} (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)) with (198.10 cm) and the minimum was recorded in T_0 control with (129.30 cm). This is in accordance with the findings of (Sharma 2004) [25], (Kunal *et al.,* 2010), (Yadav *et al.* 2012) *(*Atom 2013) [4].

In terms of plant girth the maximum plant girth was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree)) with (18.367 cm) followed by T_{10} (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)) with (18.23 cm) and the minimum was recorded in T_0 control with (17.93 cm). This study substantiates with the studies of (Kumar *et al*. 2010) [20] who reported that Significant improvement in growth parameters (plant height, spread and stem girth and tree volume) was recorded with the application of 800:600:600 g NPK + 25.00 kg FYM per tree per year (T7) which was *at par* with T8 (800:600:600 g NPK + 5.00 kg Vermicompost per tree per year).

In terms of no. of flowers the maximum numbers of flower per plant was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree)) with (80.33), followed by T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)) with (71.66), and the minimum was recorded in T_0 (control) with (43.66). This study affirms with the studies carried by (Singh *et al.*, 2018) [29] who reported that all the growth parameters, reproductive parameters, yield attributes were significantly influenced with the application of different treatments of integrated nutrient management.

In terms of no. of fruit the maximum numbers of fruit per plant was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree) with (68.66), followed by T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree) with (66.33), and the minimum

was recorded in T_0 (control) with (37.66). This study is supported by the findings of (Singh *et al.* 2018) [29] who reported that all the growth parameters, reproductive parameters (number of flowers and fruits per plant and fruit set per cent), yield attributes were significantly influenced with the application of different treatments of integrated nutrient management during both the years and in pooled analysis.

In terms of fruit set percentage the maximum fruit set percentage was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree) with (72.33), followed by T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree) with (68.66), and the minimum was recorded in T_0 (control) with (40.33). This study corroborates with the studies of (Sourabh *et al.*, 2018) [30] who revealed that the 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.

In terms of fruit, weight the maximum fruit weight (g) was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree) with (182.63 g), followed by T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree) with (173.03 g), and the minimum was recorded in T_0 (control) with (96.96 g). This study is supported by the findings of (Singh *et al.*, 2018) [29] and (Sourabh *et al.*, 2018) [30] who reported that the application of biofertilizers and organic manures increases the average fruit weight.

In terms of fruit yield, the maximum fruit yield per plant (kg) was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree) with (12.54 kg), followed by T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree) with (11.46 kg), and the minimum was recorded in T_0 (control) with (3.64 kg). This study is in accordance with the studies of (Dutta *et al.*, 2009) [11] who reported that, maximum yield (51.26 kg/tree and 14.25 t/ha) in the trees treated with full dose of nitrogen (565 g Urea) and phosphorus (200 g SSP) along with the combined application of 30 g each of *Azospirillum* and VAM.

In terms of fruit length, the maximum fruit length was recorded in T_{11} (50% RDF VAM + Azospirillum (100g/tree) + Vermicompost (10kg/tree) with (7.50), followed by T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)) with (7.36), and the minimum was recorded in T_0 (control) with (6.70). This study substantiates with the studies of (Das *et al*. 2017) [10] who reported that different treatments of bio fertilizers, *Azospirillumbrasilense*+ AMF (Arbuscular mycorhizal fungi) showed highest (56.30%) fruit retention and maximum fruit yield (41.3 kg plant-1) with maximum fruit length, diameter, fruit weight and pulp weight, this was followed by the treatment with *Azospirillumbrasilense*+ *Bacillus megatherium*.

In terms of fruit width, the maximum width of fruit was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree)) with (7.50), followed by T_9 (50% RDF Cow dung slurry (10L/tree) + Vermicompost (10kg/tree)) with (7.36), and the minimum was recorded in T_0 (control) with (6.43). This study is supported by the findings of (Atom 2013) [4] who reported that application of inorganic and biofertilizers gave maximum values of physical quality characters of guava fruits like fruit length (10.22 cm), width (11.28 cm), weight of fruit (201.90 g), weight of pulp (173.65 g), pulp: seed ratio (50.40) and minimum seed weight (3.45 g).

In terms of pulp thickness, the maximum pulp thickness was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree)) with (17.00 mm) followed by T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)) with (16.00 mm), and the minimum was recorded in T_0 (control) with (11.33 mm). This study is in accordance with the studies of (Godage *et al*., 2013) [16] who revealed the influences of chemical and biofertilizers on fruit yield of guava which resulted in significant maximum fruit diameter (10.07cm), fruit weight (215.06 g) and pulp weight (193.44 g).

In terms of T.S.S., the maximum T.S.S was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree)) with (12.70), followed by T_9 (50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)) with (12.50), and the minimum was recorded in T_0 (control) with (11.30). This study affirms with the studies carried by (Das *et al*., 2017) [10] who reported that treatment combination *Azospirillum brasilense* + AMF (Arbuscular mycorhizal fungi) exerted maximum peak in quality parameters like TSS (10.30 °Brix), total sugar (7.85%) and ascorbic acid (153.44 mg100-1 g of pulp) by increasing the leaf mineral content and soil microbial population substantially.

In terms of acidity, the minimum acidity was recorded in T_{11} (50% RDF VAM + Azospirillum (100g / tree) + Vermicompost (10kg/tree)with (0.16), followed by T_9 (50% RDF Cow dung slurry (10l/tree) + Vermicompost (10kg/tree)) with (0.19), and the minimum was recorded in T_0 (control) with (0.22). This study is supported by the findings of (Binepal *et al*., 2013) [7] who found that significant highest pulp weight (211.61 g), total soluble solids (11.67°Brix), total sugars (8.06%), non-reducing sugar (3.89%), reducing sugar (4.17%) and minimum acidity (0.20%) was recorded in T9 (100% N + 100% P2O5 + *Azospirillum*+ PSB + 10 kg Vermicompost).

In terms of Economics the Cost Benefit Ratio showed that there were significant differences among all the treatments in Cost Net Return, Gross Return and Cost Benefit Ratio of different treatments. The highest cost benefit ratio was recorded in T_{11} and the lowest was recorded in T_0.

Conclusion

On the basis of results obtained, It is concluded that the treatment T_{11} (50% RDF Vesicular arbuscular mycorrhizae (VAM 30g/tree) + Azospirillum (100g / tree) + Vermicompost (10kg/tree) found to be best in terms of plant height, crown height, plant girth, no of flower per plant, no of fruit per plant, fruit set percentage, fruit weight, fruit length, fruit width, pulp thickness, T.S.S, acidity (%) and cost benefit ratio.

Table 1: Effect of different treatments on various parameters of Guava.

Notation	Treatment combination	Plant height (cm)	Crown height (cm)	Plant Girth (cm)	No. of flowers per plants	Fruit set percentage	No. of fruit per plant	Average fruit weight (g)	Fruit yield/plant (g)	Length of fruit (cm)	Width of fruit (cm)	Pulp thickness (mm)	T.S.S. (^{0}B)	Acidity (%)
T_0	Control	129.833	129.3	17.933	43.667	40.333	37.667	96.967	3,644.93	6.43	6.467	11.333	11.3	0.22
T_1	100% RDF (600:300:300g NPK / Tree)	170.03	170.30	17.73	47.33	41.33	39.33	143.10	5,717.00	6.96	6.90	14.33	12.30	0.20
T_2	75% RDF Cow dung slurry (10Lt./tree)	163.93	161.86	17.23	46.33	40.66	38.33	169.40	6,511.37	6.63	6.53	14.00	11.60	0.27
T_3	50% RDF *Azospirillum* (100g / tree)	169.10	164.00	17.53	54.33	48.66	46.33	108.50	5,065.87	6.80	6.93	13.00	11.90	0.25
T_4	75% RDF VAM (30g/Tree)	187.27	178.83	17.60	48.33	43.33	41.33	149.63	6,128.60	7.16	6.80	15.33	11.66	0.24
T_5	50% RDF Vermicompost (10kg/tree)	195.10	188.50	17.73	58.66	51.66	48.33	161.90	7,731.07	6.73	6.83	15.00	11.86	0.24
T_6	75% RDF Cow dung slurry (10kg/tree)+ *Azospirillum* (100g / tree)	195.27	185.63	17.36	64.66	57.33	54.33	137.76	7,486.57	6.76	6.73	15.00	11.90	0.23
T_7	50% RDF VAM (30g/Tree) + *Azospirillum* (100g/Tree)	195.33	188.56	17.73	51.66	45.66	43.66	112.06	4,913.00	6.73	6.50	15.33	11.66	0.24
T_8	75% RDF Cow dung slurry (10Lt./tree) + VAM (30g/Tree)	187.40	181.93	17.70	50.33	46.33	43.66	170.36	7,432.90	6.90	6.96	16.00	11.83	0.25
T_9	50% RDF Cow dung slurry (10Lt./tree) + Vermicompost (10kg/tree)	194.33	197.73	18.10	71.66	68.66	66.33	173.03	11,463.23	7.36	7.36	16.00	12.50	0.19
T_{10}	75% RDF VAM (30g/Tree) + Vermicompost (10kg/tree)	196.60	198.10	18.23	69.33	64.66	62.33	171.86	10,575.63	7.20	7.20	13.33	12.20	0.21
T_{11}	50% RDF VAM (30g/tree) +*Azospirillum* (100g/tree) + Vermicompost (10kg/tree)	204.43	199.76	18.36	80.33	72.33	68.66	182.63	12,544.83	7.50	7.50	17.00	12.70	0.16
	CD	3.205	6.921	0.526	5.836	5.766	5.155	30.213	1,429.63	0.429	0.641	2.315	0.544	0.044
	SE (D)	1.536	3.316	0.252	2.796	2.762	2.47	14.475	684.93	0.205	0.307	1.109	0.261	0.021
	F-Test	S	S	S	S	S	S	S	S	S	S	S	S	S

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