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Response of guava plants to integrated nutrient management practices

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Abstract
The experiment was conducted under All India Coordinated Research Project on Fruits at Horticulture Farm, Rajasthan College of Agriculture, MPUAT, and Udaipur to evaluate the effect of integrated nutrient management on yield, quality and economics of guava. Application of T_7 treatment i.e. $^1/_2$ RDF (i.e. 250:100:250 g NPK per tree, respectively) and 25 kg FYM with 250 g *Azotobacter* recorded higher fruit weight (205 g) and yield (35.26 kg/tree) over other treatments. Further, same treatment was found to be effective in improving plant height (4.95 m), canopy volume (238.60 m^3), and leaf nutrient status (1.83, 0.41 & 1.81% NPK, respectively). However, fruit quality attributes i.e., maximum TSS (12.65°B), and lower acidity (0.32%) were observed in T_2 treatment i.e. full dose of recommended dose of fertilizer (i.e. 500 g N: 200 g P_2O_5: 500 g K_2O/tree) with foliar spray of micronutrients (i.e. Zn (0.5%) + B (0.2%) + Mn (1%)) during August and October. Soil micro-organism counts were recorded maximum in the treatment T_{10} (5.35 x 10^8 per g soil) for bacteria and T_5 (6.80 x10^4 per g soil) for fungus. Yield plant^{-1} was significantly and positively associated with leaf nitrogen and potassium content.

Keywords: Guava, RDF, FYM, vermicompost, organic mulching, *Trichoderma*, *Azospirillum* and *Pseudomonas fluorescens*

Introduction
Guava (*Psidium guajava* L.) is one of the most promising fruit crops of India and is considered to be one of the exquisite nutritionally valuable and remunerative crops (Singh *et al*. 2000) [12]. Guava is one of the richest natural sources of vitamin- C containing 2 to 5 times more vitamin-C than oranges. Among fruits, it ranks third in vitamin- C content after Barbados cherry and Aonla. However, these fruits unlike guava are not used in fresh form. Compared to other fruits, the whole guava is a moderately good source of calcium, a fair source of phosphorus and a good source of iron. Guava is an excellent source of dietary fiber, pectin and minerals. it is also stewed and used in short cake and pies. However, guava fruits are processed commercially into jellies, jam, cheese, puree, juice, powder and nectar. Due to their astringent properties, mature guava fruits, leaves, roots, bark and immature fruits are used in local medicines to treat gastroenteritis, diarrhea, and dysentery. Conventional (chemical based) farming is non-sustainable because of many problems such as loss of soil health and productivity from excessive erosion and low farm income from high production costs etc. In view of these, there is an increasing awareness about alternate agriculture system known as integrated nutrient management. The basic concept of integrated nutrient management (INM) is the adjustment of plant nutrient supply with proper combination of chemical fertilizers, organic manure and biofertilizers suitable to the system of land use and ecological, social and economic conditions. Azotobacter is known to add nitrogen to the soil through biological nitrogen fixation. Vermicompost, the compost prepared by earthworms has gained popularity in recent years, which is a rich source of growth promoting substances *viz*., growth hormones, enzymes and vitamins (Bhawalkar, 1992) [11]. There is an urgent need for an alternative nutritional package to attain long term sustainability for fruit production as well as for maintaining soil health and productivity under INM system. Keeping the above facts in view, the said experiment was conducted to find out the INM effects of integrated nutrient management on pre bearing growth and sustainable production of guava.

Material and Methods
The present experiment was carried out under All India Coordinated Research Project on Fruits at Horticulture Farm, Rajasthan College of Agriculture, MPUAT, and Udaipur. The experiment was conducted in Randomized Block Design (RBD) with four replications planted

at the distance of 6×6 m in square system. Ring basin method of irrigation was followed and treatments were applied as per technical programme i.e., May-June, August and October (spray of micronutrient). Trees were maintained under uniform cultural practices. The experiment was consisted of eleven treatments *viz.*, T_1- Recommended dose of NPK @ 500: 200: 500 g/tree, T_2- i.e. T_1 + Zn (0.5%) + B (0.2%) + Mn (1%) as foliar spray twice (August & October), T_3- i.e. T_1 + organic mulching 10 cm thick, T_4- i.e. T_2+ organic mulching 10 cm thick, T_5- i.e. ½ T_1 + 25 kg FYM + *Trichoderma* (250 g), T_6- i.e. ½ of RDF + 25 kg FYM + *Azospirillum* (250 g), T_7- i.e. ½ of RDF + 25 kg FYM + *Azotobacter* (250 g) + PSB (100g), T_8- i.e. ½ RDF + 25 kg FYM + 5 kg *Vermicompost*, T_9 - i.e. ½ of RDF + 25 kg FYM + *Pseudomonas fluroncense* (250 g), T_{10}- i.e. ½ of RDF + 25 kg FYM + *Trichoderma* (250g) + *Pseudomonas fluroncense* (250 g), T_{11}- i.e. ½ of RDF + 25 kg FYM enrich with *Aspergillus niger*. The whole of the organic manure was applied as a basal dose on the onset of monsoon. Then required doses of fertilizers were applied in the month of August and then bio-fertilizers were applied one week after each application of inorganic fertilizer. For application of manure and fertilizers the top soil around the tree equal to the leaf canopy of the tree was dug up to 30 cm and the fertilizers were uniformly mixed into the soil, which was then leveled. Irrigation was supplied immediately after fertilizer application. Micronutrient was applied before flowering of guava plants. The various growth parameters *viz*., plant height, plant girth, plant spread, canopy volume, yield tree^{-1} (kg), No. of fruits tree^{-1}, fruit weight (g), pulp seed ratio, TSS, acidity (%), vitamin- C (mg/100 g pulp) and leaf nutrients (%).

Result and Discussion

The applications of integrated nutrient management treatments were significantly effective in improving the growth, yield and quality characters mention in following below table. Among treatments application of T_7 treatment i.e. $^1/_2$ RDF (250: 100:250 g, NPK respectively) and 25 kg FYM with 250g *Azotobacter* recorded higher fruit weight (205 g) and yield (35.26 kg/tree) over other treatments. Further, same treatment was found to be effective in improving plant height (4.95m), canopy volume (238.60m^3), and leaf nutrient status (1.83, 0.41 & 1.81% NPK, respectively). However, fruit quality attributes i.e., maximum TSS (12.65ºB), and lower acidity (0.32%) were observed in T_2 treatment i.e. full dose of recommended dose of fertilizer (500g N: 200g P_2O_5: 500 g K_2O/tree) with foliar spray of micronutrients (Zn (0.5%) + B (0.2%) + Mn (1%)) during August and October. Soil micro-organism counts were recorded maximum in the treatment T_{10} (5.35 x 10^8 per g soil) for bacteria and T_5 (6.80 x10^4 per g soil) for fungus. Yield plant^{-1} was significantly and positively associated with leaf nitrogen and potassium content. Thus, on the basis of yield, economics and fruit quality treatment T_7 (i.e. ½ of RDF + 25 kg FYM + *Azotobacter* (250 g)) was effective combination of substrate dynamic for integrated plant nutrient management in guava crop.

This might be due to the fact that growth and development of above ground parts of plant are determined primarily by the activity of apical meristem, because the leaf primordial is formed there. The stem elongation depends initially on the new tissue formed at the apex and many of the hormonal signals which determine the later growth and development of all plant parts. It becomes clear that, higher dose of inorganic fertilizers along with manures and micronutrients increased availability of nutrients. Similar findings have been reported by Dutta *et al*. (2009) [1], Dwivedi and Agnihotri (2018) [2] and Jamwal *et al*. (2018) [4] in guava. Nitrogen positively influenced the vegetative growth of the plant, phosphorus plays an important role in photosynthesis and accumulation of food material and potassium plays an important role in carbohydrate and protein synthesis and in the regulation of water relations. It may also act as a catalyst in the formation of more complex substances and in the acceleration of enzyme activity. These nutrients also play an important role in metabolic activities of the plant resulting in the synthesis of chlorophyll and cytochromes which are essential for photosynthesis and respiration process in the plants. Application of organic manures with biofertilizers reported to facilitate the wider absorption of micro and micronutrient which help in better growth and development of plant. Sahu *et al*. (2015) [8] also confirm the results of present investigation.

The higher yield with different combinations of organic, inorganic and micronutrients could be attributed to sustained availability of major as well as micro nutrients which is evident from the higher accumulation of nutrients by guava plant from soil. The effect was more pronounced due to the combination of organic and inorganic with micronutrients. It is well known that nitrogen is the constituent of proteins, enzymes and chlorophyll and involves in all the processes associated with photosynthesis and growth, hence increase in weight and yield due to nitrogen application is obvious. The increase in weight and yield by addition of adequate quantity of phosphorus was possibly due to its association with various chemical reactions in the cell and is responsible for the synthesis of protoplasm. Hence, an increase in the vegetative growth was resulted in more carbohydrates assimilation, which may partly be responsible for higher yields. It is assumed that potassium plays an important part in carbohydrate and protein synthesis and in the regulation of water relations in living cells. It may also act as a catalyst in the formation of more complex substances and in the acceleration of enzyme activity. Carbohydrates and co-enzymes are beneficial in increasing size of fruits and ultimately weight of the fruit. The inclusion of FYM and micronutrients with chemical fertilizer greatly helped in improving the flower and fruit attributes. The application of nitrogen, phosphorus, potash, manures, bio-fertilizer to synthesize of amino acid act as precursor of polyamine and secondary messenger in growth characters and development of flowers. Synthesis of this amino acid is also influenced by phyto-hormones which are formed in plant due to the application of chemical and biofertilizers. Similar results in guava were also reported by Goswami *et al*. (2012) [3], Surage *et al*. (2017) [10] and Dwivedi and Agnihotri (2018) [2]. The significant increase in number of fruits per plant might be due to active and rapid multiplication of bacteria especially in rhizosphere creating favourable condition for nitrogen fixation and phosphorus solubilization at higher rate through nitrogen supply by nitrogenous fertilizers and supply of other nutrients, bacterial secretion, hormone production and supply of antibacterial and antifungal compounds, which were favourable for growth and ultimately increased yield. These findings corroborate with that of Singh (2008) [9], Rubee Lata *et al*. (2011) [7], Mamnindla *et al*. (2014) [6] and Kumrawat *et al*. (2018) [5].

Table 1: Effect of integrated nutrient treatments on vegetative attributes of guava

Treatments	Plant height (m)	Plant girth (cm)	Plant spread (m)		Canopy volume (m^3)	Yield $tree^{-1}$ (kg)	No. of fruits $tree^{-1}$	Fruit weight (g)	Pulp seed ratio
			EW	NS					
T_1	3.65	67.00	3.80	3.75	28.38	23.78	145	164	2.20
T_2	4.35	66.33	4.45	4.50	110.32	24.64	154	160	2.58
T_3	4.50	77.00	4.55	4.65	139.41	27.23	165	165	3.35
T_4	4.38	84.33	4.60	4.70	127.67	27.72	164	169	3.07
T_5	4.65	83.67	4.20	4.15	120.31	29.24	169	173	3.33
T_6	4.75	86.00	4.65	4.50	173.50	29.89	167	179	3.62
T_7	4.95	88.33	4.85	4.75	238.60	35.26	172	205	3.67
T_8	4.15	93.67	4.65	4.55	96.55	32.42	168	193	2.80
T_9	4.35	79.33	4.25	4.15	91.21	29.97	162	185	2.58
T_{10}	4.15	68.67	3.80	4.00	58.84	32.96	164	201	2.35
T_{11}	4.20	65.33	4.15	4.25	77.69	29.34	163	180	2.27
SEm ±	0.18	3.14	0.18	0.18	5.50	1.19	6.59	7.24	0.12
CD at 5%	0.51	9.06	0.52	0.52	15.88	3.42	19.04	20.91	0.35

Table 2: Effect of integrated nutrient treatments on quality attributes of guava and soil micro-organism (i.e. bacteria and fungus) count

Treatments	TSS (^{0}B)	Acidity (%)	Vitamin C (mg/100 g pulp)	Leaf nutrient (%)			Bacteria colony/g soil (10^8)	Fungus colony/g soil (10^4)
				N	P	K		
T_1	11.75	0.36	176	1.60	0.33	1.64	2.65	2.70
T_2	12.65	0.30	178	1.66	0.35	1.67	2.95	3.25
T_3	12.25	0.34	178	1.69	0.37	1.73	3.90	3.95
T_4	12.60	0.33	180	1.73	0.38	1.76	4.50	4.65
T_5	12.60	0.38	181	1.75	0.39	1.78	2.70	6.65
T_6	12.30	0.37	183	1.77	0.38	1.74	2.75	3.60
T_7	12.25	0.34	185	1.83	0.41	1.81	2.95	4.75
T_8	11.70	0.33	183	1.79	0.39	1.79	4.80	5.55
T_9	12.30	0.38	182	1.74	0.38	1.71	5.10	4.85
T_{10}	12.25	0.37	181	1.73	0.37	1.73	5.35	6.80
T_{11}	12.10	0.37	181	1.70	0.37	1.69	3.80	6.50
S.Em ±	0.50	0.01	7.30	0.07	0.02	0.07	0.15	0.20
CD at 5%	1.43	0.04	21.09	0.20	0.04	0.20	0.44	0.57

Conclusion

T_7 treatment has recorded higher yield (35.26 kg/tree) and its attributes compared to control i.e. T_1 treatment with lowest fruit yield of 23.78 kg/tree. Though, the best fruit quality attributes i.e., maximum TSS (12.67°B), and lower acidity (0.32%) were observed in T_2 treatment i.e. full dose of recommended dose of fertilizer (i.e. 500 N: 200 P_2O_5: 500 g K_2O per tree) with foliar spray of micronutrients (i.e. Zn (0.5%) + B (0.2%) + Mn (1%)) during August and October. Further, under T_7 treatment the leaf nutrient status was recorded highest i.e. 1.83% N, 0.41% P_2O_5 and 1.81% K_2O as compared to the other treatments. While, the soil micro-organism count was found maximum in the treatment T_{10} (5.35 x 10^8 per g soil) for bacteria and (6.80 x 10^4 per g soil) for fungus.

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