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Integrated nutrient management on yield and quality of guava (*Psidium guajava* L.) Cv. Allahabad Safeda under high density planting

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Abstract
The present investigation entitled, "Integrated nutrient managemnt on yield and quality of guava (*psidium guajava* L.) cv. Allahabad Safeda under high density planting" was conducted at Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad during 2016-17 and 2017-18. The experiment laid out in Randomized Block Design (RBD) with three replications. The experiment consisted of ten treatments *viz*. (T_0) 100% RDF (NPK-180,90,90g), (T_1) 75% RDF+2.5 kg Vermicompost, (T_2) 50% RDF+2.5 kg Vermicompost, (T_3) 75% RDF+10 kg FYM, (T_4) 50% RDF+10 kg FYM, (T_5) T_3 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%), (T_6) T_4 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%), (T_7) 50% RDF+10 kg FYM+Azotobactor, (T_8) 50% RDF+10 kg FYM+ Azotobactor+ PSB (100g/P), (T_9) 50% RDF+10 kg FYM+ VAM, (T_{10}) 50% RDF+10 kg FYM+ Azotobactor+ VAM. The application of integrated nutrient management had significant effect on yield and quality of guava fruits in both rainy and winter season. The treatment T5, 75% RDF+10 kg FYM + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%), recorded maximum number of flowers (70.80 and 80.75), higher fruit diameter (6.32 and 6.69 cm), maximum fruit length (5.98 and 6.12 cm), more number of fruits (39.20 and 37.25), fruit volume (119.25 and 124.25 ml), average fruit weight (136.35 and 169.32 g), fruits yield per plant (5348.77 and 6310.41 g) and highest yield (82.36 and 116.76 q/ha) whereas To (100% RDF) recorded lowest value of these characters during rainy and winter season, respectively. The regarding quality characters of fruits treatment 75% recommended dose of NPK with FYM (10 kg) and micronutrient recorded minimum acidity (0.398 and 0.405%), maximum total sugar (0.7.98 and 7.80%), TSS (11.49 and 11.88 brix), ascorbic acid (247.55 and 228.10), and higher pectin content (1.19 and 1.24%) while minimum in control.

Keywords: INM, bio fertilizer, micronutrient, winter season, quality, ascorbic acid

Introduction
Guava is an important fruit crop in tropical and subtropical regions of the country due to the hardy nature of its tree and prolific bearing even in marginal lands. Its cultivation requires little care and inputs. But, of late, this crop has exhibited a paradigm shift in the production system, from subsistence farming to commercial production. The traditional system of cultivation has often posed problems in attaining desired levels of productivity due to large tree canopy. Hence, a need arose to improve the existing production system, besides increasing its productivity. Currently, there is a worldwide trend to plant fruit trees at higher density or meadow orcharding to control tree size and maintain desired architecture for better light interception and ease in operations such as pruning, pest control and harvesting. The high density or meadow orcharding facilitates enhance production and quality of fruits. The fruit is in demand in domestic as well as international markets and is traded in more than 60 countries. 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. Guava is one of the richest natural source of vitamin C containing 2 to 5 times more vitamin C than oranges. 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.

The basic concept of integrated nutrient management (INM) is the adjustment of plant nutrient supply with proper combination of chemical fertilizers, organic manure and bio fertilizers suitable to the system of land use and ecological, social and economic conditions.

Azotobacter and Azospirillum is known to add nitrogen to the soil through biological nitrogen fixation. VAM fungi function mnutualistically by transporting slowly mobile ions of P, Zn and Cu from soil profile which lies beyond depletion zone of active roots. It also promotes and increase nitrate reduce enzyme activity and promotion of antifungal substances. Phosphorus solubilising microorganisms helps in transforming inorganic fixed phosphates to available form by microbial action and have greater economical importance in improving plant nutrition. The activity of phosphorus solubilizing microbes (PSM) can be improved by using them in combination with organic manures. 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, an experiment was conducted to find out the integrated nutrient management effect on yield, yield attributes and quality of fruits in rainy and winter season under high density planting of guava.

Materials and Methods

The present experiment was carried out at Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (UP) during rainy and winter season of the years, 2016-17 and 2017-18. The experiment was conducted in Randomized Block Design (RBD) with three replications. The experiment was consisted of ten treatments *viz*., Control (T_0) 100% RDF (NPK-180,90,90g), (T_1) 75% RDF+2.5 kg Vermicompost, (T_2) 50% RDF+2.5 kg Vermicompost, (T_3) 75% RDF+10 kg FYM, (T_4) 50% RDF+10 kg FYM, (T_5) T_3 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%), (T_6) T_4 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%), (T_7) 50% RDF+10 kg FYM+Azotobactor, (T_8) 50% RDF+10 kg FYM+ Azotobactor+ PSB (100g/P), (T_9) 50% RDF+10 kg FYM+ VAM, (T_{10}) 50% RDF+10 kg FYM+ Azotobactor+ VAM. 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 were applied before flowering of guava plants. The various fruit parameters fruit length and diameter were noted using the vernier caliper, volume of fruit was recorded by water displacement method and weight of fruit was recorded using electronic weigh balance. Yield per hectare was calculated on the basis number of tree per hectare and yield per plant.

For determination of chemical parameters of fruit *viz.*, acidity, total soluble solids (TSS), sugars, ascorbic acid, pH and pectin content, four healthy fruits were selected randomly from each tree at full maturity stage. Hand refractometer was used for determination of T.S.S. in 0Brix. Acidity was estimated by simple acid–alkali titration method as described in A.O.A.C. (1970) [1]. Sugars in fruit juice were estimated by the method as suggested by Nelson (1944) [12]. Assay method of ascorbic acid was followed given by Ranganna (1977) [13]. The estimation of pectin was according to the methods of Kertesz (1951) [6].

Results and Discussion

Effect of INM on yield and yield attributes

Yield in terms of number of fruits per tree, fruit weight per plant, diameter of fruits, fruit length and yield kg/tree were significantly influenced by integrated use of organic and inorganic fertilizers during rainy and winter season investigation. It is clear that all these traits were higher in winter season as compared to the rainy season except number of fruits per plant.

The plants received 75% RDF + FYM 10 t/ha + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%) have shown significant effect on number of fruits per plant as compared to control plants in both the season during both the years. This may be due to addition of these fertilizers boost up the yield of crop possibly due to addition of macro nutrients, prolonged release of nitrogen and improved soil health, which make plant roots to proliferate, resulting in better utilization of nutrients. The application of organic fertilizer with combination of inorganic fertilizer and micronutrient were significantly affected yield and yield attributing characters of guava in present experimentation. The treatment receiving (T_5) 75% RDF, (NPK 120:60:60 kg/ha) + 10t FYM + (Zn+B+Mn (0.5,0.2,0.1%), maximum number of flowers (70.80 and 80.75), higher fruit diameter (6.32 and 6.69 cm), maximum fruit length (5.98 and 6.12 cm), more number of fruits (39.20 and 37.25), fruit volume (119.25 and 124.25 ml), average fruit weight (136.35 and 169.32 g) which was at par with treatment 75% RDF+ 10 T FYM and significantly higher all other treatments, whereas To (100% RDF) recorded lowest value of these characters during rainy and winter season, respectively. Among different treatment combinations, treatment containing 75% RDF, (NPK 120:60:60 kg/ha) + 10t FYM + (Zn+B+Mn (0.5,0.2,0.1%), had positive influence on yield per plant and per hectare (Table 3). This treatment recorded significantly maximum fruits yield per plant (5348.77 and 6310.41 g) and highest yield (82.36 and 116.76 q/ha) which were at par with treatments 75% RDF+ 10 T FYM during winter and rainy season. The application of 100% RDF produced minimum fruit yield per plant and per hectare in 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 during the second year with 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 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 Rubee Lata *et al.* (2011) [14], Goswami *et al.* (2012) [5], Mamnindla *et al.* (2014) [10], Surage *et al.* (2017) [16] and Dwivedi *et al.* (2018) [4].

Results pertinent to chemical characters i.e. acidity, total sugars, ascorbic acid, TSS, pH and pectin content were found more during winter season fruits than in rainy season results. Uma Shankar *et al.* (2002) [17] and Rubee Lata *et al.* (2011) [14] recorded highest total soluble solid, ascorbic acid, reducing sugar and total sugar contents were obtained in winter season than rainy season. The total acidity was significantly influenced by various treatments in both the seasons of study and minimum acidity was recorded in plants receiving 75% recommended dose of fertilizers + FYM 10 t/ha + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%) while maximum acidity percent was observed in treatment (100% RDF) which was significantly at par with (50% RDF+10 kg FYM+ VAM) and (50% RDF+2.5 kg Vermicompost) during rainy and winter season. Maximum total sugars (7.98 and 7.80%) was found in rainy season fruits with 75% RDF + FYM 10 t/ha + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%) followed by 75% RDF+10 kg FYM and 50% RDF + FYM 10 t/ha Micronutrients (Zn+B+Mn (0.5,0.2,0.1%). The plant treated with 75% RDF + FYM 10 t/ha + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%) showed highest values of pectin content in both the seasons. These results were also experimentally supported by Mitra *et al.* (2010) [11] who observed maximum pectin content in winter season with the application of 50 g N, 40 g P2O5 and 50 g K2O/plant/ year of age along with 10 kg of farm-yard-manure and 20 kg of A*zotobacter*/tree/year. The superiority of fruits in respect of quality characters in winter season may be due to the effect of low temperature obtained at the time of fruit ripening. Low temperature not only retards the excessive loss of respiratory substances (Kliewar and Lider, 1970) [7] but also increased the translocation of photosynthesis from leaves to other parts of the plants including fruits (Went, 1944). Maximum ascorbic acid was found by application of 75% recommended dose of fertilizers + FYM 10 t/ha + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%) while minimum value of ascorbic acid in 100% RDF during both the season. The highest value of ascorbic content with this treatment might be due to the catalytic activity of several enzymes which participate in biosynthesis of ascorbic acid and its precursor (Bhobia *et al.* 2006) [3].

Table 1: Effect of integrated nutrient management on yield and yield attributes of guava (mean of two years)

Treatment		No of flowers/plant		Fruit diameter (cm)		Fruit length (cm)		Fruit volume (cm)	
		Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter
T_0	100% RDF (NPK-180,90,90g)	47.55	50.30	5.45	5.82	4.48	4.70	101.04	103.15
T_1	75% RDF+2.5 kg Vermicompost	68.30	71.70	6.01	6.37	5.64	5.76	112.33	116.90
T_2	50% RDF+2.5 kg Vermicompost	65.55	67.35	5.82	6.25	5.44	5.64	107.31	113.80
T_3	75% RDF+10 kg FYM	75.40	76.90	6.19	6.56	5.83	6.03	117.87	121.85
T_4	50% RDF+10 kg FYM	66.15	67.70	5.93	6.28	5.52	5.70	109.68	116.15
T_5	T_3 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%)	77.90	80.75	6.32	6.69	5.98	6.12	119.25	124.25
T_6	T_4 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%)	73.10	75.90	6.10	6.48	5.76	5.96	116.33	120.90
T_7	50% RDF+10 kg FYM+Azotobactor	61.15	64.30	5.72	6.10	5.20	5.37	104.66	112.60
T_8	50% RDF+10 kg FYM+ Azotobactor+ PSB (100g/P)	70.90	74.40	6.06	6.45	5.67	5.86	114.25	119.20
T_9	50% RDF+10 kg FYM+ VAM	58.85	62.20	5.67	6.00	5.08	5.16	104.11	108.50
T_{10}	50% RDF+10 kg FYM+ Azotobactor+ VAM	64.20	65.40	5.80	6.18	5.37	5.53	105.84	111.30
	SEm ±	0.99	1.10	0.09	0.10	0.08	0.07	1.43	1.57
	CD at 5%	2.93	3.26	0.27	0.29	0.24	0.22	4.25	4.67

Table 2: Effect of integrated nutrient management on yield and yield attributes of guava (mean of two years)

Treatment		No of fruit/plant		Fruit weight (g)		Fruit yield/plant (g)		Fruit yield q/ha	
		Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter
T_0	100% RDF (NPK-180,90,90g)	18.85	17.80	88.80	103.75	1683.16	1848.33	17.82	37.18
T_1	75% RDF+2.5 kg Vermicompost	29.60	27.50	120.45	146.50	3565.18	4038.27	46.97	77.88
T_2	50% RDF+2.5 kg Vermicompost	28.05	25.55	112.90	141.50	3173.40	3623.74	38.28	64.39
T_3	75% RDF+10 kg FYM	36.80	34.55	132.40	164.22	4876.24	5679.18	73.89	106.35
T_4	50% RDF+10 kg FYM	28.20	26.30	116.70	141.95	3295.59	3738.40	43.08	70.94
T_5	T_3 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%)	39.20	37.25	136.35	169.32	5348.77	6310.41	82.36	116.76
T_6	T_4 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%)	34.75	33.25	127.90	158.75	4448.40	5281.12	60.89	98.04
T_7	50% RDF+10 kg FYM+Azotobactor	26.20	23.95	106.95	115.55	2811.06	2770.09	33.54	57.71
T_8	50% RDF+10 kg FYM+ Azotobactor+ PSB (100g/P)	32.60	31.45	122.60	152.15	4000.01	4790.81	53.16	88.34
T_9	50% RDF+10 kg FYM+ VAM	24.65	22.60	101.35	110.85	2503.48	2503.95	27.93	54.01
T_{10}	50% RDF+10 kg FYM+ Azotobactor+ VAM	27.20	25.30	110.95	122.80	3024.73	3113.56	35.48	62.03
	SEm ±	0.37	0.39	1.43	2.05	54.35	67.94	0.86	1.30
	CD at 5%	1.10	1.15	4.25	6.08	161.47	201.83	2.54	3.85

Table 3: Effect of integrated nutrient management on chemical characters of guava (mean of two years)

Treatment		Acidity (%)		Total sugar (%)		TSS (Brix)		Ascorbic acid		pH		Pectin content (%)	
		Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter
T_0	100% RDF (NPK-180,90,90g)	0.545	0.557	5.19	5.28	9.13	9.47	174.30	145.70	3.97	3.96	0.84	0.88
T_1	75% RDF+2.5 kg Vermicompost	0.490	0.504	6.80	6.06	10.18	10.59	208.45	186.80	4.09	4.02	1.09	1.15
T_2	50% RDF+2.5 kg Vermicompost	0.531	0.541	6.30	6.22	9.97	10.28	192.35	168.15	4.03	4.02	1.02	1.08
T_3	75% RDF+10 kg FYM	0.433	0.465	7.81	7.64	11.29	11.70	235.55	216.95	4.18	4.09	1.17	1.21
T_4	50% RDF+10 kg FYM	0.492	0.511	6.42	6.21	10.09	10.47	201.45	176.80	4.04	4.02	1.06	1.10
T_5	T_3 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%)	0.398	0.405	7.98	7.80	11.49	11.88	247.55	228.10	4.20	4.12	1.19	1.24
T_6	T_4 + Micronutrients (Zn+B+Mn (0.5,0.2,0.1%)	0.428	0.460	7.72	7.49	10.51	11.10	227.00	205.95	4.17	4.07	1.16	1.22
T_7	50% RDF+10 kg FYM+Azotobactor	0.477	0.493	5.83	5.85	9.80	9.91	186.85	164.00	4.00	3.98	0.98	1.01
T_8	50% RDF+10 kg FYM+ Azotobactor+ PSB (100g/P)	0.523	0.537	7.07	7.22	10.29	10.72	212.10	191.90	4.12	4.04	1.15	1.18
T_9	50% RDF+10 kg FYM+ VAM	0.539	0.545	6.11	6.32	9.27	9.74	183.00	164.35	4.00	3.96	0.91	0.96
T_{10}	50% RDF+10 kg FYM+ Azotobactor+ VAM	0.484	0.525	6.40	6.51	9.90	10.08	189.75	165.65	4.01	4.01	1.00	1.05
	SEm ±	0.008	0.009	0.11	0.10	0.15	0.16	3.12	2.80	0.06	0.07	0.017	0.017
	CD at 5%	0.024	0.026	0.33	0.30	0.45	0.48	9.28	8.31	N/A	N/A	0.049	0.051

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