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Effect of NPK fertilization on growth and yield of guava under high density planting

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Abstract
A field experiment was conducted during 2012-13 and 2013-14 to study the effect of different levels of nitrogen, phosphorus and potassium individually and in combinations on growth and yield parameters of young bearing guava grown under high density planting system. Experimental findings revealed that, plant growth was significantly influenced by applied nutrients. Plant height, plant spread, plant volume, length of shoot, number of leaves, leaf area and chlorophyll content showed significant improvement with the application of 300 g nitrogen, 150 g phosphorus and 150 g potassium per plant during both the years of experimentation. Second order interactions also influenced the growth characters of guava and it was observed that combination of 300 g N + 150 g P_2O_5 + 150 g K_2O per plant recorded maximum plant growth. Yield attributing characters *viz*., number of flowers per shoot, fruit set, fruit drop, fruit weight were significantly influenced by the increasing levels of applied nutrients. The results obtained on pooled basis reveals that treatment consisting 300 g N + 150 g P_2O_5 + 150 g K_2O per plant was noteworthy in increasing yield parameters of guava over all other combinations and control.

Keywords: Guava, high density planting, nitrogen, phosphorus, potassium, growth, yield parameters

Introduction
Maharashtra is one of the leading producers of guava in the country. Owing to its high nutritive value, adoptability this crop has great scope in the fruit culture of Vidarbha region which is primarily known for citrus cultivation. There is substantial increase in production area under guava in Vidarbha region. The districts *viz*., Amravati, Akola and Wardha are identified as command area of guava in the region. Dr. Panjabrao Deshmukh Krishi Vidyapeeth has recommended planting of guava under high density planting system (3x2 m) accommodating 1666 plants per hectare to maximize the production in initial years of planting.

Nutrient management is a vital aspect in high density planting for sustainable production. Due to increased plant population per unit area, the amount of nutrients removed by the plants is substantially more and importantly different under different soil conditions. The present system of guava nutrition is based on general recommendation for a whole state, without considering the variation in the inherent soil fertility and the productivity of guava. The application of manures and fertilizers is one of the most costly recurring inputs in fruit production (Singh and Malhotra, 2011) [9]. Hence the nutrient management should aims to supply essential nutrients at optimum rate for proper growth, development and increasing fruit production in sustainable manner (Singh and Singh, 2007) [10]. Under such conditions, location specific research for providing the information on proper nutrition management could be helpful for the growers.

Materials and Methods
The experiment was carried out at farm of College of Horticulture, Dr. PDKV, and Akola during two consecutive years 2012-13 and 2013-14 on 3 year old guava plants of cv. L-49. The plantation rose on medium black soil having pH 7.79 and organic carbon 0.37 per cent. The experiment was laid out in a factorial randomized block design with three replications considering two plants as a unit. All the trees received uniform cultural and plant protection measures except fertilization practices. The experiment comprised of three levels of nitrogen (N_0- 0, N_1- 200 and N_2- 300 g plant^{-1}year^{-1}), three levels of phosphorus (P_0- 0, P_1- 100 and P_2- 150 g plant^{-1}year^{-1}) and two levels of potassium (K_0- 0 and K_1- 150 g plant^{-1}year^{-1}). Altogether there were eighteen treatment combinations. During both years, full dose of phosphorus and potassium along with half dose of nitrogen were applied in the month of July, while remaining half dose of nitrogen was applied in the month of September.

The data on plant height (m), plant spread (m) in east-west and north-south directions and shoot length (cm) were recorded with meter scale. Plant volume (cm^3) was calculated by formula 4/6 ∏ hr2 (h=Plant height (m) r = E-W spread + N-S spread (m)/4). Number of leaves counted on tagged shoots of all sides and average number of leaves computed. Leaf area (cm^2) of ten randomly selected fully grown leaves from tagged shoot was measured with the help of digital leaf area meter (Systronics 211). Chlorophyll content (mg g^{-1}) of the leaves was measured by the method of (Arnon 1948) [1]. For recording yield attributing characters four shoots were tagged on each observational plant and data were recorded on number of flowers, fruit set (%) and fruit drop (%). Average fruit weight (g) of selected fruits was recorded with the help of electronic balance (ANAMED, M-series) with 0.05 g resolution. The yield data was recorded as per the treatment on the basis of number and weight at each harvest and final data was recorded as fruit yield.

Results and Discussion

Nitrogen, phosphorus and potassium application to guava plants showed beneficial effect on plant growth. Perusal of data presented in Table 1 indicated that the growth of the plant in respect of plant spread, plant volume, shoot length, leaf area and chlorophyll content was increased in linear order with the application of nitrogen, except plant height and number of leaves where an application of nitrogen at the rate of 200 g per plant was found at par with higher dose (300 g N). An application of phosphorus (150 g P_20_5) significantly increased the shoot length, number of leaves and leaf area while, this treatment was found at par with (P_1, 100 g P_20_5) treatment in enhancement of growth parameters *viz*., plant height, plant spread, plant volume and chlorophyll content. Similarly, application of potassium (150 g K_2O) was found superior over control in improvement of growth parameters of guava. It is evident from the data mentioned in the Table 1 that the nutrients applied in combination produced the good plant growth and the response was more visualize when nutrients were combined at higher doses. Plant volume, length of shoot and leaf area were significantly influenced by the different treatment combinations. Among the various treatments, maximum plant volume (12.60 m^3) was recorded with $N_2P_2K_1$ combination which was found at par with $N_2P_1K_1$ (11.59 m^3), $N_1P_2K_1$ (11.83 m^3), $N_2P_1K_1$ (11.59 m^3), $N_1P_1K_1$ (11.20 m^3) and $N_2P_0K_1$ (11.15 m^3) combinations. The treatment combination of $N_2P_2K_1$ recorded maximum shoot length (68.51 cm) which was found at par with, $N_1P_2K_1$ (67.96 cm), $N_2P_1K_1$ (67.56 cm), $N_2P_0K_1$ (67.17 cm) and $N_1P_1K_1$ (66.85 cm) treatment combinations while $N_0P_0K_0$ recorded minimum shoot length (51.31 cm). The treatment combination of $N_2P_2K_1$ recorded maximum leaf area (61.72 cm^2) which was found at par with (60.37 cm^2) in $N_2P_1K_1$ and (60.30 cm^2) in $N_2P_0K_1$ combinations whereas; minimum leaf area (38.87 cm^2) was recorded in $N_0P_0K_0$. Treatment combination of 300 g N + 150 g P_2O_5 + 150 g K_2O per plant has found to be most effective for obtaining superior growth of guava. The growth parameters seem to be enhanced by the application of nutrients in present investigation. It was anticipated that the applied mineral fertilizers helped in adequate build-up of nutrients in soil and these nutrients were extracted by the plant root system and used in the metabolic processes as the growth advances. The findings of present study are in accordance with Wagh and Mahajan (1985) [17], Khattak *et al*. (2005) [3], Kumar *et al*. (2009) [4], Singh *et al*. (2009) [12], Kumar *et al*. (2010) [6], Tripathy *et al*. (2015) [16] and Singh *et al*. (2016) [13].

Table 1: Effect of NPK on growth parameters of guava (Pooled Data)

Treatments	Plant height (m)	Plant sprea (m)		Plant volume (m^3)	Length of shoot (cm)	Number of leaves	Leaf area (cm^2)	Chlorophyll content (mg g^{-1})
		E-W	N-S					
N_0 (0 g N)	2.26	2.29	2.36	6.42	55.64	29.42	42.32	2.201
N_1 (200 g N)	2.70	2.58	2.60	9.52	62.63	32.79	55.63	2.286
N_2 (300 g N)	2.75	2.66	2.71	10.32	63.38	33.83	57.89	2.363
S.Em.±	0.04	0.03	0.02	0.22	0.39	0.44	0.24	0.011
CD at 5%	0.12	0.08	0.05	0.62	1.12	1.25	0.68	0.032
P_0 (0 g P)	2.43	2.41	2.43	7.53	58.29	31.18	50.00	2.200
P_1 (100 g P)	2.64	2.54	2.60	9.18	60.74	31.85	52.43	2.316
P_2 (150 g P)	2.63	2.57	2.65	9.55	62.63	33.01	53.43	2.333
S.Em.±	0.04	0.03	0.02	0.24	0.41	0.39	0.26	0.010
CD at 5%	0.11	0.10	0.07	0.67	1.16	1.09	0.72	0.029
K_0 (0 g K)	2.49	2.42	2.47	7.87	57.45	30.61	49.77	2.249
K_1 (150 g K)	2.65	2.60	2.65	9.64	63.66	33.42	54.13	2.317
S.Em.±	0.03	0.03	0.02	0.19	0.34	0.32	0.21	0.008
CD at 5%	0.09	0.08	0.06	0.54	0.95	0.89	0.59	0.024
$N_0P_0K_0$	2.13	2.20	2.23	5.46	51.31	27.44	38.87	2.107
$N_0P_0K_1$	2.30	2.34	2.39	6.57	53.27	29.53	39.77	2.162
$N_0P_1K_0$	2.15	2.26	2.24	5.82	53.33	27.89	41.88	2.175
$N_0P_1K_1$	2.55	2.35	2.49	7.75	57.70	30.02	43.10	2.278
$N_0P_2K_0$	2.24	2.37	2.36	6.39	56.97	30.42	44.17	2.208
$N_0P_2K_1$	2.22	2.25	2.44	6.53	61.27	31.20	46.17	2.277
$N_1P_0K_0$	2.55	2.38	2.31	7.39	59.05	30.64	49.07	2.177
$N_1P_0K_1$	2.46	2.42	2.44	7.52	62.62	32.96	57.06	2.190
$N_1P_1K_0$	2.67	2.51	2.65	9.19	58.70	30.28	54.42	2.310
$N_1P_1K_1$	2.88	2.75	2.71	11.20	66.85	35.18	59.00	2.350
$N_1P_2K_0$	2.77	2.60	2.67	9.98	60.62	31.90	54.53	2.303
$N_1P_2K_1$	2.87	2.80	2.83	11.83	67.96	35.77	59.72	2.387
$N_2P_0K_0$	2.33	2.42	2.52	7.09	56.34	31.67	54.94	2.203
$N_2P_0K_1$	2.81	2.72	2.71	11.15	67.17	34.83	60.30	2.363
$N_2P_1K_0$	2.76	2.53	2.61	9.55	60.31	32.53	55.78	2.377
$N_2P_1K_1$	2.84	2.87	2.87	11.59	67.56	35.21	60.37	2.407
$N_2P_2K_0$	2.77	2.54	2.62	9.95	60.44	32.69	54.26	2.383
$N_2P_2K_1$	2.92	2.90	2.96	12.60	68.51	36.06	61.72	2.442
S.Em.±	0.10	0.06	0.05	0.53	0.96	1.07	0.58	0.027
CD at 5%	NS	NS	NS	1.49	2.72	NS	1.64	NS

The data presented in Table 2 revealed that, the yield and yield attributing parameters were significantly influenced by application of nutrients alone and in combinations. Higher level of applied nitrogen and phosphorus recorded maximum number of flowers per shoot with higher fruit set and least fruit drop over medium level and no application. Similar trend was also observed with potassium application over control. It is seen that NPK interactions had non-significant effect on number of flowers and fruit set. Although, numerically maximum number of flowers per shoot (26.17) and maximum fruit set (83.50%) was recorded with $N_2P_2K_1$ combination while, minimum number of flowers per shoot (10.50) and least fruit set (54.38%) was recorded in control i.e. $N_0P_0K_0$. The possible reason for the above trend might be due to the fact that nitrogen is component of chlorophyll and potash help in chlorophyll formation that regulate the build-up of proper C:N ratio, which control the flowering and fruiting of plant. These results also confirm the earlier findings of Kumar *et al*. (2008) [5] and Singh *et al*. (2008) [14]. Fruit drop was significantly influenced by different NPK interactions and treatment combination of $N_2P_2K_1$ recorded least fruit drop (40.07%) which was found at par with $N_2P_1K_1$ (42.05%) and $N_2P_2K_0$ (42.91%) combinations whereas maximum fruit drop (56.48%) was recorded in control. Fruit drop has been considered to be a complex phenomenon involving the role of nitrogen and auxins. The effect of nitrogen in reducing fruit drop might be due to its role in the retardation of formation of abscission layer in the fruit pedicels (Gupta *et al*. 1989) [2]. Further application of phosphorus and potassium also showed response in controlling fruit drop in the present study. Similar findings have also been reported by Singh *et al*. (2003) [11], Shukla *et al*. (2004) [8] and Kumar *et al*. (2008) [5].

Table 2: Effect of NPK on yield parameters and yield of guava (Pooled Data)

Treatments	Number of flowers per shoot	Fruit set (%)	Fruit drop (%)	Number of fruits	Average weight of fruit (g)	Fruit yield (Kg plant^{-1})	Fruit yield (Tonne ha^{-1})
N_0 (0 g N)	14.69	65.56	52.23	30.42	154.96	4.73	7.87
N_1 (200 g N)	18.69	72.65	46.90	35.28	166.59	5.90	9.83
N_2 (300 g N)	21.75	79.37	43.58	40.17	171.05	6.91	11.52
S.Em.±	0.37	0.58	0.46	0.33	1.27	0.06	0.10
CD at 5%	1.07	1.65	1.31	0.95	3.66	0.18	0.30
P_0 (0 g P)	16.28	67.98	50.37	30.14	156.73	4.74	7.90
P_1 (100 g P)	18.33	73.98	46.65	37.31	166.24	6.24	10.40
P_2 (150 g P)	20.53	75.62	45.69	38.42	169.63	6.56	10.93
S.Em.±	0.37	0.53	0.40	0.14	1.42	0.05	0.09
CD at 5%	1.03	1.50	1.12	0.38	4.02	0.15	0.24
K_0 (0 g K)	16.93	70.03	48.52	33.02	161.29	5.36	8.92
K_1 (150 g K)	19.83	75.03	46.62	37.56	167.11	6.34	10.56
S.Em.±	0.30	0.43	0.32	0.11	1.16	0.04	0.07
CD at 5%	0.84	1.22	0.92	0.31	3.28	0.12	0.20
$N_0P_0K_0$	10.50	54.38	56.48	26.33	143.00	3.76	6.27
$N_0P_0K_1$	14.00	60.42	53.41	28.17	151.67	4.27	7.11
$N_0P_1K_0$	13.50	69.54	51.78	29.83	153.10	4.57	7.61
$N_0P_1K_1$	15.50	70.97	51.81	33.00	162.80	5.37	8.94
$N_0P_2K_0$	16.00	67.86	51.81	30.50	160.73	4.90	8.16
$N_0P_2K_1$	18.67	70.19	48.09	34.67	158.43	5.49	9.15
$N_1P_0K_0$	16.67	66.14	50.34	29.50	157.95	4.66	7.77
$N_1P_0K_1$	16.50	73.79	49.46	30.00	161.95	4.86	8.10
$N_1P_1K_0$	18.00	65.74	46.82	36.00	164.80	5.93	9.88
$N_1P_1K_1$	19.67	76.59	43.51	40.50	171.58	6.95	11.58
$N_1P_2K_0$	18.00	72.60	47.33	33.00	169.03	5.58	9.30
$N_1P_2K_1$	23.33	81.03	43.93	42.67	174.25	7.43	12.38
$N_2P_0K_0$	19.00	76.26	45.29	32.83	163.00	5.35	8.92
$N_2P_0K_1$	21.00	76.91	47.26	34.00	162.80	5.54	9.22
$N_2P_1K_0$	19.67	77.52	43.91	39.50	165.17	6.53	10.87
$N_2P_1K_1$	23.67	83.50	42.05	45.00	180.00	8.10	13.50
$N_2P_2K_0$	21.00	80.21	42.91	39.67	174.83	6.93	11.55
$N_2P_2K_1$	26.17	81.82	40.07	50.00	180.50	9.03	15.04
S.Em.±	0.91	1.41	1.11	0.81	3.12	0.15	0.25
CD at 5%	NS	NS	3.20	2.28	9.20	0.43	0.72

It is evident from the data presented in Table 2 that, the number of fruits harvested, average weight of fruit, fruit yield per plant and fruit yield per hectare were significantly influenced by the application of nutrients over no application and it was observed that nutrients at higher levels interacted synergistically and resulted in higher fruit yield of guava. Treatment consisting of 300 g N + 150 g P_2O_5 + 150 g K_2O per plant recorded significantly maximum number of fruits (50.00) with maximum average fruit weight (180.50 g). Same treatment recorded significantly highest fruit yield per plant (9.03 kg) with maximum fruit yield per hectare (15.04 tonne) whereas, $N_0P_0K_0$ combination recorded minimum number of fruits (26.33) with average weight of fruit (143.00 g) and fruit yield (3.76 kg plant^{-1} and 6.27 tonne ha^{-1}). The findings of present study are in accordance with the findings of Singh *et al*. (2008) [14], Mitra *et al*. (2010) [7] and Thirupathi (2014) [15] who reported increased fruit yield with the application of nutrients under high density orcharding.

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