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Effect of NPK fertilization on physico-chemical properties of guava under high density planting

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Abstract
A field experiment was conducted for two consecutive years to study the effect of different levels of nitrogen, phosphorus and potassium individually and in combinations on physical and chemical properties of guava grown under high density planting system. Experimental findings revealed that, better fruit quality in respect of fruit size, fruit volume, pulp weight and acidity was noted when nutrients were applied in combination of 300 g N + 150 g P_2O_5 + 150 g K_2O per plant. Chemical quality attributes *viz*., TSS, ascorbic acid content, pectin content, sugars and acid sugar ratio were found superior with a combination of 300 g N + 100 g P_2O_5 + 150 g K_2O per plant. Principal components analysis suggests that treatment combinations *viz*., $N_2P_2K_1$, $N_2P_1K_1$, $N_1P_2K_1$ and $N_1P_1K_1$ are significant contributors for variables *viz*., TSS, acidity, ascorbic acid content, total sugars and pectin content.

Keywords: Guava, high density planting, nitrogen, phosphorus, potassium, physico-chemical properties

Introduction

Guava crop has exhibited a paradigm shift in the production system, from subsistence farming to commercial production owing to its hardiness, high yield, long supply season and high nutritive value. Demand of more foods due to increasing population, decreasing natural resources, encouraged the search of innovative methods of production that can obtain higher sustainable yields. High density planting is one of the advanced technique that have proven significantly good in increasing yield per unit area and it is exploited successfully in guava. The basic function of high density planting is to confine the exploitation zone of the plant with regard to light, water and nutrients so that the highest total yield potential can be reached in the smallest possible area (Singh, 2005) [14]. The effect of closer planting on fruit quality is mainly marked by the changes in quantity and quality of intercepted light and the partitioning of assimilate between vegetative and reproductive shoots (Policarpo *et al*. 2006) [7]. With proper nutrient management this phenomenon could be balanced and hence will be helpful in improvement of fruit quality.

With the increase in the plant and fruit number per unit area in dense planting, the nutrient management becomes the first and most important consideration. Input management is slightly modified under high density planting compared to normal planting. It has been observed that fertilizer requirements in high density arrangements are greater when compared to conventional planting. Higher yield removes more nutrients and even in soils with high natural fertility these nutrients must be replenished to sustain high yields (Mishra, 2014) [5]. Hence the nutrient management should aims to supply essential nutrients at optimum rate for proper growth, development and increasing quality fruit production in sustainable manner (Singh and Singh, 2007) [13]. Keeping this in view, the study was undertaken to find out the effect of different levels of N, P and K fertilization on physico-chemical properties of guava under high density planting.

Materials and Methods

The experiment was carried out at farm of College of Horticulture, Dr. PDKV, Akola during two consecutive years 2012-13 and 2013-14 on 3 year old guava plants of cv. L-49. The experiment was laid out in a factorial randomized block design with three replications considering two plants as a unit. To maintain the compact and strong structure of plants, sequential and periodic pruning was carried out in January. The multiple shoots developed as a result of periodic pruning, which produced flower buds for rainy season crop. However, as winter season crop has more market value due to its quality and taste; to check the onset of rainy season crop, shoot pruning (50%) was done again in May during both the years of study. 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. With this, 10 Kilogram farm yard manure as a basal dose was also applied excluding control plants. Sources to supply nitrogen, phosphorus and potassium were urea, single super phosphate and muriate of potash respectively. For recording the fruit quality observations, five fruits were randomly selected and harvested from each observational plant at edible ripe stage and same fruits were used for recording the various physical properties of guava. Fruit length (cm) from stalk end to styler end and fruit breadth (cm) at maximum thickness was measured with the help of 'vernier calliper'. Fruit volume (cc) of selected fruits was measured by water displacement method. After separating pulp from core of selected fruits, the pulp weight (g) was recorded using electronic balance. Three composite samples from selected fruits of each treatment were obtained by cutting small pieces from all sides of each fruit. These pieces were analyzed for various chemical properties following standard procedures. Total soluble solids (^{0}Brix) was determined with help of temperature self-compensating digital refract meter (ATAGO, RX-7000X). Acidity of fruit was determined by titrating a known quantity of sample diluted with water against standard NaOH solution, using phenolphthalein as an indicator and after computing with the standard formula the mean was recorded and expressed in percentage as acidity equivalent to citric acid. Ratio of total soluble solids (TSS) and titrable acidity was expressed as TSS:Acidity ratio. Ascorbic acid content was determined by 2, 6- dinitrophenol indophenols visual titration method (Ranganna, 1986) [8]. Pectin is extracted from sample and saponified with alkali. Further it is precipitated as calcium pectate by addition of calcium chloride to an acid solution. After thoroughly washing to eliminate chloride ion, the precipitate is dried and weighed (Ranganna, 1986) [8]. Reducing sugar and total sugars were determined by "Dubois method" (Sadasivam and Manickam, 1996) [9]. The non-reducing sugars present in the sample were calculated by subtracting values of reducing sugars from values of total sugars and multiplying by factor 0.95. The data analysis was carried out using the OPSTAT software (1998) [12] and principal component analysis was done by SAS software (2015) [10].

Results and Discussion

In the present investigation application of nitrogen, phosphorus and potassium alone and in combinations showed enhancement in fruit quality of guava. On perusal of data presented in Table 1 it is seen that physical properties were significantly influenced by the increasing levels of applied nutrients and maximum values for these parameters were recorded with an application of 300 g N, 150 g P_2O_5 and 150 g K_20. The effect of applied nutrients on quality enhancement was more visualized when these nutrients were applied in combinations and it was observed that all the nutrients at higher levels interacted synergistically to improve the physical quality of fruit. Maximum fruit breadth (7.07 cm) was recorded in $N_2P_2K_1$ (300 g N + 150 g P_2O_5 + 150 g K_20) treatment combination which was found at par with $N_2P_1K_1$ (6.99 cm), $N_2P_2K_0$ (6.92 cm) and $N_1P_2K_1$ (6.78 cm) treatments. The maximum fruit volume (172.07 cc) was recorded with $N_2P_2K_1$ treatment combination which was found at par with $N_2P_1K_1$ (170.62 cc) and $N_1P_2K_1$ (166.60 cc) treatments. Similarly, maximum pulp weight (158.05 g) was recorded in $N_2P_2K_1$ combination which was found at par with $N_2P_1K_1$ (156.68 g), $N_2P_0K_1$ (155.43 g) and $N_1P_2K_1$ (152.89 g) combinations. Minimum fruit breadth (5.85 cm), fruit volume (125.78 cc) and pulp weight (110.21 g) was recorded in control ($N_0P_0K_0$). An enhancement in physical fruit quality by the application of mineral fertilizers might be due to optimum supply of plant nutrients in right amount during the crop growth period which caused vital vegetative development of the plants which supplies constant nutrition to developing fruits during maturation phase. Phosphorus plays an important role in photosynthesis and accumulation of food material, nitrogen in carbohydrate and protein synthesis and potassium in the regulation of water relations. It also acts as a catalyst in the formation of more complex substances and in the acceleration of enzymatic activities which ultimately leads to improvement in physical properties of the fruit. Similar results have also been reported by Mitra and Bose (1985) [6], Sharma *et al*. (2012) [11], Kumar *et al*. (2013) [4] and Brar *et al*. (2015) [1] in guava.

Table 1: Effect of NPK on physical properties of guava (Pooled Data)

Treatments	Fruit size (cm)		Fruit volume (cc)	Pulp weight (g)
	Length	Breadth		
N_0 (0 g N)	6.06	6.28	146.30	126.54
N_1 (200 g N)	6.31	6.54	159.54	139.32
N_2 (300 g N)	6.50	6.75	163.59	147.91
S.Em.±	0.08	0.04	1.23	1.13
CD at 5%	0.23	0.12	3.54	3.25
P_0 (0 g P)	6.08	6.34	148.71	130.18
P_1 (100 g P)	6.36	6.53	158.25	139.11
P_2 (150 g P)	6.44	6.70	162.47	144.48
S.Em.±	0.06	0.04	1.49	1.04
CD at 5%	0.17	0.12	4.20	2.92
K_0 (0 g K)	6.18	6.41	152.35	132.69
K_1 (150 g K)	6.41	6.64	160.61	143.16
S.Em.±	0.05	0.03	1.22	0.85
CD at 5%	0.14	0.09	3.43	2.39
$N_0P_0K_0$	5.62	5.85	125.78	110.21
$N_0P_0K_1$	5.97	6.25	136.48	121.55
$N_0P_1K_0$	6.08	6.30	144.00	125.58
$N_0P_1K_1$	6.37	6.45	160.00	131.53
$N_0P_2K_0$	6.08	6.37	149.65	130.52
$N_0P_2K_1$	6.23	6.53	161.90	139.83
$N_1P_0K_0$	6.08	6.33	153.73	131.15
$N_1P_0K_1$	6.22	6.52	155.98	128.83
$N_1P_1K_0$	6.27	6.45	157.13	135.73
$N_1P_1K_1$	6.42	6.53	161.38	143.68
$N_1P_2K_0$	6.38	6.60	162.40	141.73
$N_1P_2K_1$	6.52	6.78	166.60	152.89
$N_2P_0K_0$	6.22	6.43	159.87	133.88
$N_2P_0K_1$	6.38	6.70	160.43	155.43
$N_2P_1K_0$	6.27	6.48	156.35	143.37
$N_2P_1K_1$	6.73	6.99	170.62	156.68
$N_2P_2K_0$	6.60	6.92	162.22	142.03
$N_2P_2K_1$	6.82	7.07	172.07	158.05
S.Em.±	0.20	0.10	3.02	2.77
CD at 5%	NS	0.30	8.74	7.82

It is evident from the data presented in Table 2 that, the chemical fruit quality properties were significantly influenced by the application of nutrients. Highest rate of applied nitrogen, phosphorus and potassium were found most effective for improvement of fruit quality (Table 2). Variation in chemical composition of fruits was also recorded due to interaction effect between different levels of applied nutrients. Treatment combination of $N_2P_1K_1$ (300 g N + 100 g P_2O_5 and + 150 g K_2O) recorded maximum TSS (12.72^0Brix), TSS:Acidity ratio (38.81), ascorbic acid content (134.3 mg per 100 g), pectin content (0.831%), reducing sugar (4.131%) and total sugars (8.117%) while minimum acidity (0.322%) was recorded in $N_2P_2K_1$ combination which was found at par with $N_2P_1K_1$ combination. Quality parameters in terms of TSS, acidity, ascorbic acid content, pectin content and total sugars seems to be improved by application of nutrients under this study. Nitrogen stimulates the functioning of number of enzymes in the physiological processes, which might have improved the total soluble solid content of the fruits. The highest mean values for total sugars could be attributed to the involvement of nitrogen in various energy sources likes' amino acids and amino sugars. The useful effect of phosphorus on quality parameters was due to the fact that it increased the efficiency of metabolic and physiological processes of plants and thus improved the chemical quality of guava fruits. Potassium is widely regarded as element required to improve quality of fruits and in this study it is established that the application of potassium is necessary in fruit orchard to harvest good quality crop. Among various combinations of nutrients applied in this study, higher doses produced better quality fruits. It might be due to application of higher doses of fertilizers maximized plant growth and facilitated the accumulation of more carbohydrates into the fruit and during the subsequent fruit development such metabolites hydrolyzed into sugar that increased the TSS, sugars content and decrease the acidity. The applied nutrients also bring favourable changes in ascorbic acid and pectin content of fruits harvested from treated plants than fruits from non treated plants. The betterment in the fruit quality of guava by application of nitrogen, phosphorus and potassium in combination has also been emphasized by numerous researchers over the years such as Mitra and Bose (1985) [6], Kumar *et al.* (2008) [3], Kumar *et al*. (2009) [2], Sharma *et al*. (2012) [11] and Kumar *et al*. (2013) [4].

Table 2: Effect of NPK on chemical properties of guava (Pooled Data)

Treatments	TSS (^{0}Brix)	Acidity (%)	TSS: Acidity ratio	Ascorbic acid content (mg/100g)	Pectin content (%)	Sugars		
						Reducing sugar (%)	Non-reducing sugar (%)	Total sugars (%)
N_0 (0 g N)	11.08	0.567	19.67	114.51	0.638	3.360	3.145	6.505
N_1 (200 g N)	12.09	0.432	29.10	123.98	0.724	3.553	3.537	7.091
N_2 (300 g N)	12.28	0.360	34.68	127.92	0.786	3.667	3.661	7.329
S.Em.±	0.06	0.005	0.44	0.69	0.005	0.024	0.033	0.023
CD at 5%	0.18	0.015	1.26	1.99	0.015	0.068	0.095	0.067
P_0 (0 g P)	11.39	0.485	25.26	116.61	0.650	3.343	3.294	6.637
P_1 (100 g P)	11.94	0.458	27.64	123.83	0.724	3.592	3.484	7.076
P_2 (150 g P)	12.09	0.416	30.54	125.98	0.773	3.646	3.566	7.212
S.Em.±	0.06	0.006	0.48	0.61	0.005	0.018	0.025	0.021
CD at 5%	0.16	0.016	1.35	1.73	0.015	0.051	0.071	0.060
K_0 (0 g K)	11.60	0.470	26.11	117.72	0.688	3.404	3.324	6.729
K_1 (150 g K)	12.02	0.436	29.52	126.56	0.744	3.649	3.572	7.221
S.Em.±	0.05	0.005	0.39	0.50	0.004	0.015	0.020	0.017
CD at 5%	0.13	0.013	1.10	1.41	0.012	0.042	0.058	0.049
$N_0P_0K_0$	10.38	0.613	16.93	98.88	0.543	2.978	3.195	6.173
$N_0P_0K_1$	10.93	0.582	18.80	112.58	0.556	3.150	3.120	6.270
$N_0P_1K_0$	10.48	0.595	17.62	110.62	0.584	3.375	3.136	6.510
$N_0P_1K_1$	11.38	0.560	20.34	125.07	0.736	3.593	3.112	6.705
$N_0P_2K_0$	11.43	0.533	21.45	113.78	0.661	3.355	3.291	6.646
$N_0P_2K_1$	11.87	0.518	22.89	126.15	0.747	3.706	3.019	6.725
$N_1P_0K_0$	11.42	0.522	21.90	114.33	0.667	3.458	3.216	6.673
$N_1P_0K_1$	11.55	0.518	22.36	119.67	0.635	3.450	3.330	6.780
$N_1P_1K_0$	12.57	0.390	32.78	123.87	0.676	3.401	3.477	6.878
$N_1P_1K_1$	12.42	0.428	29.15	126.72	0.780	3.646	3.763	7.409
$N_1P_2K_0$	12.28	0.402	30.99	125.82	0.766	3.580	3.486	7.065
$N_1P_2K_1$	12.32	0.330	37.40	133.50	0.821	3.786	3.953	7.739
$N_2P_0K_0$	11.57	0.337	34.45	124.30	0.734	3.455	3.226	6.680
$N_2P_0K_1$	12.52	0.338	37.16	129.92	0.767	3.565	3.678	7.243
$N_2P_1K_0$	12.07	0.445	27.13	122.67	0.740	3.403	3.434	6.837
$N_2P_1K_1$	12.72	0.328	38.81	134.03	0.831	4.131	3.986	8.117
$N_2P_2K_0$	12.22	0.392	31.78	125.20	0.818	3.637	3.458	7.095
$N_2P_2K_1$	12.45	0.322	38.73	131.42	0.825	3.813	4.187	8.000
S.Em.±	0.16	0.013	1.07	1.70	0.013	0.058	0.081	0.057
CD at 5%	0.47	0.037	3.03	4.90	0.036	0.163	NS	0.162

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