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Studies on macronutrient fertilization in pomegranate under sub-tropical plains

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ABSTRACT

An investigation was carried out to study the influence of different levels of NPK fertilizers on plant growth, fruit yield and quality, and leaf NPK content in pomegranate cv. Kandhari under sub-tropical conditions. Graded doses of nitrogen (0-300g/plant), phosphorus (0-150g/plant) and potassium (0-300g/plant) fertilizers were applied through soil, in addition to a basal dose of FYM. Control plants were fed FYM only. Maximum increase in plant growth and fruit yield was recorded in plants receiving NPK @ 300:50:100g/plant, while Control plants registered least growth and yield. Potassium levels improved fruit weight over the Control. Higher dose of potassium also improved fruit colour and enhanced peel thickness and grain weight. Maximum TSS:acid ratio was seen with NPK @ 200:50:100g/plant. Reducing sugars were not affected by any treatment. Leaf N, P and K content increased with application of the respective nutrient.

Key words: Pomegranate, macronutrients, growth, yield, quality, leaf analysis

INTRODUCTION

Pomegranate (*Punica granatum* L.) is one of the important fruits exported from India. In North-Western plains, it is primarily grown as a backyard plant. Commercial plantations are limited in number. To boost cultivation its management practices need to be refined and mineral nutrition influences yield and quality of the fruits most. Under sub-tropical conditions, pomegranate bears heavily which can exhaust the plant and essential elements in soil needed for proper growth and development. A regular supply of these nutrients needs to be ensured for sustainable production. Earlier studies revealed that application of balanced fertilizers improved growth, yield and quality pomegranate (Kumar and Dhandar 1996 and Dhanumjaya and Subramanyam, 2009). Hence, application of optimum dose of fertilizer is a prime necessity for obtaining higher yields in pomegranate. In view of importance of mineral nutrition in growth and development in pomegranate, an attempt was made to ascertain the requirement of macronutrients in pomegranate grown under sub-tropical plains.

MATERIAL AND METHODS

Fertilizer application was imposed on seven year old pomegranate cv. Kandhari plants spaced at 4x4m distance at New Orchard, Department of Fruit Science, Punjab Agricultural University, Ludhiana, during the year 2010. Soil in the experimental plot was alluvial, with sandy-loam texture at pH 7.7, EC 0.092 dsm^{-1}, organic carbon 0.51% and available P 17.3kg/ha and K 205.4kg/ha. Single-nutrient application was chosen to conduct this experiment. Plants were applied with graded doses of N (0-300g/plant), P_2O_5 (0-150g/plant) and K_2O (0-300g/plant) in the form of urea, single super phosphate and muriate of potash, respectively. Half dose of N and full dose of P_2O_5 and K_2O was applied during February, and the remaining half of N dose was applied after fruit-set. When applying a particular nutrient, level of the other two nutrients was kept constant. All the plants (including Control) were supplied with FYM @ 20kg/plant in December. Eleven treatment combinations (Table 1) were replicated thrice in Randomized Block Design. For growth traits, plant height and spread were recorded before application of fertilizer during the dormant period. Increase in annual growth was calculated by noting observations the following dormant season. Fruit weight and fruit yield were recorded in each tree at harvest. Fruit colour was rated visually on a scale of 1- 10 by a panel of five judges. Peel thickness was estimated by digital Vernier Callipers (*MITUTOYO*, Japan). Juice was extracted from grains by sieving through a muslin cloth and juice percentage was calculated on the basis of total fruit weight. For elemental analysis, leaf sampling was done as per Bhargava

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Table 1. Treatment details

S. No.	NPK composition (g/plant)
T_1	$N_0P_{50}K_{100}$
T_2	$N_{200}P_{50}K_{100}$
T_3	$N_{300}P_{50}K_{100}$
T_4	$P_0N_{100}K_{100}$
T_5	$P_{100}N_{100}K_{100}$
T_6	$P_{150}N_{100}K_{100}$
T_7	$K_0N_{100}P_{50}$
T_8	$K_{200}N_{100}P_{50}$
T_9	$K_{300}N_{100}P_{50}$
T_{10}	$N_{100}P_{50}K_{100}$
T_{11}	$N_0P_0K_0$ (Control)

Table 2. Effect of various NPK combinations on growth and fruit yield in pomegranate cv. Kandhari

Treatment	Increase in plant height (cm)	Increase in plant spread (m)		Fruit yield (kg/plant)
		North-South	East-West	
T_1-$N_0P_{50}K_{100}$	24.8	0.49	0.47	15.81
T_2-$N_{200}P_{50}K_{100}$	49.3	0.63	0.60	20.69
T_3-$N_{300}P_{50}K_{100}$	55.1	0.67	0.64	21.74
T_4-$P_0N_{100}K_{100}$	24.8	0.47	0.46	15.40
T_5-$P_{100}N_{100}K_{100}$	30.1	0.51	0.53	18.11
T_6-$P_{150}N_{100}K_{100}$	35.7	0.55	0.56	17.74
T_7-$K_0N_{100}P_{50}$	35.7	0.50	0.51	15.68
T_8-$K_{200}N_{100}P_{50}$	43.3	0.58	0.58	20.47
T_9-$K_{300}N_{100}P_{50}$	49.2	0.52	0.54	19.86
T_{10}-$N_{100}P_{50}K_{100}$	32.7	0.56	0.55	17.68
T_{11}-$N_0P_0K_0$ (Control)	22.4	0.41	0.43	14.60
CD (*P=0.05*)	5.07	0.04	0.03	1.01

and Chadha (1988). Leaf nitrogen was estimated by Kjeldahl method, using KEL PLUS System (Pelican Equipments, India); phosphorus by vanadomolybdo phosphoric yellow colour method, and potassium by flame photometer method. Data were analyzed as per standard statistical procedures described by Singh *et al* (1998).

RESULTS AND DISCUSSION

Effect of various NPK combinations on plant height and plant spread are presented in Table 2. Significant increase in plant height was recorded in all fertilizer treatments compared to Control, except, in plants under T_1 treatment (NPK: 0:50:100g/plant). Maximum increase in plant height (55.0cm) was recorded in T_3 (NPK: 300:50:100g/plant) where highest dose of N and low levels of P and K were applied. Data further showed that higher dose each of N, P and K nutrients resulted in increased plant height. Nitrogen, phosphorus and potassium (being major essential nutrients for plant growth and development) may have resulted in enhanced growth with increased levels of the nutrients. Similar findings were earlier reported by Dhanumjaya and Subramanyam (2009) also in pomegranate. Likewise, plant spread in both North-South and East-West directions increased significantly with various N, P and K applications compared to Control. Maximum increase in plant spread in North-South and East-West directions (0.67m E-W and 0.64m N-S) was recorded in T_3 (NPK 300:50:100g/plant) and minimum spread (0.41m E-W and 0.43m N-S) in Control trees. Similarly, phosphorus at all levels significantly increased plant spread in both directions compared to Control. Among K levels, plant spread increased up to 200g/plant, and then decreased with increasing levels. These findings are in agreement with Chougule (1976) also in pomegranate.

Fruit yield (Table 2) increased linearly with higher levels of nitrogen, and maximum fruit yield (21.74kg/ plant) was registered in T_3 (NPK: 300:50:100g/plant), followed by T_2 (20.69kg/ plant). Medium levels of phosphorus and potash recorded better fruit yield over lower or higher levels of these nutrients. Minimum fruit yield was observed in T_{11}, where no fertilizer was applied. Increase in yield with N and K application has also been reported by Bewoor *et al* (1990) in pomegranate cv. Jyoti.

Data presented in Table 3 shows that different combinations of NPK increased fruit weight in pomegranate over Control. Maximum fruit weight (270.65g) was recorded in T_9 (NPK 100:50:300g/plant) which was statistically at par with T_2 (NPK 200:50:100g/plant) and T_8 (NPK 100:50:200g/plant). Minimum fruit weight (221.44g) was obtained in Control plants. Nitrogen application also helped increase fruit weight and maximum fruit weight was observed when 200g N/plant was applied, but further increase in N levels did not cause increased fruit weight. Increased fruit size with potassium application was also reported by Dutta and Banik (2007) in guava. Fruit colour score too was significantly affected by various NPK combinations (Table 3). Data show that highest dose of K (300g/plant) produced superior colored fruits (score of 7.48), followed by application of K @ 200g/plant. Improvement in colour with K fertilization could be due to increased carbohydrate accumulation by the fruit (Fisher and Kwong, 1961). Minimum colour rating of 5.83 was observed in fruits under T_3 (NPK: 300:50:100g/plant), where the highest dose of nitrogen was applied. Peel thickness was affected significantly by various NPK combinations (Table 3). Maximum peel thickness (3.5mm) was registered with the highest dose of K (300g/plant). Phosphorus doses reduced

Table 3. Effect of varioius NPK combinations on fruit quality in pomegranate cv. Kandhari

Treatment	Fruit weight (g)	Fruit colour (Max. 10)	Peel thickness (mm)	Weight of 100 grains (g)	Fruit juice (%)	TSS/ acid ratio	Reducing sugars (%)
T_1 – $N_0P_{50}K_{100}$	232.19	7.04	3.14	25.53	33.27 (35.21)	19.9	8.39 (16.82)
T_2 – $N_{200}P_{50}K_{100}$	265.33	6.48	3.33	27.19	36.53 (37.17)	23.4	9.22 (17.67)
T_3 – $N_{300}P_{50}K_{100}$	259.15	5.83	3.27	28.25	37.00 (37.45)	21.2	9.12 (17.57)
T_4 – P_0N_{100} K_{100}	229.53	6.71	3.16	28.00	34.30 (35.83)	20.3	8.12 (16.53)
T_5 – $P_{100}N_{100}K_{100}$	237.46	7.08	2.89	23.58	34.67 (34.06)	21.8	8.58 (17.02)
T_6 – $P_{150}N_{100}K_{100}$	236.61	7.10	2.84	29.90	34.70 (36.08)	21.3	8.33 (16.74)
T_7 – $K_0N_{100}P_{50}$	226.27	6.67	3.26	27.82	32.77 (34.90)	19.8	8.22 (16.64)
T_8 – K_{200} $N_{100}P_{50}$	265.19	7.13	3.32	29.33	37.95 (38.02)	22.0	8.43 (16.86)
T_9 – K_{300} $N_{100}P_{50}$	270.65	7.48	3.50	31.70	36.32 (37.04)	22.9	8.37 (16.79)
T_{10} –$N_{100}P_{50}K_{100}$	259.38	6.93	3.37	26.58	34.60 (36.01)	21.1	8.75 (17.19)
T_{11} – $N_0P_0K_0$ (Control)	221.44	6.91	3.04	23.30	32.11 (34.50)	20.0	8.11 (16.53)
CD (*P=0.05*)	18.42	0.47	0.19	0.91	0.97	0.72	NS

Figures in parentheses indicate arcsine transformed values of percentages; NS = Non-significant

peel thickness; minimum peel thickness (2.89mm) was observed in plants supplied with NPK @ 100:100:100g. Maximum 100 grain weight was seen in NPK: 100:50:300g/ plant (31.70g). Where higher dose of K (300g/plant) was applied, it was significantly higher than in all other treatments. Minimum weight of 100 grains was recorded in plants that received no NPK dose. In general, grain weight increased with increasing levels of N, P and K. Present findings are in agreement with Prasad and Mali (2000) who observed seed weight to increase appreciably with increasing dose of nitrogen. Various NPK combinations had a significant effect on fruit juice percentage. Maximum juice percentage (37.95) was seen in T_8 (NPK 100:50:200 g/plant) and it was statistically at par with the juice content of fruits under T_3 (NPK: 300:50:100g/plant) and T_2 (NPK: 200:50:100g/plant) treatments. Minimum juice percentage (32.11) was observed in fruits under Control. Fruit juice percentage increased in linearly as level of nitrogen increased upto 300g/plant. These results are in line with those of Bose *et al* (1988) and Sen and Chauhan (1983) who reported an increase in nitrogen rate resulting in greater absorption of water and minerals from the soil, resulting in increased juice percent in pomegranate. Among various P levels, no significant difference in juice content was observed. NPK fertilizer combinations had a varied effect on TSS:acid ratio in pomegranate. Highest TSS/acid ratio was recorded in T_2 (NPK: 200:50:100g/plant), and minimum in T_1 treatment (NPK 100:50:100g/plant). Similarly, all phosphorus and potassium applications improved TSS:acid ratio compared to Control. Similar results have been reported by Arora *et al* (2012). Reducing-sugar content was not significantly influenced by treatments (Table 3). However, maximum content of reducing sugars (9.22%) was recorded in T_2 (NPK 200:50:100g/plant), whereas, lowest value of 8.11% was found in the Control.

Table 4. Effect of various NPK combinations on macronutrient content in leaves of pomegranate cv. Kandhari

Treatment	Leaf N(%)	Leaf P(%)	Leaf K(%)
T_1 – $N_0P_{50}K_{100}$	1.88 (7.88)	0.13 (2.08)	1.63 (7.33)
T_2 – $N_{200}P_{50}K_{100}$	2.18 (8.49)	0.12 (2.02)	1.58 (7.22)
T_3 – $N_{300}P_{50}K_{100}$	2.23 (8.58)	0.12 (1.99)	1.56 (7.17)
T_4 – P_0N_{100} K_{100}	2.17 (8.47)	0.09 (1.73)	1.62 (7.31)
T_5 – $P_{100}N_{100}K_{100}$	2.11 (8.35)	0.15 (2.20)	1.60 (7.26)
T_6 – $P_{150}N_{100}K_{100}$	2.10 (8.33)	0.15 (2.24)	1.57 (7.20)
T_7 – $K_0N_{100}P_{50}$	2.16 (8.45)	0.12 (1.97)	1.43 (6.87)
T_8 – K_{200} $N_{100}P_{50}$	2.12 (8.37)	0.12 (2.01)	1.63 (7.33)
T_9 – K_{300} $N_{100}P_{50}$	2.00 (8.13)	0.10 (1.83)	1.70 (7.49)
T_{10} –$N_{100}P_{50}K_{100}$	2.15 (8.43)	0.14 (2.14)	1.62 (7.31)
T_{11} – $N_0P_0K_0$ (Control)	1.91 (7.94)	0.10 (1.83)	1.49 (7.01)
CD (*P=0.05*)	0.123	0.085	0.095

Figures in parentheses indicate arcsine transformed values of percentages

It is evident from data presented in Table 4 that different fertilizer combinations significantly influenced leaf N, P and K content. Nitrogen, phosphorus and potassium content of leaves showed an increasing trend with increasing levels of the respective nutrient. Our study showed that foliar NPK status of trees supplied with different doses of N, P and K fell within the optimum range (N: 0.44-2.54, P: 0.10-0.26 & K: 0.20-2.37%) of high-yielding plants as suggested by Raghupati and Bhargava (1998) in pomegranate. Significantly higher leaf nitrogen content (2.23%) was recorded in T_3 treatment which had the highest dose of N (300g/plant) and was statistically at par with T_2, T_4 and T_7 treatments. Leaf nitrogen content was minimum (1.88%) in T_1 where no N was applied. Increased rate of nitrogen fertilization was associated with increased nitrogen

accumulation as might be expected, while, leaf phosphorus and potassium levels decreased. Similarly, leaf P content ranged from 0.09% (T_4) to 0.15% (T_5 & T_6), while, minimum leaf P content was recorded in NPK 100:50:200g/plant combination. Leaf K content significantly improved from 1.43% (NPK 100:50:0g/plant) to 1.70% (NPK 100:50:300g/plant). High N application seemed to have a negative effect on leaf K content. Leaf composition of 2.23% N, 0.12% P and 1.56% K was associated with highest fruit yield.

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