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BIMONTHLY NUTRIENT APPLICATION PROGRAMME ON CALCAREOUS SOIL IMPROVES FLOWERING AND FRUIT SET IN MANGO (*MANGIFERA INDICA* L.)

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Abstract

Fertilizer management particularly for mango trees is tedious on alkaline and calcareous soil. Mango (*Mangifera indica* L.) cv. Langra trees were supplied fertilizer through soil application under bimonthly nutrient application programme to ensure the continuous supply of nutrition to plants throughout the year. Fertilizer (N, P and K) was supplied five times a year at regular intervals while skipping one application randomly in each treatment. Amount of fertilizer supplied was equal in all treatments i.e., 910g N, 680g P_2O_5 and 680g K_2O per tree. Complete dose of P and K and half dose of N were applied in February while rest of the half dose of N was applied in April as control. It was observed that trees supplied with nutrients in February, April, June, August and October, produced maximum number of flowers per panicle with highest percentage of perfect flowers (62.4%), maximum final fruit set (0.165%) and maximum nutrient use efficiency for nitrogen (25.57%), phosphorus (2%) and potassium (14.97%) over control. The results revealed the superiority of split application of nutrients in February, April, June, August and October over bulk application of fertilizer only in February and April (control).

Introduction

Pakistan is bestowed with good agro-climatic conditions needed for the successful production of mango. Bud induction, flowering and fruit setting in mango are one of the most critical phenological events which demand continuous supply of nutrients for better crop production. Understanding and controlling these vital events has been of prime interest for scientists over a century. Application of proper amount of nutrients at appropriate time is required to overcome nutrient disorders, achieve healthy growth and high yield with good fruit quality. Average yield of mango fruit in Pakistan (11.2 tonnes ha^{-1}) and Brazil (12.6 tonnes ha^{-1}) is higher than most of top mango fruit countries of the world (Anon., 2006). However, still there is a great potential to increase per hectare yield as soil and climatic conditions of Pakistan are ideally suitable to achieve high yield and good quality mango if proper management is practiced. Nutrient management is considered one of the important components of mango production technology. Application of balanced amount of nutrients at right growth stage by proper method could return in improved quality and yield of mango.

Increase in yield could be achieved by adopting proper fertilizer application in split doses as annual applications may not be suitable especially on the soils having high pH and calcareous in nature as these soils make nutrients unavailable due to fixation of applied nutrients. Therefore, appropriate time and right amount of nutrient application, keeping in view an understanding of vital phenological stages, may be useful strategy to obtain good production on such soils. Young *et al.*, (1962) reported a significant relationship between leaf N and yield but leaf K did not show any effect. In the same way, Embleton & Jones (1966) obtained maximum yield when the leaf N content was 1.35%. The nitrogen content in leaves of 18 years old mango cv. Banganapally was found to vary from 0.88 to 1.19% and the highest fruit yield was noted in trees whose leaves had a N content of 1.02 to 1.20% (Rameshwar & Sultan, 1979). In another study, Rameshwar & Sultan (1981) correlated leaf nutrient levels and yield of 14 years old mango trees belonging to cv. Banganapally. The optimum leaf nutrient level revealed by them were N 1.00-1.25%, P 0.07-0.10% and K 0.60-0.74%. These results suggest use of leaf analysis as a nutrient indexing parameter.

In the past, researchers have paid more attention on the use of proper amount of fertilizer to increase the yields in mango, but very little work has been done on the split and continuous application of fertilizers on regular basis. The objective of this research was the supply of N, P and K to plants on calcareous soils throughout the year in split doses and to determine its effect on sex expression and fruit set of mango tree cv. Langra.

Materials and Methods

This experiment was conducted at Experimental Fruit Orchard, Square 9 (31°- 26' N, 73°- 06' E, 184.4 m), Institute of Horticultural Sciences, University of Agriculture, Faisalabad (Pakistan) from January 2004 to September 2006. Experimental material consisted of 26, eighteen years old healthy trees of mango cv. Langra planted in calcareous soil containing 2.5% $CaCO_3$. The soil at top horizon (0-30 cm layer) had 58.0% sand, 18.5% silt and 23.5% clay with 34% moisture concentration, pH 8.0, EC_e 1.89 dS m^{-1}, 0.57% organic matter and 7.29 mg kg^{-1} available phosphorus. Fertilizer was applied in seven treatments (four replications per treatment keeping one plant as experimental unit). Each treatment plant was supplied with 910g N, 680g P_2O_5 and 680g K_2O in each year including control. In T_0 (control), fertilizer was applied as per conventional practice i.e. half dose of N and full dose of P and K during February and rest of the half dose of N in April, while rest of the treatments included Treatment plants supplied with fertilizer on 15th of month as per schedule of 5 times skipping one interval randomly in each case. Fertilizer NPK (17:17:17) of Engro Chemical Pakistan Ltd. was used as compound fertilizer being a primary source of N, P and K while rest of the N was supplemented by urea (46% N). In all treatments, except T_1, 0.5 kg urea (230 g nitrogen) was applied in February to encourage flowering while in T_1 the same amount was supplied in April. Rest of applications in all treatments included 1.0 kg of NPK containing 170g of each nutrient i.e. N, P and K.

Before soil application of fertilizer, weeds were removed and light hoeing was done under the canopy of trees, then fertilizer was applied by broadcast method uniformly under the canopy of the trees, 2 feet away from the trunk of tree. Hoeing was done again to mix the fertilizer completely in the soil. Immediately after fertilizer application, plants were irrigated under modified basin system.

To determine leaf mineral content, 6-7 months old, 40 leaves were taken randomly (Chadha *et al.*, 1980) during February, May and August to find out the relationship between leaf nutrient concentration and reproductive physiology of plant. Leaf samples were washed with tap water, then with distilled water and dried at 70°C, finally ground and digested. The digested solution was used to determine N, P and K content as percentage on dry weight bases using the methods described by Cottenie *et al.*, (1982). Nutrient uptake was calculated by multiplying nutrient concentration in fruit with weight per tree (Yaseen *et al.*, 2005; Mahmood *et al.*, 2007). Nutrient use efficiency was calculated by converting nutrient uptake difference between treatments and control into percentage. No intercropping was ever practiced in experimental plants. During research study, all experimental trees received similar cultural practices for irrigation and plant protection measures.

Thirty panicles were randomly selected and tagged in each plant (experimental unit) to record observations for floral biology (total number of flowers per panicle and sex ratio percentage), initial and final fruit set (including fruit set at initial and proximal portion) and total fruit drop. Initial fruit set was recorded at button stage while final fruit set was recorded in June before harvest at weekly interval

Experiment was laid out under randomized complete block design (RCBD). The experimental data were subjected to analysis of variance (ANOVA) using Genstat Release 10 (Lawes Agricultural trust, Rothmsted Experimental Station, UK). Treatment's means were compared with Duncan multiple range test at 5% probability level (Duncan, 1955).

Results and Discussion

Effect of bimonthly nutrient application on mango trees showed highly significant results on production of total number of flowers per panicle (Table 1). Maximum number of flowers per panicle were observed in T_3 (840.3) followed by T_6 (755.2) and T_2 (711.2) while minimum number of flowers per panicle was found in T_1 (542.7). Effect of split application of fertilizer on sex expression showed superiority over control. Maximum percentage of perfect flowers was observed in T_6 (62.4%) followed by T_3 (62.2%), T_2 (61.5%) and T_5 (61.3%) while percentage of perfect flowers in T_1 (57.7%) was found minimum. These significant results showed positive relationship between bimonthly nutrient application and production of perfect flowers. T_6 (62.4%) produced highest percentage of perfect flowers when fertilizer was applied during February, April, June, August and October. Minimum number of flowers per panicle and perfect flower percentage in T_1 revealed the fact that application of nutrients prior to blooming not only improve plant health for better flower set but also increase perfect flower percentage.

Leaf nutrient status was estimated three times a year during February, May and August (Table 2). It was further observed that among N, P and K, nitrogen had a significant contribution towards production of perfect flowers (Fig. 1). Leaf N level in February exhibited a clear and positive relationship with percentage of perfect flowers. These results confirmed the earlier studies (Anon., 1982) revealed that number of perfect flowers increased when the nitrogen level was increased from 0 to 900g per plant and same observations were made by Rajput & Tiwari (1975) that pre-bloom foliar spray of N @ 2%, 4% and 6% improved the perfect flowers percentage and fruit set ratio in mango. Increased N level of leaves during flowering resulted more production of hermaphrodite/perfect flowers i.e., 63% of total flowers per panicle.

Effect of bimonthly nutrient application was also observed on initial fruit set per panicle stage and significant difference among treatments was observed (Table 1). Maximum total initial fruit set was observed in T_6 (15.57%) followed by T_4 (15.5%), T_5 (14.7%), T_3 (14.5%). Total fruit set percentage was recorded minimum in T_1 (12.4%) due to non-availability of nutrition at pre-bloom stage while control plants showed better total fruit set (14.1%) than T_1. Furthermore, fruit set percentage on proximal and distal portion of panicle was also recorded and it was revealed that bimonthly nutrient application showed non-significant results on initial fruit set per panicle at proximal portion (data not shown) while initial fruit set at distal portion showed highly significant results (Table 1). Maximum initial fruit set at distal portion was observed in T_6 (13.8%) followed by T_4 (12.6%) and T_5 (12.0%) while minimum in T_1 (10.4%). The pattern of abscission of initially set fruitlets is asymptotic with the greatest losses occurring during the first week following the completion of anthesis (Searle *et al.*, 1995).

Table 1. Effect of bimonthly nutrient application on floral biology and fruit set in mango cv. Langra.

Fertilizer application schedule	Flowers per panicle		Initial fruit set per panicle (%)		Final fruit set per panicle (%)		Total fruit drop per panicle (%)
	Total number of flowers	Perfect flowers (%)	Total fruit set	Fruit set at distal portion	Total fruit set	Fruit set at distal portion	
February, April (T_0)	571.0c	59.2bc	14.1ab	10.9cd	0.120g	0.103f	99.90a
Apr., Jun., Aug., Oct., & Dec. (T_1)	542.7c	57.7c	12.4b	10.4d	0.125f	0.103f	99.90a
Feb., Jun., Aug., Oct. & Dec. (T_2)	711.2b	61.5ab	14.2ab	11.5bcd	0.130e	0.105e	99.85ab
Feb., Apr. Aug., Oct. & Dec. (T_3)	840.3a	62.2ab	14.5a	11.8bc	0.135d	0.113d	99.88ab
Feb., Apr., Jun., Oct. & Dec. (T_4)	689.0b	60.6abc	15.5a	12.6ab	0.150c	0.118c	99.88ab
Feb., Apr., Jun., Aug. & Dec. (T_5)	680.2b	61.3ab	14.7a	12.0bc	0.163b	0.138b	99.83b
Feb., Apr., Jun., Aug. & Nov. (T_6)	755.2ab	62.4a	14.1ab	13.8a	0.165a	0.145a	99.83b

Values in same column with different letter(s) differ significantly ($p \leq 0.05$) according to DMRT

Table 2. Effect of bimonthly nutrient application on leaf mineral composition of mango cv. Langra.

Fertilizer application schedule	Nutrient concentration in leaves (%)								
	Nitrogen			Phosphorus			Potassium		
	Feb.	May	Aug.	Feb.	May	Aug.	Feb.	May	Aug.
February, April (T_0)	1.51d	1.18b	1.30de	0.09^{NS}	0.10^{NS}	0.11bc	0.64^{NS}	0.56d	0.57bc
Apr., Jun., Aug., Oct., & Dec. (T_1)	1.52cd	1.20b	1.37bc	0.09	0.09	0.10c	0.65	0.60bc	0.62a
Feb., Jun., Aug., Oct. & Dec. (T_2)	1.54c	1.18b	1.34cd	0.09	0.09	0.11ab	0.67	0.59bc	0.58b
Feb., Apr. Aug., Oct. & Dec. (T_3)	1.66b	1.27a	1.45a	0.09	0.09	0.11bc	0.66	0.60bc	0.57bc
Feb., Apr., Jun., Oct. & Dec. (T_4)	1.44f	1.13c	1.26e	0.09	0.09	0.11bc	0.64	0.57cd	0.55cd
Feb., Apr., Jun., Aug. & Dec. (T_5)	1.46e	1.21b	1.32cd	0.10	0.09	0.12a	0.63	0.62ab	0.54d
Feb., Apr., Jun., Aug. & Nov. (T_6)	1.69a	1.26a	1.40ab	0.09	0.10	0.11ab	0.68	0.64a	0.61a

Values in same column with different letter(s) differ significantly ($p \leq 0.05$) according to DMRT

NS = Non significant

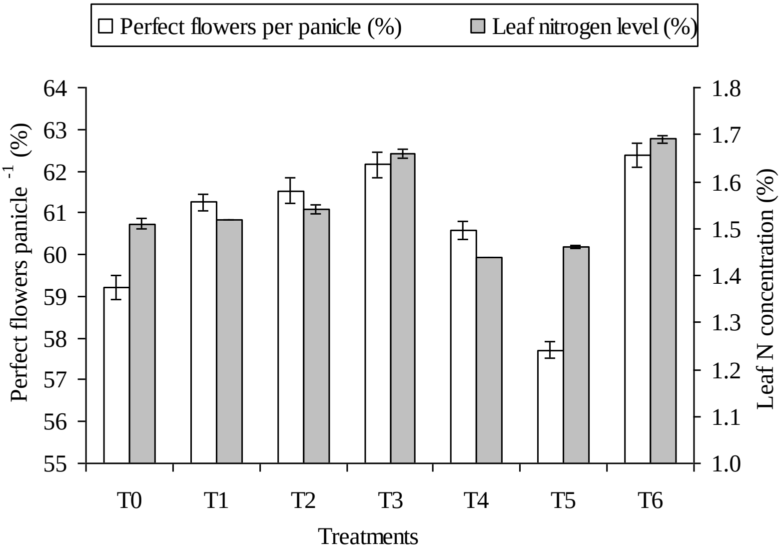

Fig. 1. Effect of leaf N level in February on perfect flowers per panicle (%) in mango under bimonthly nutrient application programme. Treatments, except T_0 (control), indicate bimonthly nutrient application during Apr., Jun., Aug., Oct., & Dec. (T_1); Feb., Jun., Aug., Oct. & Dec. (T_2); Feb., Apr. Aug., Oct. & Dec. (T_3); Feb., Apr., Jun., Oct. & Dec. (T_4); Feb., Apr., Jun., Aug. & Dec. (T_5) and Feb., Apr., Jun., Aug. & Nov. (T_6). Vertical bars represent means (±S.E.) of three replications ($p \leq 0.05$).

Data regarding final fruit set was recorded in May and split application of N, P and K showed significant results on final fruit set (Table 1). Maximum final fruit set was observed in T_6 (0.165%) followed by T_5 (0.163%) and T_1 (0.150%) while minimal final fruit set was observed in T_0 (0.120%). The significant results showed relationship between bimonthly nutrient application and final fruit set per panicle. The results confirmed the earlier studies of Syamal & Mishra (1985) who recorded maximum fruit set (1.2%) by application of 1000g N, 2000g P_2O_5 and 1000g K_2O in three equal doses during February, April and June. Also, Hays (1953) found that in cv. Bombay, 0.1% flowers matured which was sufficient to yield an average crop of 200 fruit per tree and these findings were confirmed by these observations that fruit set percentage did not increase more than 0.17%. As, nutritional status of mango leaves was also estimated along with study of different parameters, strong correlation between fruit set per panicle and K level during May was observed. Statistically significant nutrient levels in months of February, May and August are given in Table 2. Higher final fruit set was observed in T_6 (0.165%) which had also higher K level (0.64%) in its leaves followed by T_5 and T_1. Minimum K level was estimated in control (0.56%) and that same treatment exhibited minimum fruit set (0.12%) (Fig. 2). This relation confirmed the earlier studies of Kanwar *et al.*, (1987), who in a long term trials on mango, applied N, P and K to young mango trees in different rates and combinations and found K as essential element for good fruit set (0.143%).

Effect of split application of fertilizer on final fruit set at proximal portion showed non-significant results (data not shown) which proved superiority over control regarding final fruit set per panicle at distal portion (Table 1). Maximum final fruit set was observed in T_6 (0.145%) followed by T_5 (0.138%) and T_4 (0.118%) while final fruit set in

T_1 and T_0 (0.103%) was found minimum and statistically at par with each other. Scholefield & Oag (1989) reported final fruit set ranging from 0.33 to 1.39% with peak results attained with better nutritional management. Singh (1954) reported that the structural and functional abnormalities in flowers, competition between rapidly growing young fruits and environmental components may be attributed to the high degree of fruit drop at initial stage. Anila & Radha (2003) further revealed higher fruit drop percentage (39.6 to 74.7%) during first 15 days after fruit set which decrease with passage of time. The initial drop may be due to the internal competition between large number of small fruits initially formed and some incompletely fertilized ovules also dropped (Thimmappaiah & Suman, 1987). Present studies further revealed the vital role time and dose of nutrition application as continuous supply of N, P and K fortifies plant health and support fruit retention capacity at early stages, thus ultimately give higher final fruit set and improve yield per tree.

Fruit drop is a natural phenomenon, which occurs at different levels during the fruit growth and development. It is especially high in mangoes, as a healthy mango tree produces more than 1000 panicles and each panicle has 1000-3000 flowers, which comprise 21.1-90.6% hermaphrodite flowers (Anjum *et al.*, 1999). Therefore, fruit drop appears a natural means of load shedding and a relief to tree. Data regarding total fruit drop was statistically analyzed which showed significant difference among treatments (Table 1). Panicles with maximum fruit drop were found in T_0 and T_1 (99.90%). Minimum drop was observed in T_6 and T_5 (99.83%) which were statistically at par with each other. It has already been reported by Singh (1954) that in mango under normal condition, less than 0.1% of hermaphrodite flowers developed into mature fruit, while more than 99% of them dropped off.

At harvest, fruit nutrient status in fruit was estimated and nutrient use efficiency of each treatment was compared with control. It was observed that bimonthly nutrient application programme significantly increased N, P and K use efficiency which further enhanced fruit yield (36.6%) from 43.4 kg plant^{-1} (control) to 59.3 kg plant^{-1} (T_6) (Fig. 3). Trees supplied with nutrients in February, April, June, August and October exhibited maximum nutrient use efficiency for nitrogen (25.6%), phosphorus (2%) and potassium (15.0%) over control. Bimonthly nutrient application throughout reproductive cycle proved to be better over control as it not only increased percentage of perfect flowers per panicle and fruit retention at pre-harvest stage but also improved nutrient use efficiency with ultimate effect on increased yield. These results supports the earlier findings of Kanwar *et al.*, (1987) who, in long-term trials on mango, revealed phosphorus had no appreciable effect on cropping while N and K had a significant effect on increased yield. Furthermore, Feungchan *et al.*, (1989) applied N, P and K fertilizer at 300 g tree^{-1} to mango at interval of 7 and 15 days and 1, 3, 6 and 12 months. They concluded that plant growth, fruit yield and earliness were all promoted by frequent fertilizer application.

Conclusion

Bimonthly nutrient application programme seems to have an edge over conventional fertilizer application schedule on calcareous soils as it improve nutrient use efficiency of plant through continuously provision of needful amount of nutrients at each growth phase of a plant which ultimately guarantee good fruit production. Thus, split application of fertilizer in February, April, June, August and October is better than bulk application of fertilizer only in February and April (control). Moreover, ample supply of N at pre-bloom stage and K at pre-harvest stage needs further emphasis to further improve crop production.

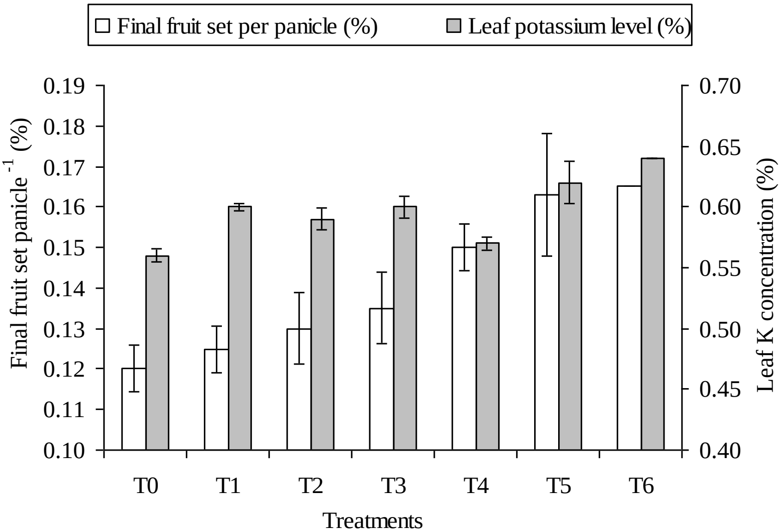

Fig. 2. Effect of leaf K in May on final fruit set (%) in mango under bimonthly nutrient application programme. Treatments, except T_0 (control), indicate bimonthly nutrient application during Apr., Jun., Aug., Oct., & Dec. (T_1); Feb., Jun., Aug., Oct. & Dec. (T_2); Feb., Apr. Aug., Oct. & Dec. (T_3); Feb., Apr., Jun., Oct. & Dec. (T_4); Feb., Apr., Jun., Aug. & Dec. (T_5) and Feb., Apr., Jun., Aug. & Nov. (T_6). Vertical bars represent means (±S.E.) of three replications ($p \leq 0.05$).

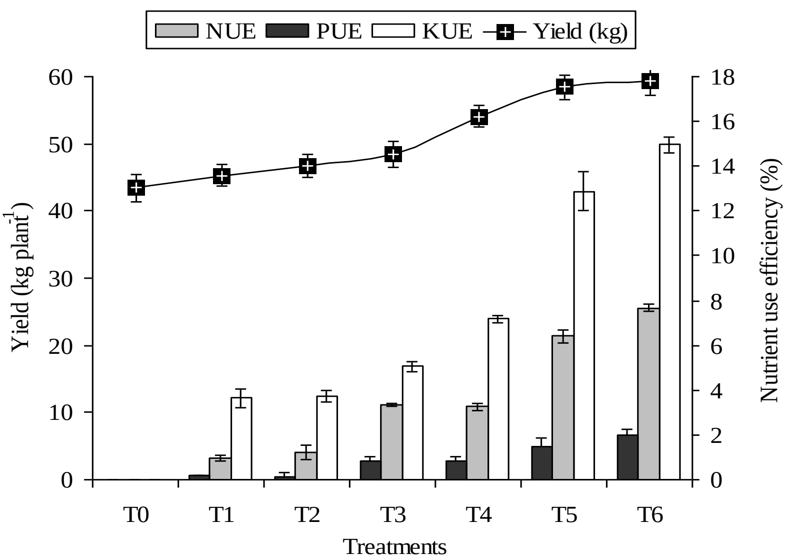

Fig. 3. Nutrient use efficiency (%) of nitrogen (NUE), phosphorus (PUE) and potassium (KUE) under bimonthly nutrient application programme and their effect on yield (kg plant^{-1}) of mango. Treatments, except T_0 (control), indicate bimonthly nutrient application during Apr., Jun., Aug., Oct., & Dec. (T_1); Feb., Jun., Aug., Oct. & Dec. (T_2); Feb., Apr. Aug., Oct. & Dec. (T_3); Feb., Apr., Jun., Oct. & Dec. (T_4); Feb., Apr., Jun., Aug. & Dec. (T_5) and Feb., Apr., Jun., Aug. & Nov. (T_6). Vertical bars represent means (±S.E.) of three replications ($p \leq 0.05$).

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