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INFLUENCE OF FOLIAR FEEDING OF KNO_3 ON FRUIT YIELD AND QUALITY PARAMETERS OF MANGO

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ABSTRACT

Foliar feeding with potassium (K) nutrient was carried out for two successive years to study the impact on fruit yield related parameters and quality attributes of 'Amrapali' mango. Plants were sprayed with KNO3 (2, 3, 4 %) as single, double and triple sprays during 10, 20 and 30 days after fruit set (DAFS) and the control trees were applied with water spray. Improvement in percentage of fruit retention was registered with double sprays of KNO3 3% followed by triple applications of KNO3 2% and single spray of KNO3 4%. Higher pulp/stone ratio and fruit yield was attained significantly in the plants treated with K feedings in comparison to the control. TSS, reducing and non-reducing sugars content also exhibited similar trends. Leaf N and K concentrations were observed maximum in all the plants treated with K nutrient. It is envisioned that foliar feeding with double sprays (KNO3 3%) on 10 and 20 DAFS directly to metabolite sites considerably enhanced fruit yield and quality attributes under sub-mountainous zone of North India.

Keywords: *KNO_3, Mango, Physico-chemical attributes, Quality, Yield*

Mango (*Mangifera indica* L) is grown commercially in the tropical and sub-tropical countries of the world. India produces about 20.8 m MT mangoes from an acreage of 2.29 million ha with an annual productivity of 9.17 Mt/ha (Anonymous, 2019). India has also earned foreign exchange of 1064.6 crores during 2018-19 from the export of mango pulp and fresh fruits. Despite favourable ecological conditions, mango productivity in the country is quite low compared to other mango growing countries of the world and that seems to be related to imbalanced fertilization, excessive fruit drop and poor orchard management practices. It is postulated that higher drop of mango fruitlets during pin and marble stages is directly related to limited supply of nutrients and abiotic stresses.

Drastic reduction in the availability of K content in the trees is due to more competition among developing fruits for photo-assimilates resulting in the restriction of root growth and translocation of K nutrient in fruit plants (Lester *et al.,* 2010a). This eventually leads to deficiency of K^+ cations in developing fruits, which, in turn, drastically reduces fruit size, yield and quality characters. Amrapali mango is a dwarf and regular bearing cultivar, however, it produces fruit of irregular size and weight due to internal competition. For sustainable yield and production, fruit size has been improved with the application of nutrients as foliar feeding as well as with soil applications. Generally, K fertilization has synergistic outcome as K^+ cations are essential for both biochemical and physiological processes required for plant growth, fruit size regulation, yield and stress tolerance (Baiea *et al*., 2015). KNO_3 feeding enhanced fruit set, yield and quality in many horticultural crops (Singh *et al*., 2005; Tandel and Patel, 2011). Potassium (K^+) is readily absorbed before the appearance of visual symptoms and better-quality fruits in terms of juice sugars, ascorbic acid and carotenoids content are produced (Lester *et al*., 2010b). Foliar feeding with KNO_3 and urea substantially increased flowering and fruit yield of 'Tommy Atkins' mangoes (Yeshitela *et al.,* 2005). With this objective, the present study was intended to ascertain the effect of KNO_3 as foliar application on fruit retention, fruit size, yield and quality traits in Amrapali mango cultivar.

MATERIALS AND METHODS

The present investigations were carried out for two consecutive years 2016-17 and 2017-18 at MS Randhawa Fruit Research Station Gangian (Dasuya) Hoshiarpur situated in sub-mountainous zone of Punjab at 31.79°N and 76.17°E co-ordinates. Amrapali mangoes planted at 5 m x 5 m spacing with uniform growth and vigour were selected for the experimentation. Recommended doses of fertilizers were applied as per Punjab Agricultural University, *Package of Practices for Fruit crops*. Soil of the study site is loamy sand with soil pH of 7.6, OC of 0.34 % and EC of 0.2 mmhos/cm. The available P and K content in soil were computed as 13.2 and 142.7 kg/ha, respectively. The KNO_3 (13:0:45) LR grade was applied as foliar sprays @ 2, 3 and 4

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% levels, each at single, double and triple doses at a frequency of 10, 20 and 30 days after fruit set (DAFS) using Tween 80 as a surfactant. The control included only water spray. Five uniform branches/tree were tagged in all the directions of the tree canopy randomly for recording observations. The fruit retention (%) was determined at physiological maturity by subtracting the total number of fruits harvested from the selected panicles from initial fruit set. At the time of harvesting, 10 fruits/replication were randomly selected and the observations were noted for fruit related physical traits viz. fruit length (cm), fruit width (cm), fruit weight (g), pulp (%) and pulp/stone ratio. Fruit weight was estimated by weighing fruits/replication on electronic precision calibrate scale. Total fruit yield was computed in kg/tree by counting and multiplying the fruit number with average weight. Total soluble solids (TSS) were determined with digital refractometer (ATAGO, PAL-1, Model 3810, Japan) and values were corrected at 20˚C. Titratable acidity (TA) was determined by neutralization juice with 0.1 N NaOH. Reducing sugars, total sugars and ascorbic acid contents were determined as per the procedure described by AOAC (2005). Leaf samples were collected as per standard procedures and were washed with tap water, followed by 0.1 N HCl, rinsed with distilled water and oven dried at 60°C for 72 hrs. The samples were finely ground and stored in paper bags. The estimation of N was done with Kel Plus Nitrogen Estimation System (*Pelican Equipments, India*), while K was determined by flame photometer method (AOAC, 2005). The experiment was laid out in randomized block design with three replications and two plants as a unit per replication. Data were analyzed for variance by two factor Randomized Block Design using SAS (V 9.3, SAS Institute Inc., USA) software. Comparisons were made among treatments for observed changes in parameters during study. When interactions between treatments were found significant ($p \le 0.05$), the effect of each treatment was determined by pairwise mean comparison using LSD.

RESULTS AND DISCUSSION

Fruit physical attributes

The effect of foliar feeding with KNO_3 on fruit retention of Amrapali mango is presented in Fig. 1 and the results revealed that significant improvement was registered in the plants treated with K nutrients

Table 1. Effect of foliar application of KNO_3 on fruit physical attributes of mango

Treatment (A)	Number of Sprays (B)			
	Single spray	Double spray	Triple spray	Mean
Fruit weight (g)				
KNO_3 2%	155.10^{gh}	164.20^{ef}	177.10^{bc}	165.47 ± 3.36^{b}
KNO_3 3%	158.50^{fgh}	186.40^{a}	173.10^{cd}	172.67 ± 4.18^{a}
KNO_3 4%	167.30^{de}	179.40^{b}	160.80^{fg}	169.17 ± 2.93^{a}
Control	152.70^{hi}	153.00^{hi}	152.48^{hi}	152.73 ± 1.06^{c}
Mean	158.40 ± 1.88^{c}	170.75 ± 4.03^{a}	165.87 ± 3.29^{b}	
LSD (p≤0.05) A = 3.60	B = 3.11	A x B = 6.23		
Pulp (%)				
KNO_3 2%	72.58^{a}	72.01^{ab}	68.36^{cd}	70.99 ± 0.87^{a}
KNO_3 3%	70.96^{abc}	73.43^{a}	68.17^{cd}	70.85 ± 0.95^{a}
KNO_3 4%	69.27^{bcd}	72.13^{ab}	70.58^{abc}	70.66 ± 0.70^{a}
Control	66.23^{d}	66.44^{d}	66.18^{d}	66.28 ± 0.53^{b}
Mean	69.76 ± 0.85^{ab}	71.00 ± 0.94^{a}	68.32 ± 0.66^{b}	
LSD (p≤0.05) A = 1.89	B = 1.64	A x B = 3.29		
Pulp/stone ratio				
KNO_3 2%	5.54^{b}	5.38^{bc}	4.64^{f}	5.19 ± 0.14^{a}
KNO_3 3%	5.11^{d}	5.88^{a}	4.43^{g}	5.14 ± 0.21^{a}
KNO_3 4%	4.84^{e}	5.32^{c}	4.67^{ef}	4.94 ± 0.10^{b}
Control	4.04^{h}	4.01^{h}	4.06^{h}	4.04 ± 0.02^{c}
Mean	4.88 ± 0.16^{b}	5.15 ± 0.21^{a}	4.45 ± 0.07^{c}	
LSD (p≤0.05) A = 0.10	B = 0.09	A x B = 0.18		

*Means with the same value are not significantly different at P≤0.05.

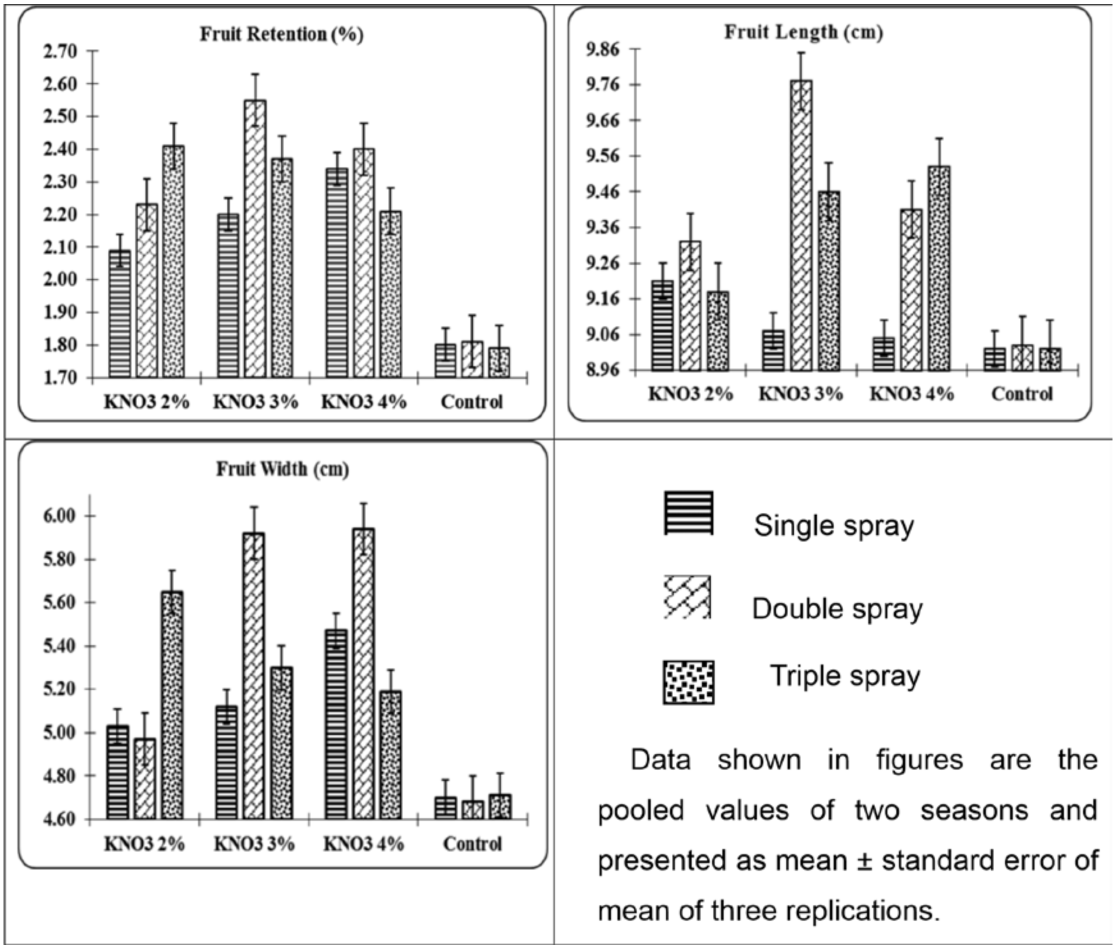

Fig. 1. Effect of foliar application of KNO_3 on physical attributes of mango fruit.

and values ranged from 2.24% to 2.37% as compared to the control (1.80%). The interactive effect of concentrations and number of applications was also statistically significant. Double sprays of KNO_3 (3%) at 10 and 20 DAFS resulted in maximum fruit retention of 2.55% followed by triple sprays of KNO_3 2 % and double sprays of KNO_3 4%. These fruit retention values were enhanced by 40.9, 34.6 and 32.6 %, respectively than the control. These findings are corroborated with the observations suggested by Taha *et al.* (2014) who implicated the beneficial effects of KNO_3 on the enhancement of mango fruit set and retention per cent.

As evident from Fig. 1, fruit size was significantly higher with the foliar feedings of KNO_3 as compared to the control. Overall, sprays of KNO_3 applied at 10 and 20 DAFS documented maximum fruit length of 9.38 cm and width (5.38 cm), followed by triple and single applications. Double sprays of KNO_3 (3%) registered the higher values for fruit retention and fruit size. Average fruit weight (Table 1) was maximum in the plants treated with KNO_3 3% which resulted in nearly 13.1% more weight than the control. The highest fruit weight of 186.4g was registered in the plants treated with KNO_3 3% applied during 10 and 20 DAFS followed by double sprays of KNO_3 4% (179.4g) and increment in values of about 21.8 and 17.3 %, respectively was noted over the control.

The experimental results relevant to percentage of fruit pulp recovery (Table 1) showed positive improvement with KNO_3 treatments over the control. The least recovery of pulp per cent was observed in the control. Double applications of KNO_3 3% yielded maximum pulp per cent in comparison to other treatments and yielded about 10.5% more pulp content than the control and was statistically at par with 2% applied singly which depicts about 9.6% increment over the control. The interaction between concentrations and number of sprays was statistically significant. Pulp/stone ratio (Fig. 2) was maximum in the plants applied twice with KNO_3 (3%) to the tune of 5.88 followed by single spray of KNO_3 2% (5.54), two sprays of 2% KNO_3 (5.38) and KNO_3 4 % (5.32) and minimum in the control (4.04). The present investigations therefore, signify the importance of KNO_3 in the improvement of physical

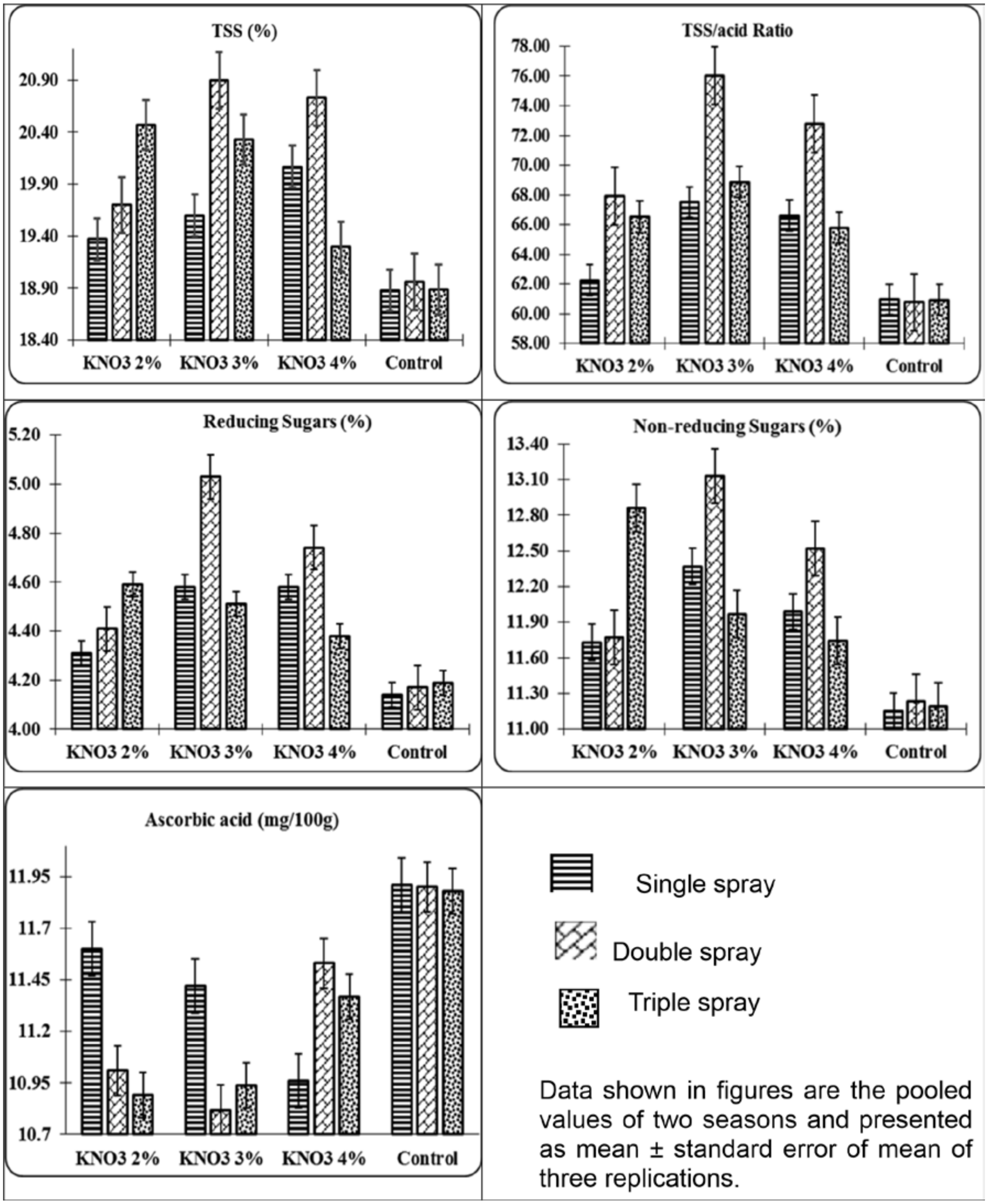

Fig. 2. Effect of foliar application of KNO_3 on chemical attributes of mango fruit.

fruit traits of mangoes which can be attributed to the involvement of nutrients in cell division, cell expansion and increased volume of inter-cellular spaces in the mesocarpic cells as suggested by Krishnamoorthy, (1981) and Sarkar and Rahim, (2013).

Improvement in fruit yield contributing parameters is the most important objective of present studies for successful cultivation of mango. The results pertaining to the effect of various KNO_3 concentrations on fruit yield are presented in Table 2. The data of year 1 and year 2 exhibited the significant increase in yield with KNO_3 treatments in comparison with control. The fruit yield during both the years was recorded to be maximum with KNO_3 3% (39.79 and 34.72 kg/tree). The mean maximum yield with KNO_3 3% was followed by 4% and 2% registering improvement by 22.1, 16.9 and 14.2 % in comparison to the control. KNO_3 applied twice at 3% also exhibited the highest escalation in mean fruit yield

Table 2. Effect of foliar application of KNO_3 on fruit yield of mango (year wise data)

Treatment (A)	Year	Number of Sprays (B)			
		Single spray	Double spray	Triple spray	Mean
Fruit yield (kg/tree)					
KNO_3 2%	Ist Year	36.66[de]	36.59[de]	35.42[e]	36.22 ± 0.31[c]
	2nd Year	30.58[ef]	33.93[bc]	35.81[a]	33.44 ± 0.59[b]
	Pooled	32.91[e]	35.26[bc]	36.4[ab]	34.86 ± 0.60[b]
KNO_3 3%	Ist Year	38.86[bc]	42.39[a]	38.12[cd]	39.79 ± 0.59[a]
	2nd Year	32.28[d]	36.22[a]	35.66[a]	34.72 ± 0.50[a]
	Pooled	35.57[cde]	40.17[a]	36.11[cde]	37.28 ± 0.79[a]
KNO_3 4%	Ist Year	37.28[cd]	40.31[b]	36.61[de]	38.07 ± 0.49[b]
	2nd Year	32.74[cd]	35.31[ab]	31.87[de]	33.31 ± 0.45[b]
	Pooled	35.78[bcd]	37.01[b]	34.24[de]	35.68 ± 0.51[b]
Control	Ist Year	32.72[f]	32.70[f]	31.51[f]	32.31 ± 0.29[d]
	2nd Year	29.72[fg]	28.56[gh]	27.96[h]	28.74 ± 0.29[c]
	Pooled	30.56[f]	30.63[f]	30.39[f]	30.53 ± 0.28[c]
Mean	Ist Year	36.38 ± 0.53[b]	38.00 ± 0.81[a]	35.42 ± 0.58[c]	34.59
	2nd Year	31.33 ± 0.34[b]	33.50± 0.56[a]	32.82± 0.70[b]	36.41
	Pooled mean	33.71 ± 0.52[b]	35.77 ± 0.87[a]	34.31 ± 0.69[b]	
Year 1: LSD ($p \leq 0.05$)	A = 0.93	B = 0.80	A x B = 1.61		
Year 2: LSD ($p \leq 0.05$)	A = 0.80	B = 0.69	A x B = 1.39		
Pooled: LSD ($p \leq 0.05$)	A = 1.04	B = 0.90	A x B = 1.80		

followed by double sprays of 4% and gave more yield/ plant by nearly 31.2 and 20.8%, respectively over the control. The enhancement in fruit yield in the plants treated with KNO_3 signifies the role of N and K nutrients in mango trees to obtain higher productivity. Fruit yield was enhanced due to contributing physical traits and exogenous supply of KNO_3 might be responsible for the enhancement in the mobilization of food and minerals from other parts of the plant towards developing fruits that act as extremely active metabolic sinks, which result in higher fruit retention, fruit weight and marketable yield (Krishnamoorthy, 1981). In accordance with the present investigations, Yeshitela *et al.* (2005) also reported positive response of K nutrient as foliar feeding on improvement of mango fruit yield. These results are corroborated with the findings of Sarkar and Rahim (2013).

Bio-chemical attributes

Foliar sprays of KNO_3 at various concentrations expressively enhanced mango biochemical parameters as cleared from Fig. 2. The data revealed that TSS content was higher significantly with the foliar applications of KNO_3 (13:0:45). Maximum juice TSS concentration was attained with 3 % KNO_3 applied twice with the value of 20.9 % followed by double applications of KNO_3 4 % (20.7 %); however, both the treatments were statistically at par with each other and registered an increment to the tune of 10.2 and 9.3 %, respectively over the control. These results revealed that application of KNO_3 has substantial and direct role in the accumulation of assimilation of metabolic compounds within the fruits which resulted in higher accumulation of sugar content and thus ultimately improved the juice TSS concentrations (Wahdan *et al.*, 2011). K nutrient contributions in the translocation of sugars from leaves to the developing fruits and higher TSS content and better quality of the fruits were observed (Prasad *et al.*, 2015). There are several composite studies in the available literature that pulp measured as °Brix is an important parameter for the value addition of horticultural crops and is used to prepare array of quality products like candy, jelly, mango leather, RTS, nectar, chutney, etc. The present studies are in corroboration with the findings of Yeshitela *et al.* (2005) and Taha *et al.* (2014).

TSS/acid ratio significantly improved with the sprays of KNO_3 3% applied as single, twice and triple (Fig. 2) and exhibited an increment of 16.3 % in its value than the control. Two sprays of KNO_3 3% expressed maximum improvement in TSS/acid ratio as compared to other treatments and depicted 25.1 % enhancement over the control. Untreated control plants had the lowest TSS/acid ratio. Plants treated with KNO_3 at various doses and intervals significantly improved TSS/

Table 3. Effect of foliar application of KNO_3 on leaf N and K content of mango

Treatment (A)	Number of Sprays (B)			
	Single spray	Double spray	Triple spray	Mean
Leaf N (%)				
KNO_3 2%	0.93^{e}	0.95^{de}	0.97^{d}	0.95 ± 0.03^{c}
KNO_3 3%	0.96^{d}	0.98^{cd}	1.02^{c}	0.99 ± 0.04^{b}
KNO_3 4%	1.03^{c}	1.08^{b}	1.16^{a}	1.09 ± 0.04^{a}
Control	0.92^{ef}	0.91^{f}	0.93^{e}	0.92 ± 0.03^{d}
Mean	0.96 ± 0.05^{b}	0.98 ± 0.04^{b}	1.02 ± 0.04^{a}	
LSD (p≤0.05) A = 0.02	B = 0.02	A x B = 0.04		
Leaf K (%)				
KNO_3 2%	0.30^{fg}	0.34^{e}	0.36^{d}	0.33 ± 0.02^{c}
KNO_3 3%	0.32^{f}	0.38^{c}	0.41^{b}	0.37 ± 0.01^{b}
KNO_3 4%	0.35^{de}	0.40^{b}	0.44^{a}	0.40 ± 0.01^{a}
Control	0.23^{i}	0.24^{hi}	0.25^{h}	0.24 ± 0.02^{d}
Mean	0.30 ± 0.01^{c}	0.34 ± 0.01^{b}	0.37 ± 0.01^{a}	
LSD (p≤0.05) A = 0.01	B = 0.01	A x B = 0.01		

*Means with the same value are not significantly different at P≤0.05.

acid ratio and values ranged between 62.3 to 76.0 in comparison to the control (60.9). The effect of KNO_3 at different doses showed impact on juice reducing sugars and significantly higher reducing sugars were obtained with KNO_3 3% with an increment of about 13.0 % over the control. The interaction between concentrations and number of applications also influenced significantly reducing sugars and highest value was exhibited in the plants sprayed with double doses of KNO_3 3% recording an augmentation of 20.6% than the control. All treatments indicated significantly positive impact on non-reducing sugars as compared to untreated plants. The incremental trend for non-reducing sugars was similar as noted for juice reducing sugars (Fig. 2) and the best concentration was KNO_3 3 % and interactive treatments were two sprays of KNO_3 3 % which expressed nearly 11.6 and 16.9 % over the control. The similar results have also been reported by Singh *et al*. (2005). The ascorbic acid content revealed decreased levels in all treatments as compared to control, however, interaction between concentrations and number of applications did not differ significantly with each other. Minimum ascorbic acid content was attained in the plants sprayed three times with KNO_3 2 % and two applications of KNO_3 3% and the values decreased to the tune of 9.1 and 8.5 %, respectively than the control. Significant enhancement in sugars is attributed to the application of KNO_3 which results in higher concentrations of volatile components in fruits and hydrolysis of starch into both reducing and non-reducing sugars. The K application contributes towards earlier ripening and the neutralization of acids due to high level of K in plant tissues and reduction of organic acids. K ions facilitate loading and unloading of sucrose and starch compounds by phloem and deposition as starch which ultimately get converted into sugars due to activation of sucrose synthetase enzyme (Wahdan *et al.,* 2011).

Leaf N and K content (%)

The data pertaining to N and K content (Table 3) indicated that foliar applications of KNO_3 registered significantly higher leaf N and K content in comparison to the control. Overall, KNO_3 applied at 4% recorded the maximum leaf N content followed by KNO_3 3% than the other treatments. Leaf K content (%) was observed to be the highest with triple application of KNO_3 @ 4%, followed by 3% triple and 4% double application. Similar trends were also reported by Shen *et al*. (2016), indicating the importance of these elements in improvement of fruit quality.

The present studies highlighted that foliar feeding of KNO_3 at different concentrations and intervals had significant yield impact and improved physico-chemical attributes of Amrapali mangoes. Fruit retention, yield and quality attributes were enhanced significantly with two sprays of KNO_3 (3%) applied at 10 and 20 DAFS. Thus, the foliar K nutrition substantially improves fruit yield related parameters by ameliorating fruit retention, fruit size and quality attributes.

Authors' contribution

Conceptualization of research work and designing of experiments (NS, RA); Execution of field/lab experiments and data collection (RA, SK); Analysis of data and interpretation (RA, MSG); Preparation of manuscript (RA, MSG, NS)

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