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Effect of foliar feeding of potassium nitrate (KNO_3) on yield and fruit quality parameters of litchi cv. Dehradun

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Abstract
An investigation was conducted in litchi cv. Dehradun during the year 2015-16 to study effect of potassium nitrate on yield and quality. 35 years old uniformly grown litchi plants were treated with KNO_3 @ 1.0, 1.5 and 2% at three different stages i.e. single spray 10 days after fruit set; double spray 10 and 20 days after fruit set and triple spray 10, 20 and 30 days after fruit set and the control (water spray). Fruit yield was observed to increase by 14% with treatment of KNO_3 @ 1% when sprayed once along with the fruit weight. Fruit quality parameters viz. TSS/acid ratio and total sugars also improved over untreated trees. Colour values (chroma and hue angle hº) were also observed. Leaf N and K contents were significantly higher. The present study concluded that single foliar spray of KNO_3 1% after 10 days after fruit set considerably improved fruit weight, biochemical quality parameters and fruit yield.

Keywords: Litchi, potassium, fruit quality, yield, leaf nutrient

Introduction
Litchi (*Litchi chinensis* Sonn.) recognized as "Queen of the fruits" is an important sub tropical evergreen fruit crop belongs to the family Sapindaceae. Litchi crop is widely distributed in the tropics and warm subtropics of the world. It is a highly priced fruit and is used in the form of fresh fruit and preparation of value added products. It performs best in regions possessing cool dry frost-free winters and warm summers with high rainfall and humid climatic conditions as well as optimum nutrients in the soil at desired level (Menzel 1983) [5]. Generally, fruit plants require seventeen mineral elements for various physiological processes whereas N and K are required in sufficient amount for the production of quality fruits. It is postulated that 10 MT litchi fruits annually remove nearly 67 kg N, 16 kg P_2O_5 and 73 kg K_2O from the soil.
Litchi nutrition management should be based on monitoring of leaf and soil nutrients status; and fertilizer doses are likely to be adjusted on the basis of tree canopy and yield potential (Menzel 2001) [6, 7]. Several workers suggested that foliar feeding of nutrients directly to the metabolite sites as a substitute or supplement to soil application considerably enhanced fruit yield and quality attributes. It has been also observed that leaves absorbed most of the nutrients within 24-72 hours after spray and thereafter depletion of leaf nutrients content was noted due to translocation of N, P and K to the active developing organs in plant system (Singh *et al.* 2007) [12]. Yang *et al.* (2014) [15] reported that fruit-strengthening potassium fertilizer (40% appropriately) should also be applied during the fruit enlargement period to promote litchi fruit expansion and to improve '*Feizixiao*' litchi yield and quality. Under sub montane zone of northern India, Singh *et al.* (2013) studied interactions between soil nutrients and fruit characteristics in litchi orchards and revealed that soil N, K and Zn content had shown positive and statistically significant correlations with fruit yield whereas soil K also exhibited strong positive relationships with fruit size, pulp and TSS and pulp stone ratio. It is suggested that K as foliar feeding or soil application during fruit development is substantially beneficial for the enhancement of fruit yield and quality. Potassium is one of the essential nutrient requires for numerous biochemical and physiological processes vital to plant growth, yield, quality and stresses. In horticultural crops, potassium improves fruit yield, fruit size, soluble solids concentrations, ascorbic acid, colour, shelf life, and shipping quality (Lester *et al.* 2007) [3] as it concerns with the process of phosphorylation; transportation of photo assimilates from source tissues via the phloem to sink tissues, enzyme activation, turgor maintenance, transpiration, photosynthesis and stress tolerance (Pettigrew 2008) [10].

Likely, Menzel and Kirkby (2001) [6, 7] reported that potassium enhances cell hydration and its deficiency causes tissue dehydration; and act as the main osmotic solute in the plants for stomatal functioning.

The adequate information on foliar applications of nutrients as supplement to soil application on fruit sensory parameters in different litchi cultivars is lacking under Punjab conditions. Therefore, the present investigations was planned to study the effect of different spray timings and KNO_3 (15:0:45) concentrations as foliar feeding in 'Dehradun' litchi cultivar.

Material and Method

The present investigation was conducted on 35 years old fully mature and healthy plants of litchi cultivar 'Dehradun' planted at 9.0 m x 9.0 m. The uniform cultural practices were given to all the trees as per recommendations. The experimental site was situated in the sub-mountane zone of Punjab (India) between latitude of 31^0 N and longitude of 75^0E at an elevation of 248.9 m above the mean sea level. Available soil pH upto the depth of 30 cm was 7.6, electrical conductivity (dS/m) was 0.16, organic carbon (%) 0.24% was recorded, while calcium carbonate (%) was found to be 3.28%.

The experiment layout was Factorial Randomized Block Design (FRBD) and trees were (in addition to soil application of recommended doses of fertilizers) sprayed with different concentrations of chemical potassium nitrate (15:0:45) i.e. 1.0%, 1.5%, 2.0% and the control at three different sub treatments (stages) i.e. 10 days after fruit set (single spray), 10 and 20 days after fruit set (double spray) and 10, 20 and 30 days after fruit set (triple spray). Each treatment was replicated three times and total number of plants were thirty six. In litchi cultivar Dehradun, fruit set was observed on 25th April, 2015 and subsequently trees were sprayed at ten days interval from fruit set depending on the basis of respective treatment. The plants were sprayed with Foot sprayer during early morning hours after dissolving calculated dose of respective treatment in 75 litre of water and Tween 20 (0.01%) sticker was used as a spreader. Quality parameters of fruits were analyzed using standard methods of the AOAC (1990) [1].

The fruit samples from litchi cultivar 'Dehradun' were harvested randomly at physiological maturity, whereas, the leaf samples to estimate nutrients concentrations after fruit harvest were collected from the middle of the shoot in the end-June. The fruit and leaf samples were analyzed for various physico-chemical characteristics at PG Laboratory and Nutrition laboratory, respectively in Department of Fruit Science, Punjab Agricultural University, Ludhiana. Weight of ten fruits was recorded in each treatment with the help of electronic balance. The mean fruit weight was expressed in gram per fruit. Total soluble solids content of juice were determined with the help of *Erma* hand refractometer in terms of degree Brix (%). Total titratable acidity was determined with two ml of strained juice, diluted to 20 ml with distilled water and then titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The end point was noted with change in colour from colourless to light pink. The acidity was calculated in terms of anhydrous malic acid as follows:

$$\text{Acidity (\%)} = \frac{0.0067 \times \text{Vol. of NaOH used}}{\text{Volume of juice taken}} \times 100$$

However, TSS/acid ratio was calculated by dividing the value of total soluble solids with that of the corresponding total titratable acidity. The estimation of total and reducing sugars was done by using method suggested by Lane and Eynon (AOAC 1990) [1]. Nitrogen content of leaves was estimated using Micro Kjeldahl's method of Mckenzine and Wallace (1964). Potassium was determined by the Flame Photometer method (AOAC 1990) [1].

Colour of the whole litchi pericarp was measured by a Hunter Lab Colorimeter, DP-9000 standard model (Hunterlab Associates Laboratory, Inc., Reston, VA). Hue angle and chroma was calculated from L, a,b values using formulas

Hue angle = (a<0,(ATAN(b/a)*180/PI())+180,ATAN(b/c)*180/PI())
Chroma = SQRT(a*a+b*b)

Results and Discussion

Fruit weight is considered as important external factor in determining fruit quality as it greatly influences consumers appeal. The effect of foliar application of potassium fertilizer and number of sprays on fruit weight. The data showed in Table 1 depicts that number of sprays applied at different KNO_3 concentrations significantly affected fruit weight in litchi cv. Dehradun. Higher mean fruit weight (21.5g) was recorded with the spray of KNO_3 1% as compared to the control (20.0 g). With respect to number of sprays, significantly maximum fruit weight (20.9 g) was recorded when trees were sprayed with one spray of KNO_3 as compared to two sprays (20.6 g) and minimum (20.0g) with three sprays. The interaction between different treatments and number of sprays were significant and the improvement in fruit weight to the tune of 22.2 g was noted when trees were sprayed twice at the interval of 10 and 20 days after fruit set with KNO_3 1% concentration. Overall, trees sprayed with potassium improved the fruit weight over the control. These results are in conformity with the findings of Pathak and Mitra (2010) [8] who noted improvement in fruit weight with higher leaf K content in litchi cultivar**.**

The data presented in Table 2 represents improvement in fruit juice total soluble solids with the foliar feeding of KNO_3. Increase in TSS (20.97%) was noted with KNO_3 1.5% and it was at par with (20.83%) in KNO_3 2% and the least (18.80%) in the control. Number of sprays also affected the soluble solid content of fruits. Highest fruit TSS (20.45%) was recorded with three sprays followed by (20.18%) two sprays and lowest in trees sprayed once. Among the interactions, the effect of combination of 2% KNO_3 when sprayed once had pronounced effect while, the lowest was in the fruits of control.

The different K treatments as foliar feeding significantly influenced fruit juice titratable acidity Table 2. The highest titratable acidity (0.58%) was obtained in KNO_3 2% while minimum (0.50%) in treatment of KNO_3 @ 1.5%. Among comparison between number of sprays, minimum (0.52%) juice acid content was recorded with three sprays and the maximum (0.55%) with one spray of KNO_3. Among the interactions, maximum mean titratable acidity (0.61%) was recorded in two sprays of 2% KNO_3 and minimum with single spray in 1% KNO_3. The relationship between the leaf nutrients and fruit quality attributes showed positive relationships between leaf potassium (K) and titratable acidity as also reported by Sivakumar and Korsten (2007) [13].

In Table 3 it is shown that KNO_3 treatments significantly influenced litchi juice total sugars content. Among different treatments, maximum total sugars (14.85%) was recorded

with KNO_3 2% followed by KNO_3 1.5% (14.37%) and minimum (14.07%) in KNO_3 1%. Among the comparison between numbers of spray, three sprays prominently improved total sugars to the tune of 14.79% and minimum (13.84%) was observed from the fruits of trees treated with one spray. Regarding the interaction, the effect was significantly higher (15.84%) with three spray of KNO_3 2% and minimum (13.54%) with single application of 1% KNO_3. Potassium is known to enhance photophosphorylation and dark reaction of photosynthesis resulting in increased accumulation of carbohydrates. The efflux of sucrose to the apoplast is facilitated by potassium availability, which thereby increases sugar translocation from source to sink tissues, promoting their growth (Taiz and Zeiger 2004) [14]. Similar findings were recorded by Kumar and Kumar (2004) in litchi cv. Rose scented.

The effect of foliar application of KNO_3 had a positive effect on the reducing sugars as presented in Table 3. The highest (10.63%) significant reducing sugar was obtained from the treatment KNO_3 @ 2% and minimum in the control. The number of sprays also affected the reducing sugar content in the fruits of litchi. Maximum mean value (9.54%) was obtained from three sprays while minimum (9.16%) was from trees sprayed once. The interaction effect was also evident with the combination of KNO_3 @ 2% when sprayed thrice (10.97%) produced the maximum and minimum in the control (7.35%). Pathak and Mitra (2010) [8] reported the similar results in fruits of litchi cv. Bombai.

In Table 4 Hue angle (h) depicts lightness or darkness of colour i.e. black is a dark value or low value while white is a light value or high value. Hue angle was observed to be lowest mean value i.e. highest anthocyanin colour development was found with treatment KNO_3 2% while with sprays lowest mean value was observed with three sprays. In the interaction least value was observed with KNO_3 2% when sprayed thrice as compared to control values. Chroma depicts the quality of colour's purity, intensity or saturation. In treatment KNO_3 1% highest mean value of chroma was observed i.e. maximum purity in red colouration whereas within sprays maximum purity of colour was developed with three sprays. Amongst interactions maximum value was observed when KNO_3 1% was sprayed once as compared to control values.

Data in Table 5 revealed that foliar application of potassium nitrate affected the fruit yield in litchi cv. Dehradun as compared to the control. The highest fruit yield 89.8 Kg/tree was obtained in trees sprayed with KNO_3 1% followed by (78.8 Kg/tree) in KNO_3 1.5% and minimum (73.4 Kg/tree) in KNO_3 2% treatment. It was evident from the observations that with an increase in the K dose, significant decreased in fruit yield was noted. However, number of sprays also marked their effect on the yield of litchi fruits and trees sprayed once with KNO_3 produced maximum yield 84.1 Kg/tree followed by double spray 82.2 Kg/tree and minimum with three sprays 73.9 Kg/tree. Among the interactions, maximum effect was noted with two sprays of KNO 1%. The improvement in fruit yield was due to increase in yield related components like fruit weight, fruit size and fruit retention. The present findings also correlated with previous findings reported by Yang *et al.* (2014) [15] in litchi cv. '*Feizixiao*'.

Leaf N content (Table 6) was also influenced with different concentrations of KNO_3, however, the effect of potassium nitrate on leaf N content was statistically significant. The results had shown that maximum leaf N content (1.80) was observed in trees treated with KNO_3 2%, however, treatments Of KNO_3 @ 1.5%(1.53), 2%(1.63) as well as control (1.64) were statistically at par with each other. Leaf N content, where trees were sprayed one, two and three times as well as the interactions between doses and number of sprays were statistically significant. Sarrwy (2012) [11] stated that foliar application of various forms of potassium on "Balady" Mandarin trees significantly raised the nitrogen content in leaves.

The trees applied with KNO_3 at different doses as single, double and thrice as foliar sprays in litchi cv. Dehradun had significantly influenced leaf K content. In treatment i.e. 2% KNO_3 significantly the highest (0.99%) leaf K content was recorded as compared to minimum (0.61) in the control (Table 6). The results validate the earlier findings that application of higher level of potassium increase the potassium content in leaf in litchi cv. Bombai (Pathak *et al.* 2013) [9].

Table 1: Effect of foliar application of KNO_3 in fruit weight (g) in litchi cv. Dehradun

Treatment	One Spray	Two Sprays	Three Sprays	Mean
KNO_3 – 1.0%	21.7	22.2	20.7	21.5
KNO_3 – 1.5%	21.4	21.1	19.7	20.7
KNO_3 – 2.0%	20.7	19.0	19.8	19.8
Control	19.9	20.0	20.0	20.0
Mean	20.9	20.6	20.1	
CD (p=0.05) A:0.22 B: 0.19 A x B: 0.38				

Table 2: Effect of foliar feeding of potassium on TSS, titrable acidity of litchi cv. Dehradun

TS (Brix)					Acidity (%)			
Treatment	One Spray	Two Sprays	Three Sprays	Mean	One Spray	Two Sprays	Three Sprays	Mean
KNO_3 -1.0%	19.30	21.05	20.90	20.42	0.51	0.56	0.57	0.55
KNO_3 – 1.5%	21.15	20.80	20.95	20.97	0.60	0.45	0.46	0.50
KNO_3 – 2.0%	21.25	20.10	21.15	20.83	0.58	0.61	0.56	0.58
Control	18.80	18.77	18.80	18.79	0.49	0.50	0.48	0.49
Mean	20.13	20.18	20.45		0.55	0.53	0.52	
CD(p=0.05) A: 0.49 B: 0.42 A x B : 0.84					CD(p=0.05) A : 0.13 B : 0.012 A x B : 0.14			

Table 3: Effect of foliar feeding of potassium on total sugars (%) and reducing sugar (%) in litchi cv. Dehradun

Total sugars (%)					Reducing sugar (%)			
Treatment	**One Spray**	**Two Sprays**	**Three Sprays**	**Mean**	**One Spray**	**Two Sprays**	**Three Sprays**	**Mean**
KNO_3 – 1.0%	13.5	14.3	14.6	14.1	9.3	9.3	9.5	9.4
KNO_3 – 1.5%	14.1	14.8	15.4	14.8	9.5	9.7	10.0	9.7
KNO_3 – 2.0%	15.6	13.7	14.5	14.6	10.3	10.6	11.0	10.6
Control	13.0	13.1	13.1	13.1	7.5	7.4	7.7	7.5
Mean	14.1	14.0	14.4		9.2	9.2	9.5	
CD(p=0.05) A: 0.30 B: 0.26 A x B: 0.52					CD(p=0.05) A: 0.17 B: 0.14 A x B : 0.29			

Table 4: Effect of foliar application of KNO_3 on hue and chroma of fruit colour in litchi cv. Dehradun

Treatment	**Hue**				**Chroma**			
	One Spray	**Two Spray**	**Three Spray**	**Mean**	**One Spray**	**Two Sprays**	**Three Sprays**	**Mean**
KNO_3 – 1.0%	41.23	44.87	44.45	43.52	26.40	24.69	23.39	24.82
KNO_3 – 1.5%	38.47	43.09	46.90	42.82	26.48	24.47	22.41	24.45
KNO_3 – 2.0%	39.84	39.57	37.02	38.81	26.80	21.76	23.47	24.01
Control	44.64	44.65	44.65	44.65	22.32	22.37	22.27	22.32
Mean	41.05	43.05	43.26		25.85	23.02	22.83	
	CD (p=0.05) A: 0.81 B: 0.70 A x B : 1.41				CD (p=0.05) A: 0.69 B : NS A x B :1.19			

Table 5: Effect of foliar application of KNO_3 on fruit yield (Kg/tree) in litchi cv. Dehradun

Treatment	**One Spray**	**Two Sprays**	**Three Sprays**	**Mean**
KNO_3 – 1.0%	89.7	94.8	84.9	89.8
KNO_3 – 1.5%	86.8	82.2	67.6	78.8
KNO_3 – 2.0%	82.4	73.1	64.9	73.4
Control	77.6	79.0	78.3	78.3
Mean	84.1	82.2	73.9	
CD(p=0.05) A : 2.82 B : 1.77 A x B : 3.82				

Table 6: Effect of foliar feeding of potassium on nitrogen and potassium content of leaves in litchi cv. Dehradun

Leaf nitrogen content (%)					Leaf potassium content (%)			
Treatment	**One Spray**	**Two Sprays**	**Three Sprays**	**Mean**	**One Spray**	**Two Sprays**	**Three Sprays**	**Mean**
KNO_3 – 1.0%	1.54	1.58	1.48	1.53	0.80	0.82	0.85	0.82
KNO_3 – 1.5%	1.63	1.63	1.62	1.63	0.63	0.73	1.15	0.84
KNO_3 – 2.0%	1.63	1.88	1.91	1.80	1.01	0.91	1.05	0.99
Control	1.61	1.63	1.67	1.64	0.52	0.55	0.53	0.53
Mean	1.60	1.68	1.67		0.74	0.75	0.90	
CD(p=0.05) A : 0.11 B : 0.03 A x B : 0.25					CD(p=0.05) A : 0.31 B: NS A x B : NS			

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