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JC Chandola
Krishi Vigyan Kendra, Saran, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Satish Chand
Department of Horticulture, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar), Uttarakhand, India

Ranjan Srivastava
Department of Horticulture, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar), Uttarakhand, India

Ratna Rai
Department of Horticulture, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar), Uttarakhand, India

Sachin Kumar
Department of Post-Harvest Process and Food Engineering, College of Technology, G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar), Uttarakhand, India

Vijay Kumar
Krishi Vigyan Kendra, Saran, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Corresponding Author:
JC Chandola
Krishi Vigyan Kendra, Saran, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Effect of potassic compounds and ethrel sprays on fruiting and quality attributes of litchi (*Litchi chinensis* Sonn.) cv. rose scented

JC Chandola, Satish Chand, Ranjan Srivastava, Ratna Rai, Sachin Kumar and Vijay Kumar

Abstract
The present study was carried out at Horticultural Research Centre, Patharchatta, G. B. Pant University of Agriculture and Technology Pantnagar, Uttarakhand to find out the most effective combination of potassic compounds and ethrel sprays on fruit and quality attributes of litchi cv. Rose Scented during two successive years *i.e.*, 2013 and 2014. The experiment comprised of nine treatments *viz.*, KNO_3 (1%), K_2HPO_4 (1%), KH_2PO_4 (1%), $K_2H\ PO_4$ (2%), KH_2PO_4 (2%), K_2HPO_4 (1%) + KNO_3 (1%), KH_2PO_4 (1%) + KNO_3 (1%), Ethrel (400 ppm) and water which were sprayed thrice at monthly interval from October to December. The results obtained indicate that foliar application of KNO_3 (1%) was effective for improving fruit breadth(3.82 cm), fruit weight (21.93g), fruit retention (28.33%) and significantly reduced fruit drop (45.37%), total acidity (0.33%) of fruits in litchi. On the other hand, Ethrel (400 ppm) was effective for increasing fruit length (3.93cm), early fruit harvest (10th June and 5th June during the years 2014 and 2015), TSS (20.70^{0}B). Therefore, it could be concluded that KNO_3 (1%) and Ethrel (400 ppm) sprays can be recommended for enhancing quality and fruit characters of litchi fruits cv. Rose Scented.

Keywords: Litchi, potassium, ethrel, quality parameters

Introduction
Litchi (*Litchi chinensis* Sonn.) is an important subtropical, evergreen fruit belonging to the family Sapindaceae and sub-family Nephelae. It is native to South China and is regarded as "Queen of fruits". India is the second largest litchi producer in the world next to China with 5.83 million metric tonnes production from an area of 0.92 lakh hectare with an average productivity of 6.33 tons/ha. (Anonymous, 2017) [1]. Although grown commercially in the Indo-Gangetic plains of Bihar, Uttar Pradesh and West Bengal, its cultivation in the *Tarai* region of Uttarakhand, Haryana and Himachal Pradesh has increased over the last decade because of the conducive climate prevailing in different regions of these states. In Uttarakhand, annual production of litchi is 19.16 thousand metric tonnes from an area of 9.49 thousand hectares and productivity is 2.0 metric tonnes per hectares (NHB, 2017).
Litchi is highly specific in its climatic requirement as it does not tolerate frost and vegetative growth is normally restricted at temperature below 10 °C and above 35 °C with maximum growth at a temperature ranging between 25-30 °C depending on cultivars (Menzel *et al*. 1989) [21]. Vegetative flushing in late autumn and early winter are associated with irregular flowering of litchi trees during spring and offer result in inconsistent yields (Nagao *et al*. 2000) [23]. The main reason for low, irregular cropping is excessive vegetative growth during 1-2 months before panicle growth (Menzel *et al*. 1988) [19]. The premature fruit drop commences soon after fruit set and continues till fruit maturity, with most fruit abscising in the first 2 to 4 weeks. The drop of fruit is said to the associated with failure of fertilization, embryo abortion, internal nutrition and hormonal imbalance and external factors like high temperature, low humidity and strong winds (Menzel *et al*. 1986) [20].
Chemicals and plant growth regulators play a significant role in altering the plant response from vegetative stage towards reproductive stage of litchi. Foliar application of plant nutrients is helpful in satisfying plant requirements and can be highly efficient when nutrient uptake *via* the root system is limited. Potassium is an essential macro-element required in large amounts for normal plant growth and development. While involved in many physiological processes, potassium impact on water relations, photosynthesis, assimilate transport and enzyme activation can have direct consequences on crop productivity. When potassium uptake is lower than demand, foliar potassium is mobilized to the fruit, to the detriment of plant growth, fruit

set and quality (Besford and Maw, 1975) [4]. Therefore, it is imperative to improve the productivity of litchi in terms of vegetative, flowering and yield of quality fruits with the use of foliar application of plant bio-regulators like ethrel and potassic compounds. Keeping in view the above factors under consideration, the proposed study was focused on use of ethrel and potassic compounds for better flowering and yield of commercial litchi cultivar grown under the *Tarai* region of Uttarakhand.

Materials and Methods

The present experiment was conducted at Horticultural Research Centre, Patharchatta, Department of Horticulture, GBPUA&T, Pantnagar, India during 2013-14 and 2014-15 growing seasons. The experiment was conducted to determine the effect of chemicals *viz*., KNO_3 (1%), K_2HPO_4 (1%), KH_2PO_4 (1%), $K_2H\ PO_4$ (2%), KH_2PO_4 (2%), K_2HPO_4 (1%) + KNO_3 (1%), KH_2PO_4 (1%) + KNO_3 (1%), Ethrel (400 ppm) and water which were sprayed thrice at monthly interval from October to December. The experiment was laid out in randomized block design with 9 treatments and 3 replications. The present experiment was carried out with the objective of evaluating the flowering, fruiting, physico-chemical and shelf life of litchi cv. Rose Scented at Horticultural Research Centre, Patharachatta. It is situated in the foot hills of Himalyas and falls in humid subtropical climate. It is situated between 29.5ºN latitude and 79.3ºE longitude and an altitude of 243.84 meters above the mean sea level.The region is characterized by humid subtropical climate with maximum temperature ranging from 30 °C to 43 °C in summer and minimum from 5 °C to 10 °C in winter. The summer is dry and hot, the winter is cold and the rainy season is experienced with heavy rainfall. The onset of Monsoon usually occurs in the second or third week of June and continues in appreciable amount up to mid-September. Frost can be expected from last week of December to first week of February. Occasionally light rains are expected during winter.

Fruit Characteristics

Five fruits from each replication of each treatment were randomly collected and were measured by digital verniercallipers. The average fruit breath was expressed in centimeters (cm). Five fruits from each replication of each treatment was collected and measured by digital verniercalliper. The average fruit length was expressed in centimeters (cm). Five fruits from each replications of each treatment were randomly taken and weight (g) was recorded on a physical balance and mean weight (g) was obtained by dividing the total weight of the fruits with the number of fruits. The fruit volume was recorded by water displacement method and average fruit volume was expressed in millilitres (ml). For this purpose, five fruits were dipped in large jar containing water up to rim. The amount of water displaced by the fruits was collected in a tray and was measured with the help of measuring cylinder. The mean volume per fruits was determined by dividing total volume of displaced water with the number of fruits. Number of fruits on five tagged panicles of each replication of each treatment at "pea stage" was counted and average initial fruit set was calculated on the basis of total number of female flower per panicle.

$$\text{Fruit set (\%)} = \frac{\text{Number of fruits/panicle}}{\text{Number of female flowers/panicle}} \text{ x } 100$$

At the initial fruit set stage, the total number of fruits on the tagged panicles were counted and the number of fruits dropped on the panicles were counted at weekly intervals. The differences between the weekly figures obtained from initial fruit counts were calculated and expressed as fruit drop (%).

$$\text{Fruit drop (\%)} = \frac{\text{Number of fruits dropped}}{\text{Total number of fruits initially set}} \text{ x } 100$$

The total number of fruits on the tagged panicles were counted at the initial fruit set and the number of fruits retained on the panicles were also counted at weekly intervals and differences between the weekly figures obtained from initial fruit count were calculated and expressed as fruit retention (%).

$$\text{Fruit retention (\%)} = \frac{\text{Number of fruits retained}}{\text{Total number of fruits initially set}} \text{ x } 100$$

Number of fruits having brown coloured patch on the skin due to sun burn or sun scald was counted by visual observation out of total number of fruits retained in the tagged panicles and expressed in terms of percentage. During the fruiting season, 10 panicles were tagged in each replication of each treatment in all the directions for recording the data on fruit cracking. The percentage of fruit cracking was calculated on the basis of observations recorded on all the trees. Total cracking percentage of fruit in a particular treatment was calculated by following formula:

$$\text{Fruit cracking (\%)} = \frac{\text{Number of fruits cracked per panicle at the time of harvesting}}{\text{Number of fruits ratained per panicle at the time of harvesting}} \text{X } 100$$

Colour of fruit was recorded by comparing fruit colour with Mushial colour chart. Date of fruit harvest was recorded when fruits were harvested. Subsequently, days taken from full bloom to harvest were calculated by subtracting date of full bloom from date of harvest. Five fruits were randomly collected from each replication and the average fruit weight was measured with the help of a physical balance and expressed in grams (g).It was calculated by dividing fruit length by its breadth. The specific gravity was calculated by dividing the average fruit weight with average fruit volume of each replication.

$$\text{Specific gravity} = \frac{\text{Average fruit weight}}{\text{Specific gravity}}$$

Fruits from each sample per replication were taken and peel was extracted and weight of peel was recorded with the help of electronic balance and average peel (%) was calculated over the weight of fruit. Five fruits from each replication were collected.

Quality characters

Total soluble solids in the fruits were recorded at room temperature using hand refractometer and were expressed in^{0}Brix. Five fruits were taken from each replication for taking the average value. A small amount of fruit pulp was taken in muslin cloth and crushed to obtain the juice. The refractometer was wiped clear with a moist muslin cloth. A drop of juice of crushed pulp was taken on the refractometer and the value was read against light. itratable acidity of litchi fruits was calculated by titrating the fruit pulp extract with 0.1 N NaOH as per method described by Ranganna (1986) [27] using phenolphthalein as indicator using the following formula and was expressed in percentage. Sample was prepared by taking 10 g of fruit pulp and grinding it properly by mortar and pestle. The ground material was then filtered into a 100 ml volumetric flask and final volume was made up with distilled water. The 10 ml of this solution was taken for the purpose of titration.

$$\text{Titratable acidity (\%)} = \frac{\text{Titre x Normality of alkali x equiv. wt.of acid x100}}{\text{Volume of Sample taken x weight or Volume of sample x 1000}}$$

It was calculated by dividing the total soluble solids with titratable acidity. Ascorbic acid content of litchi fruits was determined by 2, 6-dichlorophenol-indophenol visual titration method (Ranganna, 1986) [27]. Ten ml of juice was taken and volume was made up to 100milliliter with three per cent metaphosphoric acid. It was filtered and 10ml aliquot of metaphosphoric extract were taken and titrated with the standard dye to a pink end point (which should be present for 15 seconds). Before titration, 40 per cent formaldehyde and 0.1ml HCI were added to the sample to eliminate the interference due to SO_2. The ascorbic acid was computed by using following formula:

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot of extract} \times \text{Weight of sample taken}} \times 100$$

Finally, the data were subjected to statistical analysis in order to find out significant variation in different treatments under study. The technique of analysis of variance (ANOVA) for randomized block design (RBD) was adopted as per Gomez and Gomez (1984) [4].

Result and Discussion

Fruit yield attributes

The data pertaining is fruit breadth presented in Table 1 revealed the significant variation among all the treatments. During 2013-14, fruit breadth was maximum (3.82cm) with T_1 which was statistically at par with T_8 but significantly higher than the rest of the treatments. It was minimum (3.09cm) with T_9 (control). A similar trend was recorded during 2014-15, where fruit breadth was maximum (3.94cm) with T_1 which was statistically at par with T_6, T_7 andT_8but significantly higher than the rest of the treatments. It was minimum (3.38cm) with control. The pooled data for fruit breadth was found to be maximum (3.82 cm) in treatment T_1 (KNO_3@1%) followed by application of ethrel@400ppm (3.74 cm).Minimum fruit breadth (3.11cm) was found with control treatment.

The data depicted in Table 1revealed that the fruit length significantly varied among the treatments. The pooled data showed maximum fruit length (3.93cm) in T_1 treatment followed by treatment T_8 (ethrel @400ppm) i.e., 3.80 cm. The fruit length obtained with treatment KH_2PO_4 (1%) + KNO_3(1%) and K_2HPO_4 (1%) + KNO_3(1%) were statistically at par. Minimum fruit length (3.00 cm) was recorded in control treatment. These results are also substantiated by the findings of Ghos *et al.* (1988) who reported that the length of fruit was maximum in Bombai (4cm) while it was 3.8 and 3.7 cm in Elaichi and Purbi, respectively compared to Early Large Red and the maximum fruit breadth was found in Bedana (3.5 cm) followed by 3.2 cm in Muzaffarpur Early and 3.1 cm in Purbi and Early Large Red. The smallest fruit breadth of fruit (2.8 cm) was noted in cultivars Bombai and McLean. Dabral and Misra (2007) [7] reported that, the fruit length was found significantly high in Calcuttia followed by Rose Scented, Mandraji and Dehra Dun, while minimum fruit length was noted with Longia.

A perusal of data presented in Table 1 shows that all the treatments had significant effect on the specific gravity. During 2013-14, specific gravity was maximum (1.07) with T_6 whereas it was minimum (0.94) with T_4. A similar trend was recorded during 2014-15, where specific gravity was maximum (1.09) with T_8.It was minimum (0.98) with T_4. In the pooled data maximum specific gravity (1.07) was observed in the treatment T_8. On the other hand treatment T_4resulted in minimum specific gravity (0.96).Gaur and Bajpai (1978) [11] observed that during the early stages (up to 10 days after fruit setting) of fruit development there was a fall in the specific gravity, a regular increase between 13th and 34th days, a brief period of full increase between 34th and 40th days after fruit setting and a quick increase from 40th t0 46th days after which it showed a declining trend. In litchi cultivar Bombai specific gravity maintained a rapid increase up to 105 days after anthesis and thereafter becomes more or less constant (Biswas and Roy, 1983) [5].

A perusal of data presented in Table 1 shows that all the treatments had significant effect on the fruit weight. During 2013-14, fruit weight was maximum (21.96g) with T_1 whereas it was minimum (17.68 g) with T_9 (control). A similar trend was recorded during 2014-15, where fruit weight was maximum (21.95 g) with T_7 which was statistically at par with T_1 andT_8but significantly higher than the rest of the treatments. It was minimum (18.28 g) with control. In the pooled data maximum fruit weight (21.93g) was observed in the treatment T_1 (KNO_3 1%). On the other hand treatment T_9 (control) resulted in minimum fruit weight (17.98g).Similar results were observed by Saxena (1994) [30] who reported increase fruit weight by application of ethrel @ 400 ppm applied 25 days before harvesting. These results was also supported by Jones *et al.* (1993) [15] who reported that application of ethrel @ 200 ppm resulted in increase in size and weight of Jonagold apples. Pathakand Mitra (2010) [26] observed maximum fruit weight and aril recovery with the application of potassium @ 600 g in two equal splits at 15 days after fruit set and 30 days before flowering. Influence of plant growth regulators and mineral nutrients on physico-chemical characteristics in Rose Scented litchi cultivar was investigated by Lal *et al* (2010) [18] and observed that tree

sprayed with KNO_3 (1.5%) and Ca $(NO_3)_2$ (2%) produced the highest fruit weight of 20.41g and 20.37 g, respectively.

The data presented in Table in 2showed the effect of various treatments on fruit volume. During 2013-14, fruit volume was maximum (21.53ml) with T_1 whereas it was minimum (18.47ml) with T_9 (control). A similar trend was recorded during 2014-15 where fruit volume was maximum (21.77ml) with T_1 where as it was minimum (18.54ml) with control. The pooled data showed that the maximum fruit volume was obtained in treatment T_1 (KNO_3 1%) i.e., 21.65ml followed by treatment T_7 KH_2PO_4 @1% + KNO_3 @1% (19.97ml) which was at par with T_6 K_2HPO_4 @1% + KNO_3 @1% (19.95ml) whereas the minimum fruit volume (18.51ml) was obtained in treatment control. Ranjan *et al.* (2002) [29] studied evaluation between Kasba and Bedana and Kasba recorded the highest volume (22.10 cc). The physical characters of litchi culivarsviz, Deshi, Purbi, China and Kasba were studied and China and Kasba cv. showed the highest fruit volume (Kumari *et al.*, 2004) [17]. Rani (2006) [28] reported that fruit volume was significantly highest in cv. Late Seedless (24.00 ml) followed by cv. Rose Scented (19.66 ml) and minimum fruit volume was observed in Longia (16.00 ml) followed by cv. McLean (16.20 ml).Dabral and Misra (2007) [7] reported that Litchi cv. Dehradun showed maximum fruit volume and minimum fruit volume was observed in Longia among litchi cultivars under study. The variation in physical attributes of fruits show genetic variability, which might be due to effectiveness in selection of mother trees. The differences in different physical characters between varieties might be due to their genetic varietal characteristics. Similar results were also obtained by Ghosh *et al.* (1988) [12] and Badiyal and Awasthi (1991) [2].

A perusal of data presented in Table 2 shows that all the treatments had significant effect on the fruit drop. During 2013-14, fruit drop was maximum (58.62%) with T_2whereas it was minimum (45.51%) in T_1. A similar trend was recorded during 2014-15, where fruit drop was maximum (58.10) with T_2 and minimum (45.24%) in T_1.The pooled data showed that maximum fruit drop (58.40%) occurred in T_2 (K_2HPO_4 @1%). On the other hand.

Table 1: Effect of different treatments on fruit breadth, fruit length, specific gravity and fruit weight in litchi cv. Rose Scented

Treatment		Fruit breadth (cm)			Fruit length (cm)			Specific gravity			Fruit weight(g)		
		2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	KNO_3 (1%)	3.82^{a}	3.83^{a}	3.82^{a}	3.92^{a}	3.94^{a}	3.93^{a}	1.02^{b}	1.00^{b}	1.01^{bc}	21.96^{a}	21.90^{a}	21.93^{a}
T_2	K_2HPO_4 (1%)	3.12^{d}	3.13^{d}	3.12^{ef}	3.56^{d}	3.57^{cd}	3.57^{c}	1.00^{bc}	0.99^{b}	0.99^{c}	19.18^{c}	18.92^{d}	19.05^{f}
T_3	KH_2PO_4 (1%)	3.34^{b}	3.36^{b}	3.35^{c}	3.55^{d}	3.56^{de}	3.55^{c}	0.98^{cd}	1.07^{a}	1.02^{b}	20.64^{b}	20.51^{bc}	20.57^{b}
T_4	K_2H PO_4 (2%)	3.27^{bc}	3.28^{bc}	3.27^{d}	3.53^{d}	3.59^{cd}	3.56^{c}	0.94^{e}	0.98^{b}	0.96^{d}	20.40^{b}	18.95^{d}	19.67^{de}
T_5	KH_2 PO_4 (2%)	3.15^{d}	3.16^{d}	3.15^{ef}	3.55^{d}	3.60^{bcd}	3.57^{c}	1.00^{bc}	1.05^{a}	1.02^{b}	18.83^{c}	20.18^{c}	19.50^{ef}
T_6	K_2HPO_4(1%) +KNO_3 (1%)	3.25^{c}	3.26^{c}	3.25^{d}	3.73^{c}	3.73^{bcd}	3.73^{b}	1.07^{a}	0.99^{b}	1.03^{b}	20.89^{b}	20.35^{c}	20.62^{b}
T_7	KH_2PO_4(1%) +KNO_3 (1%)	3.18^{cd}	3.19^{cd}	3.18^{e}	3.74^{c}	3.75^{bc}	3.74^{b}	1.06^{a}	1.07^{a}	1.06^{a}	18.18^{d}	21.95^{a}	20.06^{cd}
T_8	Ethrel (400 ppm)	3.74^{a}	3.74^{a}	3.74^{b}	3.82^{b}	3.78^{ab}	3.80^{b}	1.06^{a}	1.09^{a}	1.07^{a}	19.23^{c}	21.26^{ab}	20.25^{bc}
T_9	Control	3.09^{d}	3.11^{d}	3.10^{f}	3.22^{e}	3.38^{e}	3.30^{d}	0.95^{de}	0.98^{b}	0.97^{d}	17.68^{d}	18.28^{d}	17.98^{g}
	SEm±	0.03	0.03	0.02	0.01	0.06	0.03	0.01	0.01	0.00	0.17	0.27	0.15
	$LSD_{(0.05)}$	0.09	0.09	0.06	0.05	0.18	0.09	0.02	0.04	0.02	0.52	0.81	0.45

minimum fruit drop (45.37%) occurred in T_1 (KNO_3 @ 1%) Pandey and Sharma (1984), Kanwar and Nijjar (1975) [16] Pandey and Sharma (1984), Kanwar and Nijjar (1975) [16] and Verma *et al.* (1980) [36] reported that fruit drop in litchi occured due to soil and environmental conditions, however, factors such as lack of pollination, failure of fertilization, embryo abortion, poor nutritional availability, competition between vegetative phase and reproductive phase, hormonal imbalances were the main cause for fruit drop. The results obtained were in support with the work of Sharma *et al.* (1980) who recorded the reduced fruit drop and increased fruit retention by foliar application of KNO_3 in mango cv. Langra. However, the results obtained were in support with the work of Dhaliwal *et al*. (2002) [8] who observed increased fruit drop byfoliar application of potassium iodite and potassium nitrate sprayed at 0.25 to 0.5%, 4 to 6% concentration, respectively at full bloom stage.

The data presented in Table 2 shows that all the treatments significantly enhanced the fruit retention per cent as compared to control. During 2013-14, fruit retention was maximum (28.28% with T_1 which was significantly *at par* withT_8 treatment whereas it was minimum (20.46%) with T_9 (control). A similar trend was recorded during 2014-15, where fruit retention was maximum (28.38%) with T_1 which was significantly higher thanwithT_8 treatment whereas it was minimum (21.13%) with T_9 (control). It is evident from the pooled data that maximum fruit drop (58.40%) occurred in T_2 (K_2HPO_4 @1%). On the other hand, minimum fruit drop (45.37%) occurred in T_1 (KNO_3 @ 1%). from the pooled data that fruit retention in all the treatments was significantly higher as compared to the control. The maximum fruit retention (28.33%) was observed in treatment T_1 (KNO_3 @ 1%) whereas, T_9 (control) recorded the minimum retention (20.79%) of fruits. The results are supported by the findings of Elkhishen (2015) [10] who reported the increased percent of fruit retention by application of KNO_3 (6%) in mango cv. Zebda. Sharma *et al.* (1980) also recorded increased fruit retention by foliar application of KNO_3 in mango cv. Langra. The retention of fruits varied significantly in different varieties and ranged from 3% to 39.62%upto harvest viz. Shahi (4%), Rose Scented (5.54%), Purbi (3%), China (39.62%) and Bedana (23.57%) as reported by Sharma and Roy (1987) [33].

A perusal of data presented in Table 3 shows that all the treatments significantly reduced the fruit cracking per cent as compared to control. During 2013-14, fruit cracking per cent was minimum (6.62%) with T_3whereas it was maximum (18.31%) with T_5treatment. A similar trend was recorded during 2014-15, where fruit cracking percent was minimum (6.27%) with T_3whereas it was maximum (17.07%) with T_1treatment. The pooled data showed that maximum fruit drop (58.40%) occurred in T_2 (K_2HPO_4 @1%).

Table 2: Effect of treatments on fruit volume, fruit drop and fruit retention in litchi cv. Rose Scented

Treatment		Fruit Volume (ml)			Per cent fruit drop			Fruit retention (%)		
		2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	KNO_3 (1%)	21.53^{a}	21.77^{a}	21.65^{a}	45.51	45.24	45.37	28.28^{a}	28.38^{a}	28.33^{a}
T_2	K_2HPO_4 (1%)	19.09^{c}	19.12^{c}	19.17^{c}	58.62	58.19	58.40	24.30^{d}	24.63^{de}	24.47^{e}
T_3	KH_2PO_4 (1%)	19.21^{bc}	19.21^{c}	19.21^{c}	49.60	50.08	49.84	24.42^{d}	25.09^{cd}	24.75^{de}
T_4	K_2H PO_4 (2%)	19.28^{bc}	19.38^{c}	19.33^{c}	49.32	51.74	50.53	25.13^{c}	25.34^{cd}	25.24^{cd}
T_5	KH_2 PO_4 (2%)	19.15^{bc}	19.13^{c}	19.14^{c}	48.51	47.19	47.85	24.42^{d}	24.09^{e}	24.25^{e}
T_6	K_2HPO_4(1%) +KNO_3 (1%)	19.39^{b}	20.51^{b}	19.95^{b}	50.53	49.85	50.17	25.65^{c}	25.98^{bc}	25.82^{c}
T_7	KH_2PO_4 (1%) +KNO_3 (1%)	19.36^{bc}	20.59^{b}	19.97^{b}	53.36	53.34	53.35	25.47^{c}	25.80^{c}	25.64^{c}
T_8	Ethrel (400 ppm)	19.15^{bc}	19.52^{c}	19.33^{c}	52.56	48.23	50.39	27.41^{b}	27.04^{b}	27.23^{b}
T_9	Control	18.49^{d}	18.54^{d}	18.51^{d}	53.58	50.00	51.79	20.46^{e}	21.13^{f}	20.79^{f}
	SEm±	0.10	0.17	0.09	4.75	4.36	3.13	0.20	0.36	0.20
	$LSD_{(0.05)}$	0.30	0.51	0.28	NS	NS	NS	0.60	1.09	0.58

On the other hand, minimum fruit drop (45.37%) occurred in T_1 (KNO_3 @ 1%). The pooled data on sun burn and fruit cracking per cent presented in Table 4.9 revealed that cracking per cent in the present experiment varied significantly among the treatments. However, the maximum fruit cracking (16.56%) was reported in T_1 (KNO_3 @ 1%) while the minimum fruit cracking (6.270%) occurred in T_3 (KH_2PO_4 @ 1%). While conducting an experiment, Dongariyal (2017) [9] revealed that cracking per cent in the present experiment varied from 11.46 to 19.50 without any significant differences among the treatments. However, the maximum fruit cracking was reported in T_{13} (control) while the minimum fruit cracking (11.46%) occurred in T_4 (KH_2PO_4 @ 1%).

The fruit colour observed was deep rose pink in all the treatments similar to that of control. Hence, there was no effect of any treatment on the fruit colour. Singh *et al.* (2015) [35] had reported that ethephon treatments enhanced colour development as compared to control.

There was no effect of any treatment on the fruit shape applied on the Litchi cv. Rose Scented. The fruit shape was oval or oblong-conical in all the treatments similar as the control.

Quality characters

The data presented in Table 4 shows that all the treatments significantly increased the Total soluble solids as compared to the control. During 2013-14, total soluble solids was maximum (20.63^{0}B) with T_8 (Ethrel @400 ppm) whereas it was minimum (17.14^{0}B) with T_1 treatment. A similar trend was recorded during 2014-15, where total soluble solids was maximum (20.78^{0}B) with T_8(Ethrel @400 ppm)whereas it was minimum (17.18^{0}B) with T_1treatment. The pooled data showed that maximum TSS content (20.70^{0}B) was observed in treatment T_8 (ethrel @ 400 ppm) while the minimum TSS content (18.18^{0}B) was recorded in T_9 (control).Similar results were found by Dongariyal (2017) [9] in litchi cv. Rose Scented. Increase in TSS content was mostly due to the increase in sugar content which depends mostly upon conversion of starch on hydrolysis.

The data presented in Table 4 shows that all the treatments significantly reduced the titratable acidity per cent. During 2013-14, titratable acidity was maximum (0.34%) with T_1whereas it was minimum (0.25%) with T_8 and T_6treatment which was statistically *at par* with T_3, T_5 and T_8 treatment. A similar trend was recorded during 2014-15, where titratable acidity was maximum (0.33%) with T_9 (control) whereas it was minimum (0.23%) with T_8which was statistically *at par* with T_3, T_6 and T_7treatment.

Table 3: Effect of different treatments on fruit cracking, fruit shape and colourin litchi cv. Rose Scented

Treatment		Fruit Cracking (%)			Shape of fruits	Fruit colour (Visual)
		2013-14	2014-15	Pooled		
T_1	KNO_3 (1%)	16.08^{a}	17.04^{a}	16.56^{a}	Oval or oblong-conical	Deep rose pink
T_2	K_2HPO_4 (1%)	8.42^{cd}	8.80^{bc}	8.613^{cd}	Oval or oblong-conical	Deep rose pink
T_3	KH_2PO_4 (1%)	6.62^{d}	6.27^{c}	6.44^{d}	Oval or oblong-conical	Deep rose pink
T_4	K_2H PO_4 (2%)	9.05^{bcd}	9.85^{bc}	9.45^{cd}	Oval or oblong-conical	Deep rose pink
T_5	KH_2 PO_4 (2%)	18.31^{a}	16.62^{a}	17.46^{a}	Oval or oblong-conical	Deep rose pink
T_6	K_2HPO_4(1%)+KNO_3(1%)	8.39^{cd}	8.017^{bc}	8.20^{cd}	Oval or oblong-conical	Deep rose pink
T_7	KH_2PO_4(1%)+KNO_3(1%)	12.18^{abcd}	12.02^{abc}	12.10^{bc}	Oval or oblong-conical	Deep rose pink
T_8	Ethrel (400 ppm)	13.75^{abc}	13.88^{ab}	13.82^{ab}	Oval or oblong-conical	Deep rose pink
T_9	Control	14.99^{ab}	16.21^{a}	15.60^{ab}	Oval or oblong-conical	Deep rose pink
	SEm±	2.19	2.00	1.44	-	-
	$LSD_{(0.05)}$	6.56	6.00	4.14	-	-

A critical examination of pooled data indicated that treatments T_1 (KNO_3@1%) as well as T_9 (control) resulted in maximum acidity per cent (0.33), whereas, the minimum acidity% (0.24) was recorded with T_8 (ethrel @ 400 ppm). Chundawat *et al.* (1977) who revealed that application of ethephon at 500 ppm two weeks before harvesting decreased acidity of a plum fruit cv. Dabba and Motia. Ethrel application increases the rate of ethylene production due to which fructose, glucose and sucrose contents in fruit increase significantly which leads to the increase in soluble solids and decrease in titratable acidity (Park, 1996) [24, 25].

The data presented in Table 4 shows that all the treatments significantly affected total soluble solids/acidity ratio compared to the control. During 2013-14, total soluble solids/acidity ratio was maximum (80.92) with T_8 (Ethrel @400 ppm) whereas it was minimum (50.45) with T_1 treatment. A similar trend was recorded during 2014-15, where total soluble solids/acidity ratio was maximum (90.45) with T_8 (Ethrel @400 ppm) whereas it was minimum (53.73)

with T_1 treatment. The pooled analysis revealed that the treatments T_1 (KNO_3 @1%) as well as T_9 (control) resulted in maximum acidity% (0.33), whereas, the minimum acidity% (0.24) was recorded with T_8 (ethrel @ 400 ppm). Similar results were found by Dongariyal (2017) [9] in litchi cv. Rose Scented, Sheibert *et al*. (2000) [31] in Pear cv. Triumph and Bal *et al.* (2006) [3] in Ber. However, the results obtained are not in support of Shaybany *et al.* (2015) who found that ethephon increased the percentage of soluble solids and vitamin C content while TSS: acidity ratio of juice decreased significantly in pomegranate.

The data presented in Table 4 shows that all the treatments significantly affected the ascorbic acid content. During 2013-14, ascorbic acid content was maximum (24.55 mg/100g pulp) with T_6whereas it was minimum (21.20 mg/100 g pulp)) with T_9 treatment. A similar trend was recorded during 2014-15, where ascorbic acid content was maximum (22.66 mg/100g pulp) with T_8whereas it was minimum (21.20 mg/100 g pulp) with T_9 treatment. The pooled data revealed that treatment T_6 (K_2HPO_4 1% + KNO_3 1%) resulted into the highest ascorbic acid content (23.36) followed by T_2 (K_2HPO_4) i.e., 22.87. The minimum content was obtained with control (21.20). The increase in ascorbic acid content may be dueto the catalytic influence of the growth substances on the biosynthesis of ascorbic acid from sugar (Shanmugavelu *et al*., 1973) [32]. Inhibited activity of oxidative enzyme and enhanced photo-phosphorylation in prolonged photo synthesizing ability of chlorophylous leaves and fruits themselves, probably caused by these chemicals might have helped in increasing the amount of ascorbic acid.

Table 4: Effect of different treatments on TSS, acidity, TSS: Acidity ratio and Ascorbic acid in litchi cv. Rose Scented.

Treatments		TSS (°Brix)			Acidity (%)			TSS: Acidity Ratio			Ascorbic Acid (mg $100g^{-1}$ pulp)		
		2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	KNO_3 (1%)	17.14^{g}	17.13^{e}	17.16^{g}	0.34^{a}	0.32^{a}	0.33	50.45	53.73^{f}	52.09^{g}	22.15^{c}	23.12^{a}	22.63^{bc}
T_2	K_2HPO_4 (1%)	18.56^{d}	18.5^{c}	18.57^{d}	0.30^{abc}	0.29^{b}	0.29^{b}	61.62^{de}	64.31^{e}	62.96^{f}	23.42^{b}	22.32^{abc}	22.87^{ab}
T_3	KH_2PO_4 (1%)	18.59^{d}	18.64^{c}	18.61^{d}	0.270^{d}	0.25^{de}	0.26^{de}	69.10^{bcd}	73.13^{cd}	71.11^{cd}	22.33^{c}	21.20^{c}	21.76^{de}
T_4	K_2H PO_4 (2%)	18.53^{d}	18.68^{c}	18.60^{d}	0.29^{bc}	0.28^{bc}	0.28^{bc}	63.07^{d}	66.91^{de}	64.99^{ef}	23.15^{b}	22.52^{ab}	22.83^{ab}
T_5	KH_2 PO_4 (2%)	18.20^{e}	18.46^{c}	18.33^{e}	0.27^{cd}	0.26^{cd}	0.26^{cd}	66.99^{cd}	71.07^{d}	69.03^{de}	21.28	22.58^{ab}	21.93^{d}
T_6	K_2HPO_4(1%)+KNO_3(1%)	19.66^{b}	19.72^{b}	19.69^{b}	0.25^{d}	0.24^{de}	0.24^{de}	77.65^{ab}	82.27^{b}	79.96^{b}	24.55^{a}	22.10^{abc}	23.36^{a}
T_7	KH_2PO_4(1%)+KNO_3(1%)	19.38^{c}	19.57^{b}	19.47^{c}	0.26^{cd}	0.25^{de}	0.25^{de}	73.16^{abc}	78.51^{bc}	75.84^{bc}	22.26^{c}	21.93^{bc}	22.10^{cd}
T_8	Ethrel (400 ppm)	20.63^{a}	20.78^{a}	20.70^{a}	0.25^{d}	0.23^{e}	0.24^{e}	80.92^{a}	90.45^{a}	85.68^{a}	22.46^{c}	22.66^{ab}	22.56^{bc}
T_9	Control	17.76^{f}	17.76^{d}	17.76^{f}	0.33^{ab}	0.33^{a}	0.33^{a}	53.97^{ef}	53.97^{f}	53.97^{g}	21.20^{d}	21.20^{c}	21.20^{e}
	SEm±	0.07	0.104	0.0	0.01	0.00	0.00	3.03	2.19	1.86	0.15	0.38	0.20
	LSD (0.05)	0.23	0.31	0.18	0.03	0.02	0.02	9.08	6.58	5.35	0.451	1.142	0.584

Conclusion

On the basis of findings of the present investigation, it can be concluded that foliar application of KNO_3 (1%) was effective for improving fruit breadth, fruit weight, fruit retention and significantly reduced fruit drop, total acidity of fruits in litchi. On the other hand, Ethrel (400 ppm) was effective for increasing fruit length, TSS. Therefore, KNO_3 (1%) and Ethrel (400 ppm) sprays can be recommended for enhancing fruit and quality characters of litchi fruits cv. Rose Scented.

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