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Improving fruit set, yield and fruit quality of Litchi (*Litchi chinensis* Sonn. cv. Rose Scented) through foliar spray of different concentrations of macro and micro nutrients

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Abstract
Foliar application of macro and micro nutrients influencing the fruit growth quality of litchi cultivars was investigated by applying calcium urea borax multiplex and potassium nitrate either alone or in combination with each other. The objective of this investigation was to see the effect of nutrients viz., urea (1%), KNO_3 (2%), calcium chloride (1%), borax (1%), multiplex (0.4%) and their combinations on fruit quality and shelf life of litchi cv. Rose Scented. The litchi cultivar varied significantly for quantity and quality traits. Calcium chloride ($CaCl_2$), Boron or Multiplex alone when applied alone as foliar spray had no significant effect on most of the quality attributes, however, Urea + borax (1% + 1%) application on Litchi fruit showed highest fruit retention (44.7 %), fruit yield (74.80 kg/tree), fruit size (3.78 cm), TSS (22.54%), reduced fruit cracking and acidity as the fruit prolonged towards maturity. Thus foliar application of Urea + borax (1% + 1%) was an optimum dose for maintaining the physio-chemical properties of Litchi fruit cv. Rose Scented.

Keywords: Litchi, (*Litchi chinensis* Sonn. cv. Rose Scented), foliar spray, macro and micro nutrients

Introduction

Litchi being a non-climacteric fruit, does not improve in quality after harvesting, but has to ripen on the tree. It is a fruit with sweet, translucent and juicy flesh. Sugar content in different cultivars ranges from 6.74 to 18.86 per cent. Besides sugar, litchi contains 0.7% protein, 0.3% fat, 0.7% minerals and vitamin C 40-60 mg/100g pulp. In Uttarakhand, it is mainly grown in Dehradun, Haridwar, Nainital, Ramnagar and US Nagar districts with minor production in Pithoragarh and Pauri Garhwal. Poor fruit setting, heavy fruit drop and fruit cracking in litchi are some of the major problems of litchi growing areas. Recent studies on fruit nutrition have focused attention upon the significance of zinc, copper, boron, calcium, magnesium, iron and manganese in modifying various enzymatic and physiological processes**.** The fruits after harvest are very perishable and rapidly loose quality. Harvesting at proper physiological maturity is essential for true quality and shelf life. Nutrient management is essential for maximum yield (Menzel and Simpson, 1987), for good quality and profitability. Pre-harvest foliar application of various chemicals have been reported to enhance the shelf life of fruits by reducing physiological loss in weight and decay losses during storage of fruits. Foliar application of nutrients has become an important practice in the production of fruits. Foliar spray of nutrients is an important method for micronutrient application because plants can absorb the nutrients much quicker and smaller quantities may be required for normal growth as against the large quantities of the same may be required for soil application. At early stage of litchi growth there is initiation of cracking of pericarp. Fruit cracking is enhanced by hot dry winds, low relative humidity, high temperature, lack or excessive irrigation. Calcium is structural component of cell wall. In litchi fruit calcium participates in cracking resistance because trees having higher calcium levels shows lower cracking incidence while low exchangeable calcium in plants results in high cracking incidence **(Li *et al*., 2001**). Thus, calcium related physiological disorders can be decreased by the foliar application of calcium on the fruit. Experiment in litchi shows that borax at 0.4% not only decreased the fruit cracking but also increased total soluble solids and total sugar contents of the fruits

(Ruby *et al*., 2001). Application of Urea reduces fruit drop along with harvest delay in litchi. Similarly, Potassium nitrate sprays increase yield, fruit quality and income of litchi growers. Due to shortage of potassium many metabolic processes are affected like rate of photosynthesis and translocation (Marschner, 1995). For perennial tree crops flowering, fruit set and June drop are stages with higher nutrient demand. During these stages greatest gains in fruit number and retention, can be made. Moreover, treatments during these stages also impart fruit size, quality and shelf life. So, with these ideas in view, concerning all the factors discussed above, it is assumed that altering the concentrations and time of application of nutrients to a critical point may cause many changes leading to the improvement in yield, quality and storage life of fruits.

Material and Methods

The experiment entitled, "Pre-harvest foliar application of nutrients in Litchi (*Litchi chinensis* Sonn.) in order to improve its quality and shelf life" was conducted at Horticultural Research Centre, Patharchatta, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand during the year 2014-15. Fifteen year old Litchi bearing tree cv. Rose Scented with uniform vigour and size were selected for the present investigation. The experiment was performed under Randomized Block Design (RBD) with control. All treatments with control were replicated three times. The plants were sprayed with different concentrations of Urea (1%), Potassium nitrate (2%), Calcium chloride (1%), Borax (1%), Multiplex (0.40%), Urea + calcium chloride (1% + 1%), Urea + borax (1% + 1%), Urea + multiplex (1% + 0.4%) along with control, twice with the help of foot sprayer, first application was done in the month of April and second in the month of May during the year 2015. The following observations were recorded under following heads:

Fruit drop percentage

Percentage of fruit drop was calculated by total number of fruits dropped from initial fruit set to harvesting maturity. Total fruit drop percentage was calculated by using following formula:

$$\text{Fruit drop (\%)} = \frac{\text{Number of fruit dropped}}{\text{Number of fruit set initially}} \times 100$$

Fruit retention percentage

Percentage of fruit retention was calculated by total fruit retained, total number of retained at harvesting maturity. Total fruit retention was calculated by using the following formula:

$$\text{Total fruit retention (\%)} = \frac{\text{Number of fruit retained per panicle}}{\text{Number of fruit set initially per panicle}} \times 100$$

Fruit cracking percentage

Percentage of fruit cracking was calculated by total number of fruit cracked and total fruits retained. Fruit cracking percentage was calculated by using the following formula:

$$\text{Fruit cracking (\%)} = \frac{\text{Number of fruits cracked per panicle}}{\text{Number of fruits retained per panicle}} \times 100$$

Fruit yield (kg/tree)

The data on fruit yield were recorded by weighing all the fruits of each experimental tree at the time of harvesting and was expressed in kg per tree.

Fruit length (cm)

Lengths of the ten fruits each of the three replication of the treatments were recorded by using digital vernier calliper.

Total soluble solids

Total soluble solids of a fruit juice were recorded by using digital refractometer in all the treatment replication wise at harvesting time and were expressed in ^{0}Brix.

Titratable acidity (per cent)

Total acidity of litchi fruit was calculated by titrating the pulp extract with N/10 NaOH as per method described in the manual of analyzing of fruits and vegetables product by Ranganna (1991) using 1 per cent phenolphthalene as an indicator. Since the predominating acid of ripe fruit is malic acid (80 % of all the acid), the calculation of total acidity was based on the equivalent weight of malic acid. The acidity was expressed in percentage by following formula:

$$\text{Total acidity (\%)} = \frac{\text{Titre value} \times \text{normality of alkali} \times \text{equivalent weight of acid} \times 100}{\text{Volume of sample taken} \times 1000}$$

Ascorbic acid (mg/100g flesh)

Ascorbic acid content of litchi fruit was determined by using 2,6-dichlorophenol indophenol dye. Visual titration method as described in the hand book of analysis and quality control for fruits and vegetable products by Ranganna (1991). This was expressed in terms of mg ascorbic acid per 100/g of pulp.

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

Result and Discussion

The data on effect of various treatments on fruit drop of litchi are presented in Table 1. It indicated that all the treatments exerted a significant influence on fruit drop. Minimum fruit drop (55.30%) was observed in urea 1% + borax 1% while maximum fruit drop (65.80%) was found in control followed by (59.45%) in urea 1%. Yehia and Hassan (2005) reported that borax and urea applications could be attributed to enhanced pollen germination and pollen tube growth which increased fruit set and yield. The application of boron reported to improve the fruit set in LeConte pear (Badawi *et al*., 1981). Similarly, exogenous application of urea and borax on pear trees had shown good response with respect to lower fruit drop (Gill *et al*., 2012). A significant influence on fruit retention was exerted that all the treatments as depicted by Table 2 Maximum fruit retention (44.70%) was observed in urea 1% + borax 1% (T_7) which was statistically *at par* with T_4 (43.50%), T_6 (43.90%), while minimum (34.20%) was recorded in control (T_9) followed by (40.55%) in urea 1% (T_1). The results indicated that spraying the trees twice or thrice is more effective than spraying once a year for improving micronutrients content of peach trees (El Sheikh *et al*., 2007). Boron is also responsible for activation of dehydrogenase enzymes, sugar translocation, nucleic acids and plant hormones (Brady and Weil, 1996).

From Table3 data interpreted that minimum fruit cracking (4.50%) was observed in urea 1% + borax 1% (T_7) while maximum fruit cracking (7.29%) was found in control (T_9) followed by (5.98%) in urea 1% (T_1). It is reported that differences in the thickness of cuticle and spongy layers in litchi could contribute to susceptibility of a cultivar to cracking (Huang *et al.*, 2004). Misra and Khan (1981) reported that the role of boron application may probably due to translocation of sugars and synthesis of cell wall material and increase in methyl esterase activity. Our findings are in support of work done by Haq and Rab (2012) (Kumar *et al*., 2001) (Wojvik *et al*., 1999). Spraying urea 1% + borax 1% (T_7) also led to increase the yield of litchi fruit which was followed by borax 1% (T_4) while minimum fruit yield was found in control (T_9) as depicted from Table 4. The results are in agreement with Singh *et al*. (2013) who reported that application of boric acid (0.02%) enhanced yield in mango cv. Dashehari. Similar findings were reported by Hassan and Chatopadhyay (1990) who showed that highest fruit yield was obtained by spray of borax (0.5%) in litchi cv. Bombai.

From the perusal of data in Table 5 it is clear that fruit size was significantly affected by spraying of nutrient either alone or in combination with one another and the maximum length (3.78 cm) was obtained on spraying of urea 1% in combination with borax 1% (T_7), while minimum (3.45 cm) was recorded in control (T_9). This might due to role of borax in improving the internal physiology of developing fruit in terms of better supply of water nutrients and other compounds vital for their proper growth and development (Dutta and Banik, 2007). Role of boron in increasing the fruit length is reported in mango cv. Dashehari (Singh *et al*., 2003). Similar findings were observed by Katiyar *et al*. (1998) who reported that foliar spray of urea 2.0% significantly increased the fruit length in ber cv. Banarsi.

T.S.S from Table 6 data revealed Maximum T.S.S (21.80 ^{0}Brix) in fruits having foliar spray of urea 1% + borax 1% (T_7) which was statistically *at par* with T_3 (21.01 ^{0}Brix), while minimum T.S.S. (19.20 ^{0}Brix) was found in control (T_9). Increase in fruit TSS following borax application might be attributed to rapid mobilization of sugars and other soluble solids to developing fruits. These results are in conformity with the findings of Singh *et al*. (2004) who noted that TSS was enhanced by application of boron in guava fruits. Increase in T.S.S. content with these micronutrients may be attributed to the quick metabolic transformations of polysaccharides and pectin into soluble compounds and rapid translocation from leaves to the developing fruits due to improved source- sink relationship. Acidity of fruits followed a decreasing trend with the foliar application of different nutrients in Table7. Lower amount of acidity was retained due to spray of 1% urea in combination with 1.0 percent borax. The lowest acidity by boron might be due to the role of boron in conversion of acid into sugar and their derivatives by the reaction involving reversal of glycolytic pathway. The results are also in conformity with Singh *et al*. (2012) who reported that minimum acidity (0.32%) was registered with the treatment of borax (1.0%) in mango cv. Dashehari. Similar results were reported by Misra and Khan (1981) and Pathak and Mitra (2008) in litchi. Spraying of1% urea and 1.0 percent effectively borax enhanced the process of ascorbic acid formation which leads to increase in nutritive value of the fruit Table 8. These findings were in accordance to the experiment conducted by Sankar *et al*. (2013) in which it was revealed that higher value of ascorbic acid (40.42mg/100g) content observed in the treatment receiving 0.02% boric acid, might be due to higher level of sugars in boron treated fruit which increased the content of ascorbic acid, since ascorbic acid is synthesized from sugar. Similar result was observed by Brahmachari *et al*. (1997) in litchi.

Conclusion

Litchi fruit quality varies significantly as influenced by urea, multiplex, $CaCl_2$ and Borax treatments. Although foliar application of $CaCl_2$ and Borax increased fruit weight, fruit size, Tss ascorbic acid and also maintained acidity fruit retention and reduced fruit cracking cracking but combination of $CaCl_2$ with Borax was more effective than calcium chloride or any other nutrient's alone application.

Table 1: Effect of different treatments on fruit drop

Symbols	Treatment details	Fruit drop (%)
T_1	Urea 1%	59.45
T_2	Potassium nitrate 2%	58.3
T_3	Calcium chloride 1%	57.8
T_4	Borax 1%	56.5
T_5	Multiplex 0.4%	57.2
T_6	Urea 1% + calcium chloride 1%	56.1
T_7	Urea 1% + borax 1%	55.3
T_8	Urea 1% + multiplex 0.4%	55.6
T_9	Control (water spray)	65.8
	S.E(m).±	0.93
	C.D. at 5% level	2.79

Table 2: Effect of different treatments on fruit retention

Symbols	Treatment details	Fruit retention (%)
T_1	Urea 1%	40.55
T_2	Potassium nitrate 2%	41.7
T_3	Calcium chloride 1%	42.2
T_4	Borax 1%	43.5
T_5	Multiplex 0.4%	42.8
T_6	Urea 1% + calcium chloride 1%	43.9
T_7	Urea 1% + borax 1%	44.7
T_8	Urea 1% + multiplex 0.4%	44.4
T_9	Control (water spray)	34.2
	S.E(m).±	0.47
	C.D. at 5% level	1.43

Table 3: Effect of different treatments on fruit cracking

Symbols	Treatment details	Fruit cracking (%)
T_1	Urea 1%	5.98
T_2	Potassium nitrate 2%	5.60
T_3	Calcium chloride 1%	5.32
T_4	Borax 1%	5.00
T_5	Multiplex 0.4%	5.12
T_6	Urea 1% + calcium chloride 1%	4.91
T_7	Urea 1% + borax 1%	4.50
T_8	Urea 1% + multiplex 0.4%	4.87
T_9	Control (water spray)	7.89
	S.E(m).±	0.08
	C.D. at 5% level	0.23

Table 4: Effect of different treatments on fruit yield

Symbol	Treatment details	Fruit yield (kg/tree)
T_1	Urea 1%	65.78
T_2	Potassium nitrate 2%	73.00
T_3	Calcium chloride 1%	72.10
T_4	Borax 1%	75.40
T_5	Multiplex 0.4%	71.20
T_6	Urea 1% + calcium chloride 1%	72.60
T_7	Urea 1% + borax 1%	77.38
T_8	Urea 1% + multiplex 0.4%	74.80
T_9	Control (water spray)	60.98
	SE(m)±	0.838
	C.D.	2.533

Table 5: Effect of different treatments on length of litchi fruits

Symbols	Treatment details	Length (cm)
T_1	Urea 1%	3.61
T_2	Potassium nitrate 2%	3.60
T_3	Calcium chloride 1%	3.65
T_4	Borax 1%	3.67
T_5	Multiplex 0.4%	3.62
T_6	Urea 1% + calcium chloride 1%	3.74
T_7	Urea 1% + borax 1%	3.78
T_8	Urea 1% + multiplex 0.4%	3.71
T_9	Control (water spray)	3.45
	S.E(m).±	0.059
	C.D. at 5% level	0.18

Table 6: Effect of different treatments on TSS of litchi fruits

Symbols	Treatment details	TSS (^{0}B)
T_1	Urea 1%	20.40
T_2	Potassium nitrate 2%	20.67
T_3	Calcium chloride 1%	21.01
T_4	Borax 1%	21.30
T_5	Multiplex 0.4%	20.91
T_6	Urea 1% + calcium chloride 1%	21.20
T_7	Urea 1% + borax 1%	21.80
T_8	Urea 1% + multiplex 0.4%	21.50
T_9	Control (water spray)	19.20
	S.E(m).±	0.29
	C.D. at 5% level	0.86

Table 7: Effect of different treatments on acidity

Symbols	Treatment details	Acidity (%)
T_1	Urea 1%	0.57
T_2	Potassium nitrate 2%	0.55
T_3	Calcium chloride 1%	0.53
T_4	Borax 1%	0.51
T_5	Multiplex 0.4%	0.54
T_6	Urea 1% + calcium chloride 1%	0.50
T_7	Urea 1% + borax 1%	0.47
T_8	Urea 1% + multiplex 0.4%	0.49
T_9	Control (water spray)	0.62
	S.E(m).±	0.01
	C.D.	0.02

Table 8: Effect of different treatments on ascorbic acid content of fruits

Symbols	Treatment details	Ascorbic acid (mg/100g)
T_1	Urea 1%	27.50
T_2	Potassium nitrate 2%	28.30
T_3	Calcium chloride 1%	29.40
T_4	Borax 1%	31.80
T_5	Multiplex 0.4%	28.50
T_6	Urea 1% + calcium chloride 1%	31.00
T_7	Urea 1% + borax 1%	32.57
T_8	Urea 1% + multiplex 0.4%	32.00
T_9	Control (water spray)	26.30
	S.E(m).±	0.41
	C.D. at 5% level	1.24

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