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Research Article

Effect of Micronutrients and Plant Growth Regulators on Fruit Set, Fruit Retention, Yield and Quality Attributes in Litchi Cultivar Dehradun

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Abstract

The present investigation entitled "Effect of micronutrients and plant growth regulators on fruit set, fruit retention, yield and quality attributes in litchi cultivar Dehradun." was carried out in the Punjab Agricultural University, Regional Research Station, Gurdaspur during the year 2014-15 and 2015-16. The experiment was laid out in Randomized Block Design with eleven treatments and replicated thrice with a unit of one plant in each replication of a treatment. Different doses of zinc sulphate ($ZnSO_4$) @ 0.4%, 0.6%, and 0.8%; Borax @ 0.2%, 0.4% and 0.6% along with control were sprayed on new growth flushes before initiation of inflorescence, whereas 2, 4-D @ 10 ppm, 20 ppm and 30ppm; GA_3 @25 ppm, 50 ppm and 75 ppm were sprayed after fruit setting in Dehradun litchi. Results shows that the maximum fruit set (78.15%), fruit retention (60.17%), fruit length (5.6cm), breadth (5.0cm), fruit weight (25.90gm), fruit yield(158.73kg/tree), pulp weight(22.19gm), pulp stone ratio(9.44), TSS(22.96°Brix) and sugars (18.52%) with minimum fruit cracking(2%), stone weight(2.35gm), peel weight(1.36gm) and acidity(0.4%) were recorded with 0.4% borax application followed by 50ppm GA_3.

Keywords: Fruiting, Litchi, Micronutrients, Plant growth regulators

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Introduction

The litchi (*Litchi chinensis* Sonn.) recognized as "Queen of the fruits" is the most important sub-tropical evergreen fruit tree, belongs to family Sapindaceae [1]. It is indigenous to south eastern China from where it is considered to have reached eastern India through Myanmar by the end of 17^{th} century or shortly thereafter [2]. In India, 585.30 thousand metric tonnes of litchi is produced annually from 84.20 thousand hectares area [3]. It is highly specific to climatic requirements, as it required cool dry winters and warm wet summers and due to this reason its cultivation is restricted to few states in our country. Litchi is grown mainly in the states of Bihar, West Bengal and Uttar Pradesh. It is also grown in limited scale in Tripura, Orissa, Punjab, Himachal Pradesh, Assam and Nilgiri hills in the south. In Punjab, its cultivation recommended to sub-mountainous tracts of Gurdaspur, Hoshiarpur, Roopnagar, SAS Nagar Mohali and Patiala districts. In Punjab, litchi is growing in an area of 2152 hactares with the production of 35239 metric tonnes [4]. Litchi is an arillate and nut type fruit botanically which is known for its excellent quality, juicy, slightly sour and sweet taste, characteristic pleasant flavour, attractive colour and nutritional value. The fruit is rich in sugars, minerals and vitamins [5] and can be processed into juice, wine, pickles, jam, jelly, ice cream and yoghurt [6]. It comes to the market in the months of May-June when the market is full of other fresh fruits. But, inspite of the availability of different types of fruit in the market, the demand for fresh litchi is always very high due to its unique taste, flavour and colour [7]. The problems responsible for low economic potential of litchi cultivation in various litchi growing regions include poor fruit set [8], heavy fruit drop [9], fruit cracking [10] and inferior fruit quality [11]. Therefore, plant growth regulators have been used for many years to alter the fruit plant behaviour for the economic benefits such as to control the vegetative growth, increase in flowering and fruit set, stimulation of maturity and ripening and improving fruit quality. It is also reported that growth substances like gibberellic acid(GA_3), borax, naphthaleneacetic acid(NAA) and 2, 4-D have great influence on litchi and proved beneficial in reducing the cracking and dropping of fruits and enhancing the quality of fruits along with delay in harvest. GA_3 has been found to offer suitable means of controlling ripening process in litchi and improving fruit quality [12] and other fruit crops [13]. Micronutrients plays specific role in improving the growth, yield and quality of litchi even though these elements are needed in small quantities. Zinc element is essentially required for growth, development and also involved in diverse range of enzyme system in litchi. The functional role of zinc includes auxin metabolism, influence on activating

enzyme synthesis and stability of ribosomal fractions [14]. Zinc plays an important role in the metabolic activities of plants. The principal functions of zinc in plant are as a metal activator of enzymes like dehydrogenase (pyridine nucleotide, glucose-6 phosphodiesterase, carbonic anhydrase etc.). It is involved in the synthesis of tryptophan, a precursor of IAA. It is associated with water uptake and water retention in plant bodies [15]. Plant requires boron micronutrient in relatively small quantities for number of growth processes such as new development in meristemetic tissue, translocation of sugars, starch, nitrogen and phosphorus and synthesis of amino acids and protein. Boron is also considered to be necessary for photosynthetic activities, hormone metabolism, cellular differentiation and water absorption in plant parts. Boron is also involved in reproduction, pollen tube germination and fertilization in flower parts. In case of boron deficiency, flowers are produced in less number and are mostly sterile; fruits are deformed and render themselves commercially useless [16]. Application of boron increases the yield and fruit quality [17]. Considering the importance of plant growth regulators and micronutrients in fruit production, the present investigation is carried out with the objective to study the effect of gibberellic acid (GA_3), Borax, 2, 4-D and $ZnSO_4$ (Zinc sulphate) on fruit set, fruit retention, yield and quality attributes in litchi cultivar Dehradun.

Materials and Methods

The present experiment was conducted at litchi orchard of Punjab Agricultural University, Regional Research Station, Gurdaspur during the year 2014-15 and 2015-16. Uniform and healthy plants of cultivar Dehradun were selected and maintained with uniform cultural practices as recommended by Punjab Agricultural University, Ludhiana. Different doses of $ZnSO_4$ @ 0.4%, 0.6%, and 0.8%; Borax @ 0.2%, 0.4% and 0.6%; 2, 4-D @ 10 ppm, 20 ppm and 30ppm;GA_3@25 ppm, 50 ppm and 75 ppm sprays along with control were tested. $ZnSO_4$ and borax were sprayed on new growth flushes before initiation of inflorescence, whereas 2, 4-D and GA_3 were sprayed after fruit setting in Dehradun litchi. The experiment was planned out in a randomized block design and each treatment was replicated thrice with a single tree as a treatment unit. Ten panicles in each direction of the tree were selected randomly in each treatment for recording the data on fruit set(%), fruit retention(%), fruit cracking(%), fruit length(cm), fruit breadth(cm), fruit weight(gm), fruit yield(kg/tree), pulp weight(gm), stone weight(gm), peel weight(gm), total soluble solids(TSS)(°Brix), acidity(%) and total sugars(%). Total soluble solids(TSS) of the fruit was determined by using Hand Refractometer and acidity content of the fruit was recorded as malic acid, by titration of juice with 0.1NaOH using phenolphthalein as indicator. Total sugars were estimated by the standard procedure as described in [18]. Data was analysed statistically by Randomized Block Design as described by [19] for each year and ultimately the pooled estimates for both the years were worked out.

Results and Discussion

Fruit Set, Fruit Retention and Fruit Cracking

It has been observed that 0.4% borax was most effective in increasing fruit setting(78.15%), fruit retention (50.08%)and reducing the fruit cracking (7.0%) followed by 50ppm GA_3 (Table1). Borax response was more positive due to boron, which play an important role in translocation of carbohydrates, auxin synthesis and increased pollen viability and fertilization. Minimum fruit setting and fruit retention were recorded under control. Similar results were also observed in litchi [20-23], ber [24] and guava [25]. Spray of 50ppm GA_3 also increased the fruit setting (70.50%), fruit retention (50.43%) and fruit cracking (10%) in litchi (table1). Application of GA_3 also reduced the fruit cracking in litchi as reported by [26]. Similarly, maximum fruit set, fruit retention, fruit size, fruit weight and fruit yield were observed in foliar application of 0.4% borax in litchi culivar Ambika Litchi-1 [23], Purbi litchi [23] and guava [25].

Fruit Length, Breadth, Weight and Yield

From the Table 1 and Table2 , it has been noted that with the spray of 0.4% borax treatment, the maximum fruit length (5.6cm), fruit breadth(5.0cm), fruit weight(25.9cm)and fruit yield(158.73) were observed followed by spray of 50ppm GA_3. The minimum fruit length (3.0cm), breadth (2.8cm), weight (18.81gm) and fruit yield (76.18 kg/tree) were recorded under control. These results are in conformity with those reported by [25] in guava and [27] in litchi. They reported that boron 0.4% spray increase fruit weight, length and diameter of guava fruit cultivar Sardar Guava [25]. This increase in length and breadth of litchi fruit may be due to the mineral nutrients specially boron appears to have direct role in hastening the process of cell division and cell elongation due to which size and weight would have improved. The increase in fruit weight may be due to the rapid increase in the size of cells or it is also due the fact that

foliar application of boron increased the fruit weight eventually by maintaining lighter level of auxins in various parts of the fruits which helped in increasing the fruit growth [1].The increase in the size of fruits was due to the rapid fruit development and the greater mobilization of food materials from the site of production to storage organs under the influence of applied nutrients. A similar increase in size of fruits by treatment of boron had also been reported in litchi [22, 23, 27-29] and guava [25]. The increase in the fruit yield was due to the accumulation of sugars and other soluble solids in the fruits.

Table 1 Effect of micronutrients and growth regulators on fruit set, fruit retention, fruit cracking, fruit length, fruit breadth and fruit weight of litchi cultivar Dehradun

Treatment	Fruit set (%)	Fruit retention (%)	Fruit cracking (%)	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (gm)
$ZnSO_4$ (0.4%)	50.83	30.04	18.04	3.96	3.46	22.61
$ZnSO_4$(0.6%)	62.12	33.08	17.08	3.68	3.40	21.43
$ZnSO_4$(0.8%)	60.08	35.30	20.03	3.58	3.36	20.89
Borax(0.2%)	57.17	33.04	15.11	4.03	3.55	21.13
Borax(0.4%)	78.15	60.17	2.00	5.60	5.00	25.90
Borax(0.6%)	62.25	40.18	14.50	4.25	3.64	23.03
2,4-D(10ppm)	50.18	31.50	18.08	3.85	3.25	22.37
2,4-D(20ppm)	55.10	32.07	16.04	3.62	3.30	21.56
2,4-D(30ppm)	52.07	31.02	19.50	3.55	3.20	21.31
GA_3(25ppm)	50.00	34.05	18.45	3.50	2.80	22.60
GA_3(50ppm)	70.50	50.43	10.00	5.15	4.50	23.95
GA_3(75ppm)	52.17	38.08	15.50	4.03	3.30	21.94
Control	41.33	25.15	26.00	3.00	2.80	18.81
CD(5%)	3.56	3.15	1.80	1.09	0.90	2.00

Fruit Pulp Weight, Stone Weight, Peel Weight and Pulp/Stone Ratio

The maximum fruit pulp weight (22.19gm) and pulp/stone ratio (9.44) were observed in 0.4% borax spray treatment followed by 50ppm GA_3. Whereas minimum fruit pulp weight (10.45gm) and pulp/stone ratio (2.54) were observed in control (Table2). Pulp/stone ratio is the ratio between the weight of pulp and weight of stone. The pulp weight depends on the fruit and seed size [30], but is affected by the plant nutrition [31]. Minimum fruit stone weight (2.35gm) and peel weight (1.36gm) were recorded in the treatment of 0.4% borax followed by 50ppm GA_3. The maximum stone weight (4.25gm) and peel weight (4.11gm) was observed in the fruits harvested from untreated plants (Table2). Boron produced fruits with smaller stone. This may be due to their involvement in IAA metabolism which reduces stone size. The decrease in stone weight may be due to the fact that auxins induced parthenocarpic effect to some extent there by resulting lesser stone weight [32]. It pertains to the fact that application of boron enhanced the pulp weight and reduced the stone weight which as a consequence gave high pulp/stone ratio. These findings are in line with the findings of [33] and [27] in litchi and [34] in apricot.

Total Soluble Solids, Acidity and Sugar contents of fruits

The maximum total soluble solids (22.96°Brix) content of fruits were recorded with foliar application of 0.4% borax followed by 50ppm GA_3(Table2). Increase in total soluble solids might be that boron helps in Trans-membrane sugar transport, which may be the possible cause for improvement in boron sprayed trees. A notable characteristic of borax is that it directly affects photosynthesis activity of plants [35]. These results are in close conformity with [36, 37, 25] in guava, ber [24] and litchi [29]. The results of the present study are in agreement with the findings of [9, 11, 38, 39] who reported similar type of TSS encouragement in litchi fruit with the application of micronutrients. The increase in TSS content in litchi fruit with boron and zinc was also reported by [40-42]. Increase in TSS content with these micronutrients may be attributed to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to developing fruits [11].

Minimum acidity (0.40%) content in litchi fruits was found with 0.4% borax spray followed by 50ppm GA_3 while it was maximum (0.49%) in control (Table2). Acidity was reduced with borax treated fruits which might be due to early ripening induced by this treatment during which degradation of acid might have occurred. It also appears that

total soluble solids increased at the expense of acidity under these fruits. The acid under the influence of borax might have been fastly converted into sugars and their derivatives by the reaction involving the reversal of glycolytic path way or be used in respiration as bot similarity. These results are close conformity with [43, 29] in litchi, custard apple [44] and guava [45, 25].

The maximum (18.52%) total sugar content in litchi fruits was recorded with foliar application of 0.4 % borax followed by 50ppm GA_3, while it was minimum (14.40%) under control (Table2). These results are in close conformity with findings of [25, 29, 46] in litchi.

Table 2 Effect of micronutrients and growth regulators on fruit yield, pulp weight, stone weight, peel weight, pulp/stone ratio, total soluble solids(TSS),acidity and total sugars content of litchi cultivar Dehradun.

Treatment	Fruit yield (kg/tree)	Pulp weight (gm)	Stone weight (gm)	Peel weight (gm)	Pulp/stone ratio	TSS (°Brix)	Acidity (%)	Total Sugars (%)
$ZnSO_4$ (0.4%)	104.57	17.25	3.15	2.21	5.48	18.95	0.46	14.96
$ZnSO_4$(0.6%)	98.26	15.55	3.13	2.75	4.97	18.76	0.45	15.25
$ZnSO_4$(0.8%)	90.75	14.95	3.46	2.48	4.32	18.21	0.47	15.68
Borax(0.2%)	116.32	15.25	3.48	2.40	4.38	18.15	0.45	16.35
Borax(0.4%)	158.73	22.19	2.35	1.36	9.44	22.96	0.40	18.52
Borax(0.6%)	127.03	17.00	3.33	2.70	5.11	19.31	0.42	16.50
2,4-D(10ppm)	100.67	16.00	3.32	3.05	4.82	19.44	0.44	15.00
2,4-D(20ppm)	97.50	15.00	3.37	3.19	4.45	19.18	0.43	15.35
2,4-D(30ppm)	91.39	15.10	3.45	2.76	4.38	18.56	0.45	15.25
GA_3(25ppm)	109.27	16.75	3.35	2.50	5.00	18.65	0.46	16.22
GA_3(50ppm)	150.05	20.00	2.45	1.50	8.160	21.25	0.41	17.09
GA_3(75ppm)	115.05	16.50	3.44	2.00	4.80	19.50	0.45	16.45
Control	76.18	10.45	4.25	4.11	2.54	17.00	0.49	14.40
CD(5%)	3.45	2.27	0.88	0.85	1.29	2.00	0.02	2.15

Conclusion

The experiment clearly demonstrated that sprays of micronutrients and plant growth regulators could influence the fruit set, fruit retention, yield and quality attributes in litchi cultivar Dehradun. It was concluded from the experiment that spray of 0.4% borax on new growth flushes before initiation of inflorescence resulted in maximum fruit set, fruit retention, fruit length, breadth, fruit weight, fruit yield, pulp weight, pulp stone ratio, TSS and sugars with minimum fruit cracking, stone weight, peel weight and acidity.

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