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RESEARCH ARTICLE :

Effect of growth regulators and micronutrients spray on vegetative growth of litchi (*Litchi chinensis* Sonn.) cv. CALCUTTIA

VIKRAMADITYA PRIYADARSHI, K. MEHTA, DEBASHISH HOTA, GOPA MISHRA AND ABHIJIT JOGUR

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SUMMARY : Being one of the finest fruit litchi still need a major attention towards the problem like irregular flowering, poor fruit set, heavy fruit drop, low yield, fruit cracking and poor quality to meet the growing demand of national and international market. Bio-regulators and micro-nutrient are being used by the growers to increase the yield by improving the yield attribute parameters.The present experiment was laid out at the Regional Horticulture Research and Training Station, Dhaulakuan, Dr.Yashwant Singh Parmar University of Horticulture and Forestry, Nauni-Solan (HP). Keeping the objective to increase the yield, in the recent studies; trees were subjected to 19 treatments *viz.*, GA_3 (T_1=25 ppm, T_2 = 50 ppm, T_3 = 75 ppm), CPPU (T_4 = 5 ppm, T_5 = 10 ppm, T_6 = 15 ppm), $ZnSO_4$ (T_7= 0.25%, T_8= 0.50%, T_9= 0.75%), Boric acid (T_{10}= 0.25%, T_{11}= 0.50%, T_{12}= 0.75%), GA_3 + CPPU(T_{13}= 25+5 ppm, T_{14} = 50+5 ppm, T_{15}= 75+5 ppm), Boric acid + $ZnSO_4$ (T_{16}= 0.25+0.50%, T_{17}= 0.50+0.50%, T_{18}= 0.75+0.50%) and T_{19}control.The plants treated with boric acid 0.75% + $ZnSO_4$ 0.50% recorded highest annual shoot growth, tree volume and tree height.From the above research it could be concluded that Boric acid (0.75%) + $ZnSO_4$ (0.50 %) should be treated to the plant for better vegetative growth and yield.

KEY WORDS :
Bio regulator, CPPU, GA 3 , Boric acid, $ZnSO_4$

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Author for correspondence :

DEBASHISH HOTA
Department of Fruit Science, Dr. Y.S. Paramar University of Horticulture and Forestry, Nauni, SOLAN (H.P.) INDIA
Email : dhota3@gmail.com

See end of the article for authors' affiliations

BACKGROUND AND OBJECTIVES

Litchi recognized as "Queen of the fruits" is the most important subtropical fruit crop which belongs to family Sapindaceae.It is a subtropical evergreen tree is adapted to the areas of cool dry winters and warm wet summers. It usually likes low elevations but can be grown upto an altitude of 800 meters above mean sea level with varying degree of success. Due to its exact climatic requirements its cultivation is restricted to few states in our country. Being one of the finest fruit litchi still need a major attention towards the problem like irregular flowering, poor fruit set, heavy fruit drop, low yield, fruit cracking and poor quality to meet the growing demand of national and international market.

In India 5,94,430 metric tones of litchi is produced annually from 84,140 hectare area (Anonymous, 2013). In Himachal Pradesh it is being cultivated commercially in Kangra, Sirmour, Bilaspur and Una districts, occupying an area of 3059 hectare and production 2980 metric tonne, out of which maximum area and production is under Kangra district (Anonymous, 2012).Recent studies on fruit physiology and nutrition have focussed attention on significance of plant growth regulators and micronutrients in overcoming the problems by modifying various physiological and metabolic processes.

Plant growth regulators have been used for many years to alter the behaviour of fruit or fruit plants for the economic benefits.It is also reported that growth substances like Gibberellic acid, NAA and CPPU have great influence on litchi.Micronutrients plays specific role in improving the growth, yield and quality of litchi even though these elements are needed in small quantities.Boron and Zinc is essentially required for growth and development in litchi and is involved in diverse range of enzyme system. Considering the importance of Plant Growth Regulators and micronutrients in fruit production, the present investigation is carried out on litchi cv. CALCUTTIA to observe the effect of Gibberellic acid (GA_3), CPPU (N-(2-Chloro-4-pyridyl)-N-phenylurea), Boric acid and $ZnSO_4$ (Zinc sulphate) on litchi.

RESOURCES AND METHODS

The experiment was conductedon 12-year old trees of litchi cultivar Calcuttia, at Regional Horticulture Research and Training Centre, Dhaulakuan, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni-Solan (Himachal Pradesh).Fifty seven uniform bearing trees with uniform vigour and size, planted at a spacing of 8m x 8m were selected for study.The required amount of each plant growth regulators was taken and final volume was made to one litre with water to serve as stock solution.Two to Three drops of surfactant (Teepol) per litre of solution was added to reduce surface tension and to facilitate the absorption of solution. Spraying was done with the help of foot sprayer, till the leaves were wet and droplets of solution started trickling down, on clear and calm day during the morning hours at fruit set stage and repeated after one weak, during 2014 and 2015. The experiment was carried on by 19 treatments and 3 replications with Randomized Block Design. The data generated from these investigations were appropriately computed, tabulated and analyzed by applying Randomized Block Design (RBD). The level of significance was tested for different variables at 5 per cent level of significance.

Treatments	Chemical	Concentration
T_1	GA_3	25 ppm
T_2	GA_3	50 ppm
T_3	GA_3	75 ppm
T_4	CPPU	5 ppm
T_5	CPPU	10 ppm
T_6	CPPU	15 ppm
T_7	$ZnSO_4$	0.25 %
T_8	$ZnSO_4$	0.50 %
T_9	$ZnSO_4$	0.75 %
T_{10}	Boric acid	0.25 %
T_{11}	Boric acid	0.50 %
T_{12}	Boric acid	0.75 %
T_{13}	GA_3 + CPPU	25 ppm + 5 ppm
T_{14}	GA_3 + CPPU	50 ppm + 5 ppm
T_{15}	GA_3 + CPPU	75 ppm + 5 ppm
T_{16}	Boric acid+ $ZnSO_4$	0.25 % + 0.50 %
T_{17}	Boric acid + $ZnSO_4$	0.50 % + 0.50 %
T_{18}	Boric acid + $ZnSO_4$	0.75 % + 0.50 %
T_{19}	Control	Water spray

Annual shoot growth :

Ten shoots from the current season's growth were randomly selected from all over the periphery of each tree. The length of these shoots was measured with measuring tape after the cessation of growth and the average shoot length was expressed in centimetre (cm).

Tree height :

The height of the tree was measured in meter (m) with the help of graduated flag staff from the soil surface to the top of a tree, once before the start of the growing season and again after the termination of the growth. The increase in height was expressed in percentage.

Trunk girth :

Trunk girth was recorded at 30 cm above the ground level with the help of measuring tape once before the start of the growth and again after cessation of growth. The average increase in the trunk girth was expressed in percentage.

Tree volume :

The volume of the tree was worked out from tree height and spread measurements once before the start of the experiment and again after the completion of the experiment in each year as per formulae given by Westwood (1978).

Volume = $4/3\pi a^2 b$ if a<b, or

= $4/3\pi ab^2$ if a>b

a = 1/2 the length of major axis (height)

b = 1/2 the length of minor axis (spread)

The average increase in tree volume was worked out and expressed in percentage.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Annual shoot growth :

The growth regulators and micronutrients significantly increased the annual shoot growth, which varied from 16.50 to 20.40 cm. The maximum shoot growth (20.40 cm) was recorded in treatment T_{18}(Boric acid 0.75% + $ZnSO_4$ 0.50%) which was significantly superior to all other treatments. This was statistically at par with T_7, T_8, T_9, T_{11}, T_{12}, T_{13}, T_{15}, T_{16} and T_{17}which recorded statistically higher annual shoot growth than the control. The minimum shoot growth (16.50 cm) was observed in treatment T_{19} (control).

The results further showed that the mean value of all the concentration of Boric acid + $ZnSO_4$ had the highest increase in shoot growth which was 1.20 times more than the control, 1.03 times more than $ZnSO_4$, 1.04 times more than Boric acid and 1.05 times more than the combined application of GA_3 and CPPU.

Trunk girth :

The increase in trunk girth ranged from 2.70 to 9.62 per cent. The maximum increase in trunk girth (9.62%) was recorded in treatment T_{11} (Boric acid 0.50%) which was significantly superior to all other treatments and was followed by treatment T_{12} and T_7 with 8.74 and 8.23 per cent increase in trunk girth and T_1, T_2, T_3, T_{10}, T_{16} and T_{17} were statistically at par with each other. The minimum increase in trunk girth (2.70%) was observed in treatment T_{19} (control).

The results further revealed that the mean value of all the concentration of Boric acid had the highest increase in trunk girth (8.64 %), which was 3.20 times more than the control and was followed by $ZnSO_4$ (7.10 %), 1.28 times more than the combination of $ZnSO_4$ and Boric acid, 1.37 times more than the combined application of GA_3 and CPPU and 1.62 times more than GA_3.

Tree volume :

The increase intree volume varied from 11.62 to 19.30 per cent. The maximum increase in tree volume (19.30%) was recorded in treatment T_{18}(Boric acid 0.75% + $ZnSO_4$ 0.50%) and was significantly superior to all other treatments and was followed by treatment T_{17} (18.88%) which was statistically at par with T_{10} (18.51%), T_{13} (18.84%) and T_{16} (18.54%), whereas T_1, T_2, T_7, T_9, T_{11}, T_{12} and T_{15} recorded statistically similar increase in tree volume over control. The minimum increase in tree volume (11.62%) was observed in treatment T_{19} (control).

The results further showed that the mean value of all the concentration of Boric acid and $ZnSO_4$ used had the highest increase in tree volume which was 1.6 times more than the control, 1.05 times more than the $ZnSO_4$ and 1.04 times than the combined application of GA_3 and CPPU and boric acid.

Tree height :

The observations on tree height ranged from 4.10 to 6.80 per cent. The maximum increase in tree height (6.80%) was observed in treatment T_{18} (boric acid 0.75% + $ZnSO_4$ 0.25%) which was significantly higher to all other treatments and was followed bytreatment T_5 (6.50%) and T_{16} (6.40%), while T_3, T_4, T_6, T_7, T_8, T_{10}, T_{11}, T_{12}, T_{14}, T_{15} and T_{16} recorded higher increase in tree height than control which was statistically similar to each other. The minimum increase in tree height (4.10%) was observed in treatment T_{19} (Control).

Further the mean value of all the concentrations of boric acid and $ZnSO_4$ had the highest increase in tree height(6.13), which registered 1.49 times more increase than the control, 1.17 times more than GA_3, 1.23 times more than CPPU, 1.26 times more than $ZnSO_4$ and 1.30 and 1.42 times more than the combined application of GA_3 + CPPU and boric acid, respectively.

The growth regulators and micronutrients significantly increased annual shoot growth, tree volume and tree height of litchi cv. CALCUTTIA. The maximum annual shoot growth, tree volume and tree heightwere recorded with T_{18}(Boric acid 0.75% + Zinc sulphate 0.50%) (Table 1). The increase in annual shoot growth, tree volume and tree height with the application of boric acid and zinc sulphate together, may be due to rapid development and differentiation of tissues caused by boron application, as well as, synthesis of auxins favoured by zinc application, which caused increase in annual shoot growth, tree volume and tree height.

Meena (2010) reported that the increase in vegetative growth of tomato which could be attributed tophysiological role of boron and its involvement in the metabolism of protein, synthesis of pectin, maintaining the correct water relation within the plant, re-synthesis of adenosine triphosphate (ATP) and translocation of sugar at development of the flowering and fruiting stages. Boron and zinc sprays being highly helpful in the process of photosynthesis which laid to accumulation of carbohydrate which ultimately improved the fruits quality in fact zinc works as a stimulant for amino acid synthesis and helps in the process of photosynthesis(Singh *et al.* 2012).

Furthermore, boron is known to play an important role for the structure of cell wall membranes and its integrity and function in plants(Brown *et al*., 2002). Its role in activating both cell division and elongation in the meristematic tissues as well as the biosynthesis of organic assymelates could explain its positive action on increasing leaf area (Ahmed and Morsy, 2001). It is also known to stimulate carbohydrate, RNA and hormonal metabolism, as well as the rapid mobilization of water and sugars in the fruit tissues (Kato *et al.*, 2009).

Never the less, zinc is an important micronutrient associated especially with several enzymatic activities and growth regulators biosynthesis in all photosynthetic plants (Ved *et al*., 2002). It is considered a functional, structural or regulatory factor of a large number of enzymes (Bowler *et al*., 1994). It has been identified as component of almost 60 enzymesand it has a role in synthesis of growth promoting hormone (auxin), which would be directly associated with inducing pollen tube growth (Chaplin and Westwood, 1980), delaying the formation of abscission layer during early stages of fruit development and thus enhancing fruit set and retention (Yadav *et al.*, 2013).Zinc is involved in chlorophyll formation which might have favoured cell division, meristematicgrowth in apical tissue, enlargement of cell and synthesis of new cell wall (Singh *et al.*, 1989).

Table 1 : Effect of growth regulators and micronutrients spray on vegetative growth of litchi

Treatments		Annual shoot growth (cm)	Increase in trunk girth (%)	Increase in tree volume (%)	Increase in tree height (%)
T_1	GA_3 (25 ppm)	17.80	7.32 (2.87)	17.10(4.25)	5.50(2.54)
T_2	GA_3 (50 ppm)	17.10	7.61 (2.93)	17.30 (4.27)	5.50(2.54)
T_3	GA_3 (75 ppm)	18.50	7.00 (2.82)	18.26 (4.35)	4.60(2.36)
T_4	CPPU (5 ppm)	18.20	2.75 (1.93)	13.49 (3.80)	4.22(2.28)
T_5	CPPU (10 ppm)	17.80	4.20 (2.27)	13.26 (3.77)	6.50(2.73)
T_6	CPPU (15 ppm)	17.82	2.95 (1.98)	13.02 (3.74)	4.21(2.28)
T_7	$ZnSO_4$ (0.25 %)	19.90	8.23 (3.03)	17.95 (4.35)	4.40(2.32)
T_8	$ZnSO_4$ (0.50 %)	19.20	6.63 (2.74)	18.17 (4.37)	4.40(2.32)
T_9	$ZnSO_4$ (0.75 %)	19.21	6.45 (2.72)	17.76 (4.33)	5.80(2.60)
T_{10}	Boric acid (0.25 %)	18.60	7.57 (2.91)	18.51 (4.41)	4.20(2.28)
T_{11}	Boric acid (0.50 %)	19.53	9.62 (3.23)	17.94 (4.35)	4.40(2.32)
T_{12}	Boric acid (0.75 %)	19.60	8.74 (3.11)	17.79 (4.33)	4.30(2.29)
T_{13}	GA_3 (25 ppm) + CPPU (5ppm)	19.90	6.51 (2.74)	18.84 (4.45)	5.20(2.49)
T_{14}	GA_3 (50 ppm) + CPPU (5 ppm)	18.60	6.21 (2.68)	18.27 (4.38)	4.70(2.38)
T_{15}	GA_3 (75 ppm) + CPPU (5 ppm)	18.80	6.18 (2.67)	17.31 (4.22)	4.20(2.28)
T_{16}	Boric acid (0.25 %) + $ZnSO_4$ (0.50 %)	19.70	7.30 (2.88)	18.54 (4.41)	6.40(2.72)
T_{17}	Boric acid (0.50 %) + $ZnSO_4$ (0.50 %)	20.30	7.17 (2.84)	18.88 (4.45)	5.20(2.48)
T_{18}	Boric acid (0.75 %) + $ZnSO_4$ (0.50 %)	20.40	5.62 (2.55)	19.30 (4.50)	6.80(2.79)
T_{19}	Control (Water spray)	16.50	2.70 (1.89)	11.62 (3.55)	4.10(2.25)
C.D. (P=0.05)		1.62	0.41	0.45	0.12

The increase in vegetative growth due to application of boric acid and zinc sulphate are in agreement with the work of Awasthi *et al.* (1975) and Hoda and Syamal (1975) on litchi, who reported increase in plant vigour with application of boron and zinc. These findings are also in congruence with work of Sharma (2001)on apple, Khan *et al.* (2012) on citrus, Meena *et al.* (2014) on Aonla and Prakash *et al.* (2017) on Capegoose berry.

In present study, the increase in vegetative growth was also recorded with the application of GA_3 + CPPU. These findings are supported by the work of Chen (1990) on litchi, who reported an increase in shoot growth with gibberellins. CPPU is a cytokinin like substance which has strong cytokinin activity and plays an important role on cell division and cell elongation as reported by Nickell (1985). The increase in vegetative growth in present work may be due to cell division and elongation caused by cytokinin.

The findings of present study are also supported by the studies done by Biasi *et al.* (1992) in kiwifruit, Kender and Carpenter (1972), Forshey (1982), Ono *et al.* (2002), Samia (2014) on apple and Elgendy *et al.* (2012) on grapes.

Maximum increase in trunk girth was recorded with T_{11} (Boric acid 0.50%)and appreciable increase byT_7 (zinc sulphate 0.25%),whereas,minimum trunk girth was recorded in T_{19} (Control). The findings of present investigation are in accordance with the results of Babu and Singh (2002), who reported increase in plant growth and vigour of litchi with application of boric acid (0.3%) and zinc (0.6%). The increase in trunk girth with the application of boric acid may be due to the reason that foliar application of boron has been reported to reduce biomass production in various crops (Yermiyahu *et al.*, 2007).

Authors' affiliations :

VIKRAMADITYA PRIYADARSHI, K. MEHTA AND GOPA MISHRA, Department of Fruit Science, Dr. Y.S. Paramar University of Horticulture and Forestry, Nauni, SOLAN (H.P.) INDIA

ABHIJIT JOGUR, Department of Nemotology, Dr. Y.S. Paramar University of Horticulture and Forestry, Nauni, SOLAN (H.P.) INDIA

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