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Effect of forchlorfenuron and N-acetyl thiazolidine 4-carboxylic acid on vegetative growth and fruit set of apricot (*Prunus armeniaca* L.) cv. New Castle

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Abstract
Being the third important stone fruit crops of India, apricot still requires a great improvisation in production point of view. Bio-regulators are being used by the growers to increase the yield by improving the yield attribute parameters. Keeping the objective to increase the yield, in the recent studies; twenty six-year-old apricot cv. New Castle trees were subjected to 11 treatments viz. Forchlorfenuron (CPPU) at 5 and 10 ppm and N-acetyl thiazolidine 4-carboxylic acid (NATCA) at 50 and 100 ppm and their combinations were applied at pink bud and petal fall stage during the year 2015 and 2016. Out of the two time of spray the petal fall stage was found to be superior in both the years. Foliar spray of CPPU at 10 ppm increased the vegetative character like tree height (17.40 %), tree spread (22.17 %), tree volume (27.82 %) over control. However an increase the fruit set (52.71%) and fruit retention (38.12%) was noticed by NATCA (100 ppm) at petal fall stage. Keeping all the observations in consideration CPPU 10 ppm at petal fall stage was found to be best among all the treatments.

Keywords: Forchlorfenuron (CPPU), N-acetyl thiazolidine 4-carboxylic acid (NATCA), Foliar Spray, Petal Fall stage

1. Introduction
Being the third important stone fruit crop next after peach and plum, in respect to area and production; apricot (*Prunus armeniaca* L.) still require an attention towards its increasing yield by decreasing the fruit drop and increasing the fruit size. In Himachal Pradesh, apricot is being cultivated at an elevation of 900 m to 2000 m above mean sea level over an area of 3660 ha with an annual production of 4704 MT in 2014-15 (Anonymous, 2015) [1]. Leading growing districts are Solan, Shimla, Sirmour, Chamba, Kullu, Mandi, and Kinnaur.

A low-moderate chilling New Castle is the most commercial cultivar of apricot in the mid-hills of Himachal Pradesh. This cultivar ripens towards the third week of May when no other fruit is available and hence fetches higher prices in the market. However, with the advancement of age, its fruit size and quality decreases which has less demand in market. Many of the commercially available plant growth regulators are used in stone fruit production which enhance fruit size and quality and delay the storage disorder (Lurie, 2010) [9]. It is obvious that changes in the level of endogenous hormones due to biotic and abiotic stress alter the crop growth and any sort of manipulation including exogenous application of growth substances would help for yield improvement. Plant growth regulators provide effective means for the improvement of productivity as a result of direct influence on the qualitative as well as quantitative aspects of fruit growth (Zahoor *et al*., 2011) [19].

Forchlorfenuron, a synthetic cytokinin with strong growth regulation activities has been found very effective in enhancing fruit growth by stimulating cell division and cell elongation. It has been found highly effective in increasing fruit size in some fruit crops (Cruz-Castillo *et al*., 2002) [4]. Besides, it also modifies other fruit characteristics such as shape, dry matter content, carbohydrate metabolism and ripening process. Its treatment could also increase firmness of individual fruit, reducing TSS content and TSS /acid ratio of fruit, as well as, promote starch degradation but had no effect on titratable acid content (Nevine *et al.*, 2016) [14].

Elanta Super is an organic growth promoter which contains N Acetyl Thiazolidine 4-Carboxylic Acid (NATCA), 10% Folic acid with 0.2% adjuvant, used for plant growth increase in both fruit & production quality. It is a derivative of organic amino acid, which helps to develop fruits to its optimum level of size, shape, quality and taste. It is also useful for fruit setting, enhances quality, size, colour as well as taste and keeping quality of fruits. It is also a stabilizer buffer, to tolerate certain types of stresses more effectively (Berg, 1986). This study aimed to throw some light of the prospective on the use of CPPU and NATCA singly or in combinations to promote the yield quantitatively and qualitatively in New Castle Apricot.

2. Materials and Methods

The present investigations was carried out in the 26 years old apricot cv. New Castle planted in a spacing of 3×3 meter at experimental orchard of the Department of Fruit Science, Dr. Y.S. Parmar University of Horticulture and Forestry during the years 2015 and 2016. For the experiment, thirty trees were selected on the basis of uniform vigour and were maintained under uniform cultural practices during the entire course of investigation. The two bio-regulators i.e. CPPU (5 and 10 ppm), NATCA (50 and 100 ppm) and their combinations CPPU + NATCA (5 + 50 ppm) are applied at two different stage i.e. pink bud and petal fall stage, while the untreated plant remain the control (Table 1).

Eleven treatment with three replication was setup with Randomized Block Design (RBD). For each treatment, 10 litres of spray solution was made. In order to decrease the surface tension of the droplets and facilitate absorption, a few drops of Teepol were added to the solution prior to spray.

Table 1: Description of application of forchlorfenuron (CPPU) and N-acetyl thiazolidine 4-carboxylic acid

Treatments	Chemicals	Concentration (ppm)	Time of application
T_1	CPPU	5	Pink bud
T_2	CPPU	10	Pink bud
T_3	CPPU	5	Petal fall
T_4	CPPU	10	Petal fall
T_5	N-ATCA	50	Pink bud
T_6	N-ATCA	100	Pink bud
T_7	N-ATCA	50	Petal fall
T_8	N-ATCA	100	Petal fall
T_9	CPPU + N-ATCA	5 + 50	Pink bud
T_{10}	CPPU + N-ATCA	5 + 50	Petal fall
T_{11}	CONTROL		

The spray solutions of different plant growth regulators were applied on the trees with the help of foot sprayer to wet the developing buds and flower completely without causing runoff at morning hours without obstruction of wind drift.

The tree height and spread (East-West and North-South) was measured in meter (m) once before the start of the growing season and again at the end of growing season in each year with the help of graduated flag staff at the point where the canopy spread was the maximum. The increase in height, spread and volume was calculated and expressed in percentage. Tree volume was calculated as

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)

Fruit set was determined as per the procedure suggested by Westwood (1978). Four fruiting arms of equal length were selected and marked on each tree in all possible directions. The number of flowers on these fruiting arms was counted and after 10 days of full bloom, the number of fruits was also counted. The per cent fruit set was calculated as per formula given below:

$$\text{Fruit set (\%)} = \frac{\text{Total number of fruits set on fruiting arm}}{\text{Total number of flower on fruiting arm}} \times 100$$

Total number of fruits retained on the marked branches was counted at the time of harvest and the percentage of fruit retention was calculated as:

$$\text{Fruit retention (\%)} = \frac{\text{Total number of fruit retained on fruiting arm}}{\text{Total number of fruit set on fruiting arm}} \times 100$$

The data generated from these investigations were appropriately computed, tabulated and analyzed as described by Gomez and Gomez (1983) using MS-Excel, OPSTAT, SPAR1.0 and SPSS 16.0 by applying Randomized Block Design (RBD). The level of significance was tested for different variables at 5 per cent level of significance.

3. Results and Discussion

Vegetative growth

The data pertaining to the effect of forchlorfenuron and N-acetyl thiazolidine 4-carboxylic acid on tree height, tree spread and tree volume of apricot cv. New Castle are presented in Table 2.

The percent increase in tree height over the growing seasons ranged from 11.37 to 17.40 per cent under different treatments (Table 2). Maximum increase in tree height (17.40 %) was recorded under the treatment T_4 (10 ppm CPPU at petal fall), which was statistically at par with T_2 (10 ppm CPPU at pink bud), T_3 (5 ppm CPPU at petal fall) and T_{10} (5 ppm CPPU + 50 ppm NATCA at petal fall). However, the minimum increase in tree height (11.37%) was registered in control which was significantly lowest than all other treatments.

The data on per cent increase in tree spread over the growing seasons given in Table 2 reveal that different treatments exerted significant influence on tree spread. The maximum increase in tree spread (22.17 %) was recorded in the treatment T_4 (10 ppm CPPU at petal fall), which was however, statistically at par with the treatment T_3 (5 ppm CPPU at petal fall) and T_{10} (5 ppm CPPU + 50 ppm NATCA at petal fall) but significantly higher than the remaining treatments. The minimum increase in tree spread (12.27 %) was observed in control which was significantly lowest than all other treatments.

The percent increase in tree volume over the growing seasons varied from 17.92 to 27.82 per cent. The maximum increase (27.82 %) in tree volume was observed in the treatment T_4 (10 ppm CPPU at petal fall) which was statistically similar with T_3 (5 ppm CPPU at petal fall) and T_{10} (5 ppm CPPU + 50 ppm NATCA at petal fall). The minimum increase in tree volume (17.92 %) was registered in control. In the present investigation, the increase in the tree height and tree spread leads to the increase in the tree volume.

The increase in different tree growth attributes with CPPU treatment might be due to its cytokinin like action which leads to rapid cell division and cell elongation (Thomas and Katterman, 1986) [18]. The CPPU is a strong cytokinin which having role to retard the apical dominance and increase there by cause to lateral shoot growth. Another reason for stimulation of growth may be related to an increase in RNA and DNA content, polymerase activity, and protein synthesis (Nickell, 1985) [15]. Fathi *et al.* (2011) [5] also observed similar increase in vegetative growth of Costata persimmon following the application of CPPU. An increase in the shoot growth was also observed by the application of 5 ppm CPPU in pear cv. Gola (Nimbolkar *et al*., 2016). Thakur (2014) [17] also found similar result in respect to increase in annual shoot growth, tree height, tree spread, tree volume and trunk girth by applying 10 ppm CPPU at petal fall stage in apricot cv. New Castle.

Fruit set and Fruit retention

The application of different bio-regulators exerted significant influence on different fruiting parameters (Table 2).

Significantly higher fruit set (52.71%) was observed in T_8 (100 ppm NATCA), in which was statistically at par with T_4 (10 ppm CPPU at petal fall), T_7 (50 ppm NATCA at petal fall) and T_{10} (5 ppm CPPU + 50 ppm NATCA at petal fall). The lowest fruit set (39.26%).was observed in control.

A similar trend was also observed in fruit retention. The highest fruit retention (38.12%) was observed in the tree receiving 100 ppm NATCA at petal fall stage (T_8) which was statistically at par with T_4 (10 ppm CPPU at petal fall), T_7 (50 ppm NATCA at petal fall) and T_{10} (5 ppm CPPU + 50 ppm NATCA at petal fall). The lowest fruit retention (25.25%) was observed in control.

Exogenous amino acids are absorbed by the leaves, promoting chelation and transport of mineral nutrients, increasing levels of proline and hydroxyproline, (which in turn may augment tolerance to biotic and abiotic stress), stimulating enzymatic systems (such as those of nitrate reductase, malate dehydrogenase, phosphorylase, phosphatase and peptidase), enhancing flower and fruit set, increasing chlorophyll concentration and photosynthetic output. As a result, application of amino acid bio-stimulants has been associated with accelerated biomass accumulation and/or increased fruit yield in several crops (Maini, 2006) [10]. Basak and Bielicki (2010) [2] found that the effects of LG 221 (vegetable extract rich in amino acids) reduce russeting and increase fruit set in trees damaged by late frost in apple cv. Jonagold Decosta, Golden Delicious and Gala Must. Increased fruit set has been reported by various researchers when amino acids were applied on Mango (Mangifera indica) (Morales-payan, 2015) [13], Tahiti lime (Citrus latifolia) (Flores-Torres, 2013) [6], pear (Pyrus communis), apple (Malus domestica) (Maini, 2006) [10], papaya (*Carica papaya*) (Morales-Payan and Stall, 2003) [5], kiwi (Actinida deliciosa) (Mancilla, 2000) [11], and watermelon (Citrullus lanatus) (Fuentes-Fuster, 2012) [7].

Table 2: Effect of forchlorfenuron and N-acetyl thiazolidine 4-carboxylic acid on tree height, tree spread, tree volume, fruit set and fruit retention of apricot cv. New Castle

Treatments	Tree height (%)	Tree spread (%)	Tree volume (%)	Fruit set (%)	Fruit retention (%)
T_1 -CPPU (5 ppm)	13.98(3.87)	17.13(4.25)	20.02(4.58)	41.46(6.52)	28.43(5.42)
T_2 -CPPU (10 ppm)	15.73(4.09)	18.27(4.39)	21.69(4.76)	42.31(6.58)	28.59(5.44)
T_3 -CPPU (5 ppm)	16.27(4.15)	21.33(4.72)	26.57(5.25)	48.42(7.03)	32.46(5.87)
T_4 -CPPU (10 ppm)	17.40(4.28)	22.17(4.81)	27.82(5.36)	51.24(7.22)	37.17(6.17)
T_5 -NATCA (50 ppm)	13.13(3.76)	17.03(4.25)	19.95(4.58)	43.00(6.63)	29.67(5.54)
T_6 -NATCA (100 ppm)	13.70(3.83)	17.93(4.35)	20.68(4.65)	45.61(6.83)	31.52(5.70)
T_7 -NATCA (50 ppm)	14.80(3.97)	18.30(4.39)	21.45(4.74)	51.12(7.22)	37.30(6.19)
T_8 -NATCA (100 ppm)	15.07(4.01)	19.80(4.56)	23.32(4.93)	52.71(7.32)	38.12(6.25)
T_9 -CPPU+NATCA (5+50 ppm)	13.43(3.80)	19.00(4.47)	21.60(4.75)	46.85(6.92)	33.38(5.86)
T_{10} -CPPU+NATCA (5+50 ppm)	15.97(4.12)	21.63(4.75)	26.53(5.24)	52.03(7.21)	37.28(6.18)
T_{11} -Control	11.37(3.51)	12.27(3.64)	17.92(4.35)	39.26(6.34)	25.25(5.12)
$CD_{0.05}$	0.19	0.22	0.14	0.11	0.10

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