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Effects of Bioregulator, Summer and Winter Pruning and Nutrient Spray on Fruit Grade and Yield of Kiwi Fruit

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ABSTRACT: Sitofix or CPPU (N-(2-chloro-4-pyridyl)-N-phenylurea) greatly stimulated fruit growth indicating that it could be a powerful tool for improving kiwi fruit yield. CPPU at 10ppm were applied at ten (10) days after anthesis to fruits by dipping them for about 10 seconds in aqueous solution of the compound. Sitofix applied fruits increased size by 30-75 g over the control. A higher proportion of the crop was in the large size grade and there was no loss of response as the crop load on the vine increased. CPPU produced a darker skin colour and some changes in appearance increased fruit size, advanced ripening by one week, reduced flesh firmness, increased soluble solids and decreased titrable acidity. Fruit yield also increased by the application of foliar nutrient spray. Average fruit weight has been further increased by light summer pruning (1/5th of new growth) in fruiting branches and 1/3rd pruning in non-fruiting branches at monthly intervals till harvest. Maximum A-graded fruit (above 75 gm in wt.) recorded in nutrient spray, summer pruning and CPPU application alone or in combination in addition to winter pruning (during dormancy) at six node level.

***Key words**: Kiwifruit, Summer Pruning, Bio-regulator, Nutrient, Quality, Allison, size, Grade, maturity, firmness, Yield*

INTRODUCTION

Kiwifruit (*Actinidia deliciosa* Chev.) is the most suitable diversified crop among the temperate fruit crops in India and has emerged as an alternate crop after apple in temperate fruit production due to climate change. In India, kiwi can be successfully grown at an elevation of 800-1500m above mean sea level. This fruit holds a great promise for commercial cultivation due to its biochemical properties particularly to fight against Dengue disease, suitable for diabetic patients and better keeping quality. Among the different cultivars, Allison has been recommended for commercial cultivation in mid to lower hills of India because of its prolific bearing and high productivity. However, this cultivar has a tendency to overbear, which leads to production of smaller and poor quality fruits. Profitable kiwifruit production depends upon the yield of good size fruits. The fruit size in kiwifruit can be manipulated either by thinning of fruits or directly by promoting fruit growth with the exogenous application of bio- regulators. In fruit crops, various growth promoting auxin, gibberellins and cytokinin have been found effective in improving fruit size and quality. A synthetic cytokinin, i.e. CPPU (N-(2 chloro-4-pyridyl)-N phenyl urea, has been found very effective in stimulating fruit growth in kiwifruit **(Antognozzi *et al.*, 1997)**. Therefore, an attempt was made to study the effectiveness of bio- regulator CPPU in combination with nutrient spray, summer pruning ,nutrient spray in addition to winter pruning (during dormancy) at six node level on fruiting, yield and quality of kiwifruit cv. Allison. Influence of canopy structure on fruit size development will also have to be taken in order to tackle the problem with a holistic approach. At present the percentage of A-Grade fruits is less than 5% severely affecting the marketability of the produce. Keeping this in view, an attempt was undertaken to increase the size and weight of the fruit in cv. Allison to make maximum A-Grade fruit so that it can compete with imported Kiwi fruit and get maximum price of the produce. It has shown tremendous potential in the recent years and has been assessed as a nodal fruit for diversification of mid hill horticulture, which has wider scope in domestic as well as international markets. The biggest bottleneck in the popularization of kiwifruit is the lack of awareness about its production technology. Manipulation of crop through pruning (both winter

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and summer) and use of bio-regulator especially, sitofix and nutrient supplementation has recently been followed on commercial scale in major kiwifruit growing countries of the world. Therefore, we have to devise ways and means to improve its production technology. The improvement in quality and production of the fruit will enhance the scope of export. As a result, the farmers will get good returns which will encourage them to expand the area under this fruit. Manipulation of crop through pruning (both winter and summer) and use of bio-regulators especially, CPPU has recently been followed on commercial scale in major kiwifruit growing countries of the world. Therefore, we have to devise ways and means to improve its production technology. The improvement in quality and production of the fruit will enhance the scope of export. As a result, the farmers will get good returns which will encourage them to expand the area under this fruit.

MATERIALS AND METHODS

The experiments were conducted on 12–year-old kiwifruit vines of cv. Allison planted at a spacing of 4 m x 4 m and trained on cross- bar trellis at the experiment Farm of IARI Regional Station, Shimla, H.P.,INDIA. The vines were maintained under uniform cultural practices during the course of studies. Seventy two kiwi fruit plants were selected for layout of summer pruning treatment, nutrient spray and application of bio-regulator i.e. CPPU. Winter pruning was done by heading back of shoots at six nodes level during dormancy. During the summer, the shoots were pruned back to $1/5^{th}$ of new growth in fruiting branches and $1/3^{rd}$ of new growth in non-fruiting branches at monthly intervals till harvest. Foliar NPK nutrient (15:15:15) spray was conducted from June (One month after fruit set) to September (one month before harvest). CPPU at 10ppm were applied to fruits by dipping them for about 10 seconds in aqueous solution of the compound at petal fall stage.

Experiments on bio-regulator (Sitofix), Summer Pruning, Nutrient Spray and in combination with bio-regulator, summer pruning and nutrient spray treatments were laid out in a simple Randomized Block Design. Each treatment was replicated three times having three vines under each replication. Growth regulator was dipped at 10 days after anthesis (petal fall stage) but summer pruning and nutrient spray started one month after fruit setting and continued till one month before harvest by applying maturity indices. In control vines, no treatment was done except winter pruning at six nodes level during dormancy.

After harvest, total yield and yield of different grades fruit were determined on the basis of total weight of different grades (A grade > 70g, B grade 50-70 g, C grade < 50g) fruits harvested from the vine under each treatment. The size of fruit was measured in terms of length and diameter with the help of Vernier calipers and fruit weight was taken on a top pan balance. TSS (^{o} brix) by digital refractometer and acidity and total sugars were recorded with the standard procedures of **A.O.A.C. (1990).** The data recorded were statistical analyzed in accordance with the method design by **Gomez and Gomez (1984).** The following treatments were applied:

1. Summer Pruning (T-1)
2. Nutrient (15 : 15 : 15) Spray (T-2)
3. 10 ppm CPPU dipping (T-3)
4. Summer Pruning + Nutrient spray (T-4)
5. 10 ppm CPPU dipping + Summer pruning (T-5)
6. 10 ppm CPPU dipping + Nutrient Spray (T-6)
7. 10 ppm CPPU dipping, Summer Pruning and Nutrient (15 : 15 : 15) spray (T-7)
8. Control (T-8)

RESULTS

Significant variation in total fruit yield and yield of different grades fruit was observed in vines subjected to different treatments (Table 1). The treatments alone had significant effect on total yield, however, in combination with all they exhibited more significant effect on total fruit yield. The highest yield of 95 kg/ vine was obtained in treatment T-7, which was followed by T-6 (92 kg/vine) and T-5(90 kg/vine) treatment. These treatments were statistically at par with each other but significantly superior to all other treatments in respect of total fruit yield. The lowest yield of 64 kg/ vine was obtained from control plant. The proportion of grade 'A' fruits in the total yield also increased by combination treatments. The maximum 35kg 'A' grade fruits was obtained in treatment T-7, which also produced minimum 6 kg of 'C' grade fruits. The minimum proportion of 'A' grade fruits 7kg/vine and maximum 'C' grades fruits 29kg/ vine was harvested from control vines.

The data regarding fruit size in terms of length and breadth are presented in Table 1. The maximum fruit length (6.69 cm) and breadth (4.94 cm) was recorded in T-7 treatment, followed by T-6 (6.68 cm

Table 1
Influence of bio-regulator, summer pruning and nutrient spray on yield, fruit size and fruit quality of kiwifruit cv. Allison

Treatments	Yield (Kg/ vine)	Yield of different grades fruits (Kg/vine) A	B	C	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	TSS (^{0}brix)	Acidity (%)	Total sugars (%)	Fruit Firmness (kg pressure)	Days taken from flowering to maturity	Per cent increase in "A Grade" fruit over control	Per cent increase in yield over control
Summer Pruning (T-1)	76	13	48	15	6.45	4.24	70	16.85	0.98	8.9	10.97	172	91.0	48.64
Nutrient (15 : 15 : 15) Spray (T-2)	78	11	48	19	6.54	4.25	76	16.97	0.89	9.1	10.95	176	77.0	49.92
10 ppm CPPU dipping (T-3)	85	25	47	13	6.58	4.59	88	18.19	0.77	9.8	9.87	167	175.0	54.40
Summer Pruning + Nutrient spray (T-4)	81	15	48	18	6.56	4.31	79	17.06	0.87	9.3	10.98	174	105.0	51.84
10 ppm CPPU dipping + Summer pruning (T-5)	90	31	51	8	6.61	4.63	89	18.38	0.76	9.7	9.89	168	217.0	57.60
10 ppm CPPU dipping + Nutrient Spray (T-6)	92	32	52	8	6.68	4.75	91	18.43	0.75	9.9	9.93	169	224.0	58.88
10 ppm CPPU dipping, Summer Pruning and Nutrient (15 : 15 : 15) spray (T-7)	95	35	54	6	6.69	4.94	93	18.57	0.74	10.1	9.97	171	245.0	60.80
Control (T-8)	64	7		28	29	6.01	4.04	60	16.65	1.34	8.5	11.01	175	–
CD $_{(0.05)}$	7.5	2.8		3.7	5.9	0.09	0.30	4.8	0.8	0.17	0.7	1.19	3.2	–

and 4.75 cm, respectively) treatment. The minimum fruit length (6.01cm) and breadth (4.04cm) was found in untreated control, which was significantly lower as compared to all other treatments. The average fruit weight was increased by T-7 treatment. The maximum fruit weight of 93 g was recorded in combination treatment (T-7), which was although statistically at par with T-5 and T-6 treatments but significantly higher than other treatments. However, the minimum fruit weight of 60 g was recorded in control vines.

The data pertaining to effect of different treatments on fruit quality parameters are also given in Table 1. Total soluble solids, fruit acidity and total sugars was significantly affected by combination treatment (T-7). The highest TSS (18.57^o Brix) was observed in T-7 treatment and the minimum TSS (16.65^o Brix) was recorded in control. All the treatments significantly reduced fruit acidity. The minimum fruit acidity (0.74%) was recorded in T-7 treatment. All the treatments significantly increased the total sugars as compared to control. The maximum total sugars (10.01%) was recorded in T-7 treatment and the minimum total sugars (8.5%) in untreated fruits. CPPU treated fruits produced a darker skin colour and some changes in appearance increased fruit size, advanced ripening by one week, reduced flesh firmness, increased soluble solids and decreased titrable acidity (Table-1).

Significant variation in fruit yield and yield of different grades fruit was observed in vines subjected to different treatments, however more pronounced effect was noted with the application of CPPU. The highest yield (95 kg/vine)was recorded in T-7 treatment and registered 60.80% increase in yield over control. Application of 10 ppm CPPU alone or in combination with other treatments also significantly increased total yield as compared to untreated control. Similarly, the highest yield of 'A' and 'B' grades fruit was obtained in T-7 treatment (Table 1), which gave lowest yield of 'C' grade fruits. . The effect of summer pruning and nutrient spray alone on the yield of 'A' and 'B' grade fruits was not found so pronounced as that of CPPU but it produced significantly more yield of 'A' and 'B' grades fruit as compared to untreated control.

Fruit size and weight was also recorded significantly higher in CPPU, summer pruning and nutrient spray treatments alone or in combination in comparison to control. The fruits dipped in 10 ppm CPPU with other treatments registered highest TSS, total sugars and lowest acid content (Table 1). Like wise fruits harvested from the plants treated with summer pruning and nutrient spray showed significantly more TSS and sugars content and less acidity than control. Results of economic yield have projected 10 ppm CPPU as the most beneficial

treatment alone or in combination, followed by T-4 treatment. These treatments resulted in maximum production of 'A' grade fruits with better size, quality and accounted for the higher increase in net benefits over control.

DISCUSSION

Total yield, yield of different grades fruits, fruit size and weight was significantly increased by CPPU dipping, summer pruning and nutrient spray treatment (T-7) . CPPU dipping, summer pruning and nutrient spray treatment in combination resulted in highest fruit yield and production of better size fruits. The plant achieved 60.80 per cent increase in yield over control. Total yield, yield of different grades fruits, fruit size and weight was significantly increased by the application of cytokinin based growth regulator (CPPU) in combination with light summer pruning. These results are in agreement with those of **Galliano *et al.* (1990) and Inglese and Gullo (1992)**, who found the summer pruning significantly increased production of A grade fruits and better size fruits**.** Fruit size of kiwifruit is greatly influenced by source-sink relationship as reported by **Boyd and Barnett (2011).** These results are in also agreement with those of Thakur (2000), who found the hand thinning significantly increased production of A grade fruits and better size fruits. **Famiani *et al*. (1999)** also reported that bioregulator significantly increased fruit length and diameter and decreased fruit L/D ratio in kiwifruit. According to **Mok *et al*. (1987)** thidiazuron stimulate endogenous adenine type cytokinin biosynthesis or alter endogenous cytokinins metabolism, resulting in increased level of natural cytokinins and increased cell division, which could result in increased fruit size.. The increased yield in kiwifruit, in the present investigation may be due to larger fruit size and weight induced by CPPU, summer pruning and nutrient spray. The proportion of grade 'A' fruit was increased. The maximum grade 'A' fruit (35kg) was recorded in CPPU dipping, summer pruning and nutrient spray in combination treatment. The increase in proportion of grade 'A' fruits and fruit size and weight in this treatment may be attributed to cell division and cell enlargement of fruits on the tree and optimum leaf to fruit ratio, supplement nutrition which causes reduction in competition among the fruits for water and nutrients thereby resulting in production of bigger size fruits. . Kiwi vines treated with Benefit ® kiwi have been shown to have a 26.4g fruit weight increase compared to untreated vines as suggested by **Brown and Woolley (2010)**.Similarly **Woolley and Cruzcastillo (2006)** reported 16.9g weight increase of an *Actinidia chinensis* selection. The proportion of grade 'A' fruit was increased. **Vasilakakis *et al*. (1997),** found that small size fruits in kiwifruit cv. Hayward were mainly due to overloading of vines. CPPU may be attributed to its effects in promoting larger fruit growth by increased cell division as a cytokinin like substance. **Greene (1995)** in apple**, and Famiani *et al*. (1999)** in kiwifruit have also obtained larger and heavier fruits following bioregulato treatments.

All treatments of CPPU dipping, summer pruning and nutrient spray increased TSS , total sugars and decreased per cent acidity. The higher TSS content might be attributed to higher rate of assimilation of photosynthates, as cytokinins are known to influence mobilization of metabolites and nutrients to the cytokinin treated portion of plants **(Leopold and Kriedemann, 1975). Famiani *et al*. (1999)** also reported an increase in total soluble solids and reduction in acidity with the application of thidiazuron in kiwifruit. The highest net return from combination treatment(T-7) may be due to more production of A and B grade fruits, which have better market price. **Woolley and Cruz-Castillo (2006)** reported evidence that CPPU interacts positively with naturally occurring cytokinins in stimulating kiwi fruit growth.

Significant variation in fruit yield and yield of different grades fruit was observed in vines subjected to different treatments of CPPU dipping, summer pruning and nutrient spray treatment, however more pronounced effect was noted with the application of CPPU. The highest yield and yield of 'A' and 'B' grades fruit was obtained in 10 ppm CPPU dipping treatment alone and in combination, which gave lowest yield of 'C' grade fruits. Summer pruning treatments alone had significant effect on graded fruit (**Inglese *and Gullo*,1992**), however, in combination with bio-regulator they exhibited significant effect on total fruit yield as well as graded fruit, increased TSS , total sugars and decreased per cent acidity as reported by **Gerasopoulos and Drogoudi ,2005** which indicated summer-pruning increased fruit SSC (Soluble Solids Content).The higher TSS content might be attributed to higher rate of assimilation of photosynthates, as cytokinins are known to influence mobilization of metabolites and nutrients to the cytokinin treated portion of plants **(Leopold and Kriedemann, 1975).** The increase in total yield of 'A' and 'B' grades fruit with the application at 10 ppm CPPU alone or in combination was mainly attributed to the increase in fruit size (Table 1), which incurred due to direct effect

of CPPU on cell division and enlargement **(Antognozzi *et al*,. 1993).** Similarly, **Costa *et.al*. (1997)** reported that CPPU enhanced yield in kiwifruit. The effect of summer pruning and nutrient spray treatment on the yield of 'A' and 'B' grade fruits was not found so pronounced as that of CPPU but it produced significantly more yield of 'A' and 'B' grades fruit as compared to untreated control. The increase in fruit size and weight with CPPU combination might be attributed to the stimulation of cell division and elongation by CPPU, which increased the number and size of small cells in the outer and inner pericarp and increased cell number in core **(Antognozzi *et al*., 1997).** However, **Patrick (1988)** was of the opinion that increase in fruit size of kiwifruit was mainly due to the direct effect of CPPU on sink strength of fruit, which further causes increase rate of assimilate transfer towards the fruits and it act as a sink. A significant increase in total soluble solids and sugar content was found in CPPU dipping, summer pruning and nutrient spray treatment. The fruits dipped in 10 ppm CPPU in combination with summer pruning and nutrient spray treatment achieved highest TSS, total sugars, and lowest acid content (Table 1). This increase in TSS and sugar content with CPPU combination treatment application may be attributed to early ripening induced by CPPU due to more ethylene evolution **(Costa *et al*., 1997)** The observation of **Biasi and Costa (1991)** also corroborate these findings, who reported that CPPU treatment increased TSS and sugar content and reduced acidity in kiwifruit. Likewise fruits harvested from the trees sprayed with nutrient solution and summer pruning showed significantly more TSS and sugars content than control. Results of economic analysis have projected 10 ppm CPPU dipping along with summer pruning and nutrient spray treatment as the most beneficial treatment, followed by CPPU plus nutrient spray. These treatments resulted in maximum production of A grade fruits with better size quality and accounted for the higher increase in net benefits over control.

The situation calls for standardizing proper pruning and training operations and /or proper application of bio-regulators. In fruit crops, various growth promoting auxin, gibberellins and cytokinin have been found effective in improving fruit size and quality. Recently, a synthetic cytokinin, i.e. CPPU (N-(2 chloro-4-pyridyl)-N phenylurea, has been found very effective in stimulating fruit growth in kiwifruit **(Antognozzi *et al.*, 1997).** The observation of **Galliano *et al.*(1990)** also suggested that total yield and fruit quality have been reduced by 'heavy' pruning performed 'early' (at fruit set) and 'late' (30 days later) and increased by 'light' pruning only if applied early at fruit set. Average fruit weight has been increased indirectly by late pruning and directly only by 'light' early pruning. In a previous study, **Boyd and Barnett (2011)** assessed the effects on fruit of kiwi cultivars, due to manipulating whole vine carbon allocation by pruning.

CONCLUSION

Although kiwifruit cultivar Allison occupies an important position in mid hills of Indian Himalayas, yet due to the problem of overbearing, fruit size and quality are adversely affected which are the important determinants of financial returns. Based on the results obtained, it is concluded that summer pruning and nutrient spray treatment along with dipping of fruits in 10 ppm CPPU two at petal fall stage improved fruit size, yield and quality and give higher returns. Sitofix or CPPU (N-(2-chloro-4-pyridyl)-N-phenylurea) greatly stimulated fruit growth indicating that it could be a powerful tool for improving kiwi fruit yield. CPPU at 10ppm were applied at ten(10) days after anthesis (petal fall stage) to fruits by dipping them for about 10 seconds in aqueous solution of the compound. Sitofix applied fruits increased size by 30-75 g over the control. A higher proportion of the crop was in the large size grade and there was no loss of response as the crop load on the vine increased. CPPU produced a darker skin colour and some changes in appearance increased fruit size, advanced ripening by one week, reduced flesh firmness, increased soluble solids and decreased titrable acidity. Fruit yield also increased by the application of foliar nutrient spray. Average fruit weight has been further increased by light summer pruning ($1/5^{th}$ of new growth) in fruiting branches and $1/3^{rd}$ pruning in non-fruiting branches at monthly intervals till harvest. Maximum A-graded fruit (above 75 gm in wt.) recorded in combination with nutrient spray, summer pruning and CPPU application in addition to winter pruning (during dormancy) at six node level.

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