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Effect of Manual Fruit Thinning and CPPU on the Fruit Yield and Changes in Physico-chemical Composition at Harvest and after Storage of Allison Kiwifruit

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Abstract

The present investigation was carried out in the Kiwifruit Block of Department of Fruit Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.) during the year 2011-12 on 27-year-old Kiwifruit cv. Allison comprising of manual fruit thinning alone and in combination with 5 ppm CPPU. This experiment included 8 treatments viz., control, 5 ppm CPPU, thinning up-to 4 fruits shoot^{-1}, thinning up-to 4 fruits shoot^{-1}+5 ppm CPPU, thinning up-to 6 fruits shoot^{-1}, thinning up-to 6 fruits shoot^{-1}+5 ppm CPPU, thinning up-to 8 fruits shoot^{-1} and thinning up-to 8 fruits shoot^{-1}+5 ppm CPPU. The CPPU (urea based cytokinin) was applied as a fruit dip treatment after 10 days of petal fall. The maximum average fruit weight (105.64 g), length (7.48 cm) and diameter (4.96 cm) were found with manual thinning of 4 fruits shoot^{-1} along with dip treatment in 5 ppm CPPU. The highest (16.54 g) % loss in weight was recorded with thinning up-to 6 fruits shoot^{-1}+5 ppm CPPU). The highest TSS contents (7.78, 15.47%), minimum acidity (1.35, 0.74%), highest total sugars (4.19, 9.88%), maximum TSS acid ratio (5.78, 21.04), highest ascorbic acid (90.13, 64.53 mg 100 g^{-1}) content at harvest and after storage, respectively, were also found with the treatment T_4. However, the highest (87.26 k vine^{-1}) fruit yield was recorded in vines, retained with 8 fruits shoot^{-1} along with the application of 5 ppm CPPU.

1. Introduction

The Kiwifruit or Chinese gooseberry (*Actinidia deliciosa* Chev.) is a deciduous and dioecious vine, native to the Yangtze River valley of Northern China (Ferguson, s1984). It has gained enormous popularity in many countries of the world. In fact, no other fruit has attracted so much attention in such a short period in the history of commercial fruit production. There are several attributes that make the Kiwifruit as a viable and productive commercial proposition in the mid and foot hills of Indian Himalayan region. The economic importance of Kiwifruit has recently increased due to its export potential. Mid-hills and valley areas of Himachal Pradesh representing Solan, Shimla, Sirmaur, Mandi and Kullu districts are ideally suited for Kiwifruit cultivation. Recently, its commercial cultivation has been extended to Jammu and Kashmir, Arunachal Pradesh, Sikkim, Meghalaya and Manipur.

Among Kiwifruit cultivars, Allison is a prolific bearer and the most promising cultivar for mid-hill zone of Himachal Pradesh. It has a tendency to overbear which leads to production of small and poor quality fruits. In Kiwifruit, the fruit size is one of the major factors which determine the marketability and price. Production of large Kiwifruit has become essential for economic profitability of the crop. Several factors, like, crop load, irrigation, nutrition, pollination and level of endogenous hormones affect fruit size in Kiwifruit (Woolley, 1991). Manipulation of crop load through fruit thinning and use of plant growth regulators can be employed for getting better quality fruits.

Among growth regulators, a synthetic cytokinin i.e. CPPU (N-(2-chloro-4-pyridyl)-N-phenylurea) has been found very effective in stimulating fruit growth in grape, apple, craneberry and Kiwifruit (Devlin and Kiszanski, 1988). Sitofex (CPPU) is a plant growth regulator of Cytokinin type and its physiological effects were cited by Arie-Ben et al. (2008) who recorded that CPPU increased the number and density of cells causing an appreciable increase in berry size of Seedless grapes. Thinning is also practiced to improve the fruit size by thinning of

blossom or small fruitlets by hand. Thinning in combination with application of plant growth regulator can prove more useful in improving the size and quality of fruits. It ensures consistency in obtaining good crops of better quality year after year. These reports further necessitate the verification of CPPU in combination with thinning for improving fruit size, yield and quality of Kiwifruit. Keeping this in view, the present was undertaken to study the combined effect of CPPU and manual fruit thinning on the fruit yield and quality characteristics of Kiwifruit both at harvest and after storage at ambient temperature.

2. Materials and Methods

A field trial was conducted to study the effect of manual fruit thinning and CPPU in Kiwifruit cv. Allison in the Kiwifruit Block of Department of Fruit Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.), located at 30°51 N latitude during the year 2011-12. Twenty-one years old vines of Allison Kiwifruit, planted at a distance of 4×6 m^2 and trained on T-bar system were selected for the study which comprised of seven treatments viz., T_1 (control), T_2 (5 ppm CPPU), T_3 (thinning up-to 4 fruits $shoot^{-1}$), T_4 (thinning up-to 4 fruits $shoot^{-1}$+5 ppm CPPU), T_5 (thinning up-to 6 fruits $shoot^{-1}$), T_6 (thinning up-to 6 fruits $shoot^{-1}$+5 ppm CPPU) T_7 (thinning up-to 8 fruits $shoot^{-1}$) and T_8 (thinning up-to 8 fruits $shoot^{-1}$+5 ppm CPPU).

Manual fruit thinning was carried out by removing fruits. Only 4, 6 and 8 well spaced fruits depending upon treatment were retained and remaining fruits were removed. Beside this, all lateral fruits typical of Allison cultivars were also removed. The fruit thinning was done after 10 days petal fall. The CPPU was applied as a fruit dip treatment at pea stage i.e. after 10 days petal fall. The fruit samples for physico-chemical analyses were collected when the fruits had attained optimum maturity (>6.2% TSS). Five fruits were collected randomly from all sides of the vines and then were brought to the laboratory in perforated polythene bags for physico-chemical analyses. Analysis was done at harvesting stage and after 10 days storage (ripening stage) at ambient temperature (25±2 °C).

Physical parameters like fruit length (cm) and diameter (cm) were measured with the help of Digital Vernier Calliper. The fruit weight (g) was recorded at harvest and after 10 days storage at 25±2 °C on a top pan balance. The physiological loss in weight (PLW) was expressed as per cent of the initial weight. Chemical attributes includes determination of total soluble sugars were determined with the help of Erma-hand refractometer (0-32 °Brix) (AOAC, 1980). The total titratable acidity was calculated on the basis of one ml N/10 NaOH equivalent to 0.0064 g of anhydrous citric acid or per cent citric acid in juice. Sugar to acid ratio was calculated by dividing TSS (%) with titratable acidity (%). The total sugars were estimated by titrating the boiling mixture of 5 ml, each of Fehling A and Fehling B solution against the hydrolyzed aliquot by using methylene blue as an indicator. Non-reducing sugars were calculated by substracting reducing sugars from the total sugars and multiplying the difference by standard factor i.e., 0.95 and ascorbic acid was determined by AOAC (1980) method.

The yield was expressed in kg $vine^{-1}$ and were categorized in 4 grades viz., A grade (>80 g), B grade (50-80 g), C grade (50-30 g) and D grade (<30 g). The yields of different grade fruits were expressed in kg $vine^{-1}$. The economic viability of various treatments was ascertained by comparing the net benefit of various treatments with that of the control. For this purpose, the current grade wise price of Kiwifruit i.e., "A" grade @ ₹ 64/k, "B" grade @ ₹ 47/k, "C" grade @ ₹ 32 and "D" grade @ ₹ 22/k were taken into consideration. Per cent increase in net benefit over the control was calculated by substracting total cost from the net return $vine^{-1}$. The data obtained from the investigation were statistically analyzed according to Randomized Block Design and the differences exhibited by different treatments were tested for their significance as per the procedure described by Gomez and Gomez (1984).

3. Results and Discussion

In the present study, significant effects of manual fruit thinning alone and in combination with CPPU were recorded in terms of all physico-chemical parameters than that of control. The physical characteristics of fruits i.e. weight, length and diameter data depicted in (Table 1). and revealed that manual thinning of 4 fruits $shoot^{-1}$ along with dip treatment in 5 ppm CPPU significantly increased the average fruit weight (105.64 g), length (7.48 cm) and diameter (4.96 cm) over control which was followed by treatment T_6 (thinning up-to 6 fruits $shoot^{-1}$ +5 ppm CPPU). The interaction between thinning levels and CPPU were also noticed non significant in increasing fruit weight and size. This improvement in fruit size and weight under these treatments may be due to the less number of fruits $vine^{-1}$ and CPPU influence. These factors might have resulted in availability of higher amount of photosynthates, nutrients, water for development along with increase in cell division and elongation by CPPU which further increased the number and size of small cells in outer pericarp, inner pericarp and the core (Antognozzi et al., 1997). Cell division in the fruit tissues is induced by CPPU, as a citochinensis-promoting substance (Fellman et al., 1987).

The higher per cent loss in fruit weight was recorded in all treatments as compared to untreated fruits after 10 days

storage at ambient temperature. The highest (16.54 g) % loss in weight was recorded with treatment T_6 (thinning up-to 6 fruits shoot^{-1}+5 ppm CPPU), followed by treatment T_8 i.e. thinning up-to 8 fruits shoot^{-1}+5 ppm CPPU and T_2 comprising of 5 ppm CPPU alone, recording 15.52 and 14.67%, respectively (Figure 1). The findings of present study on the physiological loss in weight are supported by the findings of Antognozzi et al. (1996) who also reported during storage of Kiwifruit that the highest fruit weight loss was recorded in CPPU treated Kiwifruit during storage than the untreated ones which may be attributed to enhanced ripening. Antognozzi et al. (1997) also reported that CPPU treated fruits had a lower dry matter percentage than the untreated fruits of Kiwifruit.

A significant increase in the total soluble solids and sugars contents was noticed in the fruits subjected to different levels of fruit thinning along with application of 5 ppm CPPU at harvest and during storage. The soluble solids concentration incorporates not only the soluble sugars but also organic and inorganic salts. The highest TSS contents at harvest (7.78%) and after storage (15.47%) were recorded with treatment, representing where 4 fruits shoot^{-1} along with application of 5 ppm CPPU (Table 2). However, the lowest TSS contents,

Table 1: Effect of fruit thinning and CPPU on the fruit size and fruit weight of kiwifruit cv. Allison

Treatment code	Treatments details	Fruit size			Fruit weight (g fruit^{-1})
		Fruit length (cm)	Fruit diameter (cm)	L/D ratio	
T_1	Control	5.96	4.03	1.48	51.34
T_2	CPPU 5 ppm	7.15	4.70	1.49	84.78
T_3	Thinning upto 4 fruits shoot^{-1}	6.27	4.19	1.50	66.09
T_4	Thinning upto 4 fruits shoot^{-1}+CPPU 5 ppm	7.48	4.96	1.51	105.64
T_5	Thinning upto 6 fruits shoot^{-1}	6.23	4.20	1.48	61.53
T_6	Thinning upto 6 fruits shoot^{-1}+CPPU 5 ppm	7.44	4.93	1.51	101.35
T_7	Thinning upto 8 fruits shoot^{-1}	6.12	4.13	1.48	56.93
T_8	Thinning upto 8 fruits shoot^{-1}+CPPU 5 ppm	6.87	4.65	1.48	80.28
CD (p=0.05)		0.48	0.21	NS	8.9

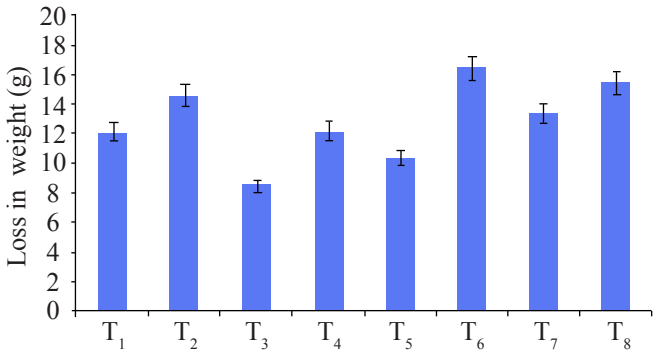

Figure 1: Effect of fruits thinning and CPPU on the percent physiological loss in weight (PLW) of fruits after 10 days strong at ambient temperature (25±2 °C)

Table 2: Effect of fruit thinning and CPPU on the total soluble solids and titratable acidity of kiwifruit at harvest and after 10 days storage at ambient temperature (25±2 °C) in Kiwifruit cv. Allison

Treatment code	Treatments details	Total sugars (%)		Reducing sugars (%)	
		At harvest	After storage	At harvest	After storage
T_1	Control	3.30	8.45	1.60	6.88
T_2	CPPU 5 ppm	3.45	9.17	1.71	7.39
T_3	Thinning upto 4 fruits shoot^{-1}	3.71	8.84	1.89	7.16
T_4	Thinning upto 4 fruits shoot^{-1}+CPPU 5 ppm	4.19	9.88	2.16	7.80
T_5	Thinning upto 6 fruits shoot^{-1}	3.48	8.77	1.75	6.92
T_6	Thinning upto 6 fruits shoot^{-1}+CPPU 5 ppm	4.12	9.56	2.12	7.69
T_7	Thinning upto 8 fruits shoot^{-1}	3.39	8.67	1.69	6.88
T_8	Thinning upto 8 fruits shoot^{-1}+CPPU 5 ppm	3.43	9.24	1.96	7.58
CD (p=0.05)		0.18	0.07	0.07	0.86

both at harvest and after storage were recorded in the untreated fruits. This increase in TSS content with application of CPPU may be attributed to the advanced ripening induced by CPPU, probably due to more ethylene production as reported by Lotter (1991); Lawes et al. (1991); Patterson et al. (1994); Costa et al. (1995) in Kiwifruit. The higher TSS content might be attributed to a higher rate of photosynthates assimilation, as cytokinins are known to influence mobilization of metabolites and nutrients to the cytokinin treated portion of the plant (Leopold and Kriedemann, 1975).

The results of the present study revealed that all the fruit thinning treatments and application of CPPU significantly reduced the acid content of fruit is illustrated in (Table 2). The minimum acidity was recorded in the fruits treated with treatment T_4 (thinning up-to 4 fruits shoot^{-1}+5 ppm CPPU) both at harvest (1.35%) and after storage (0.74%). These findings are more or less in accordance with those of Park and Park (1997) in Kiwifruit, Chahill et al. (1980); Kim et al. (2008) in peach. The results are also supported by the findings of Antognozzi et al. (1993), who also observed decrease in acidity with CPPU application in Kiwifruit. Similarly, Costa et al. (1995); Jinbao et al. (1996) found reduction in acid content of Kiwifruit with CPPU application. The decline in the content of organic acids during ripening may be attributed to an increase in the membrane permeability which allows acids stored in the cells to be respired (Kliewer, 1971), formation of salts of mallic acid, reduction of the acid translocated from the leaves, reduced ability (Hardy,1968) translocation into sugars and dilution effect due to volume increases in fruit. Huang et al. (2003) studied the effect of CPPU application at 16 ppm, applied at 15 days after pollination in 10 accessions belonging to 6 species of *Actinidia* which resulted in higher soluble solids content and the total titratable acidity was lower in treated fruits in most accessions.

In (Table 3). an increased level of total sugars contents may also be attributed to the translocation of photsynthates from leaves to young fruits which are partly used for the synthesis of pectin substances and other cell wall constituents and partly converted to the usual storage product, the starch. Sugars either in free state or as derivatives play an important role in imparting attractive flavor, appearance and texture to the fruit (Whiting, 1970). The highest (4.19%) total sugars content was obtained in the fruits subject to treatment T_4, where 4 fruits shoot^{-1} were retained along with application of 5 ppm CPPU. This treatment exhibited non-significant differences with T_6 (thinning up-to 6 fruits shoot^{-1}+5 ppm CPPU) which recorded total sugars content of 4.12% in fruit at the time of harvest.

After 10 days storage (ripening stage), the lowest (8.45%) sugars content was recorded in untreated fruits which was statistically lower than with all treatments namely; T_2 (9.17%), T_3 (8.84%), T_4(9.88%) , T_5 (8.77%), T_7 (8.67%) and T_8 (9.24%). The highest total sugars content was recorded in fruits subject to treatment T_4 (thinning up-to 4 fruits shoot^{-1}+5 ppm CPPU) which was significantly higher than all other treatments. The reducing sugars almost followed the similar trend as that of total sugars. The treatments namely; T_4 (thinning up-to 4 fruits shoot^{-1}+5 ppm CPPU) and T_6 (thinning up-to 6 fruits shoot^{-1}+5 ppm CPPU) recorded reducing sugars contents of 2.16% and 2.12%, respectively and were found statistically at par with each other (Table 3).

The TSS acid ratio of fruits as affected by different severities of fruit thinning and 5 ppm CPPU revealed that at the time of harvest, maximum (5.78) TSS acid ratio was observed in fruits subject to treatment T_4 (thinning up-to 4 fruits shoot^{-1}+5 ppm CPPU), closely followed in T_6 (thinning up-to 6 fruits shoo^{-1}+5 ppm CPPU) treatment with a sugar acid ratio of 5.45

Table 3: Effect of manual fruit thinning and CPPU on the total and reducing sugars of kiwifruit at harvest and after 10 days storage at ambient temperature (25±2 °C) in Kiwifruit cv. Allison

Treatment code	Treatments details	TSS (%)		Titratable acidity (%)	
		At havest	After storage	At havest	After storage
T_1	Control	6.38	13.53	1.55	1.00
T_2	CPPU 5 ppm	6.63	14.87	1.47	0.81
T_3	Thinning up-to 4 fruits shoot^{-1}	6.95	14.20	1.38	0.90
T_4	Thinning upto 4 fruits shoot^{-1} +CPPU 5 ppm	7.78	15.47	1.35	0.74
T_5	Thinning up-to 6 fruits shoot^{-1}	6.62	13.87	1.41	0.92
T_6	Thinning up-to 6 fruits shoot^{-1}+CPPU 5 ppm	7.53	15.33	1.39	0.76
T_7	Thinning up-to 8 fruits shoot^{-1}	6.47	13.73	1.43	0.96
T_8	Thinning upto 8 fruits shoot^{-1}+CPPU 5 ppm	6.90	14.40	1.41	0.81
CD (p=0.05)		0.76	0.56	0.11	0.14

and these two treatments were statistically at par with each other. The TSS acid ratio increased with increase in ripening of fruits during 10 days storage at 25±2 °C**.** The maximum (21.04) TSS acid ratio was observed in fruits treated thinning treatment up-to 4 fruits/shoot along with 5 ppm CPPU which was significantly higher than all other treatments (Table 4).

At harvest, the highest (90.13 mg 100 g^{-1}) ascorbic acid content of was found in fruits subject to treatment T_4 (thinning up-to 4 fruits $shoot^{-1}$+5 ppm CPPU) which was followed by treatments T_2 (89.33 mg 100 g^{-1}), T_3 (88.53 mg 100 g^{-1}), T_5 (88.51 mg 100 g^{-1}), T_6 (89.87 mg 100 g^{-1}) and T_8 (87.60 mg 100 g^{-1}). After storage at room temperature, the ascorbic acid content decreased but different treatments did not affect the ascorbic acid content significantly. The maximum ascorbic acid content (64.53 mg 100 g^{-1}) was observed with treatment T_4 (thinning up-to 4 fruits $shoot^{-1}$ along with application of 5 ppm CPPU) and the minimum content (62.93 mg 100 g^{-1}) was found in fruits harvested from untreated vines which was closely followed by T_7 (63.20 mg 100 g^{-1}) and T_5 (63.27 mg 100 g^{-1}) treatments (Table 4).

The higher levels of ascorbic acid in fruits may be attributed to the adequate supply of hexose sugars via photosynthetic activity, while decrease in ascorbic acid content during ripening might be correlated to its role as a terminal oxidase in the electron transport system (Mapson, 1970). These findings are in agreement with that of Park and Park (1997) who observed an increase in ascorbic acid content following severe hand thinning treatments in Kiwifruit. The results of the present investigations also revealed that ascorbic acid content was not significantly influenced by application of CPPU. These results are in agreement with that of Jinbao et al. (1996) who also observed non-significant effect of CPPU on the ascorbic acid content of fruits. .

Table 4: Effect of manual fruit thinning and CPPU on the TSS acid ratio and Ascorbic acid content of kiwifruit at harvest and after 10 days storage at ambient temperature (25±2 °C) in Kiwifruit cv. Allison

Treat-ment code	Treatments details	TSS acid ratio		Ascorbic acid (mg 100 g^{-1})	
		At havest	After stor-age	At havest	After storage
T_1	Control	4.13	13.60	85.87	62.93
T_2	CPPU 5 ppm	4.51	18.43	89.33	63.47
T_3	Thinning up-to 4 fruits $shoot^{-1}$	5.04	15.86	88.53	64.00
T_4	Thinning up-to 4 fruits $shoot^{-1}$+CPPU 5 ppm	5.78	21.07	90.13	64.53
T_5	Thinning up-to 6 fruits $shoot^{-1}$	4.70	15.08	88.51	63.47
T_6	Thinning up-to 6 fruits $shoot^{-1}$+CPPU 5 ppm	5.45	20.39	89.87	64.27
T_7	Thinning up-to 8 fruits $shoot^{-1}$	4.52	14.46	86.93	63.20
T_8	Thinning upto 8 fruits $shoot^{-1}$+CPPU 5 ppm	4.90	17.99	87.60	64.00
CD (p=0.05)		0.63	3.23	NS	NS

The present investigation also revealed that manual fruit thinning alone and in combination with 5 ppm CPPU application improved the total yield of Allison Kiwifruit. The highest (87.26 k $vine^{-1}$) fruit yield was recorded in vines, retained with 8 fruits $shoot^{-1}$ along with application of 5 ppm CPPU at 10 days after petal fall (Figure 2). Whereas, the lowest (68.33 k $vine^{-1}$) yield was obtained from fruit thinning treatment of 4 fruits $shoot^{-1}$. The exogenous application of CPPU has been shown to increase the yield of several crops, such as grape

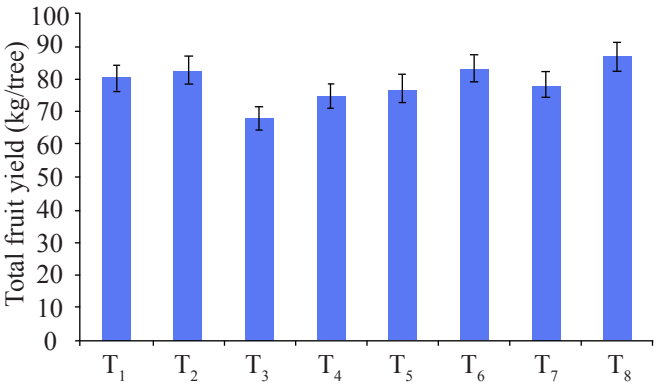

Figure 2: Effect of fruit thinning and CPPU on the total yield of kiwifruit

(Nickell.,1986), Kiwifruit (Biasi et al.,1992), persimmon (Itai et al.,1995), pear (Flaishman et al., 2001) and apple (Greene, 1989) and Antognozzi et al. (1993) obtained higher yield and per centage of 'A' grade fruits in Kiwifruit with CPPU at 10 to 20 ppm, when applied 14 days after full bloom.

4. Conclusion

In Kiwifruit cultivar namely; Allison which has prolific bearing habit, fruit thinning by retaining 6 fruits/shoot along with dipping in 5 ppm CPPU after 10 days of petal fall resulted in higher yield of better size and quality fruits.

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