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Study of Chemical Blossom Thinning on Fruiting and Fruit Quality in Japanese Plum (*Prunus salicina* Lindl.) cv Kala Amritsari

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Abstract Heavy flowering and fruiting is major problem of Japanese plum cultivars in subtropical areas, especially. Chemical thinning practices are essential for obtaining a good quality crop. Application of chemicals for thinning of blossoms at full bloom can serve the purpose of achieving quality yields. Hence, the trees of plum cv Kala Amritsari were sprayed with urea (4 and 6%), ammonium thiosulfate (2 and 4%) and NAA (20 and 40 ppm) for the purpose of blossom thinning at full bloom stage in the year 2015 and 2016. The foliar spray of ammonium thiosulfate @ 4% reduced the fruit set to 25.08% and 23.14% in the year 2015 and 2016, respectively. The fruit weight (16.61 g and 14.96 g), length and breadth were observed maximum with the application of ammonium thiosulfate (ATS) @ 4% followed by ATS @ 2%. The quality parameters viz. TSS (13.80 and 13.90%), total sugars and reducing sugars were significantly higher than the control with ATS 4% in both the years.

Keywords Japanese plum, Blossom thinning, Ammonium thiosulfate, Kala Amritsari.

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Introduction

Plums are the most taxonomically diverse of stone fruits and are adapted to a board range of climatic and edaphic factors. The nutritive value, fruit color and unique sugar-acid blend of plums makes it the choicest fruit among consumers. In India, Japanese plum (*Prunus salicina* Lindl.) is grown in temperate and subtropical regions. Though plum is native to temperate areas, but there are some varieties of Japanese plum which can be cultivated in subtropical area also viz. plains of Uttarakhand, Tarai region of Uttar Pradesh, Haryana and Punjab. The fruiting occurs in May-June and during this period there are only few fruits available at market, hence, the farmers can fetch good price by early marketing.

Though plums are performing very well in both temperature and subtropical areas, but the major problem in the cultivation of plums is heavy bearing or

Table 1. Effect of chemical blossom thinning on fruiting of Japanese plum cv Kala Amritsari. ATS=Ammonium thiosulfate, NAA=Naphthalene acetic acid.

Treatments	Friut set (%)		Total fruit retention (%)		Number of fruits/meter shoot	
	2015	2016	2015	2016	2015	2016
Urea 4%	47.62	45.35	47.42	45.88	59.73	53.52
Urea 6%	41.18	38.65	47.96	46.09	53.08	45.43
ATS 2%	27.76	24.55	52.29	50.12	37.19	30.61
ATS 4%	25.08	23.14	53.96	53.09	32.64	28.11
NAA 20 ppm	32.80	29.31	49.21	48.35	44.29	36.80
NAA 40 ppm	29.01	27.55	50.03	49.67	40.50	38.14
Water spray	52.77	49.90	46.75	43.28	66.49	54.80
Control	59.33	55.45	45.86	42.31	73.67	60.35
CD ($p \leq 0.05$)	2.97	2.62	0.57	0.43	1.67	1.90

excessive crop load. According to Hrotlco et al. [1], being self-fertile makes cherry cv Alex, prone to small fruit size in case of over cropping. Japanese plum cv Kala Amritsari flowers profusely and being self-fertile bear heavily leading to heavy yield of reduced fruit size, weight and quality. Due to these reasons its market acceptance is also reduced and the produce gets low organoleptic ratings. Heavy bearing is negatively correlated with the fruit physical and chemical characters. The increasing demand by the markets for high quality fruit is making the control of fruit tree crop load an unavoidable operation in orchard management. In *Prunus* species, final fruit size depends to a great extent on the total number of fruits per tree [2, 3]. In these species, percentage of fruit set is unaffected for a wide range of flower bud production, hence an early reduction of competition among developing fruits is of importance for increasing final fruit size at maturity.

Thinning of crop load is a necessary practice to achieve optimum fruit size and improved fruit quality. Thinning usually reduces total yield, but when properly carried out increases economic yield [4]. Japanese plum thinning can be performed as pre-bloom thinning (e.g. flower bud reduction), during the bloom (e.g. flower chemical thinning) or as post-bloom thinning (e.g. fruitlet hand thinning practice or chemical fruit thinning) [5]. Thinning of flowers at early stages is important as it affects the fruit size, positively, although the time of thinning crop load can be extended upto full bloom to ensure adequate fruit set, especially in regions where spring frosts are common. However, in sub-tropical plums caustic thinning agents are applied during bloom to reduce fruit set, which interfere the fertilization by damaging different flower parts [6, 7]. Numerous compounds were tested for plum blossom thinning including fertilizers like ammonium thiosulfate (ATS), urea, hormones viz. naphthalene acetic acid (NAA) and other caustic agents such as endothalic acid, pelargenic acid, hydrogen cyanamide, lime sulfur and different oils. Some of them demonstrated to be acceptable as blossom thinners for different fruit crops at different stage [8—12] found NAA to be effective in thinning guava flowers and increasing fruit size and quality. Since phytotoxicity may be caused using different agents, concentrations need to be determined for each cultivar at the given climatic conditions.

However, blossom thinning is not being practised commercially by the growers because of non-availability of sufficient literature and recommendations for the particular crop and cultivar. Therefore, this study was conducted to observe the effectiveness of different chemicals used as blossom thinners (urea, ATS and NAA) on fruit set, yield, size and quality of plum cv Kala Amritsari in the semi-arid conditions of Hisar, Haryana.

Materials and Methods

The trials were conducted on the experimental farm of Department of Horticulture, CCS Haryana Agricultural University, Hisar, Haryana. The experiments were performed in year 2015 and 2016. Each treatment was applied on 3 trees (1 tree=1 replication) of similar height and fruiting intensity, selected from trees distributed along the row. In this study a single spray was applied with a knapsack sprayer up to run off. The spray was performed at full flowering (at least 50% of flower open) during warm days (air temperature about 15—20°C) before noon, with no rain announced for the

Table 2. Effect of chemical blossom thinning on fruit physical parameters and yield of Japanese plum cv Kala Amritsari. ATS=Ammonium thiosulfate, NAA=Naphthalene acetic acid.

Treatments	Fruit weight (g)		Fruit length (mm)		Fruit breadth (mm)		Yield (kg/tree)	
	2015	2016	2015	2016	2015	2016	2015	2016
Urea 4%	12.72	11.05	22.20	19.89	25.57	21.67	51.42	48.58
Urea 6%	13.27	11.90	23.19	20.79	26.42	22.84	49.84	45.06
ATS 2%	16.02	13.24	24.04	22.15	28.90	26.04	43.52	39.45
ATS 4%	16.61	14.96	24.87	22.82	29.65	26.22	41.50	37.13
NAA 20 ppm	14.05	12.59	23.89	21.53	27.05	24.81	47.10	44.35
NAA 40 ppm	15.64	12.96	23.64	21.71	27.59	25.06	46.34	42.61
Water spray	9.67	9.47	21.39	18.41	22.39	20.20	52.30	48.90
Control	9.55	9.30	19.77	17.74	21.59	19.68	52.99	49.87
CD ($p \leq 0.05$)	0.88	0.73	0.72	0.82	0.95	1.65	2.00	1.60

following 24 h. Cultural practices other than thinning were applied in a manure consistent with those of commercial plum orchards to all the trees under experiment. Crops of the experimental trees were harvested at commercial time (full color development). For each experimental tree the total yield expressed in kg per tree. A mean sample of 20 fruits per treatment was used to assess the fruit quality. Mean fruit weight was determined using digital weighing machine (g). Fruit length and breadth of fruits was determined using digital caliper (mm). For acidity, fruit juice was titrated with 0.1 N NaOH and the results were expressed in terms of percentage of maleic acid as described Ranganna [13]. TSS and sugars were estimated as per standard method [14]. The observations were subjected to statistical analysis i.e. analysis of variance (ANOVA) using randomized block design (RBD) [15].

Results and Discussion

The results (Table 1) from the trails conduced for two consecutive years (2015 and 2016) showed reduction in per cent fruit set in all the treatments over control. In 2015, fruit set reduced to 25.08% which was minimum with the application of ATS (4%), while in second trail, the reduction in fruit set was even more i.e. 23.14% and it was statistically at par with ATS (2%) in both the years. It was suggested that ATS damages petals, pistils and anthers in apple and therefore prevents fertilization [16]. The same mode of action might be presumed in plum cv Kala Amritsari. The severity of flower damage depends on environmental conditions. Low relative humidity such was in the present experiment and high temperature favor rapid drying and limit chemical efficacy while the higher rates of ATS compensate for the rapid drying time. It was observed that with the decrease in the fruit set with all the treatments, the total fruit retention increased and was recorded maximum (53.96%, 53.09%) in ATS (4%) followed by ATS (2%), and NAA applications (20, 40 ppm) in both the years. The improvement in fruit retention might be due to the fact that the number of fruits set per shoot was less and there was less competition among fruits for carbohydrates and nutrients needed for longer retention on the shoots. As a result of decreased fruit set, number of fruits retained at harvesting per meter shoot is also recorded to be decreased, whereas, the nuber of fruits were highest (73.67) in the control where no chemical blossom thinning was performed. Least number of fruits was observed with ATS (32.64, 28.11) application (4%) followed by NAA and urea in both years. Similar results with ATS were observed Milic et al. [17] in apple and in peach Conova and Ctine [18], where ATS controlled crop load and improved fruit quality. Water sprayed during full bloom also reduced the fruit set and the numbers of fruits per meter shoot, significantly, over control but not as much as the other thinning chemicals. Though, ATS, urea and NAA affected fruit retention significantly, in both the years, but different concentrations of same chemical (NAA/ATS/urea) did not differ from each other, significantly (Table 1).

The chemical thinning of blossoms affected the

Table 3. Effect of chemical blossom thinning on fruit quality of Japanese plum cv Kala Amritsari. ATS=Ammonium thiosulfate, NAA=Naphthalene acetic acid.

Treatments	TSS (%)		Titratable acidity (%)		Total sugars (%)		Reducing sugars (%)	
	2015	2016	2015	2016	2015	2016	2015	2016
Urea 4%	11.58	11.28	1.81	1.89	8.97	8.82	6.19	6.12
Urea 6%	11.90	11.82	1.79	1.87	9.01	8.94	6.26	6.20
ATS 2%	13.58	13.50	1.55	1.74	9.61	9.52	6.82	6.73
ATS 4%	13.80	13.90	1.46	1.71	9.62	9.57	6.90	6.79
NAA 20 ppm	12.48	12.10	1.73	1.84	9.49	9.35	6.39	6.28
NAA 40 ppm	12.93	12.53	1.71	1.84	9.18	9.07	6.58	6.41
Water spray	10.58	9.63	1.86	1.94	8.26	8.03	6.23	5.88
Control	10.38	9.15	1.91	1.98	7.79	6.86	6.01	5.49
CD ($p \leq 0.05$)	0.40	0.28	0.06	0.03	0.06	0.05	0.07	0.04

fruit size and weight, significantly when compared to control. The fruit weight, length and breadth increased with the reduced fruit set, significantly (Table 2). The maximum fruit weight (16.61 g and 14.96 g), length (24.87 mm and 22.82 mm) and breadth (29.65 mm and 26.22 mm) was found in treatment of ATS 4% in the years 2015 and 2016 respectively, which was statistically at par with ATS 2% treatment, followed by NAA 40 ppm and NAA 20 ppm. Water spray alone could not be found to increase fruit size and weight as compared to control, significantly, whereas, impact of all other treatments was significant. The increased weight and size of fruits might be attributed to decrease in number of fruits per tree in comparison of control and water spray. The reason for increased fruit size that might be a very low fruit set and a lack of competition for the resources among the fruits [19]. On the other hand, the yield in the treated trees reduced as compared to non-treated ones (52.99 kg/tree and 49.87 kg/tree) in both the trails being minimum in ATS 4% (41.50 and 37.13 kg in 2015 and 2016, respectively). Although, water spray treatment yields did not differ significantly, but the other treatments caused significant reduction in yields. However, in the second trail, the yield was lower than the first trail. The resulted decrease in yields from blossom thinning is directly related to the reduced fruit set. The unfavorable weather conditions and abrupt increase in temperature might be the reason behind this reduction. The results were in line with those obtained Milic et al. [20].

As far as quality of fruits is concerned, the chemical flower thinning affected the quality parameters viz. TSS, acidity and sugars, significantly when compared with control. In various studies, researchers [21—23] found that fruit from the trees, where thinning has been performed at the time of flowering, have a higher quality than the fruits from unthinned trees. This is due to the fact that after removal of the part of the flowers, those that set fruits; have better conditions for growth.

Urea (4, 6%), NAA (20, 40 ppm) and ATS (2, 4%) improved the TSS and sugar content of fruits in both years, individually (Table 3); however, the two concentrations of same chemicals, could not impart any significant effect on TSS during year 2015; as in year 2016, all treatments improved TSS (From 10.38 to 13.80% and 9.15 to 13.90%), significantly. The titratable acidity was recorded to be decreased in the fruits of treated trees and minimum (1.46%, 1.71% in 2015 and 2016, respectively) was observed in ATS 4% in both years. There found to be a negative correlation between TSS and acidity in the fruits. The higher TSS values may be the results of accumulation of more soluble solids. Similar to the TSS and contrary to acidity, total and reducing sugars were also found to be increased slightly in the fruits of treated trees as compared to control ones. The percentage of total sugars (9.62 and 9.57%) and reducing sugars (6.90 and 6.79%) was also observed highest with the ATS 4% application followed by ATS 2% and NAA treatments. The fruits from the flower thinned trees were of superior quality in terms of high TSS and sugar content with good blend of acidity. The results obtained (Table

3) were in line with those earlier observed [24, 25], who reported that fruits from thinned trees had higher soluble solids due to the lower fruit to leaf area ratio and reduced competition for assimilates among the fruits. Overall blossom thinning using application of chemicals (urea, NAA, ATS) and water spray during full bloom significantly affected the fruit set, weight, size, yield and quality. The reduced number of fruits per tree resulted in proper supply of carbohydrates and nutrients to the remained fruitlets for proper growth and development and ripening. Ammonium thiosulfate (4% and 2%) was most effective chemical blossom thinner followed by NAA (20 and 40 ppm). Fruit size was almost doubled and TSS of fruit was also increased to a remarkable per cent. Despite of slight leaf burning, urea also (4 and 6%) performed well in quality improvement.

However, there is an indication that for the cultivar studied, the application of blossom thinning chemicals at full bloom can be a good and cost effective approach toward reducing hand thinning expenses and achieving good fruit size and quality.

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