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EFFECT OF GIRDLING ON YIELD, PHYSICAL QUALITY AND COLOUR DEVELOPMENT IN PLUM cv. KALA AMRITSARI

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ABSTRACT

An experiment was conducted with the objective to improve the fruit quality through girdling in low chilling requiring sub tropical plum cv. Kala Amritsari during 2022 and 2023 at CCS HAU, Hisar. The experiment comprises of five treatments *viz.*; girdling at full bloom stage (more than 70% flower anthesis), girdling after fruit set (14 days after petal fall), girdling at pit hardening stage, girdling at 15 days before harvesting and control (un girdled) by using 2mm width girdling knife laid out in randomize block design. It may be inferred from the present study that among various girdling treatments, girdling at pit hardening stage significantly increased fruits physical quality (fruit weight, size, pulp per cent, pulp stone ratio) and decreased fruit firmness followed by girdling 15 days before harvesting over the other remaining girdling treatments. Girdling at latter stages of fruit development *i.e.* at pit hardening and 15 days before harvested resulted in to better colour development (L and a* and b* coordinates) than girdling at early stages. However, girdling at full bloom stage was found inferior to control (un girdled) in all parameters studied. Further, fruit yield could not be affected significantly with any of the girdling treatments.

Key words : Plum, Girdling, Yield, Quality, Colour.

Introduction

Plum comprises fifteen distinct species. While native to China, plums are cultivated across temperate and subtropical regions worldwide, making them one of India's key stone fruits. In India, Japanese plums thrive in sub-tropical climates, particularly in the plains and sub-mountain areas of northern states. Varieties that require fewer than 300 chilling hours can be successfully grown in northern plains. Plums are classified as drupe fruits, exhibiting a wide range of characteristics, including fruit size, shape, color, texture, aroma, and other quality attributes, making them particularly appealing compared to other horticultural crops (Baden and Byrne, 2012). In northern India, high-quality plums are primarily cultivated in the hilly regions of Himachal Pradesh, Jammu and Kashmir, Uttarakhand, and Chitrakoot (Uttar Pradesh). In the plains, low-chill cultivars are grown throughout Punjab, Haryana, and parts of Uttar Pradesh and Rajasthan. Nationally plums cover an area of 17,930 hectares and producing 69,530 metric tons (Anonymous, 2023a). In Haryana alone they are cultivated on 66.2 hectares and yielding 1,314.71 metric tons (Anonymous, 2023b).

Among various problems, in plum cultivation severe fruit drops and small fruit size is of serious concern, cause losses of plants health. This problem is mainly due to heavy bearing nature of Kala Amritsari, which results intense competition for assimilates among the fruits, and finally causes small size fruits fetching low price in the market. So, quality improvement of fruit is one of the foremost need for successful cultivation of plum and to fetch good revenue. Girdling is an important cultural practice, used to reduce vegetative growth, promote flowering, improve fruit set, increase yield and improve

fruit quality by blocking the downward translocation of photosynthates and metabolites through the phloem, which in turn increases the accumulation of carbohydrates in the parts above wounds (Eliwa, 2003). It is an attempt to manipulate the distribution of photosynthate, mineral nutrition and plants bio-regulators (Goren *et al*., 2004). Girdling enhanced color development, ripening and also had positive effects on anthocyanin accumulation in the fruits (Downey *et al*., 2006). As a results of girdling, leaf N content, C/N ratio and carbohydrate are improved. However, standardization of girdling practices inrespect of time is lacking in plum under sub-tropical condition of northern plains. Hence, considering the above facts in view, the present investigation was undertaken to evaluate the effect of time of girdling on yield and physical quality attributes in plum.

Materials and Methods

Experimental site and climate: The present study was carried out at experimental orchard, Department of Horticulture, CCS HAU, Hisar, Haryana, situated at an altitude of 215.2 m above mean sea level with coordinates of 29°15' North and 75°68' East of Haryana. Hisar has typically semi-arid with very hot dry summers and excessively winter weather condition. The climate is characterized by dryness, high temperature and light rainfall. Temperature reaches around 45^0C accompanied by hot and dry winds in May-June, however, sometimes the temperature drops to freezing point followed by occasional frost in December-January. Hisar receives 80-85 per cent of total rainfall *i.e* 450 mm during July to September and 10-15 per cent during winter month *i.e*., December to February which is due to western disturbances.

Treatment details

The field experiment was conducted on 15 years old plum cv. Kala Amritsari with spacing 6m×6m. Twenty uniformly grown plants having similar growth were selected which were under uniform agronomic practices as per recommended package of practices. All plants were maintained under uniform practices of orchard management during the study period. The experiment was laid out in Randomized Block Design with three replications by taking one tree per replication and girdling was done with girdling knife (Falcon brand) of 2 mm width four stages at full bloom stage (more than 70% flower anthesis); after fruit set (14 days after petal fall); at pit hardening stage; at 15 days before harvesting and control (no girdling).

Observation recorded : For recording yield and quality attributes, fruits were harvested in the month of mid May. To calculate fruit yield, the total numbers of fruit per tree was collected and weighed with digital weighing balance and expressed in kilograms. Five representative fruits were selected from each replication and fruits were weighed on top pan electric balance. Fruit weight was calculated by dividing total fruit weight with total number of fruits taken and expressed in grams. The same five fruits were used for estimating length and width (diameter) with the help of digital vernier calliper and expressed in centimeters. A chroma metre of Konica Minolta, INC. 2002-2013 CR-400 Series Ver. 1.14 was used to determine color. The colorimeter was calibrated using the white and black plates that came with the devices before measuring the colour parameter. Three parameters including L*, a* and b* were used to evaluate skin colour. L* is lightness coefficient, indicating relative lightness with a range from 0 (total darkness) to 100 (total white). The a* value represents the balance between green (negative) and red (positive) and b* value represents the balance between blue (negative) and yellow (positive). Both a* and b* values vary from “100 to 100.

Five fruits were selected randomly from each replication and fruits pulp was weighed on top pan electric balance. Fruit pulp weight was calculated and expressed in grams. Pulp per cent was measured by dividing the fruit pulp weight to total fruit weight and expressed in percentage. Seed weight was calculated by subtracting the pulp weight from fruit weight and expressed in grams. The total pulp weight to stone weight ratio was calculated by dividing the value of pulp weight to stone weight. Fruits firmness was measured by digital penetrometer at the equator of the fruit. Fruit firmness was calculated and expressed in kg/inch^2.

Results and Discussion

Yield parameters : The maximum average fruit weight 12.30 and 12.46 g (Table 1) during both the years, respectively was observed in treatment girdling at pit hardening stage *i.e.*; T_4 followed by treatment girdling 15 days before harvesting *i.e* T_5 and minimum average fruit weight 8.92 and 9.12 g during both the years, respectively was observed in treatment girdling at full bloom *i.e* T_2 in year 2022 and 2023, respectively. The significant increase in fruit weight in girdled tree was attributed to the more assimilates and more availability of carbohydrates above the girdling point as a result the fruits gained more fruit weight. The results obtained are in agreement with the findings of Agusti *et al*. (1998) reported in peach and nectarine that girdling at pit hardening and after manual fruit thinning significantly

Table 1 : Effect of girdling on yield, fruit weight and size in plum cv. Kala Amritsari.

Treatments	Yield (kg/plant)		Fruit weight (g)		Fruit size (cm)			
					Fruit length (cm)		Fruit breadth (cm)	
	2022	2023	2022	2023	2022	2023	2022	2023
Control-T_1	38.96	39.86	10.20	10.41	1.92	1.95	2.10	2.14
Girdling at full bloom- T_2	36.52	37.18	8.92	9.12	1.68	1.72	1.84	1.88
Girdling after fruit set- T_3	39.14	40.33	10.53	10.62	1.98	2.04	2.17	2.24
Girdling at pit hardening - T_4	40.47	41.17	12.30	12.46	2.32	2.37	2.54	2.62
Girdling 15 days before harvesting - T_5	39.73	40.55	11.76	11.98	2.22	2.29	2.47	2.56
CD @ 5%	**NS**	**NS**	**0.76**	**0.53**	**0.13**	**0.11**	**0.11**	**0.13**

increased fruit weight and size at harvest.

It was cleared from study that girdling at pit hardening stage and 15 days before harvesting showed higher value of fruit size than treatments un girdled control, girdling at full bloom and girdling after fruit set. Whereas, the maximum average fruit length 2.32 and 2.37 cm, breadth 2.54 and 2.62 cm (Table 1) during both the years, respectively was observed when girdling was done at pit hardening stage *i.e.*; T_4 followed by treatment girdling 15 days before harvesting *i.e.*; T_5. This may be due to more accumulation of photosynthates above the girdled zone as Michailidis *et al*. (2020) found the improvement in fruit size is a common phenomenon induced by girdling in *Prunus* genus. The minimum average fruit length and breadth was observed in treatment girdling at full bloom *i.e* T_2. This might be because of more fruit set and reduced fruit drop and ultimately distribution of photosynthates in large number of fruits resulted into smaller fruits. Thus, results could be in agreement with the finding of Agusti *et al*. (1998) reported that girdling at pit hardening and after manual fruit thinning in peach and nectarine significantly increased fruit size at harvest. Further the results obtained are also, agreement with the findings of Mostafa and Saleh (2006), who reported that girdling alone increase the fruit size in Balady mandarin orange.

A non-significant effect of girdling was observed on yield during both the years. Girdling at pit hardening stage and girdling 15 days before harvesting showed higher value of yield and fruit weight than control, girdling at full bloom and girdling after fruit set. Whereas, the maximum numeric value of yield 40.47 and 41.17 kg/plant (Table 1) during both the years, respectively was observed in treatment girdling at pit hardening stage *i.e* T_4 and minimum numeric value of yield 36.52 and 37.18 kg/plant during both the years, respectively was observed in treatment girdling at full bloom *i.e* T_2 in year 2022 and 2023, respectively. This might be due to positive fact that girdling at the full bloom resulted into more number of fruit set and competition among fruits. Hence, due to presence of more number of fruits there was more competition among fruits for sink (carbohydrates) distribution. But, there were less distribution of sink (carbohydrates) among the fruits which results slow growth of fruit at full bloom and later upto pit hardening stage more sink accumulates which results in maximum yield.

Fruit color : Girdling at pit hardening stage and girdling 15 days before harvesting showed higher value of fruit color coordinates than treatments control, girdling at full bloom and girdling after fruit set. However, the maximum redness (a* coordinate) value 11.88 and 12.16 in fruit color with high brightness (L-value) 27.07 and 27.35 (Table 2) during both the years, respectively was observed in treatment girdling at pit hardening stage followed by treatment girdling 15 days before harvesting and minimum redness in fruit color with low brightness was observed in treatment girdling at full bloom (T_2). It was noticed that treatments girdling at full bloom, just after fruit set and 15 days before harvesting showed higher value of fruit skin color b* coordinates. Whereas, the minimum bluishness b* coordinate value in fruit color during both the years was observed in treatment girdling at pit hardening stage (T_4) and maximum bluishness b* coordinate -1.29 (Table 2) in fruit color was observed in treatment girdling at full bloom (T_2) in both year 2022 and 2023. This might be that girdling has been found to advance color development through the high accumulation of assimilates above the girdling zone. Further, girdling treatment influenced the pigment composition in both fruit pulp and skin, mainly promoting the biosynthesis of anthocyanins contents that were increased linearly with the girdling duration in both fruit pulp and skin. In particular, the red colouration increased in the pulp. This statement was supported by Peng and Rabe (1996) in citrus. Downey *et al*. (2006) found that girdling enhanced color development, ripening and also had positive effects on anthocyanin content accumulation in the fruits of

Table 2 : Effect of girdling on fruit color values in plum cv. Kala Amritsari.

Treatments	Fruit color (L=brightness)		Fruit color (a* coordinate)		Fruit color (b* coordinate)	
	2022	2023	2022	2023	2022	2023
Control-T_1	25.36	25.78	10.42	10.46	-1.06	-1.05
Girdling at full bloom- T_2	24.46	24.95	9.34	9.98	-1.29	-1.26
Girdling after fruit set- T_3	25.98	26.17	10.83	10.87	-1.08	-1.06
Girdling at pit hardening - T_4	27.07	27.35	11.88	12.16	-0.96	-0.73
Girdling 15 days before harvesting- T_5	26.42	26.60	11.34	11.27	-1.10	-1.09
CD @ 5%	0.67	0.76	0.59	0.44	0.05	0.04

Table 3 : Effect of girdling on pulp weight, pulp, and pulp/stone ratio in plum cv. Kala Amritsari.

Treatments	Pulp weight (g)		Pulp (%)		Pulp/stone ratio	
	2022	2023	2022	2023	2022	2023
Control-T_1	9.44	9.63	92.54	92.50	12.42	12.34
Girdling at full bloom- T_2	8.15	8.32	91.36	91.22	10.58	10.40
Girdling after fruit set- T_3	9.78	9.85	92.87	92.74	13.04	12.79
Girdling at pit hardening stage- T_4	11.58	11.72	94.14	94.06	16.08	15.83
Girdling 15 days before harvesting- T_5	11.13	11.23	93.79	93.73	15.08	14.97
CD @ 5%	**0.55**	**0.67**	**0.42**	**0.44**	**1.10**	**0.92**

grapewine whereas, according to Vangdal *et al*. (2010) that fruits become lighter (L* brightness increases), redder (a* color increases) and bluer (b* color decreases) in plum as they approach technical maturity.

Quality attributes : It was observed that treatment girdling at pit hardening stage and girdling 15 days before harvesting showed higher value of pulp weight, pulp per cent and pulp/stone ratio than treatments control, girdling at full bloom and girdling after fruit set. The maximum pulp weight 11.58 and 11.72 g (Table 3), pulp 94.14 and 94.06 per cent (Table 3) and pulp/stone ratio 16.08 and 15.83 (Table 3) during both the years, respectively was observed in treatment girdling at pit hardening stage *i.e* T_4 followed by treatment girdling 15 days before harvesting *i.e* T_5 and minimum pulp weight, pulp per cent and pulp/stone ratio was observed in treatment girdling at full bloom *i.e* T_2 in year 2022 and 2023, respectively. The significant increase in pulp weight, pulp and pulp/stone ratio in late girdled tree was attributed to more availability of assimilates to the optimum numbers of fruits as a result of which the fruits gained more pulp weight, pulp and pulp/stone ratio. The results obtained are agreement with the findings of Sharma (2011), who reported that limb girdling 21 days after full bloom recorded significant increase in pulp weight and pulp/stone ratio in plum cultivar Satluj Purple. Further Kaur *et al*. (2019) reported that branch girdling with urea @ 0.2 per cent increase the pulp size and pulp/stone ratio in peach cultivar Shan-i-Punjab. Whereas, Beri (2003) found that girdling 28 days after full bloom recorded significant increase in pulp weight and decrease in stone weight in peach cultivar Shan-i-Punjab.

A non-significant result of stone weight was obtained from girdling treatments (Table 4). However, the minimum numeric values of stone weight during both the years was observed in both treatments T_4 and T_5 and maximum stone weight 0.77 and 0.80 g was observed in treatment T_2 in year 2022 and 2023, respectively. It was cleared from the study that treatments girdling at full bloom and control showed higher value of fruit firmness than treatments girdling after fruit set, girdling at pit hardening stage and girdling 15 days before harvesting. Whereas, the maximum fruit firmness during both the years, was observed in treatment girdling at full bloom *i.e* T_2 and minimum 1.37 and 1.44 kg/inch^2 in treatment girdling at pit hardening stage *i.e.*; T_4 (Table 4) followed by treatment girdling 15 days before harvesting *i.e.*; T_5. This may results because girdling at pit hardening and there after contributes to reduction in fruit firmness by increasing fruit size, fruit weight and advancement in fruit maturation (Lata *et al*. 2014). Similarly, Ran *et al*. (2022) revealed that hardness of jujube fruit from non-girdled jujube trees were significantly greater than the corresponding index value of girdled jujube trees.

It may be concluded from the present study that among various girdling treatments, girdling at pit hardening

Table 4 : Effect of girdling on stone weight and fruit firmness in plum cv. Kala Amritsari.

Treatments	Stone weight (g)		Fruit firmness (kg/inch^2)	
	2022	2023	2022	2023
Control-T_1	0.76	0.78	1.54	1.60
Girdling at full bloom- T_2	0.77	0.80	1.97	1.98
Girdling after fruit set- T_3	0.75	0.77	1.46	1.53
Girdling at pit hardening stage- T_4	0.73	0.75	1.37	1.44
Girdling 15 days before harvesting- T_5	0.73	0.75	1.38	1.48
CD @ 5%	**NS**	**NS**	**0.13**	**0.10**

stage significantly increases fruits yield and fruit physical quality attributes *i.e.*; fruit weight, fruit size, pulp per cent, pulp/stone ratio and decreasing fruit firmness followed by girdling 15 days before harvesting over the other remaining girdling treatments. However, girdling at full bloom stage was found inferior to control in all parameters studied.

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