Indian J. Hort. 71(3), September 2014: 335-339

Impact of girdling on quality and maturity of Patharnakh pear

Damandeep Singh, W.S. Dhillon*, N.P. Singh and P.P.S. Gill
Department of Fruit Science, Punjab Agricultural University, Ludhiana 141 004

ABSTRACT

The response of 'Patharnakh' pear to girdling was evaluated on 18-year-old vigorous trees growing under uniform cultural practices. The fruits with best quality characteristics in terms of juice content (58.5%), total soluble solids (11.8°Brix), TSS/acid ratio (42.8) and total sugars (8.86%) with low juice acid (0.27%) contents were observed under sub-limb girdling performed on 15 days after flower initiation (DAFI). Girdling treatments also advanced the fruit maturity over control. In conclusion, sub-limb girdling performed on 15 DAFI was the best in enhancing fruit yield (162.0 kg/tree) compared to control (135.3 kg/tree) and physico-chemical composition of 'Patharnakh' pear under sub-tropics of north India.

Key words: Girdling, pear, fruit development, fruit quality.

INTRODUCTION

Pear is successfully grown in sub-tropics due to availability of low chilling varieties of hard, semi-soft and soft pears. Commercial pear production mainly consists of European pear (*Pyrus communis*), Asian or Oriental pear (*Pyrus pyrifolia*) and their hybrids. In north Indian plains, oriental pears especially cv. Patharnakh is mainly grown. This cultivar is a prolific bearer, fruits are hardy and easily transported to distant markets. The flowers and fruitlets compete strongly with one another and with vegetative growth for photosynthetic metabolites during fruit development phase (Rivas *et al*., 14). For regulation of fruit load, the abscission process initiates when trees are unable to sustain all developing structures during profuse flowering (Agusti *et al*., 1). The production of large sized and good quality fruits is the major objective of pear growers.

The girdling technique is useful in reduction of vegetative growth, improvement of fruit size, weight, yield and enhancement of fruit maturity in various fruit crops like peach (Chanana and Gill, 5), plum (Sharma, 15), apple and pear (Dennis, 6). Although, the girdling experiments have proved beneficial in many fruit crops but the information regarding appropriate time for girdling and the plant part to be girdled is lacking in case of sub-tropical pears. Keeping this in view, the present study was undertaken to study the effect of trunk, limb and sub-limb girdling applied at different stages of growth on maturity and quality of pear cv. Patharnakh.

MATERIALS AND METHODS

The present experiment was conducted at the New Orchard, Department of Fruit Science, Punjab Agricultural University, Ludhiana during the year 2012-13 on 18-year-old uniform and healthy trees of Patharnakh pear planted at 7.5 m × 7.5 m. Throughout the course of study, all the experimental trees received uniform cultural practices. The treatments trunk girdling (T_1), limb girdling (T_2) and sub-limb girdling (T_3) were applied at three different stages, *viz*., flower initiation (S_1), 15 days after flower initiation (DAFI) (S_2) and 30 days after flower initiation (S_3). Each treatment and stage combination was replicated four times. The girdling treatments were performed with girdling knife of 4 mm thickness. Further, the fruits from treated and untreated (control) plants were used to analyze various physico-chemical characteristics.

The fruit size (length and diameter) was recorded with the help of Vernier callipers. Fruit weight was determined by randomly selecting and weighing 10 fruits from each replication at the time of harvest. Penetrometer of 8 mm thickness was used to record fruit firmness. The colour of fruits was measured with colour difference meter (Colour Flex, Hunter Lab, USA). The hunter scale 'L' measures lightness and varies from zero for black to 100 for perfect white. The chromaticity coordinates 'a' measures redness when +ve, greenness when -ve, and 'b' measures yellowness when +ve and blueness when -ve. Among various quality parameters, TSS was recorded with the help of hand refractometer at room temperature (20°C) and acidity was determined as per standard method. Total, reducing and non-reducing sugars were estimated using the method as suggested by Lane and Eynon (AOAC, 2). The data recorded during this study was analyzed using computer software SAS 9.3.

*Corresponding author's E-mail: wasakhasingh@yahoo.com
**Punjab Horticultural Post-Harvest Technology Centre, PAU campus, Ludhiana

RESULTS AND DISCUSSION

The fruit retention was improved significantly by all the girdling treatments and was maximum (44.8%) in T_3 (sub-limb girdling) followed by 36.8% in T_1 (trunk girdling), however, the fruit set (45.1%) was better only in trunk girdling (Table 1). The fruit set is quantitatively correlated with the carbohydrate availability (Goldschmidt and Huber, 8), which increased after girdling. The increase in fruit retention may be due to increase of auxins in girdled portion because of their reduced basipetal movement (Looney, 11). These results corroborate the earlier findings of Chanana and Gill (5) who also reported an increase of fruit set in apples as a result of branch ringing.

Fruit size (length and breadth) was also improved significantly by girdling treatments as compared to the control (Table 2). Maximum (7.02 and 7.10 cm, respectively) fruit size was recorded in sub-limb girdling followed by 6.89 cm (L) and 6.98 cm (B) in T_1 and minimum (6.47 and 6.51 cm) in the control. However, fruit length in T_1 was statistically at par with T_2 (6.76 cm) and T_3 (7.02 cm). Among various girdling stages, maximum fruit length and breadth (6.88 and 6.92 cm, respectively) was recorded in S_2 (15 DAFI) followed by S_1 (FI) (6.77 and 6.85 cm) and minimum (6.70 and 6.80 cm) in S_3 (30 DAFI). Similarly, the fruit weight and yield were also increased with various girdling treatments. Maximum fruit weight of 145.2 g was found in SLG (T_3) followed by 140.8 g in TG (T_1) and 138.5 g in T_2, while minimum 136.2 g in control plants. The highest significant improvement in fruit weight (141.8 g) was noted at 15 DAFI as compared to 139.9 g at 30 DAFI stage and 138.8 g at FI. The interactions between various treatments and stages were statistically significant with each other, except T_3S_2 and T_3S_3 being the highest (149.5 g) in T_3S_2 and the lowest (135.8 g) in T_4S_1. Significantly, highest average fruit yield to the tune of 154.0 kg/tree was recorded in sub-limb girdling (SLG) followed by 145.3 kg/tree yield in trunk girdling (TG), 139.9 kg/tree in limb girdling (LG) and lowest in the control plants (C) with the value of 135.3 kg/tree. Among various stages, higher yield of 146.3 kg/tree was observed at 15 DAFI (S_2) followed by FI (S_1) (142.8 kg/tree) and 30 DAFI (S_3) (141.7 kg/tree), however, S_1 and S_3 were statistically non-significant with each other. The interactions between various treatments and stages were also significant, being maximum of 162.0 kg/tree followed by 154.8 kg/tree in sub-limb girdling treatment performed on 15 and 30 DAFI, respectively. This improvement in fruit size and weight was due to more availability of photo-assimilates towards the developing fruits after girdling and subsequently yield

Table 1. Effect of girdling on fruit set and retention of pear cv. Patharnakh.

Treatment	Fruit set (%)	Fruit retention (%)			
	Stage	Stage			Mean
	S_1	S_1	S_2	S_3	
T_1 (TG)	45.1[a]	38.6	36.9	35.0	36.8[c]
T_2 (LG)	34.0[b]	34.7	32.5	30.2	32.5[b]
T_3 (SLG)	33.1[b]	46.3	44.9	43.1	44.8[a]
T_4 (C)	43.0[a]	29.3	29.3	29.0	29.2[d]
Mean	38.8	37.2[a]	35.9[b]	34.3[c]	
LSD (P ≤ 0.05)					
Treatment (T)	2.38	1.05			
Stage (S)		0.91			
T × S		NS			

T_1 = Trunk girdling, T_2 = Limb girdling, T_3 = Sub-limb girdling, T_4 = Control

Table 2. Effect of girdling on fruit size, weight, and yield of pear cv. Patharnakh.

Treatment	Length (cm)				Breadth (cm)				Weight (g)				Yield (kg/tree)			
	Stage			Mean	Stage			Mean	Stage			Mean	Stage			Mean
	S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
T_1 (TG)	7.01	6.98	6.67	6.89[ab]	7.15	7.00	6.80	6.98[b]	142.3	141.5	138.8	140.8[b]	149.7	145.1	141.0	145.3[b]
T_2 (LG)	6.73	6.90	6.64	6.76[b]	6.83	6.97	6.75	6.85[c]	138.0	139.8	137.7	138.5[c]	140.9	142.9	136.0	139.9[c]
T_3 (SLG)	6.88	7.11	7.08	7.02[a]	6.96	7.26	7.10	7.10[a]	139.3	149.5	146.8	145.2[a]	145.1	162.0	154.8	154.0[a]
T_4 (C)	6.47	6.55	6.39	6.47[c]	6.48	6.47	6.58	6.51[d]	135.8	136.3	136.5	136.2[d]	135.5	135.4	135.2	135.3[d]
Mean	6.77[b]	6.88[a]	6.70[c]		6.85[b]	6.92[a]	6.80[c]		138.8[c]	141.8[a]	139.9[b]		142.8[b]	146.3[a]	141.7[b]	
LSD (P ≤ 0.05)																
Treatment (T)	0.15				0.08				1.32				1.60			
Stage (S)	0.06				0.04				1.07				1.13			
T × S	NS				0.13				3.31				2.77			

was more due to higher fruit weight and less fruit drop. Our results are in line with those obtained by Meintjes *et al.* (12). An increase in fruit weight with various girdling treatments was also observed in apple cv. Red Boskoo (Poniedziaek *et al.*, 13).

The firmness and colour of fruits were also got improved with girdling treatments (Table 3). Minimum fruit firmness (15.3 lbs/cm^2) was observed in LG (T_2) followed by 15.4 lbs/cm^2 in T_3 (SLG) and maximum in the control (C) (16.1 lbs/cm^2). Girding performed at different stages did not show any significant effect on fruit firmness. The ideal fruit firmness of 'Patharnakh' at ripening is reported to be between 13 to 15 lbs/ cm^2 (Dhillon *et al.*, 7). The maximum values of 'L' (57.3) and 'b' (27.0) in 'Patharnakh' fruits were recorded in limb girdling (T_2) followed by T_3 (sub-limb) ('L' = 57.0 and 'b' = 26.7) and the control plants showed minimum "L" and "b" values of 55.0 and 25.5, respectively. The values of '-a' and '+a' indicate greenness and redness, respectively and these were also statistically non-significant between different girdling treatments, being maximum in T_2 followed by T_3, T_1 and T_4. The effect of different girdling treatments performed at various stages on 'L', 'a' and 'b' values were non-significant. The fruit colour changes are related to chlorophyll content degradation and development of anthocyanin and carotenoids (Kumar, 10). The colour development affected by girdling treatments might be due to carbohydrate accumulation above the girdled portion which acts as a precursor for coloured pigments. Kumar (10) reported that fruit firmness is negatively correlated to fruit weight and size.

Physico-chemical characters of fruits revealed that total soluble solids were significantly higher and acidity was significantly lesser in fruits under girdling treatments. Maximum TSS to the tune of 11.8^{0}Brix was observed in T_3 (sub-limb girdling) followed by T_1 (11.6%) (trunk girdling) and minimum of 11.0% in the control (T_4). Treatments, *viz*. T_1, T_2 and T_3 were at par with each other but all these were significantly different from the control (T_4) except T_2. Various girdling treatments performed at different stages showed significantly highest TSS (11.6%) was recorded for S_2 followed by 11.4 and 11.3% at stages S_1 and S_3, respectively. The improvement in fruit TSS content might be due to availability of more carbohydrates that gets accumulated above the girdle portion as a result of reduction in movement of metabolites to the roots (Arakawa *et al.*, 3). They also reported a significant increase in TSS content in apple fruits as a result of girdling. Significantly lowest (0.27%) average juice acidity was recorded in T_3 (SLG) followed by T_1 and T_2 (0.28 and 0.29%, respectively) as compared to maximum (0.33%) in the control, whereas T_1, T_2 and T_3 were statistically at par with each other. More TSS

Table 3. Effect of girdling on fruit firmness and colour of pear cv. Patharnakh.

Treatment	Firmness (lbs/ cm^2)				Colour											
					L*				a**				b***			
	Stage			Mean	Stage			Mean	Stage			Mean	Stage			Mean
	S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
T_1 (TG)	16.1	15.5	15.5	15.7^{bc}	55.4	55.4	55.4	55.4	-0.79	-0.30	-0.63	-0.57	25.8	25.9	25.9	25.9^{bc}
T_2 (LG)	15.4	15.2	15.3	15.3^{a}	56.8	57.6	57.5	57.3	-0.04	0.08	0.05	0.03	26.8	27.1	26.9	27.0^{a}
T_3 (SLG)	15.5	15.3	15.3	15.4^{ab}	56.5	57.1	57.2	57.0	0.07	-0.74	0.12	-0.18	26.2	26.9	26.9	26.7^{ab}
T_4 (C)	16.1	16.1	16.1	16.1^{c}	55.2	54.8	55.1	55.0	-1.01	-0.44	-1.05	-0.83	25.7	25.3	25.5	25.5^{c}
Mean	15.8	15.5	15.6		56.0	56.8	56.3		-0.44	-0.35	-0.37		26.1	26.3	26.3	
LSD (P ≤ 0.05)																
Treatment (T)		0.64				NS				NS				0.99		
Stage (S)		NS				NS				NS				NS		
T × S		NS				NS				NS				NS		

L* = Lightness (black to white), a** (a+ for redness, a- for greenness), b*** (b+ for yellowness, b- for blueness)

and less acid content led to higher TSS/acid ratio of fruits under girdling (Table 4). The significantly higher juice TSS/acid ratio (42.8) was recorded in T_3 (SLG) followed by 40.6 in T_1 (TG), T_2 (38.0) as compared to 33.5 in the control, whereas, T_1 was statistically at par with T_2 and T_3. The stages, *viz*. FI, 15 and 30 DAFI were statistically non-significant with maximum ratio of 40.9 recorded at 15 DAFI, *i.e.* S_2 followed by 38.0 and 37.3 at FI and 30 DAFI, respectively. Similar results were also observed by Kumar (10) in peach.

Maximum juice per cent was observed in the control (Table 4) when girdling was performed during stages S_1, S_2 and S_3 (FI, 15 and 30 DAFI, respectively). Highest juice content (58.5%) was recorded in SLG followed by 57.0 per cent in TG and minimum in LG (56.4%), whereas, S_1 and S_2 were at par with each other but significantly differed from S_3. The interactions were statistically non-significant when various girdling treatments were applied at different stages. The reduction in juice content was due to more increase in fruit pulp content as compared to fruit juice weight.

The total and non-reducing sugars got significantly improved with girdling treatments being maximum (9.15% total sugars) in sub-limb girdling followed by 8.75% in trunk girdling (T_1) and minimum (8.44%) in the control (T_4). Treatments T_1 and T_2 were at par with each other but were statistically different from T_3 and the control. Trees girdled at stage 15 DAFI had significantly maximum sugars content (8.86%) as compared to other two stages (8.67% in FI and 8.70% in 30 DAFI), though, S_1 and S_3 were at par with each other. Although the effect of girdling treatments on reducing sugars was non-significant, however, trees under sub-limb girdling (SLG) resulted in the highest (5.17%) content and the lowest (5.12%) in the control. Significantly higher (3.79%) non-reducing sugars were observed in SLG followed by 3.44 per cent in TG. The stages, *viz*. S_1, S_2 and S_3 were critically different from each other and maximum value of 3.50% was noted at stage 15 DAFI and least (3.38%) at 30 DAFI (S_3) (Table 4). Similar results about increase of sucrose content as a result of girdling were also reported by Rivas *et al.* (14) in citrus fruits.

The fruit maturity was observed to advance significantly by all the girdling treatments (Table 5) and the fruits under limb girdling showed maximum advancement which mature 12 days earlier than control, followed by 10 days in sub-limb girdling (fruits matured within 138.9 days). Girdling treatments performed at different time periods, *i.e.* at FI, 15 and 30 DAFI also advanced fruit maturity days counted from full bloom to physiological maturity. Maximum advancement of maturity in S_3 was 141.7 days followed by S_2 (142.4 days). The results were significant during interactions between different treatments and stages with maximum earliness of 13 days in T_2S_2 followed by 12 days in T_2S_3. The earliness in maturity may be attributed to the faster accumulation of photosynthetic assimilates for the development of fruits (Chanana and Beri, 4) and higher ethylene production by the plant in response to injuries caused by girdling.

From the experiment, it can be concluded that the sub-limb girdling performed at 15 days after flower initiation proved beneficial in improving yield, fruit quality and advancing fruit maturity in Patharnakh pear.

REFERENCES

1. Agusti, M., Garcia-mari, F. and Guardiola, J.L. 1982. The influence of flowering intensity on the shedding of reproductive structures in sweet orange. *Scientia Hort.* **17**: 343-52.

Table 4. Effect of girdling on fruit firmness, colour, TSS, acidity and TSS/acid ratio of pear cv. Patharnakh.

Treatment	Juice (%)				TSS (%)				Acidity (%)				TSS/ acid ratio			
	Stage			Mean	Stage			Mean	Stage			Mean	Stage			Mean
	S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
T_1 (TG)	58.4	57.8	54.8	57.0^{bc}	11.7	11.7	11.4	11.6^{ab}	0.27	0.28	0.31	0.28^{ab}	43.4	41.7	36.6	40.6^{ab}
T_2 (LG)	56.9	57.7	54.6	56.4^{c}	11.4	11.6	11.1	11.4^{abc}	0.30	0.28	0.32	0.29^{abc}	38.1	41.3	34.8	38.0^{b}
T_3 (SLG)	57.5	59.1	59.0	58.5^{b}	11.5	12.0	11.9	11.8^{ab}	0.30	0.26	0.27	0.27^{a}	38.2	46.2	44.0	42.8^{a}
T_4 (C)	61.4	61.8	60.1	61.1^{a}	11.0	11.1	10.8	11.0^{c}	0.34	0.32	0.32	0.33^{c}	32.2	34.6	33.8	33.5^{c}
Mean	58.5^{a}	59.1^{a}	57.1^{b}		11.4^{b}	11.6^{a}	11.3^{c}		0.30	0.28	0.30		38.0	40.9	37.3	
LSD ($P \leq 0.05$)																
Treatment (T)	1.51				0.40				0.04				3.55			
Stage (S)	1.31				0.08				NS				NS			
T × S	NS				NS				NS				NS			

Table 5. Effect of girdling on fruit juice total, reducing, non-reducing sugars and maturity of pear cv. Patharnakh.

Treatment	Total sugars (%)				Reducing sugars (%)				Non-reducing sugars (%)				Maturity (days)			
	Stage			Mean	Stage			Mean	Stage			Mean	Stage			Mean
	S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
T_1 (TG)	8.86	8.82	8.59	8.75^{bc}	5.09	5.2	5.11	5.13	3.58	3.44	3.31	3.44^{b}	146.0	144.5	141.4	143.9^{c}
T_2 (LG)	8.69	8.70	8.51	8.63^{c}	5.19	5.12	5.12	5.14	3.33	3.40	3.22	3.32^{bc}	138.2	136.1	137.0	137.1^{a}
T_3 (SLG)	8.70	9.55	9.23	9.15^{a}	5.02	5.26	5.23	5.17	3.50	4.08	3.80	3.79^{a}	140.3	140.0	139.5	138.9^{b}
T_4 (C)	8.43	8.37	8.50	8.44^{d}	5.11	5.11	5.15	5.12	3.15	3.09	3.18	3.14^{c}	148.8	149.1	149.0	149.0^{d}
Mean	8.67^{b}	8.86^{a}	8.70^{b}		5.08^{b}	5.15^{a}	5.15^{a}		3.39^{b}	3.50^{a}	3.38^{b}		143.3^{b}	142.4^{ab}	141.7^{a}	
LSD (P ≤ 0.05)																
Treatment (T)	0.16				NS				0.24				0.92			
Stage (S)	0.05				0.02				0.07				0.80			
T × S	NS				NS				NS				1.60			

2. A.O.A.C. 1990. *Official and Tentative Methods of Analysis* (15th edn.), Washington DC, USA.

3. Arakawa, O., Kanno, K., Kanetsuka, A. and Shiozaki, Y. 1997. Effects of girdling and bark inversion on tree growth and fruit quality of apple. *Acta Hort.* **451**: 579-86.

4. Chanana, Y.R. and Beri, S. 2004. Studies on the improvement of fruit quality of subtropical peaches through girdling and thinning. *Acta Hort.* **662**: 345-51.

5. Chanana, Y.R. and Gill, K.S. 2006. Impact of girdling, thinning and their combination on quality and maturity in Florda Prince peach. *Indian J. Hort.* **63**: 27-30.

6. Dennis, F.G.Jr. 1968. Growth and flowering responses of apple and pear seedlings to growth retardants and scoring. *J American Soc. Hort. Sci.* **93**: 56-61.

7. Dhillon, W.S., Mahajan, B.V.C., Dhatt, A.S. and Sandhu, A.S. 2005. Studies on ripening of pear cv. “Patharnakh”. *Haryana J. Hort. Sci.* **34**: 256-58.

8. Goldschmidt, E.E. and Huber, S.C. 1992. Regulation of photosynthesis by end-product accumulation in leaves of plants storing starch, sucrose and hexose sugars. *Pl. Physiol.* **99**: 1443-48.

9. Kumar, B. 2007. Effect of trunk and limb girdling on maturity, yield and fruit quality of peach. M.Sc. thesis, Punjab Agricultural University, Ludhiana.

10. Kumar, N. 1999. Effect of time of thinning on maturity, yield and fruit quality of Florda Prince peach (*Prunus persica* Batsch.). M.Sc. thesis, Punjab Agricultural University, Ludhiana.

11. Looney, N.E. 1998. Plant bio-regulators in fruit production: An overview and outlook. *J. Korean Soc. Hort. Sci.* **39**: 125-28.

12. Meintjes, J.J., Stassen, P. and Theron, K.I. 2005. The effect of different rates of prohexadione calcium and girdling on shoot growth and fruit quality when applied to different pear cultivars. *Acta Hort.* **671**: 539-46.

13. Poniedziaek, W., Porebski, S. and Rzeznicka, B. 2001. Influence of girdling on growth and fruiting of ‘Red Boskoop’ apple trees. *Zeszyty Naukowe Instytutu Sadowanictwa I Kuiaciarstwa W Skierniewicach.* **9**: 43-47.

14. Rivas, F., Erner, Y., Alos, E., Juan, M., Almela, V. and Agusti, M. 2006. Girdling increases carbohydrate availability and fruit set in citrus cultivars irrespective of parthenocarpic ability. *J. Hort. Sci. Biotech.* **81**: 289-95.

15. Sharma, N. 2011. Studies on improvement of fruit quality through girdling and thinning in Satluj purple plum. M.Sc. thesis, Punjab Agricultural University, Ludhiana.

Received: August, 2013; Revised: June, 2014;
Accepted: July, 2014