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Effect of girdling on leaf nutrient levels in pear cultivars Patharnakh and Punjab Beauty

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ABSTRACT

The response of hard and semi-soft pear cultivars Patharnakh and Punjab Beauty, respectively to girdling was evaluated on 18-year-old vigorous plants growing under uniform cultural practices. Girdling was practiced on trunk (TG), limb (LG) and sub-limb (SLG) during flower initiation (FI), 15 days after flower initiation (15 DAFI) and 30 days after flower initiation (30 DAFI). Foliar leaf nitrogen and potassium levels in both the cultivars were significantly reduced with girdling treatments. However, foliar calcium level was significantly enhanced up to 3.93% in Patharnakh and 3.62% in Punjab Beauty, whereas, phosphorus and magnesium levels were not significantly influenced with girdling in both the cultivars. Among micro-nutrients; iron, zinc and copper contents were recorded significantly higher in girdled trees, however, manganese content was reduced significantly in both the cultivars.

Key words: Girdling, pear, vegetative growth, nutrient content.

INTRODUCTION

Pear is an important pome fruit successfully grown under sub-tropical conditions due to the availability of low chilling varieties. The pear cultivars belong to three categories i.e. European, Asian and their hybrids (Sharma and Singh, 10). Asian pears are native to China and Japan, and are grown in various Asian countries, while European pears belong to Occidental group and have typical pear shape, soft fleshed fruits with inconspicuous gritty cells (Sharma *et al.*, 11). In India, pears are grown mainly in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Tamil Nadu, Sikkim and Chhattisgarh. A hard pear cultivar Patharnakh (*Pyrus pyrifolia* L.) and a semi-soft pear cultivar Punjab Beauty (*Pyrus communis* L.) is grown predominantly in north Indian plains and usually considered more adaptable to diverse agro-climatic conditions. Being low chilling varieties, these can also withstand high temperature during summer.

The production of good size fruits with advanced maturity and good keeping quality are the main researchable issues in pear. Several methods had been tried to improve the fruit quality in various fruit crops. Among them, girdling is considered one of the best horti-agro-techniques to alter the source sink relation to improve the fruit quality. Source-sink modification in plants leads to a better understanding of the mechanisms controlling photosynthesis and dry-matter accumulation, and their allocation in the plant system. The girdling techniques employed throughout the world are helpful to reduce vegetative growth, promote flowering and fruit set, improve size, weight and advance fruit maturity. This has been well documented in various fruit crops like olive, apple, pear, peach and nectarines. Starch accumulation occurs in source leaves after sink removal and girdling. Girdling alters assimilate partitioning in fruit crops towards developing fruits and reduces vegetative growth and hence also alters the nutritional status of vegetative portion (Chalmers, 3). This altered partitioning does not cause assimilate shortage, however, reduces vegetative sink strength or competitive ability. To determine the affect of girdling on dry matter constituents of vegetative growth, this study was planned on two pear cultivars, *i.e.* Patharnakh and Punjab Beauty.

MATERIALS AND METHODS

To determine the effect of inhibiting phloem transport on nutritional status of leaves, girdling treatments were applied to the trunks, limbs and sub-limbs of both Patharnakh and Punjab Beauty pear cultivars. The investigation was carried out at Fruit Research Farm, Department of Fruit Science, Punjab Agricultural University, Ludhiana on 18-year-old uniform and healthy trees of Patharnakh and Punjab Beauty growing at a distance of 7.5 m × 7.5 m and 6 m × 6 m, respectively. During the course of study, all the trees received uniform cultural practices. The treatments trunk girdling (T_1), limb girdling (T_2) and

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sub-limb girdling (T_3) were applied at three stages, *viz.* flower initiation (S_1), 15 days after flower initiation (S_2) and 30 days after flower initiation (S_3). Each treatment cum stage combination was replicated four times and the experiment was laid out by factorial randomized block design. The girdling knife of 4 mm thickness was used to girdle the complete girth by removing the bark part including phloem but does not hurt the cambium. Further, the leaves from treated and untreated (control) plants were analyzed for various foliar elements.

For macro- and micro-nutrients estimation, from each tree 100 leaves were collected from the middle part of current year shoots in the month of August. Then the leaves were thoroughly washed in laboratory with distilled water, 0.1N HCl and again with double-distilled water to remove dust particles, contaminants, etc and were dried by spreading on blotting paper sheets. After drying, the leaves were kept in perforated paper bags and dried in hot-air oven at 65°C for 48 h. Then a stainless steel Willy Mill was used to grind the dried leaves and the grounded material was stored in moisture proof butter paper bags for analysis. Before elemental analysis, the samples were again dried at 65°C for two hours.

The nitrogen estimation was carried out using Kel Plus Nitrogen Estimation System. For the estimation of phosphorus, Vanado-molybdo phosphoric yellow colour method as described by Chapman and Pratt (4) was followed. The potassium content was determined by the flame photometer method (AOAC, 1).The total amount of micro-nutrients in the leaf samples was estimated by atomic absorption spectrophotometer (AA Analyst 200) (Perkin Elmer Pvt. Ltd.). The analysis of data recorded during this study was done using computer software SAS 9.3 (SAS Institute, Inc; Cary, NC, USA).

RESULTS AND DISCUSSION

The girdling treatments reduced leaf nitrogen per cent in both the cultivars (Table 1). In Patharnakh, significantly lowest leaf N (1.44%) was recorded in T_3 (SLG) as compared to 1.53 per cent in T_1 (TG) and 1.68 per cent in the control (C). The leaf samples taken from trees girdled on 15th day after flower initiation (15 DAFI) had significantly higher leaf N content (1.68%) in control, followed by 1.58 per cent in LG, 1.53 per cent in TG and minimum (1.44%) in SLG. At flower initiation stage (FI), minimum leaf N was noted in TG and maximum in control. The interaction between treatments and stages were significant with minimum values in T_3S_2. In Punjab Beauty, significantly lower leaf N (1.98%) level was observed in limb girdling followed by sub-limb girdling (2.02%) and maximum in un-girdled plants, however, T_2 (LG) was at par with T_3 (SLG) treatments. Girdling performed at stage (S_2) significantly lowered leaf N content, whereas, stages S_1 and S_3 were statistically at par with each other. At FI stage, LG treatments resulted in lowest leaf N, followed by trunk and sub-limb girdling treatments. On the other hand, SLG treatments performed on 15 DAFI and 30 DAFI stages have recorded the lowest leaf N contents of 1.94 and 2.02 per cent, respectively. However, the leaf-N content significantly increased at S_3 over S_2 stage in both the cultivars. This might have happened due to delayed girdling practiced on the trees. The interactions among various treatments and stages showed significantly lower N level in girdling

Table 1. Effect of girdling on nitrogen and phosphorus content in leaves of pear.

Treatment	Nitrogen (%)								Phosphorus (%)							
	Patharnakh				Punjab Beauty				Patharnakh				Punjab Beauty			
	Stage			Mean	Stage			Mean	Stage			Mean	Stages			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)	1.46	1.50	1.63	1.53^b	2.10	1.96	2.24	2.09^b	0.17	0.15	0.24	0.19	0.18	0.17	0.21	0.19
T_2 (LG)	1.58	1.53	1.65	1.58^c	1.99	1.95	2.02	1.98^a	0.22	0.19	0.23	0.21	0.17	0.18	0.19	0.18
T_3 (SLG)	1.54	1.32	1.45	1.44^a	2.12	1.94	2.02	2.02^a	0.25	0.21	0.20	0.22	0.15	0.16	0.16	0.16
T_4 (C)	1.68	1.67	1.69	1.68^d	2.21	2.21	2.19	2.20^c	0.19	0.22	0.21	0.21	0.17	0.20	0.18	0.18
Mean	1.56^b	1.50^a	1.60^c		2.10^b	2.02^a	2.12^b		0.21	0.19	0.22		0.17	0.18	0.19	
LSD ($P \le 0.05$)																
Treatment (T)		0.04				0.05				NS				NS		
Stage (S)		0.03				0.04				NS				NS		
T × S		0.07				0.08				NS				NS		

TG = Trunk girdling, LG = Limb girdling, SLG = Sub-limb girdling, C = Control, S_1 = Flower initiation, S_2 = 15 days after flower initiation, S_3 = 30 days after flower initiation and NS = Non significant treatments as compared to control being minimum in T_3S_2 (sub-limb girdling at 15 DAFI). This decrease in leaf nitrogen content might be due to more demand for assimilates or photosynthates by the developing fruits under various girdling treatments over the control as observed in avocado by Davie *et al.* (5), peach (Day and Dejong, 6) and mango (Urban *et al*., 13).

The perusal of data in respect to leaf P content depict that un-girdled pear trees in both the cultivars had the least leaf-P content as compared to girdled trees but the results were statistically non-significant (Table 1). The sub-limb girdling treatment performed in Patharnakh had shown maximum (0.22%) leaf-P content closely followed by 0.21 per cent in both limb girdling and control treatments, and minimum in trunk girdling. There was no significant effect of girdling stages on leaf-P content, however, highest leaf-P content was observed at stage S_3 followed by S_1 and S_2. At FI stage, trees under SLG treatment had the highest (0.25%) leaf-P content, whereas at stages S_2 and S_3, the control and trunk girdled trees had maximum leaf-P values (0.22 and 0.24%, respectively). The interactions for leaf P were non-significant and the highest values were obtained in sub-limb girdling at FI stage, followed by T_1S_3. In Punjab Beauty, leaf-P content was more in girdling treatments except T_3 being highest in T_1 (0.19%), followed by 0.18 per cent in both T_2 and T_4 treatments. The results obtained on the effect of different girdling stages had shown non-significant results. The interactions between T × S were also non-significant. The observations of Schechter *et al.* (9) who reported a slight increase in leaf-P content but non-significantly due to girdling in apple trees are in line with the present findings.

The leaf-K content due to various girdling treatments was decreased significantly in both the cultivars (Table 2). In Patharnakh, minimum leaf-K content (1.10%) was observed under limb girdling, followed by sub-limb girdling and maximum (1.18%) in control. However, T_4 (1.18%) was statistically at par with T_1 (1.15%) and T_3 (1.11%). The observations under different girdling stages were statistically non-significant. Similarly, the interactions among T and S were also non-significant. The Punjab Beauty trees under sub-limb girdling treatment had significantly lowest leaf-K content, followed by limb girdling and maximum in control. In comparison to control, the treatments T_1, T_2 and T_3 had significantly lower leaf-K; however T_1 was at par with T_2. Among FI, 15 DAFI and 30 DAFI stages, S_1 recorded minimum-K level that was at par with S_3 (1.10%) but both S_1 and S_3 were significantly different from S_2. However, T × S interactions were non-significant. Similarly, Vaio *et al.* (14) reported a significant decrease in leaf-K content in peach due to girdling. A decrease in leaf potassium content was also reported (Allan *et al.*, 2) when girdling was done before stone hardening in peach cv. Florda Prince.

The girdling treatments significantly improved the leaf-Ca levels in both the cultivars (Table 2). The Ca in Patharnakh leaves had shown significantly higher content in limb girdling, followed by sub-limb girdling, and minimum in control. Girdling performed at various stages showed significant results being maximum leaf-Ca at 15 DAFI and minimum in FI. The FI and 30 DAFI stages had followed the same trend. The interaction between treatments and stages recorded significantly higher leaf-Ca to the tune of 3.93 per cent in T_2S_2, followed by 3.91 per cent in T_2S_3

Table 2. Effect of girdling on potassium and calcium content in leaves of pear.

Treatment	Potassium (%)								Calcium (%)							
	Patharnakh				Punjab Beauty				Patharnakh				Punjab Beauty			
	Stage			Mean	Stage			Mean	Stage			Mean	Stages			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)	1.18	1.13	1.15	1.15[a]	1.03	1.13	1.13	1.09[b]	3.32	3.41	3.87	3.53[b]	3.19	2.79	3.07	3.02[b]
T_2 (LG)	1.11	1.05	1.13	1.10[a]	0.98	1.25	0.98	1.07[b]	3.90	3.93	3.91	3.92[d]	3.54	2.69	3.13	3.12[c]
T_3 (SLG)	1.13	1.10	1.10	1.11[a]	0.95	1.05	0.97	0.99[a]	3.26	3.81	3.70	3.59[c]	3.21	3.18	3.62	3.34[d]
T_4 (C)	1.18	1.18	1.20	1.18[b]	1.28	1.33	1.34	1.32[c]	2.19	3.59	3.02	2.93[a]	1.89	1.90	1.90	1.90[a]
Mean	1.15	1.11	1.14		1.06[a]	1.19[b]	1.10[a]		3.17[a]	3.68[c]	3.62[b]		2.96[b]	2.64[a]	2.93[b]	
LSD ($P \leq 0.05$)																
Treatment (T)	0.07				0.07				0.05				0.07			
Stage (S)	NS				0.06				0.04				0.06			
T × S	NS				NS				0.09				0.12			

as compared to minimum (2.19%) in T_4S_1. The sub-limb girdling treatments in Punjab Beauty recorded significantly highest leaf-Ca content, followed by limb girdling and lowest in control. Flower initiation stage was seen to have maximum Ca content in leaves, which was at par with 30 DAFI and minimum at 15 DAFI stage. Leaf-Ca content was found maximum in LG within S_1 stage and in SLG within both S_2 and S_3 stages. Among all T × S interactions, significantly highest leaf-Ca content was noted in T_3S_3 that was at par with T_2S_1. Contrary to this, earlier studies in apple (Priestly, 8) and in avocado (Davie *et al.*, 5) reported reduced level of leaf-Ca with girdling.

The results pertaining to leaf-Mg content were variable as compared to control in both the cultivars (Table 3). However, the results were non-significant. Among girdling treatments, the lowest mean leaf-Mg content was recorded in sub-limb. But, among the stages, girdling at stage 2 and stage 3 resulted in minimum mean Mg content in leaves of Patharnakh as well as Punjab Beauty cultivars. Similarly, the results obtained in peach trees by Vaio *et al.,* (13) also showed a decrease in leaf-Mg content due to girdling. Significantly highest leaf-Fe content was observed in limb girdling, followed by trunk girdling and minimum in control in Patharnakh (Table 3). The results among S_1, S_2 and S_3 stages were also significant and maximum Fe was recorded at 30 DAFI and minimum at 15 DAFI. Higher leaf iron content to the tune of 91.73, 86.80 and 98.47 ppm was estimated in LG treatments under S_1, S_2 and S_3, respectively and minimum in their respective controls. The interaction T_2S_3 showed significantly highest leaf-Fe, followed by T_1S_3 among all the interactions between girdling treatments and stages. In Punjab Beauty plants, trunk girdling resulted in higher mean Fe content that was at par with sub-limb girdling and lowest in un-girdled plants. Various treatments applied at different stages, *viz.* S_1, S_2 and S_3 were also significant and recorded maximum iron in S_3 (30 DAFI) and minimum in S_2 (15 DAFI). Under stages FI, 15 DAFI and 30 DAFI, maximum leaf-Fe content of 92.85, 85.90 and 97.10 ppm was observed in TG (T_1), LG (T_2) and SLG (T_3), respectively. Among interactions, T_3S_3 had highest level of iron, followed by T_2S_3 and minimum in control. Also higher content of leaf-Fe was recorded in leaves of girdled limbs of apple trees over control (Schechter *et al.*, 9).

The level of leaf-Zn increased with girdling treatments (Table 4) in both the cultivars. The leaves of cultivar Patharnakh showed highest Zn content under sub-limb girdling treatment, followed by trunk girdling and significantly lowest in un-girdled plants. Various stages of girdling and their interaction with girdling treatments were non-significant. In Punjab Beauty pear, significantly highest Zn content was recorded in TG, followed by SLG and minimum in control trees. However, the results were at par in limb (24.93 ppm) and sub-limb (25.48 ppm) girdling treatments. The T × S interaction was also significant with maximum leaf-Zn content (30.00 ppm) in T_1S_2, followed by 28.05 ppm in T_1S_3 and minimum (22.11 ppm) in T_4S_1. Present results are in accordance with the findings of Schechter *et al.* (9), who reported improvement in leaf-Zn content as a result of girdling in leaves of apple.

The girdling treatments significantly reduced the Mn content in leaves in both the cultivars (Table 4). Significantly lowest level of leaf-Mn content was recorded in sub-limb girdling, followed by limb girdling and maximum in control in Patharnakh pear trees. Among the girdling stages minimum leaf-Mn

Table 3. Effect of girdling on magnesium and iron content in leaves of pear.

Treatment	Magnesium (ppm)								Iron (ppm)							
	Patharnakh				Punjab Beauty				Patharnakh				Punjab Beauty			
	Stage			Mean	Stage			Mean	Stage			Mean	Stages			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)	0.46	0.19	0.42	0.36	0.39	0.38	0.40	0.38	85.25	85.33	92.35	87.64^c	92.85	84.45	91.95	89.75^c
T_2 (LG)	0.38	0.29	0.38	0.35	0.36	0.37	0.40	0.37	91.73	86.80	98.47	92.33^d	80.95	85.90	94.73	87.19^b
T_3 (SLG)	0.28	0.31	0.34	0.31	0.37	0.37	0.33	0.35	88.30	84.13	84.35	85.59^b	84.75	82.00	97.10	87.95^b
T_4 (C)	0.38	0.38	0.37	0.38	0.40	0.41	0.38	0.40	84.05	83.99	84.11	84.05^a	68.70	67.69	70.04	68.81^a
Mean	0.37	0.29	0.38		0.38	0.38	0.37		87.33^b	85.06^a	89.82^c		81.81^b	79.90^a	88.45^c	
LSD ($P \leq 0.05$)																
Treatment (T)		NS				NS				0.81				1.47		
Stage (S)		NS				NS				0.70				1.28		
T × S		NS				NS				1.41				2.55		

Table 4. Effect of girdling on zinc and manganese content in leaves of pear.

Treatment	Zinc (ppm)								Manganese (ppm)							
	Patharnakh				Punjab Beauty				Patharnakh				Punjab Beauty			
	Stage			Mean	Stage			Mean	Stage			Mean	Stages			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)	28.53	28.80	28.50	28.61[b]	25.00	30.00	28.05	27.68[c]	38.60	40.70	33.80	37.70[c]	69.50	55.93	54.95	60.12[b]
T_2 (LG)	28.27	28.05	29.15	28.49[b]	24.10	25.20	25.50	24.93[b]	35.13	40.13	33.20	36.15[b]	61.25	53.20	57.40	57.28[a]
T_3 (SLG)	29.00	28.45	28.75	28.73[b]	23.85	24.65	27.95	25.48[b]	32.40	30.70	32.40	31.83[a]	56.30	61.50	60.10	59.30[b]
T_4 (C)	27.91	28.05	28.03	28.00[a]	22.11	22.46	22.62	22.40[a]	39.42	39.50	39.86	39.60[d]	73.04	71.23	71.87	72.05[c]
Mean	28.43	28.33	28.61		23.76[a]	25.58[b]	26.03[b]		36.38[b]	37.76[c]	34.81[a]		65.02[b]	60.46[a]	61.08[a]	
LSD ($P \leq 0.05$)																
Treatment (T)		0.45				0.99				0.73				1.62		
Stage (S)		NS				0.85				0.63				1.40		
T x S		NS				1.71				1.27				2.80		

content was observed in S_3, *i.e.*, 30 DAFI, followed by FI. The interactions between various treatments and stages of girdling were significant and minimum levels of leaf-Mn were observed in SLG at S_2, followed by 32.40 ppm in SLG at S_3. In pear cv. Punjab Beauty, LG treatment resulted in least leaf-Mn content and highest was in control. However, T_1 was statistically at par with T_3 treatment. The interaction between treatments and stages were significant. The similar results were also reported by Giuseppe and Ricardo (7) who reported decreased foliar-Mn content in Cleopatra rootstock of citrus with girdling treatment as compared to control.

The leaf-Cu content increased due to girdling in both the cultivars. Significantly higher content of leaf-Cu was recorded in T_3, followed by T_1 and minimum in control in Patharnakh plants. However, the results of T_1 were at par with T_2 treatment. Different stages of girdling had non-significant results on leaf-Cu content. The interaction between various treatment and stage were also non-significant. In Punjab Beauty, T_1 treatment resulted in significantly higher copper to the extent of 9.78 ppm and lowest (5.75 ppm) in control. The stage S_3 resulted in the highest leaf-Cu content as compared to other stages. Within S_1 and S_3, maximum leaf-Cu was observed in limb girdling, however, trunk girdling recorded maximum Cu content under stage S_2. Significant interaction was also recorded between T × S. the results of Schechter *et al.* (9) in apple also supported the present findings.

It has been shown athat The conclusion can be drawn that the girdling performed at various stages of growth alters the nutrient status in the leaves of pear by improving their mobility in the plant system towards fruits in place of vegetative growth, thereby helped in improving the fruit yield and quality, and advanced fruit maturity. The impact of girdling on leaf nutrient

Table 5. Effect of girdling on copper content (ppm) in leaves of pear.

Treatment	Patharnakh				Punjab Beauty			
	Stage			Mean	Stage			Mean
	S_1	S_2	S_3		S_1	S_2	S_3	
T_1 (TG)	7.87	8.40	7.80	8.02[b]	9.00	10.40	9.95	9.78[c]
T_2 (LG)	8.07	7.60	7.95	7.87[b]	9.70	7.75	10.40	9.28[b]
T_3 (SLG)	9.00	9.27	9.40	9.22[c]	8.55	10.05	8.65	9.08[b]
T_4 (C)	6.86	7.49	7.24	7.20[a]	5.75	5.77	5.72	5.75[a]
Mean	7.95	8.19	8.09		8.25[a]	8.49[b]	8.68[b]	
LSD ($P \leq 0.05$)								
Treatment (T)		0.42				0.25		
Stage (S)		NS				0.21		
T × S		NS				0.43		

status and their subsequent effect on improvement in fruit yield and quality, and advancement in fruit maturity has already been demonstrated in pear cultivars (Singh *et al.*, 12).

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