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Effect of various growth controlling strategies to control vigour and optimize flowering in Chinese sand pear (*Pyrus pyrifolia*)

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Abstract
Pear is one of the most important temperate fruits next only in importance after apple. In the state of J & K, both types of pear Viz., *Pyrus communis* and *Pyrus pyrifolia* exists. But due to excessive vigour there is problem of reduced flower bud development, light penetration and increased incidence of insect pests and diseases. In order to stimulate flower bud formation in pear, it is imperative to control vigour of plants. Root pruning, trunk incision and summer pruning are considered the major growth controlling strategies which were tested in the present study. In addition, application of growth regulators (Paclobutrazol and ethephon) were tested for their efficiency in controlling tree vigour and flower induction. The experimented trees were treated with root pruning (during dormancy upto 35 cm depth and 30 cm away from trunk), trunk incision (during dormancy upto 20% of trunk diameter on both sides at 30 cm distance), summer pruning (mid June- thinning out of most of the extension shoots from middle of canopy and 50% from upper and lower canopy), application of paclobutrazol (at full bloom-800 ppm and 15 days after full bloom-500ppm) and Ethephon (at full bloom-200 ppm and 15 days after full bloom-100 ppm). Plants treated with root pruning + paclobutrazol showed better results with minimum tree height, tree spread, TCSA and maximum flower intensity, chlorophyll content, C: N ratio and Nitrogen percentage(shoots and leaves). The overall results showed that root pruning + paclobutrazol can be considered as best strategy for optimizing tree growth and flowering in pear orchard.

Keywords: various growth, control vigour, Chinese sand pear

Introduction
Pear is one of the oldest and most patronized fruit of the world and has been under cultivation both in Europe and Asia for about 3000 years. Its fruits are excellent source of carbohydrates and rich source of proteins, minerals (potassium, phosphorus, magnesium, calcium, sodium and iron) and vitamins (Thiamin, riboflavin, nicotinic acids and ascorbic acid). Among temperate fruits, pear is next only to apple in importance, acreage and production with high degree of adaptability under different climatic conditions. *Pyrus pyrifolia* is vigorous (7-18 metre in height) and spreading tree. Its leaves are ovate-oblong, dark green, pubescent and glabrous. Inflorescence umbellate-racemose, containing 6-9 flowers, glabrous or sometimes tomentose. Flowers are white that appear prior to leaf emergence (Sharma *et al*., 2010) [33]. Growth control is one of the important elements in pear orchard management. Excessive vigour reduces the light penetration, increases the incidence of insects and pests and reduces the flower bud development in the plants (Miller, 1995) [25]. In the interim, horticultural practices which induce smaller tree size and stimulate flower buds to obtain regular and high production levels must be used to obtain the desired effect. Both non-chemical and chemical (growth regulators) methods have been followed to control growth and stimulate flowering in fruit crops. Root pruning is the most primitive method of limiting the tree growth (Webster, 2006) [36] and promote the flower bud initiation and fruiting (Geisler and Ferree, 1984). Root pruning and trunk incision in combination with foliar sprays of ethephon reduce the shoot length and improve the flower bud number, yield and fruit quality in 'Conference' pear (Mass, 2008) [23]. In addition to the orchard practices, plant growth regulators (paclobutrazol and ethephon) have been widely used as growth retardants and to induce flowering in fruit plants. Suppression of growth by paclobutrazol occurs because the compound blocks three separate steps in the terpenoid pathway for the production of gibberellins (blocks the oxidation of Kaurene to Kaurenic acid). One of the main role of gibberellic acid is the cell elongation and when its production is inhibited, cell division still occurs, but the new cells do not elongate. The result is that the shoot with the same number of leaves and internodes become compressed into a shorter length.

Natural production of ethylene in the plants is also known to counteract the gibberellic acid action and tend to produce more flowers. Faust (1989) [13] observed a higher concentration of ethylene in apples at the location where flower bud development is to take place as compared to the wood of one year old shoot that rarely produce flower buds. Since, Chinese sand pear is premier variety of Kashmir, fetches good price in the market as it is highly juicy, sweet and has good shelf life but its excessive vigorous nature reduces flower bud development and hence yield. Also during the last few years pear growers of the valley have been complaining of the problem of non-flowering of Chinese Sand pear trees. The recommendations being given to the farmers are adhoc which do not have any scientific base as no work has been conducted in the university on this crucial and important problem so far. Keeping in view these facts, the present study "Strategies to control tree vigour and optimize flowering in pear" was, therefore undertaken at fruit orchard of Division of Fruit Science, SKUAST-K, Shalimar.

Materials and methods

The details of the materials used and the techniques followed during the course of investigation are described below. The experimental farm is located at an elevation of 1570 m above mean sea level and between 34^0 75' North latitude and 74^0 50' East longitudes. The study area lies in the temperate zone of Jammu and Kashmir. 20-year-old Chinese Sand pear trees grown on seedling rootstock. Trees of similar vigour and size were selected, marked and maintained under uniform cultural operations as per the recommended package of practices for pear of SKUAST-K, Shalimar. The treatments were given during dormancy (root pruning and trunk incision), full bloom and 15 days after full bloom (foliar sprays of paclobutrazol and ethephon) and in mid June (summer pruning) details given below. On each selected tree four limbs, one along each direction (N-S and E-W) were marked for various observations. A total of sixteen treatments were given comprising three replications in each treatment.

The growth controlling strategies tried are detailed hereunder

Strategy	Year 2011	Year 2012
RP	Root Pruning[1]	-
RP+E	Root Pruning[1] + Ethephon[2]	Ethephon[2]
RP+P	Root Pruning[1] + Paclobutrazol[3]	Paclobutrazol[3]
TI	Trunk Incision[4]	-
TI+E	Trunk Incision[4] + Ethephon[2]	Ethephon[2]
TI+P	Trunk Incision[4] + Paclobutrazol[3]	Paclobutrazol[3]
SP	Summer Pruning[5]	-
SP+E	Summer Pruning[5] +Ethephon[2]	Ethephon[2]
SP+P	Summer Pruning[5] + Paclobutrazol[3]	Paclobutrazol[3]
RP+SP	Root Pruning[1] + Summer Pruning[5]	-
RP+SP+E	Root Pruning[1] + Summer Pruning[5] +Ethephon[2]	Ethephon[2]
RP+SP+P	Root Pruning[1] + Summer Pruning[5] + Paclobutrazol[3]	Paclobutrazol[3]
TI+SP	Trunk Incision[4] + Summer Pruning[5]	-
TI+SP+E	Trunk Incision[4] + Summer Pruning[5] + Ethephon[2]	Ethephon[2]
TI+SP+P	Trunk Incision[4] + Summer Pruning[5] + Paclobutrazol[3]	Paclobutrazol[3]
C	Control	Control

[2] At full bloom (200 ppm) and 15 days after full bloom (100 ppm)
[3] At full bloom (800 ppm) and 15 days after full bloom (500 ppm)
[4]Dormant season (20% of trunk diameter on both the side at 30 cm distance)
[5] Mid June (Thinning out of most of extension shoot from middle of canopy + 50% from upper and lower canopy)

Tree height increment (m)

The tree height increament was measured from ground level to the top of the highest branch and tree spread was measured in two directions i.e. East-West and North- South and average of each experimental tree with the help of a long calibrated bamboo pole and the average increment was calculated in meters.

Tree spread (m)

Spread was measured using calibrated bamboo pole in two directions i.e. East-West and North- South and average was calculated and expressed in meters.

Increment in trunk cross sectional area (cm^2)

Tree girth of each experimental tree was recorded at 15 cm above the ground and from this trunk cross sectional area of each tree was calculated using the formula:

$$\text{Cross sectional area} = \frac{(\text{Girth})^2}{12.56}$$

The average increment was calculated by subtracting it from base value and expressed in centimetres.

Flower intensity

The total number of flowers from each marked branch of a tree was counted. Flowering intensity was calculated by using formula:

Flower intensity = No. of flowers per metre shoot length.

Chlorophyll

Chlorophyll content was measured by using Chlorophyll meter (Model CL 01) and the values was expressed as ODD. The meter works by emitting two frequencies of light, one at a wavelength of 620 nm (red) and one at 940 nm (infrared). Leaf chlorophyll absorbs red light but not infrared, the difference in absorption is measured by the meter and termed Optical Density Difference (ODD).

Nitrogen percentage of leaves and shoots

Nitrogen content of leaves and shoots was estimated by method described by Amma *et. al*. (1989) [1].

C: N ratio of leaves and shoots

C:N ratio was calculated by estimating Carbohydrate and Nitrogen content of leaves and shoots using methods described by Amma *et. al*. (1989) [1] and Dubios *et. al*. (1956) [12].

Results and Discussions

All the growth controlling strategies showed reduction in tree height increment as compared to control plants. It is evident from data (Table 1) that the most effective strategy for reducing tree height increment during the first year of study was root pruning + paclobutrazol (0.127 m) which was at par with trunk incision + paclobutrazol (0.129 m). Similar results were observed in the second year, the maximum tree height increment was noticed in control and summer pruned plants (0.259 m) whereas plants treated with root pruning + paclobutrazol in first year and with paclobutrazol in second year again registered minimum tree height increment (0.124 m) which was at par with paclobutrazol treated plants previously treated with trunk incision + paclobutrazol (0.130

m). Data presented in Table 1 show that there was reduction in tree spread in all treated plants. Root pruning + paclobutrazol treated plants recorded minimum tree spread (5.23 m) while maximum was observed in untreated plants (5.87 m). Root pruning + paclobutrazol treated plants again registered minimum tree spread (5.35 m) by sequential application of paclobutrazol in second year followed by plants treated with trunk incision + paclobutrazol in first year and with paclobutrazol in second year whule as maximum tree spread among treatments was observed in reference plants (6.21 m). The relative reduction in tree height in comparison to control plants was also observed by Feree and Knee (1997) [14] by mechanical root pruning of Golden Delicious apples. Application of paclobutrazol during dormant stages reduced primocane height by 36 per cent over untreated plants of red raspberry (Braun and Garth, 1986) [7]. Foliar application of paclobutrazol (250 ppm) resulted in reduced tree spread in Gola pear as compared to untreated trees, which may be due to inhibition of gibberellin biosynthesis (Bist and Rai, 1994) [5]. Basal soil drenching of paclobutrazol at pre-blossom stage reduced increment in tree spread by 6 and 9 per cent over control in Zill mango plants (Rowley, 1990) [28].

All the growth controlling strategies show significant reduction in trunk cross sectional area increment (Table 1). The maximum trunk cross sectional area increment was observed in untreated plants (3.51 cm^2) followed by summer pruning (3.44 cm^2) and summer pruning + ethephon (3.32 cm^2) treated plants. However, root pruning + paclobutrazol (1.74 cm^2) followed by trunk incision + paclobutrazol (1.84 cm^2) were the most effective strategies in controlling trunk cross sectional area increment during the first year of study. Similarly, sequential application of paclobutrazol in second year on root pruning + paclobutrazol plants registered minimum trunk cross sectional area (1.32 cm^2) whereas maximum trunk cross sectional area (3.50 cm^2) was observed in reference plants. Reduction in trunk cross sectional area by root pruning on two sides at 50 cm away from trunk and 40 cm depth has been observed in Golden Delicious apple plant (Schupp *et al*., 1992) [31]. According to Ferree and Knee (1997) [14] mechanical root pruning annually for nine years reduced the trunk cross sectional area by 14 per cent in the first five years and 22 per cent in the last four years of the experiment over the reference plants in Golden Delicious apples. Application of paclobutrazol treatment has also showed reduction in trunk cross sectional area in Red Heaven peach (Monge *et al*., 1994) [26].

The mechanism for the influence of root pruning on growth is complex. Randolph and Wiest (1981) [27] suggested three possible ways by which growth may be influenced by root pruning: limited water absorption which may induce water stress, reduced mineral absorption and assimilation and reduced hormone synthesis. Reduction in xylem water by root pruning during dormant season at predawn and midday was observed in Sundrop apricot over the control apricot plants (Arzani *et al.,* 2000) [2]. Root pruning has been observed to reduce the water potential thereby leaving the plant in water deficit and hence reduced plant growth (Breueden and Hodges, 1978) [8] as minimum level of water is necessary for plant cells to expand (Kremer and Kozlowski, 1979) [20]. Growth inhibition due to triazole is primarily due to reduced gibberellin biosynthesis, triazoles specifically inhibit the microsomal oxidation of kaurene, kaurenol and kaurenal which is catalyzed by kaurene oxidase (Dalziel and Lawrence, 1984) [10]. According to Dry (1999) [11] root pruning on both sides at 40 cm from trunk and 40-50 cm deep at bud burst stage decreased vegetative growth (upto 20 % decrease in pruning weight) and increased bunch number per shoot in grapes as compared to control plants.

The perusal of data presented in Table 1 reveal the effect of various growth controlling strategies on flower intensity of pear trees. Maximum number of flowers was recorded in root pruning + paclobutrazol (193.20) treated plants followed by trunk incision + paclobutrazol (181.40) while the minimum number of flowers were recorded in control plants (48.50) followed by summer pruning (50.02). Similar results were observed in the second year, the minimum flower intensity was recorded in control (47.28) plants whereas plants treated with root pruning + paclobutrazol in first year and with paclobutrazol in second year again registered maximum flower numbers (210.50). Root pruning hasten the flower bud formation by allowing accumulation of metabolites in nodes to begin earlier and by earlier cessation of vegetative growth which inturn stimulated production of flowers (Schupp *et al.,* 1992) [31]. Root pruning during bud break and full bloom recorded maximum average number of flower per spur and average number of floral spur per meter (28.81) as compared to control in LeConte pear trees (Yehia *et al.,* 2011) [38]. Similar findings were reported by Asin *et al.,* (2007) [3] on Blanquilla pear orchard where root pruning resulted in increased return bloom. Root pruning promote flowering by stimulating root regeneration, root activity and more hormone (cytokinins) production (Gleiser and Ferree, 1984) [17] and flowering spurs per tree (McArtney and Belton, 1992 and Schupp, 1992) [24, 31]. Paclobutrazol on the other hand promotes flowering in two ways: it can speed up and increase the synthesis of the floral stimulus in an inductive cycle, or more plausibly, affect the ratio between flower promoting and flower inhibiting factors (Kulkarni, 1988) [29]. Soil application of paclobutrazol induced more number of flowering panicles as compared to plants treated with lower doses of paclobutrazol and control (Martinez *et al.,* 2008) [22].

The maximum chlorophyll was recorded in plants treated with root pruning + paclobutrazol (38.55 ODD) which was significantly higher than the next best strategy trunk incision + paclobutrazol (37.76 ODD) whereas minimum was recorded in reference (31.13 ODD) plants followed by summer pruning (31.53 ODD) treated plants (Table 2). The application of paclobutrazol in second year on root pruning + paclobutrazol treated plants registered maximum chlorophyll (39.36 ODD) content whereas minimum chlorophyll (31.64 ODD) was observed in untreated plants. Plants treated with root pruning impart dark green colour of foliage due to concentration effect by reducing leaf expansion. Appearance of dark green colour by paclobutrazol treatment is correlated with increased chlorophyll content of leaves (Jaggard *et al*., 1982; Wang *et al.,* 1986 and Flutcher *et al.,* 1986) [18, 37, 16]. Increase in chlorophyll content of leaves by paclobutrazol may be either due to enhanced biosynthesis of chlorophyll (Fletchur *et al.,* 2000) [15] or by more densely packed chloroplast per unit leaf area. Chaney (2005) [9] reported that paclobutrazol blocks the biosynthesis of gibberellins by way of shunting of the intermediate compound for gibberellin synthesis and production of more phytyl which is important molecule of chlorophyll. It may also be possible that paclobutrazol reduces chlorophyll degradation by reducing the activity of chlorophyllase (Fletchur *et al.,* 1986) [16]. According to Sebastian *et al.* (2002) [34] foliar application of paclobutrazol enhanced synthesis of chlorophyll in peach. Similarly, Khalil and Rehman (1995) [21] observed more

densely packed chlorophyll per unit leaf area in cereals by application of paclobutrazol.

The data (Table 2) reveal a significant reduction in nitrogen percentage under all treatments except under summer pruning in comparison to control plants in leaves. The maximum nitrogen per cent (1.57) was in untreated plants and minimum in root pruning + paclobutrazol treated plants (1.30 %). Similarly, sequential application of paclobutrazol in second year on root pruning + paclobutrazol treated plants registered minimum per cent of leaf nitrogen (1.31 %) whereas maximum (1.58 %) was observed in reference plants. The perusal of data in Table 2 reveal that maximum shoot nitrogen (0.99 %) was recorded in control plants where as the minimum shoot nitrogen percentage was observed in root pruning + paclobutrazol treated plants (0.70%). Similarly, plants treated with root pruning + paclobutrazol in first year and again with paclobutrazol sprays in second year recorded minimum shoot nitrogen (0.72 %) content whereas the maximum nitrogen (1.00 %) was observed in control plants. These findings are in agreement with Sharma *et al.*, (2002) [32] who found significant reduction in leaf mineral constituents (N, P and K) by application of paclobutrazol in Non Perail Almond. Application of paclobutrazol (1l/ha) after fruit set and one month after first spray produced leaves with lower levels of minerals in Bramleys apple plant (Santaoir *et al.*, 2010) [30].

The C: N ratio in leaves ranged from 3.07 to 4.06 during the first year (Table 2). Maximum C: N ratio was observed in root pruning + paclobutrazol (4.06) treated plants followed by trunk incision + paclobutrazol (3.97) while the minimum C: N ratio was recorded in control plants (3.07) followed by summer pruning (3.09) during the first year of study. In next year, C: N ratio in pear leaves ranged from 2.87 to 4.08 with maximum value (4.08) in plants treated with root pruning + paclobutrazol in first year and with paclobutrazol in second year and minimum in control plants (2.87) followed by summer pruned plants (2.88).

The C: N ratio in shoots ranged from 21.84 to 39.26 during first year. Maximum C: N ratio was noticed in root pruning + paclobutrazol treated plants (39.26) followed by trunk incision + paclobutrazol (37.10) while the minimum C: N ratio was observed in reference plants followed by summer pruning treated plants in the first year of study. In next year, C: N ratios in shoots ranged from 22.64 to 38.43 with minimum value (22.64) in control plants and maximum (38.43) in plants treated with root pruning + paclobutrazol in first year and with paclobutrazol in second year. The higher carbohydrate levels in shoots and leaves of strategies involving root pruning and trunk incision could be because of blockade of translocation of carbohydrates from leave to root zone through phloem and their accumulation in leaves and shoots. Pruning of root to a depth of 30 cm and 20 cm away from trunk on both sides resulted in increased total carbohydrates and number of flowering spurs in five years old Breaburn, Royal Gala, Oregon Red Delicious, Splendour, Granny Smith and Fuji apples on MM106 rootstock under high density (Khan *et al.*, 1998) [19]. The higher level of carbohydrates with the application of paclobutrazol might be due to increased chlorophyll metabolism and its direct effect on carbohydrate metabolism partitioning as also reported by Sharma *et al.*, (2002) [32].

Reduced uptake of nutrients by paclobutrazol might be due to reduced length and density of roots and hence the use of soil resources (Atkinson, 1986) [4], by existence of inverse relationship between daily water flux and paclobutrazol (Rieger and Scalabrelli, 1990) [35] and by reducing root hydraulic conductivity (Bigot and Boucuad, 1998) [6]. Paclobutrazol is also known to alter inner structure of roots and thereby affecting nutrient uptake (Rieger and Scalabrelli, 1990) [35]. The inhibition in the growth of roots and weakening of root system under the influence of paclobutrazol might be the cause of reduced nutrient uptake and increased carbohydrates in shoots and leaves (Steffens and Wang, 1986 and Atkinson, 1986) [37, 4].

Table 1: Effect of growth controlling strategies on tree height increment of Chinese Sand pear plants

Strategies		Tree Height Increment (m)		Tree Spread (m)		Increament in TCSA (m^2)		Flower Intensity	
Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist Year	IInd Year
RP	-	0.153	0.151	5.32	5.53	2.11	1.77	164.80	178.20
RP + Eth	Eth	0.144	0.142	5.30	5.45	1.96	1.63	176.50	192.30
RP+ Pbz	Pbz	0.127	0.124	5.23	5.35	1.74	1.32	193.20	210.50
TI	-	0.164	0.166	5.40	5.63	2.36	2.08	153.80	164.50
TI+ Eth	Eth	0.152	0.156	5.37	5.57	2.25	1.93	162.70	170.60
TI+ Pbz	Pbz	0.129	0.130	5.25	5.38	1.84	1.51	181.40	201.40
SP	-	0.237	0.259	5.83	6.17	3.44	3.46	50.02	49.20
SP+ Eth	Eth	0.229	0.250	5.77	6.11	3.32	3.34	85.70	84.56
SP+ Pbz	Pbz	0.208	0.219	5.60	5.96	2.86	2.86	115.30	109.20
RP+ SP	-	0.216	0.229	5.66	6.02	3.07	3.02	96.20	102.00
RP+ SP+ Eth	Eth	0.189	0.196	5.53	5.84	2.64	2.56	123.30	125.60
RP+ SP+ Pbz	Pbz	0.175	0.178	5.46	5.63	2.47	2.16	145.60	157.80
TI+ SP	-	0.220	0.241	5.71	6.07	3.18	3.22	89.11	94.32
TI+ SP+ Eth	Eth	0.199	0.205	5.60	5.91	2.77	2.74	117.40	115.50
TI+ SP + Pbz	Pbz	0.181	0.187	5.51	5.76	2.59	2.35	134.00	139.40
C	-	0.243	0.259	5.87	6.21	3.51	3.50	48.50	47.28
CD ≤ 0.05		0.007	0.008	0.04	0.06	0.07	0.05	2.19	2.21

Table 2: Effect of growth controlling strategies on nutrient content and chlorophyll of Chinese Sand pear plants

Strategies		Chlorophyll (ODD)		Leaf Nitrogen (%)		Shoot Nitrogen (%)		Leaf C: N Ratio		Shoot C:N ratio	
Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist Year	IInd Year	Ist Year	IInd Year
RP	-	36.84	37.90	1.37	1.39	0.76	0.79	3.78	3.74	34.55	33.44
RP + Eth	Eth	37.40	38.24	1.35	1.36	0.75	0.76	3.87	3.85	35.56	35.31
RP+ Pbz	Pbz	38.55	39.36	1.30	1.31	0.70	0.72	4.06	4.08	39.26	38.43
TI	-	35.84	36.89	1.41	1.42	0.81	0.82	3.62	3.51	31.45	31.27

TI+ Eth	Eth	36.32	37.42	1.40	1.40	0.79	0.81	3.68	3.60	32.67	32.14
TI+ Pbz	Pbz	37.76	38.78	1.32	1.33	0.73	0.75	3.97	3.98	37.10	36.30
SP	-	31.53	31.96	1.57	1.56	0.99	0.98	3.09	2.88	22.17	23.44
SP+ Eth	Eth	32.02	32.50	1.54	1.55	0.97	0.98	3.16	2.96	23.05	23.84
SP+ Pbz	Pbz	33.61	33.55	1.49	1.50	0.90	0.93	3.32	3.17	26.13	26.37
RP+ SP	-	33.01	33.51	1.51	1.52	0.93	0.94	3.29	3.51	24.88	25.64
RP+ SP+ Eth	Eth	35.12	34.52	1.46	1.49	0.87	0.89	3.42	3.35	27.94	27.48
RP+ SP+ Pbz	Pbz	34.70	35.74	1.43	1.45	0.84	0.85	3.54	3.47	29.86	29.69
TI+ SP	-	32.55	33.03	1.52	1.53	0.95	0.96	3.23	3.03	23.93	24.70
TI+ SP+ Eth	Eth	34.36	34.05	1.49	1.50	0.87	0.91	3.38	3.26	27.51	27.29
TI+ SP + Pbz	Pbz	35.43	35.07	1.43	1.46	0.84	0.88	3.49	3.42	29.41	28.26
C	-	31.13	31.64	1.57	1.58	0.99	1.00	3.07	2.87	21.84	22.64
CD ≤ 0.05		0.43	0.45	0.004	0.005	0.003	0.002	0.05	0.03	0.51	0.53

Conclusion

From the present study, it can be inferred that all the growth controlling strategies were effective in reducing tree vigour and inducing flower bud production in pear. However, root pruning + paclobutrazol was found most effective in reducing tree height, tree spread, increment in trunk cross sectional area increasing flower intensity, and Carbohydrate: Nitrogen ratio of leaves and shoots. In view of results obtained in the present study, it is concluded that flowering and fruiting in pear (*Pyrus prrifolia*) cv. Chinese Sand pear can be regulated by way of controlling tree vigour through adaption of proper growth controlling strategies including use of paclobutrazol, root pruning and trunk incision. Root pruning + paclobutrazol in one year followed by application of paclobutrazol in second year was found to be the best strategy in controlling tree vigour and optimizing flowering in Chinese Sand pear.

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