Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 18-24
Received: 13-05-2018
Accepted: 17-06-2018

RHS Raja
Division of Fruit Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

MS Wani
Division of Fruit Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

Rafiya Mushtaq
Division of Fruit Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

ZA Bhat
Division of Fruit Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

AR Malik
Division of Fruit Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

Kounser Javid
Division of Fruit Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

Correspondence
RHS Raja
Division of Fruit Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

Effect on vegetative growth and reproductive development of Chinese sand pear (*Pyrus pyrifolia*) treated with various growth controlling strategies

RHS Raja, MS Wani, Rafiya Mushtaq, ZA Bhat, AR Malik and Kounser Javid

Abstract
Kashmiri Nakh (Chinese Sand pear) is the most important cultivar of *Pyrus pyrifolia* group considering its yield potential as well as its consumer acceptability. 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 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 shoot length, internodal length, leaf number, leaf area, fresh weight of leaves and maximum number of nodes, dry weight of leaves and per cent bloom. The overall results showed that root pruning + paclobutrazol can be considered as best strategy for optimizing tree growth and flowering in pear orchard.

Keywords: vegetative, reproductive, Chinese, controlling strategies

Introduction
Among temperate fruits, pear is next only to apple in importance, acreage and production with high degree of adaptability under different climatic conditions. The genus *Pyrus* has probably originated in the mountainous region of western China from where it spreaded world wide (Mitra *et al*., 1991) [28]. According to Vavilov (1951) [38] there are three centres of origin for the cultivated pears, Chinese centre (it comprises *Pyrus pyrifolia, Pyrus ussuriences, Pyrus betulifolia* and *Pyrus calleryana)*, Central Asiatic Centre (it includes *Pyrus communis, Pyrus salicifolia, Pyrus regelli and Pyrus pashia*) and Near Eastern Centre (*Pyrus communis, Pyrus syriaca* and *Pyrus caucasia* are important species under this group). 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). Pear fruits are recommended for the patients suffering from diabetes because of low sucrose content, helps in lowering blood pressure and regulate heart pulse.
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) [27]. The primary method developed for size control is the clonal rootstock. Although, the change in size controlling root stock's has been very beneficial and they are widely accepted yet a number of problems have been recognized. There is considerable variability in the growth potential of a given rootstock with respect to soil type, frequently resulting in a planting which is too dense. Many are susceptible to diseases, poorly anchored thus requiring staking, or produce a larger tree than desired. 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.
Root pruning is the most primitive method of limiting the tree growth (Webster, 2006) [39] and promote the flower bud initiation and fruiting (Geisler and Ferree, 1984) [17]. Several authors have suggested the usefulness of root pruning in reduction of vegetative growth and induction of flowering (Asin and Vilardell, 2008, Mass, 2008 and Alexander and Maggs, 1971) [3, 24, 1]. The growth reduction may be the result of reduction in photosynthesis

(Geisler and Ferree, 1984 and Rook, 1971) [17, 37], water stress (Randolph and Wiest, 1981) [35] and change in hormonal balance (Detling *et al*., 1980, McDavid *et al*., 1973 and Richards and Rowe, 1977) [13, 26, 36] or combination of these factors. 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) [24].

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. It has been demonstrated that blocking a portion of the terpenoid pathway causes shunting of the accumulated intermediate compound above the blockage. This invokes an increase in the production of the hormone abscisic acid and the chlorophyll component phytyl, both beneficial to tree growth and health (Chaney, 2005) [11]. Natural production of ethylene in the plants is also known to counteract the gibberellic acid action and tend to produce more flowers. Faust (1989) [15] 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 was undertaken to evaluate the various tree vigour control strategies on shoot growth and flowering and to find out the best strategy for optimizing tree growth and flowering in a pear orchard.

Materials and Methods

The present study on "Strategies to control tree vigour and optimize flowering in pear" was carried out in experimental orchard/ laboratory of Division of Fruit Science, Sher-e-KashmirUniversity of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar (J&K) during the year 2011 and 2012. The details of the materials used and the techniques followed during the course of investigation are described below

Experimental details

The present study was conducted on 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

1. Dormant season (35 cm depth and 30 cm away from trunk on both sides)
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)

Observations recorded

Length of shoots (cm)

The length of current season shoot growth from our previously tagged branches of all the experimental trees was measured at the onset of dormancy in both the years.

Number of nodes

Out of four branches marked earlier from each of the experimental tree, one shoot 20 cm length from each marked branch was selected and the number of nodes counted after leaf fall

Internodal length (cm)
From each selected branch the distance between two nodes was measured in centimetres after leaf fall.

Leaf number/shoot
Leaves from already marked shoots from each tree were counted at 120 days after full bloom.

Leaf area (cm^2)
Twenty leaves from each marked shoot from each tree were collected and leaf area was measured with leaf area meter (model Systronic 211).

Fresh weight of leaves (g)
From each selected branch of the experimental tree, 20 leaves were taken, weighed and fresh weight was calculated.

Dry weight of leaves (mg)
Twenty leaves from each marked shoot of a tree were taken and dried at 70^0C in oven. The dried leaves were weighed and leaf dry matter of each leaf was calculated.

Per cent bloom
The number of flower and leaf buds of each marked limb of a tree was counted and per cent bloom calculated by using formula (Westwood, 1988) [40].

$$\text{Per Cent Bloom} = \frac{\text{Flower buds}}{\text{Leaf buds + flower buds}} \text{ X } 100$$

Duration of flowering (days)
Duration of flowering consists of days from first bloom to the end of flowering. First bloom was visually observed when around 10 per cent of flowers were open and the end of flowering almost when almost all the flowers had opened.

Results and Discussion
Annual shoot length
All growth controlling strategies had significant influence on annual shoot length (Table 1). In first year, root pruning + paclobutrazol (25.24 cm) and trunk incision + paclobutrazol (28.53 cm) were the strategies that demonstrated greatest capacity for reducing shoot length. Summer pruning registered maximum shoot length (58.94 cm) among treatments followed by summer pruning + ethephon (56.73 cm) but highest annual shoot length was recorded in control plants (60.10 cm). Plants which were previously treated with root pruning + paclobutrazol in first year and with paclobutrazol only in second year again registered minimum current season shoot growth (23.26 cm) and the maximum was noticed in untreated plants (60.68 cm).
Reduction in shoot length by root pruning (60 and 80 cm away from trunk) at dormant stage on Melrose apple was also observed by Schupp and Ferree (1988) [33]. Pruning roots of young and mature apple plants reduced shoot growth and thus controlled tree size (Ferree, 1989) [16]. Application of paclobutrazol to apple, peach and cherry under greenhouse conditions showed reduction in shoot growth by 90 per cent and its analog (RSWO411) reduced the shoot growth by 49 per cent over control plants (Curry, 1988) [12].

Number of nodes
All the growth controlling strategies showed non-significant effect on node number (Table 1). During the first year of study the maximum number of nodes was observed in plants treated with root pruning + paclobutrazol (11.48) whereas minimum node number was recorded in reference (10.81) plants. Similar trend of influence was recorded in second year with untreated plants registered minimum number of nodes (11.04) whereas root pruning + paclobutrazol treated plants showed maximum node number (12.19). The number of nodes during the second year showed the same trend as that of first year under various growth controlling strategies. During both the years of study number of nodes on current season shoot growth was found to be non significant. These findings are in contrast with the results obtained by Braun and Garth (1986) in red raspberry primocane.Crisp and Duke pear plants treated with soil application of paclobutrazol (4g/tree) recorded minimum number of nodes (16.1) over the control (18.9) plants (Huang *et al.,* 1989) [20]. Shoot tip application of paclobutrazol (1000 mg/l) produced less number of nodes with high proportion of floral nodes (38 %) as compared to control which produced more number of nodes with only 4 per cent of floral nodes (Browning *et al.,* 1992) [8].

Internodal length
Reduction in length of internodes with minimum value in root pruning + paclobutrazol treated plants and maximum in untreated plants was observed among the various growth controlling strategies (Table 1). The shortest internodal length was noticed in plants treated with root pruning + paclobutrazol (2.19 cm) while the maximum internodal length was recorded in control (5.29 cm) plants followed by summer pruning (5.22 cm). Similarly, sequential application of paclobutrazol in second year on root pruning + paclobutrazol and trunk incision + paclobutrazol treated plants registered minimum internodal lengths (1.90 cm and 2.05 cm respectively) whereas maximum length of internodes (5.22 cm) was observed in reference plants followed by summer pruned plants (5.13 cm). Internodal length was found to be directly affected by growth controlling strategies. Suppression of mean shoot internodal length was observed by soil application of paclobutrazol after petal fall over the control plants of pear cv. Crisp (Huang *et al.,* 1989) [20]. Foliar sprays of paclobutrazol (1000 mg/l) on Maiden Bramley's apple seedlings restricted the growth of internodes by 47 per cent over the untreated plants (Hodairi and canhem, 1990b) [19]. Paclobutrazol sprays applied to 'Minneola' tangelo plants, at 500 or 1000 ppm, before the onset of summer flush, markedly reduced internodal length as compared to control (Aron, 1985) [2].

Leaf number/ m of shoot length
A non significant effect was observed on leaf number per shoot among the various growth controlling strategies (Table 2). However, minimum leaf number per shoot was observed in plants treated with root pruning + paclobutrazol (148.6) whereas maximum number of leaves per shoot was recorded in reference plants (154.1). Similar trend of influence was recorded in second year, untreated plants registered maximum leaf number (154.9) whereas root pruning + paclobutrazol treated plants recorded minimum number of leaves (149.4) which was again non significant with rest of the treatments.

Leaf area
The data presented in Table 2 depict the effect of various growth controlling strategies on leaf area in Chinese Sand pear. The leaf area ranged between 23.10 to 28.96 cm^2 during the first year. Minimum leaf area was noticed in root pruning

+ paclobutrazol treated plants (23.10 cm^2) and control plants (28.96 cm^2) recorded maximum leaf area. In next year, average leaf area ranged from 23.50 to 28.11 cm^2 with minimum value (23.50 cm^2) in plants treated with root pruning + paclobutrazol in first year and with paclobutrazol in second year and maximum in control (28.11 cm^2) followed by summer pruning (27.86 cm^2) and summer pruning + ethephon (27.50 cm^2) treated plants. Leaf area was found to be directly affected by growth controlling strategies. Pruning of roots reduced leaf area in five year old Breaburn, Royal Gala, Oregon Red Delicious, Splendour, Granny Smith and Fuji apples under high density (Khan *et al.,* 1998) [22]. Reduction in leaf area by root pruning and trunk incision may be due to lowering of leaf expansion (Smart *et al.,* 2006) [34] possibly by creating water stress. Root pruning alters the distribution of photosynthates within plants (Ghobrial, 1983 and Benjamim and Wren, 1980) [18, 5] which are directed to the wounded root system and therefore, result in limited shoot growth and leaf development (Schupp, 1985) [32]. Paclobutrazol reduces leaf area possibly by prolonged plastochron (Kulkarni, 1998) and increase in dry weight of leaves may be due to increase in dry matter accumulation in leaf tissues and by production of additional layers of longer palisade cells and loosely arranged and increased number of spongy mesophyll cells which increase leaf thickness (Burrows *et al.,* 1992 and Jaleel *et al.,* 2007) [9, 21]. Similar findings have been reported by Ferree (1989) [16], Schupp and Ferree (1988) [33] and Bhatia and Jindal (2000a) [6] in apple

Fresh weight of leaves

The response of various growth controlling strategies with respect to fresh weight of leaves is presented in Table 2. All growth controlling strategies showed non significant effect on fresh weight of leaves. However, the minimum fresh weight of leaves was observed in control plants (10.60 g) while root pruning + paclobutrazol treated plants recorded maximum fresh weight (10.77 g) of leaves. Similarly, plants treated with root pruning + paclobutrazol in first year and with paclobutrazol in second year registered maximum leaf fresh weight (10.76 g) and untreated plants recorded minimum fresh weight of leaves (10.59 g).

Dry weight of leaves

It is clear from data presented in Table 3, that all growth controlling strategies had significant influence on dry weight of leaves. The data show that in first year minimum dry weight of leaves was observed in reference plants (3.19 g) followed by summer pruning (3.21 g). Root pruning + paclobutrazol was the strategy that demonstrated maximum dry weight (3.97 g) of leaves followed by trunk incision + paclobutrazol (3.92 g). Plants which were treated with root pruning + paclobutrazol in first year and with paclobutrazol only in second year again registered maximum leaf dry weight (3.96 g) and the minimum was noticed in untreated plants (3.15 g).

Per cent bloom

The data on the effect of various growth controlling strategies on percent bloom is presented in Table 3. The bloom percentage ranged between 14.65 to 62.98 during the first year. Maximum per cent bloom was noticed in root pruning + paclobutrazol treated plants (62.98 %) followed by trunk incision + paclobutrazol (60.28 %) and control plants (14.65 %) recorded minimum per cent bloom. In next year, per cent bloom ranged from 14.45 to 63.62 with maximum value (63.62 %) in plants treated with root pruning + paclobutrazol in first year and with paclobutrazol in second year and minimum in control plants (14.45 %) followed by summer pruned plants (15.68 %).

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 in turn stimulated production of flowers (Schupp *et al.,* 1992) [31]. Root pruning at 30 cm from trunk and 50 cm depth during bud break and full bloom recorded maximum average number of flower per spur (11.84) and average number of floral spur per meter (28.81) as compared to control (10.22 and 18.4 m repectively) in LeConte pear trees (Yehia *et al.,* 2011) [41]. Similar findings were reported by Asin *et al.,* (2007) [4] 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) [25, 31]. Paclobutrazol 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) [23]. Ethylene inhibits polar transport of IAA (act as inhibiting signal during flower bud initiation) by reducing its synthesis (Ernest and Valdouinos, 1971) [14], its transport from the site of synthesis (Byer, 1973) [10] and by increasing its conjugation and decarboxylation during transport (Sagee *et al.,* 1990) [29] and hence stimulates flower bud induction (Sanyel and Bangerth, 1998) [30].

Duration of flowering

The data presented in Table 3 show non-significant impact on flowering duration by various growth controlling strategies. The flowering duration ranged from 9.0-10.5 days with maximum duration 10.5 days in root pruning + paclobutrazol, trunk incision + paclobutrazol, summer pruning + paclobutrazol, root pruning + summer pruning + paclobutrazol and trunk incision + summer pruning + paclobutrazol and trunk incision + summer pruning and minimum 9.0 days in root pruning + ethephon. In next year, flowering duration ranged from 8.5-11.5 days among the treatments which was again non-significant.

Summing up the discussion on mechanism determining tree size, Faust (1989) [15] concludes that three mechanisms operate in trees: a hormonal mechanism centered in giberrellin availability, turgor pressure in the cells of young shoots and vigour. Gibberellic acid is the most important hormone in the hormonal mechanism and the mechanism operates in the above ground portion of the tree. Gibberellic acid taken away from the ground part by the tree has a significant effect in reducing tree vigour, cytokinins and inhibitors perhaps form a part of this mechanism

The turgor pressure of the cells in the extending shoot control the second mechanism and it is determined by water availability of the plant. Although water is taken up by the roots, this mechanism also involves the above ground portion of the tree. Vigour is determined by the functioning of the root. In turn, root functions are affected by a great variety of influences ranging from IAA transport to the root to carbohydrate supply reaching the root. Confinement of the root system and so on. In the present study the reduction in vigour (dwarfing) of trees as a result of different growth strategies has lasting effect by influencing the root system.

Table 1: Effect of growth controlling strategies on annual shoot length and number of nodes of Chinese Sand pear plants

Strategies		Annual Shoot Length (cm)		Number of Nodes		Internodal Length (cm)	
Ist Year	IInd Year	Ist Year	IInd Year	Ist Year	IIndYear	Ist Year	IInd Year
Root pruning	-	33.40	30.69	11.33	12.07	2.69	2.40
Root pruning + Ethephon	Ethephon	30.96	28.42	11.37	12.11	2.54	2.26
Root pruning + Paclobutrazol	Paclobutrazol	25.24	23.26	11.48	12.19	2.19	1.90
Trunk incision	-	38.72	36.11	11.08	11.98	2.96	2.83
Trunk incision + Ethephon	Ethephon	35.90	33.61	11.26	12.04	2.78	2.65
Trunk incision + Paclobutrazol	Paclobutrazol	28.53	25.64	11.42	12.15	2.32	2.05
Summer pruning	-	58.94	58.93	10.81	11.07	5.22	5.13
Summer pruning + Ethephon	Ethephon	56.73	56.41	10.83	11.11	5.06	5.01
Summer pruning + Paclobutrazol	Paclobutrazol	50.02	49.78	10.88	11.34	4.17	4.05
Root pruning + Summer pruning	-	52.53	52.09	10.86	11.26	4.46	4.34
Root pruning + Summer pruning + Ethephon	Ethephon	46.06	44.04	10.91	11.66	3.69	3.60
Root pruning + Summer pruning + Paclobutrazol	Paclobutrazol	40.96	38.69	10.97	11.95	3.15	2.96
Trunk incision + Summer pruning	-	53.97	54.02	10.85	11.18	4.69	4.61
Trunk incision + Summer pruning + Ethephon	Ethephon	47.72	46.25	10.91	11.43	3.84	3.78
Trunk incision + Summer pruning + Paclobutrazol	Paclobutrazol	43.42	41.70	1096	11.79	3.25	3.35
Control	-	60.10	60.68	10.81	11.04	5.29	5.22
CD ≤ 0.05		2.11	2.12	NS	NS	0.11	0.13

Table 2: Effect of growth controlling strategies on leaf number /m shoot length, leaf area and fresh weight of leaves of Chinese Sand pear plants

Strategies		Leaf number / m Shoot Length		Leaf Area (cm^2)		Fresh Weight of Leaves (g)	
Ist Year	IInd Year	Ist Year	IInd Year	Ist Year	IInd Year	Ist Year	IInd Year
Root pruning	-	149.9	150.5	24.33	24.49	10.74	10.72
Root pruning + Ethephon	Ethephon	149.5	150.2	24.07	24.15	10.75	10.73
Root pruning + Paclobutrazol	Paclobutrazol	148.6	149.4	23.10	23.50	10.77	10.76
Trunk incision	-	150.7	151.3	24.61	25.22	10.72	10.71
Trunk incision + Ethephon	Ethephon	150.4	150.9	24.49	24.94	10.72	10.72
Trunk incision + Paclobutrazol	Paclobutrazol	149.2	149.7	23.76	23.84	10.75	10.76
Summer pruning	-	153.7	154.5	28.75	27.86	10.62	10.61
Summer pruning + Ethephon	Ethephon	153.4	154.2	28.50	27.50	10.64	10.63
Summer pruning + Paclobutrazol	Paclobutrazol	152.3	153.1	27.71	26.63	10.66	10.66
Root pruning + Summer pruning	-	152.5	153.6	27.96	26.94	10.66	10.71
Root pruning + Summer pruning + Ethephon	Ethephon	151.7	152.4	25.73	26.02	10.69	10.67
Root pruning + Summer pruning + Paclobutrazol	Paclobutrazol	151.2	151.6	25.14	25.49	10.71	10.71
Trunk incision + Summer pruning	-	152.8	153.7	28.22	27.12	10.65	10.63
Trunk incision + Summer pruning + Ethephon	Ethephon	151.9	152.8	26.07	26.35	10.67	10.67
Trunk incision + Summer pruning + Paclobutrazol	Paclobutrazol	151.6	151.8	25.43	25.82	10.70	10.70
Control	-	154.1	154.9	28.96	28.11	10.60	10.59
CD ≤ 0.05		NS	NS	0.24	0.25	NS	NS

Table 3: Effect of growth controlling strategies on dry weight of leaves, per cent bloom and duration of flowering of Chinese Sand pear plants

Strategies		Dry Weight of Leaves (g)		Per cent Bloom		Duration of Flowering (Days)	
Ist Year	IInd Year	Ist Year	IInd Year	Ist Year	IInd Year	Ist Year	IInd Year
Root pruning	-	3.81	3.79	55.80	58.36	10.0	9.0
Root pruning + Ethephon	Ethephon	3.86	3.85	58.06	60.48	9.0	9.5
Root pruning + Paclobutrazol	Paclobutrazol	3.97	3.96	62.98	63.62	10.5	11.5
Trunk incision	-	3.70	3.69	50.28	53.40	10.0	8.5
Trunk incision + Ethephon	Ethephon	3.77	3.75	53.55	55.71	10.0	8.5
Trunk incision + Paclobutrazol	Paclobutrazol	3.92	3.90	60.28	62.77	10.5	10.0
Summer pruning	-	3.21	3.18	15.23	15.68	9.5	9.5
Summer pruning + Ethephon	Ethephon	3.28	3.25	25.07	26.42	10	9.5
Summer pruning + Paclobutrazol	Paclobutrazol	3.42	3.44	32.21	35.42	10.5	10.0
Root pruning + Summer pruning	-	3.36	3.39	28.99	31.65	9.5	9.0
Root pruning + Summer pruning + Ethephon	Ethephon	3.56	3.55	40.58	42.21	10.0	10.0
Root pruning + Summer pruning + Paclobutrazol	Paclobutrazol	3.65	3.66	47.21	49.22	10.5	9.5
Trunk incision + Summer pruning	-	3.33	3.31	25.98	28.54	10.5	10.0
Trunk incision + Summer pruning + Ethephon	Ethephon	3.49	3.48	35.64	38.96	9.5	8.5
Trunk incision + Summer pruning + Paclobutrazol	Paclobutrazol	3.61	3.61	47.76	46.53	10.5	10.0
Control	-	3.19	3.15	14.65	14.45	9.5	9.0
CD ≤ 0.05		0.03	0.04	2.24	2.25	NS	NS

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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