International Journal of Plant Research 2015, 5(3): 57-63
DOI: 10.5923/j.plant.20150503.02

Induction of Flowering in Asian Pear (*Pyrus spp.*) – A Review

B. R. Jana

ICAR Research Complex for Eastern Eegion, Research Centre, Ranchi

Abstract Fruit production of Asian pear (*Pyrus spp*) trees is increased by the use of plant growth regulators through bud breaking and flowering of plant grown in subtopical to tropical areas. The effective growth regulators are Hydrogen Cyanamide, Thioureas, KNO3, H_2O_2, GA_3 and GA_4 and GA 7. These plant growth regulators (PGRs) may be used singly or in combinations. In cell PGRs produce super oxide ion that alters protein structure by phosphorylation which may cause higher C:N ratio resulted in heavy flowering. As the dormant period is shortened by these bio-chemicals, earlier harvesting is noticed in treated plant. Now a day's Glutabion® or mixtures of polysaccharides and growth regulators (W Uniformity Superplus) and nutrients and N-acetil cysteine, betains and vitamins (Promvit) are effective flower forming bio-chemicals for pear where HCN and thiourea are not available (Portugal). Growth retardant chemicals like SADH and shoot bending increase ethylene synthesis in damaged cells which influence early flower bud formation in pear plant. Paclobutazol also promotes flowering in Asian pear by reduction of growth of spur.

Keywords ASian Pear, Flowering, Chmicals and Growth Regulators

1. Introduction

In the present agricultural scenario in India the major research thrust to increase crop/fruit productivity in sustainable production system. Crop diversification is one of the effective way to increase the fruit production in any country, specially India where every type of agro climatic regions are present. Now a day's temperate crops like apple .pear, peach plum etc are growing in subtropical to tropical areas of the world. Low chilling condition is the major hindrance for growing these crops out of their place. India is a large country with various climatic condition which pave the way for Asian pear cultivation with a genuine space that might be possible rather than apple which is affected by fire blight and bacterial canker *Pseudomonas syringe*) at high temperature. On the other hand Asian pear are hardy and more promising for growing in subtropical condition. It has sandy texture and rounds body crunchy in taste make the fruit eighth in world fruit production being mainly commodity of China [1]. More over recent research and development has made available a numbers new cultivars by breeding and selection. Asian pears are generally round to pyriform in shapes therefore, sometimes it is called apple pear and for presence of grit cell around ovary and large size chranchy texture it is also called sand pear. For having low fructose content (4 %), it is considered as a diabetic food and it has immense medicinal value like; controlling and lowering cholesterol, blood pressure and stoke as well as preventing cancer and osteoporosis. It provides fair amount of Bo, Ca, and vitamin C and pectin. In ancient age Greek poet homes cited per as God's Fruit.

* Corresponding author:
brjana.ars@gmail.com (B. R. Jana)
Published online at http://journal.sapub.org/plant

Table 1. Pear production in world during 2012

Position	Country	Production (tonnes)	Area harvested
1	China	16266000	1,136,700
2	USA	778582	22015
3	Argentina	700000	26,500
4	Italy	645540	35195
5	Turkey	439,656	34067
6	Spain	400,600	25000
7	Republic of KOREA	394596	14353
8	India	340000	38500
9	South Africa	338584	13,000
10	Japan	299000	14900

FAO, 2012

World pear production is dominated by Asia where more than two third of all pears are produced. China has the lion's share of the world pears and produced 13 million metric ton which contribute about 58% followed by USA. According to FAO [1] indicated that India's pear production about 340.000 tonnes from the area about 38500 ha. With the bourgeoning population and urbanization it is essential to grow profitable crops from underutilized land. In India Asian pear now a days is cultivated foothill of Himalayas (Punjab, UP, HP Uttaranchal and lower part of Jammu and Kashmir)., North Eastern Hill Region and in Nilgiri hill of Tamilnadu and Netrahat hill of and plateau of Jharkhand. In world possible subtropical Asian pear produced countries are South Africa, Brazil, Chille, Egypt, Iran and Thailand along with other leading countries mentioned in Table-1. As of now India should give emphasize on Asian pear production in the possible subtropical and tropical climate to come up with world pear production trade.

Table 2. Distribution of Asian or oriental pear in India

States	Asian pear cultivars and their hybrids
Jammu and Kashmir	Patharnakh, Yali, Kasmir Nakh.
Jharkhand	Netarhat Selection.
HP	Patharnak, Gola, China.
NEH Region	Patharnakh, Leconte.
Punjab	Patharnak, Yali, Nijiesski, Punjab Gold. Punjab Beauty, China, Housi.
UP	Gola, Leconte.
Uttaranchal	Pathernakh, Gola.
TN	Patharnakh, Punjab Gold, Punjab Beauty, Punjab Nectar. China.

2. Materials and Methods

Dormancy is always associated with low environment temperature where cessation of growth and covered buds with several bracts are common phenomenon of temperate crop like Asian pear. Induction of flowering of temperate fruits mean minimize the dormancy period of plants (e.g. Asian Pear) by initiating biological activity in dormant plant cells. There are several biochemical and plant growth regulators and their methods of application to Asian pear for inducting flowering when the plants are grown out of their natural place.

2.1. Dormancy Breaking Chemicals and Their Actions

Asian pear is a deciduous crop requires winter chilling to break dormancy. Due to global warming there is a fluctuation in low and high temperature in subtropical and tropical areas of the world. Therefore, flowering and fruiting is not consistent in pome fruits particularly Asian pear in subtropical-tropical area. At this condition endogenous hormone level does not produce greater C: N ratio in the cells at bud breaking stage. The problem of prolonged dormancy can be minimized significantly by using chemicals like dinitro orthocresol (DNOC), thiourea, Potassium nitrate (KNO3) and more recently hydrogen cyanamide (Dormex TM) [2]. Gresbach [2] also added that the use of tar oil or DNOC does not permit the growing of cultivar entirely out of their climatic rage but its effect on borderline cases is quite remarkable. In warm winter of South Africa it has been found that 0.25% DNOC and 6% mineral oil was effective when sprays at correct time. But in farmers it was unsatisfactory and sometimes it causes phyto-toxicity also. In order to overcome these problems, extensive research work with hydrogen cyanamide (Dormex) a plant growth regulator, has been undertaken. Since 1984 due to remarkable results of dormex, it is extensively used world over. In Asian pear recommended dose was 2-4% [2]. Klinac [3] investigated that the onset of flowering and shoot extension were advanced in cultivar Shinseiki and Nijiseiki when the application rate was 3% a.i. Most response was shown accordingly application time, particular dose, cultivar and age of the tree and the dose may vary. Rakngan et. al. [4] stated that abscisic acid (ABA) and placlobutrazol treatments depressed the vegetative growth in plastic house and in open field. But paclobutazol promoted flowering in plastic house more that open field. In later study revealed that hydrogen cynamide activates vegetative bud and reproductive bud respectably. But spraying of KNO_3 was effective against flowering bud only. In Jharkhand (India) pear is cultivated in and around the Netarhat hills. Low chilling pear may successfully be cultivated in low-lying areas of Ranchi, Gumla and Lohardaga. In these areas winter temperature is not enough to fulfill the chilling requirement of pear for flowering. Therefore, most of the pear orchard remain unproductive even after plants get matured. Different growth regulators like GA_3, Hydrogen Peroxide (H_2O_2) and thio-urea have been tried as complementary to chilling requirement in different warmer regions for flowering during winter season. GA_3 at higher dose (250 ppm) recorded flowering in pear culivar Le-Contee in Egypt [5]. H_2O_2 content was increased and came at peak in late dormancy when endodormancy was broken [6]. To break bud rest of apple, Japanese plum, peach and apricot thio-ureas (1.5 per cent) was most effective [7]. Thio-urea (2%) induced flowering in twenty years old Asian pear cv. Pathernakh in India [8]. Use of growth retardant SADH and shoot bending increases C_2H_4 (ethylene) synthesis in damaged cell which hastened flowering. Paclobutrazol promoted flowering and fruit set in Japanese pear in plastic house condition where higher temperature prevails [4] on the other hand placlobutrazol PP333 @ 0.2 g /cm trunk diameter of the tree followed by foliar spray of PP333 @250 ppm induced flowering and fruit set in asian pear cultivar Gola in India [9] by retarding growth process.

Plate 1. Flowering of cultivar Netrahat Selection (5%, thiourea, single spray)

2.2. Effect of Rate and Time of Application on Different Low Chill Asian Pear Cultivars

The best time for hydrogen cyanamide application in commercial orchard is from 5^{th} August to 20^{th} September when the crop is five years old Shinseiki at Rukuhia Horticulture Research Station, New Zealand [3]. Hydrogen cyanamide influenced the Nashi pear flowering advancing both the flowering and leaf emergence shortening flowering period, are in general agreement of with the results of Stevenson [10] for Nijiseiki in Australia. HCN (2-3%) spray advanced the onset of flowering by 6 days; shoot emergence by 14 days and shortened the total flowering period by 8 days. Two times spray of thiourea 5% was done on 21 January and 4^{th} February in both the years 2006-07) in Ranchi, India resulted in heavy flowering and fruiting (20kg/ plant (8 years) [11]. Single spray of 5% thiourea during 3^{rd} week of January followed by basin irrigation (32 lits/week/plant (14 years) applied 7 days after spraying and continued up to 45 day after pollination gave a miracle result of 72 kg fruit production /plant (Jana unpubl. data). This might be due to movement of flowering hormones or flower forming principles along with water from their origin to spur and similar result was also reported by Dussi [12]. Water movement is implicated in the dormancy-breaking process, as postulated by Faust et al. [13]. Changes are measured in membrane permeability and dehydration in the tissue of dormant buds of 'Kosui' Japanese pears and compared the gene expression of water channels of cyanamide-treated shoots with controls [14]. The effect of spur pruning and total defoliation in the autumn on pear trees of the cv. Nijisseiki, in the growing season 1999/2000, was studied. In the next spring during blooming the total number of flower buds was calculated. From this study Herter et al, [15] found that an average of 74.35% of flower bud abortion, whereas the spur pruned trees showed 54.11% and the completely defoliated 56.38%.

Use of sticke/adsorbant is an essential part to increase the efficiency of sprayed chemicals. Klinac et al [3] reported that Kocide 101, Shell sunsprayare DC tron ured used in case of HCN, Mineral oil 4-6% are used generally for DNOC. Filter water is simply used for thio urea (Jana and Das, 2014) and KNO_3. mineral oil also used in case of Thidiazuron (TDZ). Approximately sticker content is 150g/100 liters chemical solution.

3. Discussion

Temperature is the main climatic factor related to induction, maintenance and dormancy release in Asian pear when grown under subtropical and tropical condition. Flowering time of many rosaceous species specially apple and pear are affected by the period of winter dormancy, and especially by the timing of dormancy release i.e. low temperature ceased the growth and later endodomancy broken through high temperature, which depends on a genotype-specific chilling requirement [16-18]. The inadequate chilling exposure in Asian pear causes bud breaks problems, resulting in decrease in yield potential. Thus, the knowledge of physiological principles and environ mental factors determines the dormancy phenomenon, bud break and flowering in pear, especially low chill Asian pear. Flower induction in low chill Asian pear might be due to proper carbohydrates: nitrogen ratio or plant hormones and their ratio or vitamin minerals which are integrated part of the enzymatic reaction in meristematic cells.

1. Role of nutrient in flower induction:

Before plant hormone were identified, the dominant theory of flowering of perennial plant centered on control by nutrients this reflects the influence of the C/N ratio [19] this was also reviewed by Cameron and Dennis in 1986 [20]. As stated by C:N ratio theory, flower bud formation requires high level of carbohydrates in the cell. Many of the flower promoting orchard techniques such as ringing, summer pruning, root pruning and vigor control are accompanied by higher carbohydrates level. Energy reserves the carbohydrates are necessary for floral bud development. Flower induction requires a lot of carbohydrates and proteins [21]. Sufficient carbohydrates alone are incapable to trigger the transition of bud from vegetative to reproductive growth.

An optimum amount of nitrogen also necessary for flower bud induction Nitrogen deficiency may reduce flower induction [22] Nitrogen inform of (NH_4+) ammonia favors flower induction, while nitrate (NO_3-) does not. The effect of nitrogen can even spread to lateral buds give rise to shorter shoot and higher rate of flower induction [23]. The function of NH_4+ is not only nutritional but also involving in activity of plant hormones. An increase in cytokinin activity in apple xylem sap was found by Gao *et al.* [24] after application of NH_4+. Cytokinin in turn thought to be responsible for apple flowering initiation [25]. In case of application of thio urea leads to production of super oxide ions in cells that alters protein structure by protein phosphorylation and increase starch synthesis which may cause higher C:N ratio resulted in heavy flowering in Asian pear cultivar Netrahat Selection [11] in India (Jharkhand) under Ranchi condition .

2. Role of plant hormones and bio-molecule in flower induction:

Flower promoting effects of TIBA and B9 are due to their inhibition of IAA biosynthesis and transportation. Bangerth [26] examined that bending of vertical shoot of apple and pear decreased IAA export while GA3 application stimulated it. Less quantity of GA3 inhibit flowering while higher dose >250 ppm promotes flowering at long day condition [5]. Heterozygous *lfy* and *ag* mutant are reverted from inflorescent meristem to floral meristem under short day condition but are maintained by GA treatment [27]. It might be due to flower induction from GAs affect via expression of the floral homeotic genes. In favour of this hypothesis, Blazquez et al. [28] suggested a markedly increase of LFY:GUS expression in Aradiopsis after GA3 treatment. Tromp [29] reported among Gas the trees are more responsive to GA7. Higher GA/ABA ratio in long day condition favours plant to flowering. Cytokinin are always associated with promotion of flowering in apples and pear. Zeatin and benzyl adenine were found to promote flower induction when applied after anthesis in apple [30, 31]. In perennial and spur bearing plants, citokinin/GA plays an important role in flowering. Increased in the ratio led to heavy flowering in apples and pear [32]. On the contrary return bloom was dramatically increased by B-9(Cytokinn) and CEPA, (ethylyne releasing compound). Ethylene and ethelene-releasing compound are effective for return blooming when used after bending of branches [33] and summer pruning [34] of apple and pear plants. Asian pear Shinseiki's flowering was significantly advanced by application of 3% a.i. hydrogen cyanamide (14 days before normal flowering). HCN becomes implicated in the physiology of bud jump in nashi pear by virtue of its possible role as a plant growth regulators for flower induction of Asian pear [3]. The effect of HCN application hastened calcium dependent protein phsphorylation activities in the bud tissue were studied by Pang et.al; [35] reported that HCN induced expression of Ca^{2+}-ATPage action and evoke an increase $[Ca^{2+}]$ cyt. Similar was confirmed for calmodulin, calmodulin-binding protein and calcium dependent protein kinase (CDPK). Calcium dependent histone phosphorylation was up to 70% higher in HCN treated buds of grape. Thus, calcium signaling is involved in the mechanism of bud dormancy release [35].

Some chemicals produce superoxide ion in cell and simultaneously conserve carbohydrates and alters the protein structure resulted in aging of cell and promoting flowering under low chill subtropical condition. Further more, they can produce ions that act as a co enzyme in natural hormone synthesis process that increase in flowering induction process(like, Zn, Bo, Fe, Mg, etc.). Now a days scientist of Portugal using biochemicals like glutathione, an enzyme inhibitor and free radical precursor (Glutabion®), or mixtures of polysaccharides and growth regulators (W Uniformity Superplus) and nutrients and N-acetil cysteine, betains and vitamins (Promvit) for early flowering by at least 6 days for Rocha Pear [36]. In plastic house condition, early increasing temperature alleviate cytokinin activity in cells and content of growth inhibitor decreases gradually resulted in early flowering. Proper allocation of dry matter to shoots and roots and reserved nutrients like carbohydrates increases in bud breaking and induces flower bud formation from meristem in Kousi Japanese Pear [37]. Foliar and soil application of paclobutrazol induce flowering by retarding growth process in Asian pear [4] and [9]. It has been found that in pome fruits nuclic acid ration like RNA/DNA improves flower bud formation significantly [38].

Shoot bending causes somewhat branch breaking resulted in release of C_2H_4 synthesis in damaged cells. Bending the lateral branch to a horizontal position can induce an increase in flower bud production on the shoots of apple and Japanese pear [39-40] possibly owing to the induction of high cytokinin/auxin ratios in the lat-eral buds [41]. Growth retardant Like SADH induces early flower bud formation by better utilizing nutrient components and activating endogenous growth regulators and hormones in cells like increasing cytokinin/auxin ratio in cell resulted in early and heavy flowering in Japanese pear (*Pyrus serotina* Rehd) [42].

4. Conclusions

Thiourea increases starch content of cells [43] and alters protein structures [44] there by increases C:N ratio of the cell which broke dormancy in Asian pear Netrahat Selection India [11] adopting methods of Thimmaiah [45]. HCN (Dormex) minimizes dormancy period of Asian Pear by calcium dependent protein phosphorylation in bud cells. Application higher dose of GA4 or GA7 to increases the GA/ABA ratio of the cell which promotes flowering. Citokinin also promotes flowering in apple and pear by increasing Cytokinin: GAs ratio. There are a number of reports showing that nucleic acid ration (RNA/DNA) also responsible for flower bud formation [38]. SADH, Paclobutrazol and shoot bending have positive impact on flowering in Asian pear (cv.Gola) [9].

So we have many ways to regulate and induce early flowering in Asian pear grown in subtropical to tropical regions of the world. This review can provide a window for further research to come up with the correct incidence happening in the PGRS treated cell for flowering and thereby fruit production.

Appendix

Bud breaking agents of Temperate fruit crops in general

Crops	Dormancy Breaking Agents	Dose (a.i.)	Time*	References
Apple	HCN DNBP + mineral oil (4%) Thiourea, KNO3	2-4% 3% 1%	Dormancy Period	Petri (1996)* Griesbatch (2007)
Appricot	Thidiazuron (TDZ)	2-5%	Dormancy period	Erez et al. (2006)*
Cherry	HCN Thidiazuron (TDZ)	1-3% 0.2%	Dormancy Period	Griesbatch (2007) Erez et al. (2006)*
Grapes	HCN	5%	Dormancy Period	Griesbatch (2007)
Kiwi	HCN CPPU	5%	Dormancy Period	Salinero et.al (2007) *
Nectarine	HCN Thidiazuron (TDZ)	1-3 %	Dormancy Period	Griesbatch (2007) Erez et al. (2006)*
Peach	HCN Thidiazuron (TDZ)	1-3%	Dormancy Period	Griesbatch (2007) Erez et al. (2006)*
Pear Asian Pear	HCN HCN Thiourea Promvit, Glutabion W uniformity superplus SADH and Shoot bending	2-4% 3-5% 5%	Dormancy Period Dormancy Period Dormancy Period Active vegetative stage	Klinace al (1991) Jana and Das (2014) Banno et al (1985) Pereira et.al (2011)
Plum	HCN Thidiazuron (TDZ)	1-3%	Dormancy Period	Griesbatch (2007) Erez et al. (2006)*
Red Raspberry	HCN	3%		Snir (1988)*

- references are not listed
- Time* Dormancy period when temperature is minimum or start to rising is effective

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