Effect of Girdling on Induction of Flowering and Quality of Fruits in Horticultural Crops- A Review

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Abstract

The growth and fruitfulness of a plant is greatly influenced by the relative proportions of carbohydrates and nitrogen. The C:N ratio of crop plants can be altered through simple special horticultural practices like girdling. It is basically an intervention in the phloem transport between canopy and roots, in an attempt to manipulate the distribution of photosynthate, mineral nutrients and plant bioregulators A wide variety of fruit species are girdled to induce flowering, improve fruit set, increase in yield, enlarge fruit size, advance maturity and improve quality. Mango, Apples, grapes, olives, oranges, grapefruits, jamun and peaches have responded in at least one of these areas. The effects of girdling on fruit crops on various aspects are reviewed in this paper.

Key words: Girdling, ringing, C:N ratio, induction of flowering, fruit quality, yield.

Introduction

It is quite often that the trees do not bear fruits although they are in good health and may not show any apparent diseased symptoms. There are two chemical elements in organic matter which are extremely important, especially in proportion to each other; they are carbon and nitrogen. This relationship is called the carbon-nitrogen ratio (C:N). The growth and fruitfulness of a plant is greatly influenced by the relative proportions of carbohydrates and nitrogen. To understand what this relationship is, Miller (2000) has given example. Suppose a certain batch of organic matter is made up of 40 percent carbon and 2 percent nitrogen. Dividing 40 by 2, one gets 20. The carbon-nitrogen ratio of this material is then 20:1, which means 20 times as much carbon as nitrogen.

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A satisfactory general balance must exist between carbohydrates and nitrogen supply in the plants before conditions are suitable for good growth and fruit development (Kunte *et al.* 2005). Carbon is important because it is an energy-producing factor and nitrogen, because it builds tissue. The importance of the Nitrogen Carbon (NC) ratio concept has been known since 1918 or earlier, as documented by the work of Kraus and Kraybill (Chandler 2012). Carbon sprayed on crops and soils, such as cotton, sugar cane, tomatoes, melons and other multi-fruiting crops, has been an effective way of slowing vegetative growth and speeding fruiting. Carbohydrate levels are directly related to Nitrogen levels.

Earlier on the basis of nutritional status, fruit plants have been divided into four general groups or classes by Kunte *et al.* (2005). These are given in table 1.

As the tree comes into bearing, it tends to pass from Class i or ii to iii and then iv. The problem of the grower is to keep the plant in class iii or as near it as possible. This Class represents the proper nutritional condition for good fruiting. Such trees can be brought into proper nutritional balance condition by using different methods. Similarly, Chandler (2012) suggested three types of situations or C:N ratios (Table 2) are generally present in the field, and are described as follows.

Type 2 could be brought into proper growth as Type 3 by increasing the carbohydrate production potential that is, by increasing the sun light intensity or the available Carbon concentration, drying soils, or by root pruning or removal of the soil N through application of a soluble

Table 1. Classification of fruit plants on the basis of nutritional status

Class	Carbohydrates and Nitrogen	Effect
i)	$\frac{C}{NNNN}$	Plants in this class make poor growth and bear little or no fruit. There is a small quantity of C and abnormally large quantity of N in the tree. Young trees near the bearing age, which have been defoliated by insects, or diseases or trees, which are grown in shed or are overcrowded, may fall in this class
ii)	$\frac{C}{NNN}$	Excess N is present with sufficient amount of C for strong succulent growth. Practically all the C are used for growth and hence, there is no storage. This represents the normal growth period for trees too young to bear or for mature trees forced into growth by sever pruning or too much manuring.
iii)	$\frac{CCC}{N}$	A fair growth and fruits are produce in this class. The balance of C is right for both growth and fruitfulness, with a slight excess of C.
iv)	$\frac{CCCC}{N}$	Poor growth and small amount of fruits are produced. Excessive amounts of C and small quantities of N are present. This class represents a starved or devitalised condition. Most of the old trees may be found in this nutritional condition. So also neglected trees fall in this group

Kunte and Yawalkar *et al.* (2005)

Table 2. Three types of situations of C:N ratios generally present in the field.

Type 1- Low N - Moderate to High C	If the available N is low, but there is adequate opportunity for carbohydratesynthesis and adequate soil moisture, vegetative growth will be slow and fruiting will be poor or non-existent due to lack of N. Such plants will have a yellow-green appearance, will be rich in stored carbohydrates, reduced sugars and sucrose (Brix), and will be very low in total N as well as nitrates (NO_3). Such plants will have very woody stems.
Type 2- Moderate to High N - Low C	If, on the other hand, the supply of soil N is great and the availability of wateris also great, and there is little opportunity for sufficient carbohydrate synthesis, the plants will be very vegetative or lush and may even produce an abundance of flowers which may drop without setting fruit
Type 3- Moderate N - Moderate to High C	The desirable situation is the moderate in-between one, when N ismaintained at moderate levels determined by such external factors as adequate radiant energy, temperature (heat units) and soil moisture.

Chandler (2012)

carbohydrate to the foliage or soil. The C/N ratio in plant varies with plant species, with in varieties and with in different plant parts also.

The CN ratio of crop plants can be altered through special horticultural practices such as use of chemicals, root pruning and exposure, bending, smudging and ringing or girdling.

Among these girdling or ringing is meritorious in many fruit crops. Girdling or ringing has been, and is still, worldwide horticultural practice used to manipulate tree growth and development. Girdling consists of removal of a strip of bark from the trunk or major limbs of a fruit tree, thereby blocking the downward translocation of photosynthates and metabolites through the phloem. The immediate effect of a girdle is to interrupt the movement through the phloem of photosynthates produced by leaves. This increases foliar carbohydrates (sugars and starch) and plant hormones in above parts of the girdle which enhances the flowering (Khandaker *et al.* 2011). Ringing is a form of girdling in which a cut is made with a pruning knife or a similar instrument around the circumference of a trunk or branch, with or without removal of a ring of bark.

Ringing or Girdling

This is one of the well known methods for inducing fruit bud formation.The leaves are the main site of carbohydrate synthesis, which in turn serve as raw material for a long list of compounds found in the plant cell and in the cell wall. Carbohydrates move in form of sugars either to the terminals (growing points), or to the roots. Their paths are the sieve tubes in the phloem (bark). The temperature has a bearing on the movement of elaborated materials, 20 to 30 degrees Centigrade being the optimum. The influence of temperature is many fold, it influences the production of carbohydratesand the mobility of the sap. It moves more by day than at night (especially in herbaceous plants). The sap in the bark is sometimes under pressure and we may notice the sap oozing out upon ringing. Other very important materials, such as hormones, amino-acids etc. move in the bark in the same direction. Minerals provided that they enter the sap stream in the bark alsomove in the same direction (Ticho 1970).

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Though girdling is old horticultural practise and not commonly followed in all crops, the changing trends from agrochemical based production to green farming have made farmers to seek for practices that are less harmful to the environment and leave less or no chemical residue in fruit. Similarly, fruit producers are always looking for methods to reduce farm operation costs while maintaining high fruit quality.

In horticulture, girdling has been widely applied to increase flowering, fruit set and fruit size while in forestry it has been used to alter wood properties.

The best-known effects of girdling are presumably brought about by accumulation of assimilates above the girdle.The operation consists of removing a strip of the bark (2 to 5 mm width depending upon crop) from a branch or trunk of tree. As a results of girdling leaf N content, C/N ratio and carbohydrate were improved. Therefore, flowering and fruit set were increased (Shao *et al.* 1998). Rivas *et al.* (2007) observed reduction in fruitlet abscission, increased leaf chlorophyll content and chlorophyll fluorescencewith girdling, fewweeks before flowering. Furthermore, it increased quantum yield and carbohydrate concentration in various flowering and vegetative shoots in citrus. In another experiment Mostafa and Saleh (2006) reported that girdling plus potassium spray increased the total number of fruits and yield weight per tree. It has been well documented that the ringing of trees can bring about an increase in the size and sugar content of fruits and cause them to mature a few days to a week earlier. Ringing is sometimes resorted to induce flowering in over-vigorous mango trees. Here the ring to be removed must be very small so that the wound is healed up without causing serious damage to the tree itself. Only few selected branches should be ringed.

Jonhson and LaRue (2013) performed girdling by removing a strip of bark from around the trunk or base

Table 3. Effect of girdling on yield and harvesting date of some genotypes of Chinese date

	Treatment	Fruits harvesting date					Yield kg $tree^{-1}$	Percent increased yield (%)
		3rd Oct	8th Oct	13th Oct	17th Oct	22th Oct		
R1P8	Girdled	10.71	-	5.60	-	-	16.31	51.40
	Non-girdled	3.60	3.64	-	-	-	7.24	
R2P5	Girdled	-	7.57	-	2.27	2.57	12.41	46.57
	Non-girdled	-	-	-	1.17	4.61	5.78	
R3P5	Girdled	8.00	4.00	-	0.69	-	12.00	58.0
	Non-girdled	4.91	2.05	-	-	-	6.96	

Source: Ramona and Florin (2015)

Table 4. Effects of girdling on fruit set and fruit characteristics at Chinese date.

Genotypes	Inflorescence development (days)	Fruit set (%)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
R2P5	15	48	5.73	2.90	1.67
R2P5*Control	19	37	4.90	2.50	1.45
R2P10	13	61	19.01	3.85	2.78
R2P10*Control	17	52	18.20	3.30	2.28
R2P11	11	58	18.81	3.94	2.65
R2P11*Control	16	42	17.90	3.62	2.35
R3P6	9	65	12.70	2.60	1.94
R3P6*Control	14	37	11.89	2.24	1.54
R3P9	12	59	10.80	3.80	1.76
R3P9*Control	17	48	9.78	3.10	1.24

Source: Ramona and Florin (2015)

of each scaffold limb of peach and nectarine tree with a grape girdling knife. The cut was made 1/8 or 3/16 inch wide and only as deep as the cambium layer (the area between the bark and wood) and found temporarily disruption in downward flow of carbohydrates in the phloem and apparently made them more available for fruit growth and development. They also suggested that if the cut is not deep enough, the uninterrupted downward flow continues and the fruit will not respond. Deeper cuts that penetrate past the cambium into the xylem tissue disrupt the upward flow of water and nutrients, leading to severe stress and even death of the limb or tree and to be effective, the girdle must extend all the way around the limb with the two ends meeting or overlapping in a spiral pattern. Even if only a small section of bark is left enough, phloem may remain to continue the down ward flow of carbohydrates and the girdle will be ineffective.

- Girdling helps to
- Induce Flowering
- Improve fruit set
- Enlarge fruit size
- Advance maturity
- Increases yield
- Induce rooting in layering
- Girdling also helps in reducing juvenile period of hybrid mango and avocado seedling

Fruit crops like Grapes, Oranges, Jamun, Chinese Ber, Wax jambu, Litchi, Peaches, Pear, Olives, Avocado and Apples have responded in these areas.

Girdling for induction of flowering, improving fruit set, fruit size and fruit quality.

A wide variety of fruit species are girdled to increase their yields, improve set, enlarge fruit size and advance maturity. However, numerous examples of no response or even of negative effects exist. Girdling, therefore, must be used cautiously under conditions where the effects are well understood.

Ramona and Florin (2015) used special production practice to enhance yield and overall fruit quality of Chinese Date (*Ziziphus jujube* Mill.). The aim of the present study was to check the effects of girdling on inflorescence development, fruit set, yield and fruit quality of Chinese date under field conditions. Girdling was done at the beginning of floweringseason, and it was performed for three genotypes: R1P8, R2P5 and R3P5 by removing a circular bark strip from around the trunk with a girdling knife. The ring cut on the trunk was 2 cm wide at the deep of the cambium layer till the xylem, at 25 cm above ground.

Total Fruit Production

The most encouraging results related to the fruit yield was in case of the girdled trees which showed a total fruit production increase with more than 50% over the non-girdled (control) trees. The total fruit production of girdled tree in R1P8 genotype was 16.31 kg $tree^{-1}$ comparing with the control 7.24 kg $tree^{-1}$. Yield increase expressed as percentage for all girdled trees was substantial 51.40 per cent for R1P8, 46.57 per cent R2P5 and 58.00 per cent for R3P5. The girdled jujube trees increased their yield by improving fruit set, enlarged fruit size and advanced fruit maturity

In other experiment girdling was performed by Ramona and Florin (2015) on five other genotypes R2P10, R2P11, R3P9, R3P6 and R2P5 by removing a bark strip of 5 mm wide from lateral fruiting branches. The same number of similar un-girdled branches was used as control.

Girdling significantly reduced the time needed for inflorescence emergence and the duration of flowering. Results showed that the flowering duration was 9 days for R3P6 in girdled variant, whilst it took 14 days in control. The same behaviour after girdling was

Table 5. Yield and packout of 'Fairchild' mandarins subject to girdling treatments

		Fruit Size (%)							Economic Impact	
Girdling Time	Yield (lbs. tree^{-1})	Small	Medium	Large	Jumbo	Mammoth	Colossal	Supe Colossal	Net Returns carton^{-1} ($)	Gross Receipts acre^{-1} ($)
Control	50.4 d^z	6.2 b	23.9 b	39.7 a	23.2 b	8.4 b	0.1 b	0.0 a	$3.40	$497.81
November	121.5 b	17.8 a	44.6 a	30.2 b	6.8 c	0.8 c	0.0 b	0.0 a	$1.76	$622.57
March	159.8 a	14.7 a	41.1 a	32.2 b	11.1 c	1.9 c	0.1 b	0.0 a	$2.16	$1,005.06
May	75.0 c	2.8 b	17.4 b	32.1 b	28.9 a	18.0 a	1.5 a	0.1 a	$4.07	$886.52

Source: Wright (2000)

shown by R2P5 genotype with 15 days of flowering in comparison with 19 days of flowering in control treatment.All the girdling treatments determined higher fruit set values compared to the control. In the case for R3P6, the highest fruit set percentage per branch was of 65 per cent, while the lowest was of 37 per cent

Average fruit weight (g)

The fruit weight showed significant positive results after girdling. The increase in weight was nearly one gram per fruit. Fruit weight of 1901 g was registered for R2P10 in girdled variant and 1820 g in the control. Lowest average fruit weight of 573 g produced by R2P5 genotype in girdled variant and 490 g was found in control (Table 4).

Fruit size (length and diameter)

Promising results related to girdling effect on the fruit size expressed in fruit length and diameter, were obtained when compared with the untreated control branches. As can be seen in the Table 4, average fruit size (length and diameter) was significantly influenced by girdling compared to control. The fruit diameter increased from 3 mm for R2P11 to up to 5 mm for R3P9 genotype on girdled branch compared with control.

Citrus is one of the most important fruit tree species in the world, as the fruits are a valuable source of nutrients, vitamins and other antioxidant compounds. It is presumed that during the growing season flowers and fruits compete one another and with vegetative growth for plant metabolites (Rivas *et al.* 2007). This competition hypothesis is based mainly on the carbohydrate supply and reserves, which regulate fruit set and subsequent fruit drop (Rivas *et al*. 2006). Fruit set and growth requires large amounts of carbohydrates, which are provided by the photosynthesis of the current season's leaves and/or by the reserves accumulated during the winter. If the requirements exceed the capacity of the tree to supply assimilates, fruitlet abscission is triggered, in order to adjust the final fruit load to carbohydrate supply. Among agricultural practices which may improve carbohydrate balance and increase their availability is girdling, which increases fruit set and yield. It has been found that cytokinin and gibberellin content of the shoots are modified along with the C/N ratio, which increases. Spring girdling, i.e. pre-bloom removal of a wide strip of bark without injuring the xylem, is widely used in citrus species mainly to increase fruit set and size as well as fruit quality (Mostafa and Saleh 2006). Roussos and Tassis (2011) conducted trial to study the effects of fertilizer application (zinc plus urea) of the auxintriclopyr which is a synthetic auxin and of girdling on total yield and fruit quality attributes of Nova mandarin trees. Four treatments were applied in young mandarin trees, variety "Nova", in order toassess their effects on fruit quality. The treatments comprised an untreated control, applications of zinc plus nitrogen, post-bloom auxin application and pre-bloom girdling. Girdling improved significantly the quality characteristics of the fruits, enhancing the sweetness index, as a result of increased carbohydrate concentration, and increasing the phenolic compound concentration of the juice.

It is well recognized in Southwest Arizona that medium to large fruit size is key to profitable citrus production.

Table 6. Fruit Quality of 'Fairchild' mandarins subject to girdling treatments

Girdling Time	Juice Content (%)	Total Soluble Solids (%)	Total Acid (%)	TSS:TA	Peel Thickness (mm)
Control	48.3 a	12.8 a	0.92 a	14.2 c	2.6 b
November	43.6 c	12.8 a	0.80 b	16.3 a	2.6 b
March	46.5 ab	13.0 a	0.82 b	16.0 ab	2.9 a
May	46.1 b	12.5 a	0.85 ab	15.0 bc	2.7 b

Source: Wright 2000.

Table 7. Lemon yield, fruit size and packout of lemon trees subject to girdling treatments

Girdling Month	Yield tree^{-1} (lb)				
	1997-98	1998-99	1999-2000	Total	Average
November	42.12 a	45.17 b	84.87 b	172.16 b	57.38 b
March	28.77 b	153.33 a	92.73 b	274.83 a	91.61 a
May	27.48 b	153.83 a	72.46 b	253.77 a	84.59 a
November and March	49.57 a	54.00 b	132.18 a	235.75 a	78.58 a
Control	28.80 b	155.17 a	98.66 b	282.63 a	94.21 a

Source: Wright 2000.

Although extra large sized mandarins are sometimes hard to market due to the potential for granulation, small sized fruit receive poor prices throughout the season, except when there is a fruit shortage. Prices for medium to large sized fruit, on the other hand, remain strong during the entire harvest season from October until February. For lemons, medium and small size lemons command good prices early in the season but these prices drop precipitously during the late fall. Prices for large fruit, on the other hand, remain strong during the desert lemon harvest season from August until February. Considering this Wright (2000) conducted experiment to determine the effect of girdling time on fruit size, fruit quality and yield of 'Fairchild' mandarins and 'Lisbon' lemons andreported that November, March and May girdling of the mandarins led to the greatest yield. March girdling yield increases were generally due to greater fruit numbers, while in May, yield increases were due to greater fruit numbers and fruit size. Returns per acre suggest that March and or May girdling of mandarins will lead to greater profits for the grower (Table 5).

The juice content of the fruits of control tree was significantly greater than that of the girdle treatments (Table 6). This may be because the girdling did not inhibit root growth of these trees, thus hydraulic conductivity was greater. Total acid percentage of the control fruit was also greater than that of the girdled trees fruit, while there was no difference in the total soluble solid percentage between any of the treatments. Thus, the solid to acid ratio of the control fruits was less. Similarly, like mandarins Wright (2000) also noticed that yields of these trees dropped considerably in the second year and the trees appear to be in an alternate bearing cycle. No lemon girdling treatment appeared to be better than the untreated trees after three years.

In mandarin cv. Balady Mostafa and Saleh (2006) reported girdling (before blossoming in late Dec.) plus spraying of tree with 2% potassium nitrate (first in April and second in mid-June) had a positive effect on nitrogen (2.53%), potassium (1.75%), total carbohydrate (12.36 %) and chlorophyll (384) content in the leaves, which reflected on increasing fruit weight (157 g), number of fruits per tree (412) and yield (65 kg tree^{-1}).

In two citrus cultivars effect of girdling on fruit set and quantum yield efficiency was studied by Rivas, *et al.* (2007). For both cultivars girdling caused significant difference in fruit set between shoot type and girdling increased final fruit set only in leafy shoot.The effects of girdling branches (GB) and girdling limbs (GL) on flowering, fruit set, fruit yield as wellas leaf photosynthetic pigments and endogenous hormones content in 16 year-old Washington navel orange (*Citrus sinensis* L. Osbeck) trees were investigated during two seasons (2012-2013) by Ibrahim *et al*. (2016). It was observed that GB increased number of flowers by 34.22–41.26%, fruit set by 103.17–113.30% and number of harvested fruits/ branch by 164.44–272.25% relative to ungirdled trees (Table 8). GL increased number of flowers by 19.37–23.41%, fruit set by 59.73-76.77% and number of harvested fruits/branch by 62.84–148.11% relative to ungirdled trees. However, GB slightly decreased fruit weight (7-19%), fruit size (12-18%) and fruit Total Soluble Solids (TSS)/acid ratio (20-25%) compared to control (Table 9 and 10). They also reported that in girdling treatments, carbohydrates content was 14-153% and 7-74% more in leaves and stems respectively which was accompanied by a reduction in total chlorophyll (-38 to -70%) and an increase in carotenoids (+41 to +119%) within the leaves. In young leaves, GB increased Abscisic Acid (ABA) and decreased Gibberellins (GA3) and Indole-3-Acetic Acid (IAA) contents, whereas GL increased GA3 and decreased ABA & IAA concentrations.

Jamun (*Syzygium cuminii*) is an underexploited fruit crop gifted with abundant nutritional and medicinal values. In spite of its greater economic value, farmers are reluctant to establish jamunorchards as flowering is the major constraint. The prebearing age of jamun is fairly long even in grafts. It takes about 6 to 7 years for commencement of flowering and many times this period is extended up to 10 years.

An experiment was therefore undertaken by Haldankar *et al.* (2014) under two distinct locations having

Table 8. Effect of some girdling treatments on floral and fruiting characteristics ofWashington navel orangetrees (2012 and 2013 seasons)

Treatments	Number of flowers branch^{-1}	initial number of fruitlets branch^{-1}	Initial fruit set^{a} (%)	Number of retained fruits branch^{-1} after June drop	Fruit retention	Number of harvested fruits branch^{-1}		Final fruit retention (%) at harvest
						value	± %	
First season (2012)								
Control	245.45	57.04	23.24	8.33	14.60	6.89	-	2.82
Girdling branches	329.44	115.89	35.18	24.22	20.90	18.22	164.45	5.54
Girdling limbs	293.00	91.11	31.10	15.55	17.07	11.22	62.85	3.83
LSD at 0.05	44.28	22.60	8.86	2.15	4.14	1.85	-	0.65
Second season (2013)								
Control	234.00	62.04	26.53	8.77	14.14	6.09	-	2.60
Girdling branches	330.56	132.33	40.04	29.67	22.43	22.67	272.25	6.86
Girdling limbs	288.78	109.67	37.98	20.22	18.44	15.11	148.12	5.23
LSD at 0.05	47.54	15.40	9.14	2.41	3.53	1.68	-	1.37

Source: Ibrahim *et al*. (2016)

a In relation to number of flowers; b In relation to initial number of fruitlets c In relation to number of flowers

* ± % in number of fruits/ branch in relation to Control

different weather conditions to study the efficiency of girdling for induction of flowering in jamun Var. Konkan Bahadoli under Maharashtra conditions. The experiment was conducted in Randomized Block Design with five treatments *viz*. T_1- Deep cut on secondary branches, T_2 – Deep cut on tertiary branches, T_3- Removal of 3 mm bark on secondary branches, T_4- Removal of 3 mm bark on tertiary branches and T_5- Control (No girdling). Results presented in Table 11 and Table 12 indicated that girdling was beneficial in jamun for induction of flowering, greater flowering intensity, more number of flowers and fruits per branchlet, reduced period from flowering to harvesting and higher yield as compared to control plants. Tertiary branches were found to be more appropriate location for girdling than secondary branches. Girdling with deep cut without removal of bark was more beneficial than the removal of bark. T_2 was the best treatment of girdling in jamun

The same experiment was repeated by Department of Horticulture by adding one more location in addition to above two locations i.e. Location C Vangaon, Tal.

Table 9. Effect of some girdling treatments on physical properties of Washington navel orange fruits (2012 and 2013 seasons)

Treatments	Fruit weight (g)	Fruit size (cm^3)	Pulp weight (g)	Peel weight (g)	Peel thickness (mm)	Juice volume fruit^{-1} (cm^3)	Fruit length (cm)	Fruit diameter (cm)
First season (2012)								
Control	225.50	241.96	163.33	59.80	4.27	112.31	7.93	7.54
Girdling branches	183.64	199.04	129.80	42.20	3.35	92.00	7.08	7.12
Girdling limbs	223.24	244.40	169.13	57.73	3.92	116.29	8.01	7.61
LSD at 0.05	31.63	34.29	20.18	10.06	0.87	17.95	0.38	0.41
Second season (2013)								
Control	221.96	240.57	156.47	62.80	4.65	107.58	7.96	7.48
Girdling branches	206.66	210.66	139.90	42.93	3.51	96.31	7.39	7.17
Girdling limbs	246.66	267.34	183.53	63.53	4.43	126.19	8.17	7.67
LSD at 0.05	35.07	29.11	16.42	11.84	0.35	11.43	0.32	0.48

Source: Ibrahim et al., (2016)

Dist–Palghar from the year 2012 to 2015 and the results were similar. On the basis of the three years data at three locations, Dr. B.S.K.K.V. Dapoli recommended Single deep cut on 50 per cent tertiary branches in the month of October for increasing yield in jamun grafts.

The *Syzygium samarangense* commonly known as wax jambu is a tropical fruit tree with presumably originated in Malaysia and other south-east Asian countries. Wax jambu is a non-climacteric in nature which belongs to the family Myrtaceae. In Malaysia, the ripe pink fruits of wax apple are bell-shaped, sweet and can be eaten fresh or cooked, for sauces, jams, jellies desserts, wines, liquors and vinegars. Ninety percent or more of the fruit is edible. The fruits can be used for several inflammatory conditions, including sore throat, high blood pressure, ringworm, and as an antimicrobial, antiscorbutic, carminative, diuretic, and astringent. Malaysian climate is suitable for the wax jambu production. There is a great scope to develop wax jambu industry in Malaysia and other tropical countries. Severe fruit drop and low quality impair wax jambu production, resulting in lower market prices. Girdling considered an important practice responsible for improving fruit setting, yield as well as physical and chemical properties of fruits.

Table 10. Effect of some girdling treatments on some chemical constituents of Washington navel orange juice (2012 and 2013 seasons)

Treatments	TSS (%)	Acidity (%)	TSS/acid ratio	Vitamin C content (mg 100ml^{-1} juice)
First season (2012)				
Control	14.53	0.83	17.52	59.16
Girdling branches	13.20	0.94	14.06	54.15
Girdling limbs	15.13	0.79	19.37	71.19
LSD at 0.05	0.71	NS	5.13	8.77
Second season (2013)				
Control	15.27	0.79	19.46	63.67
Girdling branches	12.53	0.85	14.69	60.16
Girdling limbs	15.40	0.77	20.15	66.20
LSD at 0.05	0.61	0.05	1.53	NS

Source: Ibrahim *et al.* (2016)

The study was undertaken by Khandaker *et al.* (2011) to investigate the effects of different girdling techniques on the yield and quality of wax jambu fruits (*Syzygium samarangense*). Physiological and biochemical parameters were monitored at one week intervals during the three successive growth period from January 2009 to May 2010, using I-25%, C, V shaped, I-50% and 100% girdling. Girdling was applied three weeks before flowering every season. It was observed from Table 13 and Table 14 that the C-shaped girdling technique significantly enhanced the inflorescence development and produced the best results with regard to the fruit retention, fruit size, leaf chlorophyll and drymatter in comparison to the control and the other girdling techniques employed. Furthermore, C-shaped girdling enhanced faster fruit growth producing the best final fruit

Table 11. Effect of girdling on plants flowered (%) and number of days required for flowering in Jamun cv.Bahadoli

	Treatments	Location A Flowering induced (%)	No. of days required for flowering after girdling	Location B Flowering induced (%)	No. of days required for flowering after girdling
T_1	Deep cut on secondary branches	50	79.0^c (79.0±3.46)	63	79.7^c (79.7±2.75)
T_2	Deep cut on tertiary branches	100	75.25^d (75.25±2.50)	75	75.0^d (75.0±2.16)
T_3	Removal of 3mm bark on secondary branches	50	85.5^b (85.5±3.87)	50	85.0^b (85.0±1.82)
T_4	Removal of 3mm bark on tertiary branches	50	86.75^b (86.75±3.30)	63	86.7^b (86.7±3.40)
T_5	control	50	97.0a (97.0±3.41)	25	98.0^a (98.0±2.16)
	S.E±	-	0.93	-	0.88
	CD @5%	-	2.74	-	2.85
	% P value	-	0.00000192	-	0.000024

Source: Haldankar *et al.* (2014)

Table 12. Effect of girdling on flowering intensity (%), flowers per twig and days required from flowering to harvesting in Jamun cv.Bahadoli

Treatments		Location A Pachora Dist. Jalgaon			Location B Konkangaon Dist. Nashik		
		Inflorescence m^{-2} (%)	Flowers $twig^{-1}$	Days required flowering to harvesting	Inflorescence m^{-2} (%)	Flowers per twig	Days required-flowering to harvesting
T_1	Deep cut on secondary branches	55.0b (55.0+12.90)	29.0b (29.0+6.92)	123.0b (123.0+11.22)	47.5a (47.5+20.61)	33b (33+11.48)	125.0ab (125.0+12.90)
T_2	Deep cut on tertiary branches	67.5b (67.5+9.57)	40.5a (40.5+12.4)	120.5b (120.5+6.13)	55.0a (55.0+12.90)	43a (43+8.24)	120.0ab (120.0+5.71)
T3	Removal of 3 mm bark on secondary branches	52.5b (52.5+9.57)	21.0c (21.0+5.03)	128.0b (128.0+6.97)	30.0b (30.0+8.16)	14a (14+6.92)	128.25a (128.25+6.94)
T4	Removal of 3 mm bark on tertiary branches	45.0b (45.0+5.77)	28.0b (28.0+4.61)	130.5a (130.5+9.81)	37.5ab (37.5+17.07)	33b (6.5+1.91)	131.0a (131.0+9.48)
T_5	control	45.0b (45.0+12.9)	18.0c (18.0+2.30)	123.0a (123.0+11.54)	17.50b (17.50+5.0)	12c (12.0+5.65)	137.5a (137.5+9.57
	S.E±	3.69	2.20	3.41	5.32	3.3	3.46
	CD @5%	10.78	6.44	9.97	15.7	9.8	10.10
	% P value	0.0013	0.0000021	0.0047	0.0014	0.000018	0.0199

Source: Haldankar *et al.* (2014)

length and diameter, in addition to significantly increased number of fruits and mean fruit weight. It was also observed that I-50% girdling increased the L\D ration of fruit. I-shaped girdling increased the photosynthetic yield and dry matter content in the fruits compared to the control. With regard to fruit quality as expressed in Table 15, the application of C-shape girdling increased total sugars, total phenolics and anthocyanins content in the fruits by 87, 28 and 138%, respectively compared to the control treatment. V-shape girdling increased the total flavonoids 150% more than control fruits. Girdling practices increased the antioxidant activity in the fruits. From this study, it was concluded that girdling applied before flowering enhanced inflorescence development, increased yield and quality of wax jambu fruits under field conditions.

In peach fruit (*Prunus persica)* high prices are paid for early-maturing peach fruit, but these fruit often have major quality defects that reduce their marketability, such as small size, poor flavor and split pip (Allan *et al*. 1993). Small fruit size and low yield are common problems in the production of early –season stonefruit cultivars. These characteristics are tolerated by growers because the returns for commanding premium prices. However, the market is volatile and can change rapidly. Because of this, growers of early-season cultivars are interested in harvesting their fruits as quickly as possible to take advantage of favourable market conditions. Girdling has been effective in advancing maturity and increasing the fruit size in many fruit crops while often performed on early- seasonstone fruit trees. Hence, for determining the optimum dates of girdling and to reduce the danger and increasing the effectiveness, which are the major problems of growers. Day and DeJong (1990) studied the effect of four times of limb girdling on fruit and yield response of Mayfire nectarine tree (*Prunus persica)* and reported that optimum response of girdling was obtained on 31st March when the seed length was approximately 10 mm. Girdling at this time significantly

Table 13. Effects of different types of girdling on number of buds, bud dropping, fruit setting, fruit dropping and yield of wax jambu

Treatments	Inflorescence develop (d)	Fruit retention (%)	Fruit length (cm)	Fruit diam. (cm)	L/D ratio	Fruit DM (g)	Leaf DM (g)
Control	21±0.88[a]	48±1.73[e]	5.43± 0.50[f]	3.93± 0.26[f]	1.36 ±0.01	2.81± 0.13[f]	1.22±0.03[e]
I-S. stress	15±1.45[b]	59±2.95[cd]	6.49± 0.32[c]	4.50± 0.06[d]	1.44 ±0.02	3.76±0.15[a]	1.88±0.05[ab]
50% stress	13±0.89b[c]	61 ±1.52[bc]	6.46± 0.68[d]	4.43 ± 0.23[de]	1.45± 0.01	3.16±0.21[d]	1.68±0.26[bc]
100% stress	11±0.96[cd]	58±1.73[d]	6.40± 0.45[de]	4.60±0.60[bc]	1.40± 0.01	3.03±0.33[e]	1.51±0.23[d]
C-S. stress	09± 1.75[e]	65±2.64[a]	6.90 ± 0.55[a]	4.83±0.25[a]	1.43 ±0.02	3.72±0.57[ab]	1.92±0.15[a]
V-S. stress	12±1.70[c]	64±1.73[ab]	6.63± 0.34[b]	4.66±0.27[b]	1.42±0.02	3.63±0.20[c]	1.74±0.12[b]
Significance	**	*	**	**	ns	**	**

Source: Khandaker *et al.* (2011)

Table 14. Leaf chlorophyll content as affected by different types of Girdling techniques (n=6)

Treatment	Chlorophyll a (mg kg^{-1})	Chlorophyll b (mg kg^{-1})	Total chlorophylls (mg kg^{-1})
Control	2.99±0.36[f]	2.02±0.18[e]	5.01±0.54[f]
I-S. stress	3.28±0.59[d]	2.18±0.32[d]	5.46±0.91[d]
50% stress	3.53±0.48[c]	2.63±0.18[bc]	6.16±0.66[c]
100% stress	3.19±0.34[de]	1.91±0.37[f]	5.10±0.71[e]
C-S. stress	4.51±0.17[a]	3.11±0.42[a]	7.62±0.59[a]
V-S. stress	4.09±0.46[b]	2.71±0.34[b]	6.80±0.80[b]
Significance	**	*	**

increased the fruit weight (97.8 g) and soluble solid concentrate (14.2%) and per cent first pick (89.6%) as compared with control in Mayfire nectarine peach. Similar results were reported by Allan *et al*. (1993).

The region of Santa Catarina presents great potential for growing European pear (*Pyrus communis* L.), mainly with cultivars that have a greater requirement for cold hours in the winter. In addition there is great interest in producing this crop by small holders. Currently there is negligible production, and Brazil depends on imports to meet domestic market demand, and is currently the world's second largest importer of pear fruit.

In southern Brazil, the first orchards utilized *Pyrus calleryana* as a rootstock which represents about 90% of all rootstocks but it induces excessive vigor (Rufato *et al*. 2004). The high vegetative growth of pear trees on this rootstock, results in high leaf area and a greater production of carbohydrates by photosynthesis. The partition of these carbohydrates in different parts of the plant (vegetative and productive parts) determines the production of orchards. Furthermore, pear has an acropetal growth habit, that is, the branches positioned on top of the plant and edges tend to ripen first and have higher growth rates causing shading of the interior and bottom of the canopy, if not properly handled (Rufato *et al*. 2015). With the view to improve the canopy management of pear, when grown on vigorous rootstocks using physical methods such as girdling Rufato *et al*. (2015) conducted the experiment to evaluate the effect of girdling on vigor control and crop yield of the European pear cultivar 'Packham's Triumph' grafted on *Pyrus calleryana* rootstock. The experiment was planted in July 2010 in a commercial orchard on southern Brazil, using trees of 'Packham's Triumph' cultivar grafted on *Pyrus calleryana* rootstock. The treatments were different levels of cuts in the trunk: a) untreated; b) double girdle in 1/3 of the trunk; c) single girdle in 1/2 of the trunk; d) single girdling; e) double girdling. The first cut was made in September at 20 cm above the soil level and second cut was made 10 cm above the first cut. It was observed that the untreated trees had more vigour, with 7.93 m of annual growth. The double girdling reduced vigour by 34% compared with the untreated. Yield with the double girdling was 68.9 kg ha^{-1} which was 91% more than the untreated. The crop value with double girdling was increased by US$ 17.5 thousand compared with the untreated control. The use of trunk cutting and girdling in adult orchards decreased the vegetative growth of 'Packham's Triumph' pear trees. The double girdling increased crop yield in 'Packham's Triumph. Nasr *et al.* (2015) reported bending alone or combined with removal of one third lengthof shoot or girdling increased spurs %, increased floral precocity, increased

Table 15. Effects of different types of girdling on Total sugar, total phenol, total flavonoids, AEAC and DPPH concentrations of wax jambu

Treatments	Total sugar (g 100g^{-1} pulp)			Total phenols (mg /100 g)	Total flavonoids (mg 100g^{-1})	Antioxidant (mg 100g^{-1})	Anthocyanins (mg g^{-1})
	1st season	2nd season	3rd season				
Control	3.14±0.58	3.63± 0.69f	3.95 ±0.47	396± 86.51	22.00 ± 3.76f	13.70± 0.15	2.03±0.05f
I-S. stress	3.77±0.53	6.18±0.40bc	5.44±0.34	455± 112.9	34.95± 4.17c	14.25± 0.14	4.00±0.06cd
50% stress	4.85±0.55	4.75± 0.46de	4.45±0.55	585± 91.09	32.73± 3.70de	14.27± 0.16	4.32 ±0.03bc
100% stress	4.76±0.50	4.64±0.54cd	4.64±0.53	626± 74.47	32.70± 7.21b	14.32±0.19	3.87 ±0.11de
C-S. stress	5.57± 0.47	6.8 ±0.31a	6.57±0.59	635 ± 109.1	42.85± 3.21cd	14.40 ±0.13	4.84±0.02a
V-S. stress	5.07± 0.57	6.57 ±0.09b	6.41±0.34	508 ± 150.3	55.00± 7.70a	14.42 ±0.11	4.56±0.08ab
Significance	**	**	**	*	**	NS	**

Source: Khandaker *et al.* (2011)

dry matter % fruit set % yield and enhanced fruit quality moreover increased leaf area, chlorophyll content, carbohydrate % N %, C/N ratio of leaves and IAA. GA3 level of buds while decreased shoot length dormant buds %, firmness and ABA level.Bending + remove one thirdlength of shoot+girdlingwas the besttreatment followed by bending + girdlingandbending+remove one third length of shoot.

Olive (*Olea europaea* L.) is an evergreen plant of Mediterranean climate. Fruit yield and quality of olive are greatly affected by climatic, physiological and nutritional factors. Various workers have reported variation of a cultivar regarding self fertility and fruit setting when it was grown at various locations. Generally olive plant may flower profusely but the fruit set is poor. The abscission of flowers and fruit lets in olive is mostly responsible for small percentage of fruit retained to maturity. The nutritional state of the plant can significantly be altered by girdling the trees but optimum time of girdling is important hence Ahmad *et al.* (2009) conducted the experiment during 2004 and 2005 at NARC, Islamabad, to investigate the effect of girdling at 15 day intervals from February 1 to March 1 on the percentage of perfect flowers, fruit set, fruit harvested, fruit size and weight in olive cultivar Uslu. They reported that the olive girdling on 15th February had significantly increased fruit set (4.81%), fruit weight (2.94 g) and harvested fruit percentage (3.47%) over the rest of treatments including control. While, significantly higher per cent of perfect flowers (13.67%) and fruit size (2.14 cm) were observed in girdling on 1st March. Comparatively better fruit set and harvested fruit percentage was found when girdling operation was performed from February 15th to March 1st.

Ever since the avocado (*Persea americana* Mill.) became a commercial crop in California growers were aware of its poor bearing habits. It is not an alternate bearer in the accepted sense (such as some apple varieties producing alternating heavy and light crops), since a heavy crop may be followed by 2-3 poor crops. Just to show its capability, a bumper crop may be produced once in a dozen years. This situation is particularly worrisome with the Fuerte avocado (both in California and in Israel). Girdling is examined as a method of improving avocado yield, eliminating biennialbearing and increasing Hass fruit size in particular (Davie *et al*. 1995). Preliminary results indicated that bygirdling a number of branches on a Hass tree that had set a good crop at a stage whenrapid fruit growth was taking place, an increase of over 35% in fruit mass was possible. Hence it wasrecommended that only half the branches of the tree be girdled in any one year in orderto avoid root starvation.

The Fig (*Ficus carica* L.) fruit is a highly perishable climacteric fruit and oldest species of the fruit tree having been cultivated by humans for over 5000 years. The common fig (*Ficus carica* L.) is a tree indigenous to southwest Asia and the eastern Mediterranean region; belong to family Moracea and usually cultivated especially in warm, dry climates. Dwarfing fruit trees plays an important role in fruit growth, development and quality. Partial ringing (phloem stress) can be used to make tree dwarfed. Ringing tends to increase the size and sugar content of fruit and cause the fruit mature a few days to a week earlier (Tukey 1964). Fig fruit set, growth and yield, weight and maturity index as influenced by phloem stress (represented by partial bark ring) were studied by Hossain and Boyce (2009) to investigate the influence of different types of bark ringing (phloem stress) on flower bud and fruit formation, fruit bunch weight, per fruit weight, total soluble solids, titerable acidity and maturity index. The treatments were namely control (unringed), I-shape partial ring (I-SPR), X-shape partial ring (X-SPR) and S-shape partial ring (S-SPR) at pre harvest stage. Phloem stress was represented by partial bark ringing. The percent flower bud and fruit set were greater in S-SPR treated than in other treated branches. However, the result showed that all three treated branches had significantly higher percentage of flower bud and fruit set than that of the control one. Fruit length and diameter were higher in I-SPR, S-SPR, X-SPR treated branches than in control (un-ringed). Fruit number per bunch was lower in treated branches than in control branches. On the contrary, bunch weight, per fruit weight, soluble solids content and maturity index were greater in I-SPR, S-SPR, X-SPR treated branches than in control (un-ringed) branches. The result showed that phloem stress represented by partial ringing as dwarfing component was a useful practice for fig fruit growth and quality development.Ticho (1970) in Avocado reported average weight of the fruit on the ringed branches was 277 g while unringed ones was 338 grams (22% difference).

Mangoes (*Mangifera indica L*) have very low orchard efficiency in terms of commercial fruit production and many commercial cultivars tend to be alternate bearing. For normal fruit development a balanced leaf number (area) to fruit ratio, is necessary. The optimum leaf area to fruit ratio, however, varies from species to species mainly because of the variability in photosynthetic efficiency and the requirement of photo-assimilates for fruit development. Fruit growth and fruit size at harvest are affected by the number of fruits per unit of leaf surface. The optimum leaf number and area required for the development of individual fruit have been determined for several fruit species. The methods used were either girdling the shoots leaving a fixed number of leaves which directly feed the fruit attached to the shoot, or artificially adjusting the leaf number/fruit ratio on large limbs or leaf number/fruit on single trees and observing fruit development in relation to the supporting leaves. Since fruit development utilizes carbohydrates, either currently produced or stored as reserves, it would be useful to understand the leaf area/fruit growth relationship in crops like mango where biennial bearing may be caused by depletion of carbohydrates. In previous studies, it was reported that in biennial cultivars of mango 30 leaves could not support the growth of a single fruit to normal size under South Indian conditions where flowering occurred two times in a year and it was concluded that fruit development depends not only on current assimilates but also to a great extent on reserve photosynthates (Chacko *et al*. 1982). They also reported that 30 leaves, the maximum available on a shoot, could support the growth of a single fruit to normal size. The result also show that fruit development depends not only on the current assimilates but also show great extent on reserves. The utilization of reserve metabolites from vegetative organs during the "on" year could be a contributing factor towards biennial and erratic bearing. Similar study was conducted by Singh *et al.* (2007) to determine the optimum leaf number required for normal fruit growthin the regular bearing mango cultivar 'Amrapali' and the biennial bearing cultivars 'Chausa', 'Dashehari' and 'Langra' were studied by isolating individual fruits with known numbers of supporting leaves by shoot girdling at the time of fruit set. There were significant differences in the leaf area (249.01-1817.10 cm^2), fresh weight (7.0-77.0 g) and dry weight (3.7-50.0 g) of leaves on shoots having 30, 20, 10 and 5 leaves as compared with control in different cultivars. In both types of cultivars, there was a progressive reduction in fruit size in terms of total fruit, pulp, peel, and seed weight with decreasing numbers of supporting leaves, however, a minimum reduction (2.4%) in fruit growth in 'Amrapali' was noticed with 30 supporting leaves. A nonsignificant difference in photosynthetic rate with varying number of leaves was found but its efficiency in leaves was higher in 'Amrapali' as compared with biennial bearing cultivars.

Effect of girdling treatments on flowering and production of mango trees cv. Tommy Atkins was studied by José (1997). The purpose of the study was to verify the effect of girdling practice on flowering and production of mango cv. Tommy Atkins. The experiment was composed of five treatments of girdling (30, 45, 60, 75 and 90 days before potassium nitrate spraying) and a control treatment (without girdling). From the obtained data some conclusions were drawn: a) girdling mangoes trees 60 and 75 days before potassium nitrate applications resulted in higher percentage of flowering and advanced harvest in 23 days in comparison to control. All girdling treatments showed lower vegetative growth in relation to control.

A study was undertaken by Shinde *et al.* 2014 to induce flowering in mango cultivar 'Alphonso'. The experimental results opined that the number of fruits per tree, fruit yield per tree and per hectare were recorded maximum in T1 - ringing during first fortnight of May which was at par with T2-ringing in second fortnight of May and T3 - ringing in first fortnight of June. Early emergence of flowering was recorded in T1 with highest hermaphrodite flowers (24.26 %). It has also recorded the highest fruitset per panicle (8.765) but difference was non significant. The minimum days to harvest and maximum fruits per plant were also recorded in T1 and was at par with T2 and T3 (Table, 16, Table 17).

Girdling as a means of shortening the juvenile period of seedlings

In a continuing progeny evaluation program the availability of planting space, funds, or both will limit the number of plants which can be grown at one time. New plantings usually are made as soon as the trees of the preceding generation are removed. The efficiency of a procedure such as this can be indicated by the number of plants evaluated per year, for each planted acre. Shortening the juvenile period is highly important for fruit tree breedingprojects otherwisefruit tree breeding programme can be costly due to the long juvenile period. Lahav *et al.* (1986) observed only about 40% of the avocado seedlings had set fruit after a period of 8 yearsin their avocado breeding project. Four girdling dates were tested in an attempt to shorten the juvenile period in 9 crosses of 3-year-old avocado *(Perseaamericana* Mill.) seedlings. Early September girdling was more effective than later or no girdling. It significantly increased seedling flowering per cent (99.2%), flowering intensity (2.7%), the percentage of fruit set from 15% (control) to 65.4% and increased 7-fold the number of fruits

Table 16. Effect of ringing on flowering in mango cv. Alphonso

Treatment	Date of emergence of flowering	Panicle length (cm)	Panicle Diameter (cm)	No. of panicles	Hermaphrodite flowers (%)
T1- ringing during 1st fortnight of May	16/10/12	15.80	0.98	0.96	24.26
T2- ringing during 2nd fortnight of May	19/10/12	15.98	0.98	0.98	13.83
T3- ringing during 1st fortnight of June	14/10/12	17.26	0.81	1.11	13.33
T4 - ringing during 2nd fortnight of June	04/11/12	17.66	0.80	1.27	13.13
T5- ringing during 1st fortnight of July	04/11/12	20.44	0.78	1.29	12.46
T6- ringing during 2nd fortnight of July	07/11/12	21.38	0.76	1.34	12.20
T7 - ringing during 1st fortnight of August	24/11/12	20.89	0.69	1.84	11.86
T8 - ringing during 2nd fortnight of August	27/11/12	21.10	0.69	2.11	11.73
T9- ringing during 1st fortnight of September	26/11/12	21.44	0.71	2.11	11.26
T10- ringing during 2nd fortnight of September	28/11/12	21.46	0.70	2.11	11.00
T11 – No ringing (Control)	03/12/12	23.10	0.68	2.11	10.46
S.E. ±	-	0.78	0.003	0.07	0.41
C.D.	-	2.36	NS	0.20	1.20

Shinde *et al.* (2014)

Table 17. Effect of ringing on fruit set and yield in mango cv. Alphonso

Treatment	Fruitset at pea stage (%)	Days required for harvesting	No. of fruits plant^{-1}	Yield kg tree^{-1}	Yield t ha^{-1}
T1- ringing during 1st fortnight of May	8.765	101.00	154.60	35.40	3.54
T2- ringing during 2nd fortnight of May	8.357	102.11	151.20	35.07	3.51
T3- ringing during 1st fortnight of June	8.151	102.55	137.47	32.03	3.20
T4 - ringing during 2nd fortnight of June	8.129	103.89	127.40	30.19	3.02
T5- ringing during 1st fortnight of July	8.042	105.11	123.73	30.06	3.01
T6- ringing during 2nd fortnight of July	7.942	106.33	123.37	29.43	2.94
T7 - ringing during 1st fortnight of August	7.942	106.33	114.93	28.19	2.82
T8 - ringing during 2nd fortnight of August	7.861	107.00	112.93	28.00	2.80
T9- ringing during 1st fortnight of September	7.841	109.33	91.73	22.84	2.84
T10- ringing during 2nd fortnight of September	7.732	109.66	87.27	21.89	2.19
T11 – No ringing (Control)	7.696	114.11	47.13	12.11	1.21
S.E. ±	0.010	0.789	9.58	2.31	0.23
C.D.	NS	2.136	28.70	6.90	0.69

Shinde *et al.* (2014)

harvested per seedling as compared with the ungirdled control.

Gaskins (1966) used girdling technique for progeny evaluation of mango.Seedling mango trees were girdled to overcome juvenility and induce fruiting. Girdling increased the percentage of fruiting trees in two mango progenies, in both the third and fourth years after they were transplanted to the field. He further suggested that if the trees are girdled to promote fruiting, the number of years required to grow and evaluate each successive progeny can be reduced. Efficiency can be improved and program costs reduced if selections are propagated to new locations immediately and the plantings replaced without waiting for the latest-maturing plants to produce fruit.

Conclusions

From the foregoing discussion, it can be concluded that, though girdling is old horticultural practise and not commonly followed in all crops, judicious application of girdling will help to attain the changing trends from agrochemical based production to green farming, less harmful to the environment and without chemical residue in fruit. Similarly, girdling will provide themethod for fruit producers who are always looking for reducing farm operation costs while maintaining high fruit quality. In this contest girdling is importanthorticultural practice responsible for improving fruit setting, yield as well as physical and chemical properties of fruits without chemical hazard hence its potential should be considered for exploitation.

References

Allan P., Geofrg A. P., Nissen R. J. and Rasmussen T. S. 1993. Effects of girdling time on growth, yield and fruit maturity of the low chill peach cultivar Flordaprince.Austral. J. Experim. Agri. 33:

781-785.

Ahmad M., Rahman H., Ahmad I. and Tariq M. S. 2009. Effect of girdling dates on fruit setting in Olive cv. Uslu. Pak. J. Agric. Res. 22: 3-4.

Chacko E. K., Reddy Y. T. N. and Ananthanarayanan T. V. 1982. Studies on the relationship between leaf number and area and fruit development in mango (*Mangifera indica* L.). J. Hort. Sci. 57: 483-492.

Chandler, E. K. 2012. Nitrogen carbon ratios for fruiting plants. www.TexasPlantandSoilLab.com.1-2.

Chun Y., David L. W. and Eliezer E. G. 2003. Girdling affects carbohydrate-related gene expression in leaves, bark and roots of alternate-bearing citrus trees. Ann. Bot. 92: 137-143.

Davie S. J., Stassen P. J. C., Van der Walt M. and Snijder B. 1995. Girdling avocado trees for improved production. South African Avocado Growers' Association Yearbook. 18: 51-53.

Day K. R. and Dejong T. M. 1990. Girdling of early season 'May fire' nectarine trees. Hort. Sci. J. 65: 529-534.

Elkhishen M. A. 2015. Enhancing flowering and fruiting attributes of mango (*Mangifera indica*) cv. *Zebda* the off-year by binary application of KNO_3, Ethrel and Paclobutrazol. J. Hort. Sci. and Ornamental Plants. 7: 87-93.

Gaskins M. H. 1966. Procedures for accelerating evaluation of mango seedlings. Proc. Flo. State Hortic. Soc.76: 360-363.

Goren R., Huberman M. and Goldschmidt E. E. 2003. Girdling: physiological and horticultural aspects. Hortic. Rev. 30: 1–36.

Haldankar P. M., Dalvi N. V., Parulekar Y. R. and Lawande K. E. 2014. Induction of flowering by girdling in jamun cv. Konkan bahadoli. J. Plant Studies. 3: 45-49.

Hossain A. B. M. S. and Boyce A. N. 2009. Fig fruit growth and quality development as affected by phloem stress. Bulg. J. Agric. Sci. 15: 189-195.

Johnson R. S. and LaRue J. 2003. Girdling Tree. pp. 60-61.

Ibrahim M. M., Mohamed A. O., Mohamed A. H. and Omar A. A. 2016. Effect of some girdling treatments on fruiting behaviour and physio-chemical properties of Washington navel orange trees. J. Agril. and Vet. Sci. 9: 58-65.

Khandaker M. M., Abm S. H., Normaniza O., and Amru N. B. 2011. Application of girdling for improved fruit retention, yield and fruit quality in *Syzygium samarangense* under field conditions. Int. J. Agric. Biol. 13: 18-24.

Kumar M., Ponnuswami V., Jeyakumar P., Richard Kennedy R. and Saraswathy S**.** 2013. Studies on influence of season for biochemical parameters in mango cultivars. African J. Agril. Res. 849: 6394-6400.

Kunte Y. N. and Yawalkar K. S. 2005. Principles of Horticulture and Fruit Growing, 10th edition. pp.119

Lahav E., Zamet D., Gazit S. and Lavi U.1986. Girdling as a means of shortening the juvenile period of avocado seedlings. Hort. Sci. 21: 1038-1039.

Miller C. 2000. Understanding the Carbon-Nitrogen Ratio. Acres U.S.A. www.acresusa.com

Mostafa E. A. M. and M. M. S. Saleh 2006. Response of balady Mandarin trees to girdling and potassium spraysunder sandy soil conditions. Res. J. Agric. Biol. Sci. 2: 137–141.

Nasr M. M. Naglaa, Samia A. H. S. and Eman S. A. 2015. Effect of some horticultural practices-Conte on F Pear Trees. Middle East J. Appl. Sci. 05: 1115-1127.

Ramona C. and Florin S. 2015. Effect of tree girdling on some varieties of chinese date (*Ziziphus jujuba* mill.). Scientific Papers. Series B Horticulture. Vol. LIX 37-42.

Rivas F., Erner Y., E. Alos, M. Juan, Almela V. and Agusti M. 2006. Girdling increases carbohydrate availability and fruit-set in citrus cultivars irrespective of parthenocarpic ability. J. Hortic. Sci. Biotech. 81: 289-295.

Rivas F., Gravina A. and Agustí M. 2007. Girdling effects on fruit set and quantum yield efficiency of PSII in two Citrus cultivars. Tree Physiol. 27: 527-535.

Roussos P. A. and Tassis A. 2011. Effects of girdling, nitrogen, zinc and auxin foliar spray applications on mandarin fruit "Nova" quality characteristics. Emir. J. Food Agric. 23: 431-439.

Rufato L., De Rossi A., Giacobbo C. L. and Fachinello J. C. 2004. vegetative propagation of seven quince cultivars for utilization as pear rootstocks in Brazil. Acta Hortic. 658: 667-671.

Rufato L., Machado B. D., Luz A. R. and MarconFilho J. L. 2015. Effect of trunk girdling on growth and crop yield of 'packham's triumph' pear. Acta Hortic. 1094: 265-268.

Shao L. H., Deng L. and Qing L. Y. 1998. Effects of floral promotion or inhibition treatments on flowering of citrus trees and protein fraction in buds. J. Trop. Subtrop. Bot. 6: 124–130.

Shinde V. V., Dubale J. J., Haldankar P. M., Parulakar Y. R. and Thorat S. B. 2015. Effect of Ringing on Flowering and Yield of Mango *Mangifera indica* L var Alphonso. Asian Resonance. 3: ????.

Singh V. K., Tiwari A. K. M., Singh D. K. and Pathak S. M. 2007. Effect of leaf number and area on the fruit growth of regular and biennial bearing mango (*Mangifera indica* L.) grown Under North Indian Conditions. Int. J. Fruit Sci. 6: 77- 91.

Ticho R. L. 1970. Girdling, a means to increase avocado fruit production. California Avocado Society 1970-71 Yearbook. 54: 90-95.

Tukey H. B. 1964. Dwarf Fruit Trees. Cornell University Press, UK. pp.562.

Upreti K. K., Reddy Y. T. N., ShivuPrasad S. R., Bindu G. V., Jayaram H. L., Rajan S. 2013. Hormonal changes in response to Paclobutrazol induced early flowering in mango cv. Totapuri. Scientia Horticulturae. 150: 414-418.

Wright G. C. 2000. Girdling 'fairchild' mandarins and 'lisbon' lemons toimprove fruit size Citrus and Deciduous Fruit and Nut Research Report, College of Agriculture and Life Sciences, the University of Arizona, Tucson, Arizona, 85721, pp. 15-18.