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Assessment of girdling on fruiting and yield attributes of Litchi cv. Late Bedana

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Abstract
The present investigation was carried out at Sainik Farm, Patharchatta, Pantnagar, District Udham Singh Nagar, Uttarakhand to study the effect of girdling on flowering and fruiting attributes in Litchi cv. Late Bedana. Twenty year old 21 litchi trees consisted of 7 treatments with two level of girdling severity of 25% primary branches and 50% primary branches with the combination of girdling width of 2 mm, 4 mm and 6 mm, along with ungirdled control which are tested with randomized block design with three replications. The results indicated that all the litchi trees which were subjected to different severity and width of girdling have more fruit set (%) and fruit retention (%), yield (kg/tree) and girdling also reduce fruit drop as compared to control. However, the treatment girdling of 50% of primary branches + 4 mm wide had significantly effect on improving fruit yield (57.02 kg/tree). Girdling blocks the downward flow of carbohydrate from leaves to roots thus the carbohydrate may accumulate above the girdled portion which resulted in additional supply of carbohydrates from leaves to fruits, therefore, the fruit yield and fruit quality of litchi may increase.

Keywords: Litchi, girdling, fruiting and yield

Introduction
Litchi (*Litchi chinensis* Sonn.) is a non-climacteric subtropical delicious, juicy fruit of excellent quality, belonging to soapberry family Sapindaceae and subfamily Nepheleae, having about 150 genera and 2000 species (Chapman, 1984; Menzel, 1991) [3, 9]. Litchi originated in the region between latitudes 23° and 27° N in the southern China, northern Vietnam and Malaysia (Menzel and Simpson, 1990) [10]. The litchi is cultivated on 90 thousand hectare area with 559 thousand metric ton production and 6 metric ton per hectare productivity (Anonymous, 2016) [1]. Litchi is one of the most environmentally sensitive tree fruit crop and probably due to this reason its cultivation is restricted to few countries in the world characterized by warm subtropics and elevated tropics having warm wet summers and cool dry winters.

Menzel (1991) [9] described the litchi tree as a subtropical long lived, medium to large, branched, evergreen fruit tree with a round top and reaching a height upto 10 meters with stocky short trunk. Leaves are compound and borne alternate with 4-7 oblong leaflets of 7-10 cm in length and glossy dark green upper and greyish green lower surface. Vegetative growth occurs rhythmically in 3-4 recurrent flushes with alternate periods of rest. The inflorescence is a compound raceme bearing greenish white or yellowish flowers in clusters and develop from terminal as well as axillary buds on the branches. Flowers are small, apetalous and are of three types: male, hermaphrodite and pseudo-hermaphrodite which open in different flushes. The litchi tree produces fruit in a development cycle of approximately 4 months. The fruit is a heart-shaped indehiscent one-seeded nut and fleshy when ripe. The pericarp is papillate, thin, rough, leathery, wrinkled and pinkish red colour when fruit is ripe. The edible part of fruit is aril which is an outgrowth of the outer integument and it covers the single seed of brown to black in colour (Menzel and Simpson, 1994) [11].

Girdling is basically an intervention in the phloem transport between canopy and roots, in an attempt to manipulate the distribution of photosynthate (carbohydrate), mineral nutrients, and plant bio-regulators. Girdling is a procedure by which a ring of bark (or, in some cases, bark and sapwood) is removed from the trunk or branch of a tree. Girdling has immediate and long-term effects, and local, as well as whole-plant, effects. The accumulation of carbohydrates in the canopy provides a rich source of energy for all the stages of reproductive development; flowering, fruit set, fruit enlargement, and ripening.

Materials and Methods

The present investigation was carried out at Sainik Farm, Patharchatta, Pantnagar, District Udham Singh Nagar, Uttarakhand. Pantnagar is situated in foot hills of Himalayas and falls in the humid subtropical climate. It is situated between 29′5^0 N latitude, 79′3^0 E longitudes and an altitude of 243.84 meters above the mean sea level. The experiment was laid out in Randomized Block Design. There were seven treatment combinations including control with three replications and in each replication one tree served as a treatment unit. Thus 21 trees were marked for the experiment.

Results and Discussion

Effect of girdling on fruiting attributes

Fruit set: The data present in Table 1 indicate that girdling has significant role in fruit set percentage in litchi cv. Late Seedless. Statistically minimum number(32.19%) of fruit set was observed in ungirdled trees and maximum number (38.44%) of fruit set was recorded in treatment girdling of 50% of primary branches +6 mm wide (T_6). Girdling block the downward movement of photo-assimilates thus this assimilates accumulates above the girdled portion so there is significantly increased levels of carbohydrates can be found throughout the canopy. Haung (2012) [7] also reported that spiral girdling in litchi significantly increased fruit set.

Fruit retention

The data shown in Table 1 indicated that girdling in litchi cv. Late Bedana was significantly increased fruit retention percentage in litchi fruits. Maximum number of fruit retained per panicle at harvest was observed in treatment T_4 (Girdling of 50% of primary branches +4 mm wide) and minimum fruit retention was recorded in control (T_7). The reason behind that in girdled trees there was higher level of gibberellins and low level of ABA as well as higher level of carbohydrates. Similar results were observed in finding of Rani and Brahamachari (2002) [14] who examined that girdling of litchi trees was significantly increased fruit retention percentage in litchi

Fruit drop

The data regarding to final fruit drop percentage was given in Table 1 indicate that there was significant effect of girdling on control of fruit drop. Minimum fruit drop (80.03%) was observed in treatment T_6 (girdling of 50% of primary branches +6 mm wide) and maximum fruit drop (85.89%) was observed in control. The present data on fruit drop was supported by Khalkho *et al.* (2015) [8] who revealed that there is positive effect of girdling on fruit drop of litchi. Rivas *et al.* (2006) also suggested that girdling increased carbohydrate contents in developing fruitlets of mandarin. Therefore, it resulted in reduced fruit drop and thereby diminished abscission.

Fruit burn and fruit cracking

The data presented on fruit burn and fruit cracking percentage in Table1 was statistically non significant. However, the minimum fruit burning and cracking (13.03%) was observed in treatment T_4 (Girdling of 50% of primary branches + 4 mm wide) and maximum fruit burning and cracking was observed in treatment T_1 and T_7 (14.17% for both treatments). Results of present study show that girdling has no significant influence on cracking and burning of fruits in all treatments including control. However, Rabe *et al.* (1996) [13] reported that girdling increase the percentage of fruit cracking in citrus.

Table 1: Effect of girdling on date of fruit set, time taken to fruit set, fruit retention, fruit drop and fruit burn & cracking

Treatments		Fruit set (%)	Fruit retention (%)	Fruit drop (%)	Fruit burn and fruit cracking (%)
T_1	Girdling of 25% of primary branches (2 mm wide)	34.14	12.98	81.33	14.17
T_2	Girdling of 50% of primary branches (2 mm wide)	36.11	13.32	82.35	13.74
T_3	Girdling of 25% of primary branches (4 mm wide)	35.44	13.20	80.53	13.19
T_4	Girdling of 50% of primary branches (4 mm wide)	35.41	14.07	81.47	13.03
T_5	Girdling of 25% of primary branches (6 mm wide)	37.21	12.86	83.19	13.69
T_6	Girdling of 50% of primary branches (6 mm wide)	38.44	13.60	80.03	13.78
T_7	Control (no girdling)	32.19	11.89	85.89	14.17
C.V.		2.268	2.981	2.268	2.981
C.D. at 5%		1.451	0.704	1.451	0.704

Effect of girdling on harvesting and yield attributes

Harvesting date, Harvest advancement and Days taken to harvesting

The data on harvesting date and harvest advancement present in Table 2 show that girdling has a significant impact on advancement of harvesting date. The date of harvesting in all the treatments in which girdling was practiced is 12th June and in ungirdled trees (control) the date of harvesting was 18th June 2016. Therefore, girdling leads to advancement in harvesting or maturity by six days. This show that girdled litchi trees have earlier maturity of fruit and fruit growth was also higher in comparison to control. As shown in Table 2 the days taken to harvesting were varied between 70 to 74 days in litchi cv. Late Bedana. The maximum days (78 days) taken to harvesting was recorded in T_7 (control) and minimum days taken to harvesting (70 days) was found in T_3 (Girdling of 25% of primary branches +4 mm wide).The reason behind early maturity of fruits is that there was higher phenolic content and fraction of higher molecular weight phenols in girdled fruits as compared to non girdled fruits. However, there is no significant correlation among girdling stage and fruit phenolic content. The findings of present investigation was completely supportable with the findings of Villiers *et al.* (1993) who observed that girdling in peach resulted in earlier maturity of fruits. Haldankar *et al.* (2014) [6] reported that girdling in Jamun reduced the period from flowering to harvesting.

Yield

The data on fruit yield presented in Table 2 show that girdling has a significant effect on yield. Maximum fruit yield (57.02 kg/tree) was obtained in treatment T_4(Girdling of 50% of primary branches +4 mm wide) and minimum fruit yield (39.03 kg/tree) was obtained in T_7 (control). The difference between maximum fruit yield (57.02 kg/tree) and minimum fruit yield (39.03 kg/tree) was 18.00 kg per tree. Similarly average yield per hectare (t/ha) show in Table 2 indicate that maximum fruit yield per hectare was observed in treatment T_4 (5.70 t/ha) and minimum fruit yield in treatment T_7 (3.90 t/ha). The physiology of girdling revealed that girdling blocks

downward flow of photo-assimilates, thus the accumulation of photo-assimilates increase above the girdled portion which resulted in increased fruit set or finally increased fruit yield which are associated with additional supply of carbohydrate from source (leaves) to fruits and reduced supply of carbohydrate from source to sink. Carbohydrate level is one of the factors limiting fruit set and yield (Garcia Luis *et al.* 1988; and Goldschmidt 1999) [4, 5]. The findings of present experiment was supported with many findings such as Haung (2012) [7] who reported that girdling in litchi tree increase fruit set and fruit yield. Chandra (2008) [2]; Pires *et al.* (2014) and Khalkho *et al.* (2015) [8] also reported similar findings in litchi.

Table 2: Effect of girdling on harvesting and yield attributes

Treatments		Days taken to harvesting (days)	Date of Harvesting	Harvest advancement (days)	Yield (kg/tree)	Yield (t/ha)
T_1	Girdling of 25% of primary branches (2 mm wide)	72	12-June	6	51.65	5.16
T_2	Girdling of 50% of primary branches (2 mm wide)	74	12-June	6	54.76	5.47
T_3	Girdling of 25% of primary branches (4 mm wide)	70	12-June	6	51.84	5.18
T_4	Girdling of 50% of primary branches (4 mm wide)	72	12-June	6	57.02	5.70
T_5	Girdling of 25% of primary branches (6 mm wide)	72	12-June	6	54.48	5.44
T_6	Girdling of 50% of primary branches (6 mm wide)	73	12-June	6	51.26	5.126
T_7	Control (no girdling)	78	18-June	0	39.03	3.90
C.V.		-	-	-	3.999	3.999
C.D. at 5%		-	-	-	3.700	0.370

Conclusion

The results indicated that all the litchi trees which were subjected to different severity and width of girdling have more fruit set, fruit retention and fruit yield and it also reduce fruit drop as compared to control. The conclusion of the current research revealed that girdling of 50% of primary branches + 4 mm wide at the time of first week of October was significant way for improving fruiting and yield of litchi cv. Late Bedana.

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