Influence of girdling on growth, flowering and fruiting in Litchi cv. Late Bedana

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Abstract
The present investigation was carried out at farmer’s field, Sainik Farm, Patharchatta, Pantnagar, District Udham Singh Nagar, Uttarakhand. The experiment was conducted to study the effect of girdling on growth, flowering and fruiting attributes in Litchi cv. Late Bedana. Twenty-year-old litchi trees consisted of seven treatments with two level of girdling severity of 25% and 50% primary branches in combination of girdling width of 2 mm, 4 mm and 6 mm, along with ungirdled control which were 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 had more flowering intensity (%) and fruit retention (%) and girdling also reduced fruit drop as compared to control. However, the treatment girdling of 50% of primary branches + 4 mm wide had significant effect on improving fruit set (38.44%) and fruit retention (14.07%). 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, growth and flowering, yield

Introduction
Litchi (Litchi chinensis Sonn.) is an evergreen subtropical fruit tree bearing delicious juicy fruits. It is also called Queen of Sub tropical fruits (Nakasone and Paull, 1998) [9]. The origin of litchi lies in Southern China and is cultivated in few sub tropical countries of the world. Litchi belongs to family Sapindaceae and subfamily Nepheleae which has about 125 genera and 1,000 species. The genus Litchi has one species and three subspecies i.e. Litchi chinensis subsp. chinensis, Litchi chinensis subsp. javenensis and Litchichinensis subsp. Phillippinensis (Menzel and Simpson, 1998) [9].

In India, it was introduced by the end of 17th century and spread to the other parts of the country. India is the second largest producer of litchi after China. India holds a prominent position in litchi cultivation. 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]. Its contribution towards major fruit crops production is 0.7 per cent. Bihar rank 1st in area (32 thousand hectare) and production (198 thousand hectare) followed by West Bengal and Jharkhand.

Litchi tree grows to a height of 6 to 9 m with spreading branches and dense light green shining foliage. The leaf is compound, mostly paripinnate with three pairs of leaflets. Colour of leaves varies from light green to dark green. The inflorescence is terminal and branching pattern is hapaxanthic. Three distinct waves of flowering occur in litchi inflorescences, the first wave consists of M₁ (male type) flowers, the second of F (hermaphrodite) flowers, and the third of M₂ (pseudo-hermaphrodite) flowers (Goren et al., 1998) [5]. Litchi is a monoecious plant bearing separate male and hermaphrodite flowers on terminal panicles. Flowers are apetalous which are devoid of corolla and flower colour is greenish white to greyish.

Girdling is basically an intervention in the phloem transport between canopy and roots, in an attempt to manipulate the distribution of photosynthesize (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°50' N latitude, 79°30' 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.

| Treatments                              | Flushing time | Flushing intensity (no. of shoots per branch) |
|-----------------------------------------|---------------|----------------------------------------------|
| T1 Girdling of 25% of primary branches (2 mm wide) | 10-Feb        | 2.10                                         |
| T2 Girdling of 50% of primary branches (2 mm wide) | 11-Feb        | 2.20                                         |
| T3 Girdling of 25% of primary branches (4 mm wide) | 10-Feb        | 2.04                                         |
| T4 Girdling of 50% of primary branches (4 mm wide) | 10-Feb        | 1.82                                         |
| T5 Girdling of 25% of primary branches (6 mm wide) | 11-Feb        | 2.11                                         |
| T6 Girdling of 50% of primary branches (6 mm wide) | 10-Feb        | 1.99                                         |
| T7 Control (no girdling)                | 10-Feb        | 2.63                                         |
| C.V.                                    | -             | 7.364                                        |
| C.D. at 5%                              | -             | 0.280                                        |

Results and Discussion
Flushing time
The data on flushing time presented on Table 1 show that winter flush in litchi cv. Late Bedana under pantnagar conditions was started from 10th to 11th February 2016. The data indicates that there was no any appropriate difference between flushing times in all the treatments including control.

Flushing intensity (number of shoots per branch)
The data on number of shoots per branch presented in Table 1 revealed that the maximum number of shoots per branch (2.63) was recorded in T1 (ungirdled) and the minimum number of shoots per branch (1.82) was recorded in T4 (girdling of 50% of primary branches + 4 mm wide). Girdling blocks the downward flow of photo-assimilates and auxin from the leaves to roots and also blocks the movement of cytokinin from root to leaves (Lomax et al., 1995) [7], which can reduce root and shoot growth.

Table 1: Effect of girdling on flushing time and flushing intensity

Date of panicle initiation
As shown in Table 2 the panicle initiation in litchi cv. Late Bedana under Pantnagar conditions was started from 21st to 24th February 2016. In the treatments T1, T2, T6, the panicle initiation was started in 21stFebruary while in treatments T3 and T5, the time of panicle initiation was started from 22ndFebruary. The results of present experiment were supported with Chang and Chang (2001) [3] who observed that there was no significant effect of girdling on influencing the date of panicle initiation in litchi.

Flowering intensity
The data on flowering intensity presented in Table 2 indicate that girdling has a significant effect on increasing flowering intensity in litchi cv. Late Bedana. The maximum flowering intensity (57.70%) was observed in the treatment T4 (girdling of 50% of primary branches + 4 mm wide) and minimum flowering intensity (44.88%) was recorded in control (T7). The reason behind that the girdling blocks the downward flow of photo-assimilates (carbohydrates) and auxin from the source to sink (Lomax et al., 1995) [7], which can restricted root growth, vegetative growth and increase flowering percentage.

Date of full blooms
As shown in Table 2 the date of full bloom was varied from 27th March to 2nd April 2016. The date of full bloom was earliest (27th March) in the treatment girdling of 50% of primary branches + 2 mm wide (T2) and it was latest in the control that is 2nd April. These results were significant with the results of Arakawa (1997) [2] who reported that girdling has significant effect on date of flower opening and date of full bloom in apple.

Duration of Flowering
The data on flowering duration present in Table 2 revealed that the duration of flowering in cv. Late Bedana during 2016 was ranged from 12 to 16 days. The maximum flowering duration (16 days) were recorded in T7 and T4. The minimum flowering duration (12 days) was recorded in T2 and T3 treatments. There was no clear cut trend was found regarding flowering duration in girdled and ungirdled trees. Singh and Dhillon (1983) who recorded that a flowering duration of different litchi cultivars in different years may vary between 11 to 15 days.

Advancement of Flowering
The data on flowering advancement present in Table 2 indicate that girdling of litchi trees has a significant impact on advancement of flowering. The maximum advancement (4 days) was recorded in the treatment T2 and T4 as compared to control. The results of our experiment was supported by Menzal and Simpson (1987) [8] who reported that autumn girdling in litchi trees significantly increased flowering and it also flowered earlier as compare to control.
Sex ratio and number of flowers per panicle
The data on sex ratio presented in Table 3 indicate that girdling of litchi trees branches have a significant impact on sex ratio (male: female) and also on improving number of female flowers. Statistically the maximum sex ratio (2.08%) was recorded in control (T1) and the minimum sex (1.61%) ratio was recorded in treatment T4. Ramburn (2001) observed similar findings and showed that the girdling has a significant effect on sex ratio. As shown in Table 3 the maximum number (232.66) of female flower per panicle was found in the treatment T4 and the minimum number (167.66) of female flowers per panicle was recorded in control (T1). The results were supported with Chen and Luo (1998) [4] who reported that girdling or ringing significantly increased in number of female flower in litchi.

As shown in Table 3, the maximum number (232.66) of female flower per panicle was found in the treatment T4 and the minimum number (167.66) of female flowers per panicle was recorded in control (T1). The results were supported with Chen and Luo (1998) [4] who reported that girdling or ringing significantly increased in number of female flower in litchi. The data on number of male flower present in Table 4.4 show that number of male flowers in litchi cv. Late Bedana may vary between 347.33 to 381.66 male flowers per panicle. However, the results indicate that there was no girdling impact on number of male flowers

Table 2: Effect of girdling on date of panicle initiation and flowering

| Treatments                     | Date of panicle initiation | Flowering intensity (%) | Date of flower opening | Date of full bloom | Duration of flowering (days) | Advancement of flowering (days) |
|-------------------------------|-----------------------------|--------------------------|------------------------|--------------------|-----------------------------|---------------------------------|
| T1 Girdling of 25% of primary branches (2 mm wide) | 21-Feb                      | 54.69                    | 17-March               | 29 - March | 13                          | 3                              |
| T2 Girdling of 50% of primary branches (2 mm wide) | 22-Feb                      | 54.54                    | 16-March               | 27-March          | 12                          | 4                              |
| T3 Girdling of 25% of primary branches (4 mm wide) | 23-Feb                      | 51.59                    | 17-March               | 1-April           | 15                          | 3                              |
| T4 Girdling of 50% of primary branches (4 mm wide) | 21-Feb                      | 57.70                    | 16-March               | 31-March          | 16                          | 4                              |
| T5 Girdling of 25% of primary branches (6 mm wide) | 22-Feb                      | 53.58                    | 17-March               | 28-March          | 12                          | 3                              |
| T6 Girdling of 50% of primary branches (6 mm wide) | 21-Feb                      | 53.45                    | 17-March               | 29-March          | 13                          | 3                              |
| T7 Control (no girdling)       | 24-Feb                      | 44.88                    | 20-March               | 2-April           | 16                          | 0                              |

Table 3: Effect of girdling on sex ratio and number of flowers per panicle

| Treatments                     | Female flowers/ panicle | Male flowers/ panicle | Total flower/ panicle | Sex ratio (M: F) |
|-------------------------------|-------------------------|-----------------------|-----------------------|------------------|
| T1 Girdling of 25% of primary branches (2 mm wide) | 217.00                  | 375.00                | 592.00                | 1.72             |
| T2 Girdling of 50% of primary branches (2 mm wide) | 221.33                  | 364.33                | 585.66                | 1.66             |
| T3 Girdling of 25% of primary branches (4 mm wide) | 226.33                  | 367.00                | 593.33                | 1.62             |
| T4 Girdling of 50% of primary branches (4 mm wide) | 232.66                  | 374.66                | 607.33                | 1.61             |
| T5 Girdling of 25% of primary branches (6 mm wide) | 225.00                  | 381.66                | 606.66                | 1.70             |
| T6 Girdling of 50% of primary branches (6 mm wide) | 221.33                  | 380.66                | 602.00                | 1.72             |
| T7 Control (no girdling)       | 167.66                  | 347.33                | 515.00                | 2.08             |

Date of fruit set
The data on date of fruit set present in Table 4 revealed that fruit set in cv. Late Bedana under Pannagar conditions were started from 30th March to 1st April 2016. The earliest fruit set was started in Treatment T2 on 30 March and it was latest (2 April) in the treatment T3.

Time taken to fruit set
The data presented in Table 4 shows that time taken to fruit set may vary in different treatments from 14 to 16 days. The results obtained from present experiment show that there is no significant correlation among date of fruit set, time taken to fruit set and girdling of litchi trees. However, different researches reported that girdling improved fruit set in litchi and other fruit crops but there is no correlation of girdling with date of fruit set. Huang (2012) [6] concluded that spiral girdling trees were fruiting six year earlier to ungirdled tree but there is no effect of girdling on date of fruit set and time taken to fruit set.

Fruit set
The data present in Table 4 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 (T4). 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. Huang (2012) [6] also reported that spiral girdling in litchi significantly increased fruit set.

Fruit retention
The data shown in Table 4 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 T4 (Girdling of 50% of primary branches +4 mm wide) and minimum fruit retention was recorded in control (T1). 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 Brahmanchari (2002) [11] who examined that girdling of litchi trees was significantly increased fruit retention percentage in litchi.

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Table 4: Effect of girdling on date of fruit set, time taken to fruit set, fruit set and fruit retention

| Treatments                                      | Date of fruit set | Time taken to fruit set (days) | Fruit set (%) | Fruit retention (%) |
|-------------------------------------------------|-------------------|--------------------------------|---------------|---------------------|
| T₁ Girdling of 25% of primary branches (2 mm wide) | 1-April           | 15                             | 34.14         | 12.98               |
| T₂ Girdling of 50% of primary branches (2 mm wide) | 30-March          | 14                             | 36.11         | 13.32               |
| T₃ Girdling of 25% of primary branches (4 mm wide) | 2-April           | 15                             | 35.44         | 13.20               |
| T₄ Girdling of 50% of primary branches (4 mm wide) | 1-April           | 16                             | 35.41         | 14.07               |
| T₅ Girdling of 25% of primary branches (6 mm wide) | 1-April           | 14                             | 37.21         | 12.86               |
| T₆ Girdling of 50% of primary branches (6 mm wide) | 31-March          | 14                             | 38.44         | 13.60               |
| T₇ Control (no girdling)                         | 1-April           | 14                             | 32.19         | 11.89               |
| C.V.                                            | -                 | -                              | 2.268         | 2.981               |
| C.D. at 5%                                      | -                 | -                              | 1.451         | 0.704               |

Conclusion
The results indicated that all the litchi trees which were subjected to different severity and width of girdling have more flowering intensity, fruit set and fruit retention 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 flowering and fruiting of litchi cv. Late Bedana.

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