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Response of Shoot Girdling on Fruiting Characteristics of Litchi Cultivars Grown Under the Sub-Himalayan Terai Region of West Bengal

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Abstract

Litchi is an important sub-tropical fruit crops of India and grown mainly in Bihar, West Bengal, Uttarakhand, Uttar Pradesh, Punjab, Haryana, Karnataka, Assam and Tripura. It is an essentially sub-tropical fruits and requires seasonal temperature variations for best flowering and fruiting. Girdling is a worldwide practiced for improvement of flowering and fruiting in fruit crops. Even after prolific flowering and fruit set, a heavy flower and fruit drop is a major concern in litchi. Shoot girdling is method of removal of strip of bark approximately 2-5 mm to block or reducing of sap flow through the bark or phloem, to the lower part of the trees or to the roots in order to enhance profuse flowering, fruit weight, size, yield, quality and enhancement of fruit maturity in various fruit crops. An experiment was conducted at the Instructional Farm, Dept. of Pomology and Post Harvest Technology, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during 2018–2019. The girdling of shoot and its effect on different cultivars were studied with factorial randomized block design having two levels of girdling (without girdling and with 4 cm girdling) and seven levels of cultivars (Calcuttia, Elaichi, Bedana, Bombai, China, Shahi and Muzaffarpur). Results indicated that Calcuttia recorded minimum fruit drop in non girdling (36.70%) and in shoot girdling (11.20%) and also in maximum fruit yield in non girdling (33.15 kg tree^{-1}) as well in shoot girdling (37.21 kg tree^{-1}). judge the effect of girdling on yield attributes of different litchi cultivars

Keywords: Litchi, girdling, fruit cracking, fruit drop

1. Introduction

Litchi (*Litchi chinensis* Sonn.), belonging to the family Sapindaceae is an evergreen, subtropical fruit tree believed to be the native of Southern China (Menzel et al., 1992). In India litchi is grown mainly in Bihar, West Bengal, Uttarakhand, Uttar Pradesh, Punjab, Haryana, Karnataka, Assam and Tripura. Litchi is also known as *'Queen of sub-tropical fruits*' (Nakasone and Paull, 1998) due to its aromatic flavour and sweet aril taste. It is an essentially sub-tropical fruits and requires seasonal temperature variations for best flowering and fruiting. Most varieties need a cold period of 100 to 200 hours between 0° and 7°C, preferably with low rainfall and lower night temperature below 15°C during autumn months favour floral induction, and high day temperature at the same period reduce low night temperature effectiveness (Menzel and Simpson 1995). Low flowering and slight tendency to alternate bearing habit along with low productivity resulting fluctuation in litchi production has been noticed in litchi growing areas of world (Ghosh, 2001, Malhotra et al., 2018, Singh et al., 2012, Su et al., 2021). The lack of profuse and regular flowering has been attributed to several factors such as juvenility, environmental, tree manipulations, crop competition, photoperiod, genotype and interaction of factors (Menzel and Simpson, 1991). Practicing girdling in different litchi growing countries are attempted to overcome the flowering problem. Girdling is a method of complete removal of strip of bark to stop or reduce the flow of sap through the bark or phloem, to the lower part of the trees or to the roots in order to enhance profuse flowering, fruit weight, size, yield, quality and enhancement of fruit maturity in various fruit crops like peach, apple and pear (Chanana and Gill, 2006, Dennis, 1968). It is commonly is practiced by making an incision from 1.6-4.0 mm width in the whole branch circumference by the help of a pruning saw (Carvalho and Salomao, 2000). In this way a portion of bark (phloem) is removed from the wood. As the woody xylem remains intact water and nutrients reaches the leaves but the photosynthates are not transported to the other parts below the girdle portion which results accumulation of the photosynthates just above the girdle portion which in turn

improves the C:N ratio resulting profuse flowering. Girdling prevents the transportation of photo- assimilates to the root system thereby increasing the temporary carbohydrate retention in the tree canopy (Chun et al., 2003; Lopez et al., 2015; Denaxa et al., 2021). Girdling (or cincturing) suppresses vegetative flush and increased flowering intensity in lychee (Menzel, 1983). Girdling intervenes in the phloem transport between roots and canopy to regulate the partitioning of photosynthates, stem CO_2 efflux, and phytohormones, bringing an accumulation of carbohydrate above the girdling area. However, the functionality and integrity of the xylem remain unaffected by girdling and helps for the continuity of water and nutrient transport (Yuan and Huang, 1993, Zhou et al., 1996, Hogberg et al., 2001, Parrot et al., 2007, Maier et al., 2010, Van de Wal, 2017). In litchi, efforts have been made to develop an understanding of assimilate partitioning behaviour with respect to improving flowering and fruiting characteristics by proper source-sink utilization through girdling (Ramburn, 2001; Kumar et al., 2015, 2017). Rivas et al. (2007) reported that girdling few weeks before flowering reduced fruitlet abscission, increased leaf chlorophyll content and chlorophyll fluorescence. Furthermore, it increased quantum yield and carbohydrate concentration in various flowering and vegetative shoots in citrus. Shoot girdling done before flowering enhanced inflorescence development, increased yield and quality of wax jambu fruits (Khandaker et al., 2011). Considering the foregoing facts, an experiment was conducted with an aim to judge the effect of girdling on yield attributes of different litchi cultivars under sub-Himalayan Terai region of West Bengal.

2. Materials and Methods

The experiment was undertaken at the Instructional Farm of Dept. of Pomology and Post Harvest Technology, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, under the sub-Himalayan terai region of West Bengal during November, 2018-July, 2019 with factorial randomized block design having two factors (girdling and cultivars). Two levels of girdling (G_0-without and G_1-with) and seven cultivars (V_1-Calcuttia, V_2-Elaichi, V_3-Bedana, V_4-Bombai, V_5-China, V_6-Shahi and V_7-Muzaffarpur) combining fourteen treatments combination were assessed. Shoot girdling was made by removing of 4 cm wide ring of bark after 30 days of fruit setting below the panicle. Fruit drop was recorded at weekly intervals upto harvesting time by counting the number of fruits retained on the tagged panicles. The percentage of fruit drop was calculated by taking into account the number of initial fruits set and fruits harvested at maturity in the panicles. Twelve panicles distributed in all the directions of tree (three panicles in each of the 'four directions) was tagged in every plant for recording the data on fruit cracking. The data on fruit yield was recorded by weighing all the fruits in each treatment at the time of harvesting and was expressed in term of kg fruits tree^{-1}. Estimated yield per ha was calculated and expressed in term of tonnes per hectare. For statistical analysis the mean separation for different parameters were performed using least significant difference (LSD) test ($p \leq 0.05$). Normality of residuals under the assumption of ANOVA was tested using Kolmogrov-Smirnov, Shapiro-Wilk, Cramer-Von Mises and Anderson Darling procedure using Proc-Univariate procedure of SAS (version 9.3) software. Data transformation for percentage data, was made as per Gomez and Gomez (1984).

3. Results and Discussion

It was found from the main factor effect that shoot girdling has significant effect on fruit drop and the cultivars varied significantly for fruit drop, fruit cracking, fruit yield and estimated productivity. From the interaction effect of girdling operation and cultivars, it was found that the girdling reduced the fruit drop in all the cultivars compared to non-girdled plants. Lowest fruit drop was recorded in girdled Calcuttia (11.20%), comparing its non-girdled plants (36.70%) among all the treatment combinations studied under this study. Among the all varieties, the performance of cv Bedana was poor reflecting maximum fruit drop percentage irrespective of girdling (35.60%) and non-girdling (47.75%) condition. This indicates that girdling with cultivars has a strong positive effect on controlling the fruit drop of litchi in this region. Interaction effect of girdling and cultivars increased the C/N ratio as well as carbohydrate content thus reduced the fruitlet abscission and increased the fruit retention (Shao et al., 1998; Zhou et al., 1999; Li et al., 2001; Huang, 2005). The positive effect of girdling may be due to increment of high concentrations of soluble sugars, total sugars, and starch, phenolic substances (Denaxa et al., 2021). In contrast, girdling has no significant effect on fruit cracking as its own sole impact. In case of shoot girdling maximum fruit cracking (0.67%) was observed in Calcuttia and the minimum fruit cracking (0.00%) was observed in Elaichi, Bedana, China and Shahi. Considering the interaction effect of girdling and cultivars, fruit cracking was found maximum (1.00%) in non-girdled Elaichi, while, the minimum (0.00%) was observed in cvs. Bedana, Bombai and China (Table 1). In non-girdled trees, maximum fruit yield (33.15 kg tree^{-1}) and estimated yield per hectare (6.76 t ha^{-1}) was recorded in Calcuttia, whereas, it was minimum (17.16 kg tree^{-1} and 3.50 t ha^{-1}, respectively) in Muzaffarpur. In girdled plant, the maximum fruit yield (37.21 kg tree^{-1}) and estimated yield ha^{-1} (7.59 t ha^{-1}) was observed in Calcuttia, whereas, the minimum fruit yield (19.60 kg tree^{-1}) and estimated yield per hectare (4.00 t ha^{-1}) was observed in Muzaffarpur (T_7). The result indicates that the shoot girdling and its interaction with varieties had a significant role for increasing the yield and the results were in close confirmation with the findings by Mostafa and Saleh (2006). As the woody xylem remain intact after girdling, water and nutrients reaches the leaves but the photosynthates are not transported to the other parts below the girdle portion and this results in the photosynthates accumulation just above the girdle portion which in turn improves the C:N ratio and therefore it gives profuse

Table 1: Effect of girdling on fruiting characteristics of litchi (main factors)

Treatment	Fruit drop (%)	Fruit cracking (%)	Fruit yield (kg tree^{-1})	Estimated fruit yield (t ha^{-1})
G_0 (Non-girdling)	43.57(4.45)^{a}	0.43^{a}	24.63^{a}	5.02^{a}
G_1 (Girdling)	20.32(3.57)^{b}	0.19^{a}	27.91^{a}	5.70^{a}
SEm±	0.08	0.19	3.12	0.17
LSD (p≤0.05)	0.22	NS	NS	NS
V_1 (Calcuttia)	23.95(3.68)^{c}	0.67^{a}	35.18^{a}	7.18^{a}
V_2 (Elaichi)	32.26(4.04)^{abc}	0.50^{ab}	28.92^{ab}	5.90^{ab}
V_3 (Bedana)	41.68(4.41)^{a}	0.00^{c}	27.59^{abc}	5.63^{abc}
V_4 (Bombai)	30.36(3.82)^{bc}	0.17^{bc}	26.64^{abc}	5.44^{abc}
V_5 (China)	28.64(3.85)^{bc}	0.00^{c}	26.18^{abc}	5.34^{abc}
V_6 (Shahi)	31.15(4.03)^{abc}	0.33^{abc}	20.98^{bc}	4.28^{bc}
V_7 (Muzaffarpur)	35.58(4.24)^{ab}	0.50^{ab}	18.38^{c}	3.75^{c}
SEm±	0.14	0.16	3.55	0.72
LSD (p≤0.05)	0.42	0.45	10.31	2.10
Treatment combinations				
Treatments	Fruit drop (%)	Fruit cracking (%)	Fruit Yield (kg tree^{-1})	Estimated yield (t ha^{-1})
T_1 (V_1G_0)	36.70(4.25)^{ab}	0.67^{ab}	33.15^{ab}	6.76^{ab}
T_2 (V_1G_1)	11.20(3.11)^{e}	0.67^{ab}	37.21^{a}	7.59^{a}
T_3 (V_2G_0)	47.00(4.54)^{a}	1.00^{a}	27.25^{abc}	5.56^{abc}
T_4 (V_2G_1)	17.52(3.54)^{cde}	0.00^{c}	30.60^{abc}	6.25^{abc}
T_5 (V_3G_0)	47.75(4.55)^{a}	0.00^{c}	25.25^{abc}	5.15^{abc}
T_6 (V_3G_1)	35.60(4.26)^{ab}	0.00^{c}	29.93^{abc}	6.11^{abc}
T_7 (V_4G_0)	46.91(4.54)^{a}	0.00^{c}	25.19^{abc}	5.14^{abc}
T_8 (V_4G_1)	13.82(3.11)^{e}	0.33^{bc}	28.09^{abc}	5.73^{abc}
T_9 (V_5G_0)	43.72(4.47)^{a}	0.00^{c}	24.71^{abc}	5.04^{abc}
T_{10} (V_5G_1)	13.56(3.23)^{de}	0.00^{c}	27.65^{abc}	5.65^{abc}
T_{11} (V_6G_0)	40.01(4.35)^{a}	0.67^{ab}	19.67^{bc}	4.01^{bc}
T_{12} (V_6G_1)	22.30(3.72)^{bcd}	0.00^{c}	22.29^{bc}	4.55^{bc}
T_{13} (V_7G_0)	42.90(4.45)^{a}	0.67^{ab}	17.16^{c}	3.50^{c}
T_{14} (V_7G_1)	28.26(4.02)^{abc}	0.33^{bc}	19.60^{bc}	4.00^{bc}
SEm±	0.20	0.22	5.01	1.02
LSD (p≤0.05)	0.59	0.64	14.57	2.98

Means with the same letter are not significantly different (Value in parenthesis is the square root transformed value; G_0: No girdling, G_1: Shoot girdling, V_1: Calcuttia, V_2: Elaichi, V_3: Bedana, V_4: Bombai , V_5: China, V_6: Shahi, V_7: Muzaffarpur

flowering, fruiting. Girdling prevents the transportation of photo- assimilates to the root system thereby increasing the temporary carbohydrate retention in the tree canopy and thus helps in promoting greater fixation of fruit (Carvalho and Salomao, 2000). Girdling can improve carbohydrate availability to fruits and as a consequent lead to an increase in fruit set and yield as well as number of fruits (Wright, 2000, Goren et al., 2003; Rivas et al., 2004; Raffo et al., 2011). The increment in yield may also due to higher number of fruits with more size. Urban and Alphonsout (2006) found that girdling stops the basipetal movement of assimilates through phloem which therefore resulted in accumulation of carbohydrates as well as plant growth hormones above the girdle portion. Improvement of fruit retention and yield after girdling might be due to the blockage of the transport of sugar from leaves to roots which leads to accumulation of large amount of photosynthates on the shoots and leaves above the ring of girdled portion (Li et al., 2003).

4. Conclusion

Calcuttia exhibited positive results in terms of less fruit drop after shoot girdling, moreover it was also associated with highest yield in both non-girdling and girdling conditions. However girdling proved to have better response on yield as compared to non-girdling and has significant effect on controlling fruit drop and fruit cracking. Litchi cv. Calcuttia may be considered as the potential variety for most responsive by shoot girdling under the sub-Himalayan Terai region of West Bengal condition.

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