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Effect of Pollen Grain Sources on Success of hybrids in 'Bedana' Litchi

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Abstract

An experiment was conducted in the year 2018 at ICAR-NRC on Litchi to investigate the effect of different pollen grain sources on fruit set and fruit retention in 'Bedana' litchi. The enclosed flower panicles of 'Bedana' were hand pollinated with male (M_2) pollen from 'Shahi', 'China', 'Rose Scented', 'SwarnaRoopa' and 'Bedana' flowers. The current season's pollen as well as one year old pollen stored at 4 °C was used for pollination. The numbers of fruit set and fruit retention per panicle were determined throughout the fruit development period starting from pollination to harvest on a weekly basis. Initial fruit set was higher in all cross-pollination with pollen sources 'Shahi', 'China' 'Rose Scented' and 'Swarna Roopa' compared to self-pollination with pollen 'Bedana'. The final fruit retention in 'Bedana' was higher with all sources used for cross-pollination whereas there was no fruit retention in self-pollination where "Bedana" was used as source of pollen grains. Results indicated that cross-pollination in 'Bedana' litchi is essential for fruit set and fruit retention. The limited number of initial fruit set resulted in high retention of fruits (1.64% and 1.69%) in 'Bedana' with current season and one year old pollen of 'SwarnaRoopa'. It indicated that number of female flower should be restricted in a panicle for further pollination which would ensure good fruit retention at harvest.

Keywords: Self and cross pollination, fruit set, fruit retention

1. Introduction

Litchi (*Litchi chinensis* Sonn.) is evergreen fruit crop grown extensively in Bihar (31840 ha), West Bengal (9300 ha), Assam (5380 ha), Jharkhand (5270 ha), Uttarakhand (9440 ha) and Odisha (4470 ha) states of India. Recently, it is reported that litchi is also performing well in Southern parts of India (Nath et al., 2015). The litchi fruit consists of about 60% juice, 19% seed and 13% skin which varies depending upon the variety. Litchi occupies special position due to its high nutritive value with average sugar content of 11.85%, out of which more than 80% is reducing sugar and 18% sucrose, 0.8 to 0.9% protein, 0.42% pectin, 0.03% fat and a bountiful of minerals, specially calcium, phosphorus and iron with a total acidity of 0.3 to 0.6% and high vitamin C content ranging from 40.2 to 90.0 mg/100 g (Misra, 2011). Lal et al. (2018a) found wide variation in litchi fruit quality parameters i.e. TSS (17.04-19.98 B), ascorbic acid (14.62-47.50 mg 100 g^{-1}), acidity (0.23-0.55%), total sugar (10.05-13.54%), reducing sugar (7.69-10.78%) and TSS/acidity ratio (33.98-84.19). The total phenol was reported in pericarp (7.5-62.2 mg GAE g^{-1}) and in seed (23.01-59.93 mg GAE g^{-1}), and total

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flavonoids in pericarp (0.73-59.93 mg CE g^{-1}) and in seed (2.41-27.50 mg CE g^{-1}) of litchi (Lal et al., 2018b). The panicle initiation start during last week of January to first week of February and become fully developed during March in Bihar condition. However, the panicle development depends on prevailing weather condition and it varies from first week of March to last week of March and a panicle produces up to 3,000 flowers (Lal, 2018). There are three distinct flower types, two male types (M_1 and M_2 flower) and one female (F flower) which are all borne on the same panicle. Sometimes, M_1 flower is omitted by some cultivars of litchi mostly at young stage of plants. The usual sequence of flower opening, which occurs over a 2 to 6 week period, is male flower (M_1), female hermaphrodite flowers which set fruits and male hermaphrodite flowers (M_2) that do not set fruit. Most of the pollen used for fertilization is supplied by M_2 flower and M_2 pollen are more viable than M_1 (Gupta et al., 2018). The success of fruit set depends upon male parents irrespective of cultural and environmental condition. 'Bedana', a chicken tongue seed, high pulp content and free from sun burn and cracking is mainly preferred by consumers and industrialists but fruit drop is one of the major detrimental factors which lower the production (Lal et al., 2017). Fruit set vary with cultivars grown in the same condition and nutritional condition of plants as highest fruit set (23.96%) and lowest fruit drop (13.06%) was recorded in trees fertilized with calcium nitrate+urea (Jeet et al., 2016). Singh et al (2016) also recorded maximum initial fruit setting, fruit retention, minimum fruit drop, and maximum length and breath and weight of fruit in Banarasi Karaka ber when applied $FeSO_4$ and borax (1.0%). Hada and Singh (2017) reported that fruit set ranged from 24.11% in Fazli to 41.07% in Bombai mango. Adhikary et al (2019) found wide variation of fruit set (3.9 to 31.4%) in ber. Therefore, retention of fruit is very important for high production in any crops. In hybridization programme, the success of hybrids fruits depends upon the male flowers used in pollination because female parents behave differently with different male parents. An obvious field of study would therefore be to investigate ways of improving fruit set and retention to enhance the appeal of 'Bedana' on local and overseas markets. One of the factors found to be involved in fruit set and retention in litchi is pollen source. The pollen parent can have an effect on yield of litchi fruit (Stern et al., 1993; Degani et al., 1995). The importance of pollen sources are experienced in avocado (Gazit and Gafni, 1986; Degani et al., 1989). Stern and Gazit (2003) showed that the litchi flowering pattern tends to promote cross-pollination. However, the partial overlap between the female and male flowers providing an opportunity for self-pollination (Stern and Gazit, 1996; Lal, 2018). Many researchers from South Africa (Fivaz and Robbertse, 1995), Israel (Stern and Gazit, 1998), and Australia (Batten and McConchie, 1992) confirmed the self-compatibility in litchi cultivars. However, some pollen parents increased fruit set in certain cultivars (Stern and Gazit, 2003). Fruit set and its retentions are very important for higher productivity and fruit retention depend upon the male parents who provide pollen grain for pollination and fertilization. Rai and Srivastav (2012) clearly showed the importance of cross pollination in litchi for enhancing production. Therefore, present study was undertaken to assess the effect of pollen sources on fruit set and fruit retention in 'Bedana' litchi.

2. Materials and Methods

An experiment was conducted in 2018 in Field Gene Bank at ICAR-NRC on Litchi, Muzaffarpur at 26°5'87" N latitude, 85°26'64" E longitude at an elevation of 210 m above msl to assess the effect of pollen sources on fruit set and fruit retention in 'Bedana' litchi. The trial was laid out as a randomised complete block design (RCBD). Five panicles for each pollen source were marked on 'Bedana' that was used as the female parent. Litchi produces three types of flower male (M_1), female (F), hermaphrodite male (M_2) flower and M_2 flower is more fertile than M_1 flower. When all M_1 flowers were dropped off, panicles were bagged before a day of opening of female flowers and next day bag was opened and removed all M_2 flowers. Pollen of different male source parents 'Shahi', 'China' 'Rose Scented', 'SwarnaRoopa' and 'Bedana' were applied to the stigma of female flowers (Bedana) after which the panicles were again enclosed with perforated nylon bag to prevent unwanted cross-pollination by insects or wind. Pollens were primarily obtained from M_2 flowers of the pollen source cultivars, coinciding with the late female bloom of 'Bedana'. Pollination was performed at anthesis when the surface of the stigma of female flowers was shiny white. Replications comprised of three trees. The aim of study was to determine the effect of self and cross-pollination on fruit set and fruit retention in 'Bedana' litchi. Data from 'Bedana' panicles was taken by counting the number of fruit set per replication after the pollination process on a weekly basis. The fruit set was monitored by counting the number of fruit retained per panicle on a weekly basis until harvest to determine fruit retention. Data were statistically analysed as a completely randomised design with 5 treatments and 3 replications. Analysis of variance (ANOVA) was used to test for differences between the five pollen treatment effects. The data were acceptably normal with homogeneous treatment variances. Treatment means were separated using Fisher's protected t-test least significant difference (LSD) at the 5% level of significance (Snedecor and Cochran, 1980).

3. Results and Discussion

The initial fruit set and final fruit retention are presented in Figure 1 and 2 and a trend of pollen source effect on fruit set and subsequent fruit retention of 'Bedana' on 15 flower panicles per treatment is demonstrated in Figure 3 and 4. Initial fruit set in 'Bedana' panicles were higher in all cross-pollinating treatments compared to self-pollination with 'Bedana' and final fruit retention was higher in all the cross-pollinating treatments while no fruit was retained in self-pollination with 'Bedana'. Compared to self-pollination with 'Bedana' pollen, a significantly higher (p<0.05) initial fruit set (20.26 and 19.46%, 51.75 and 49.67%, 24.15 and 22.65%,

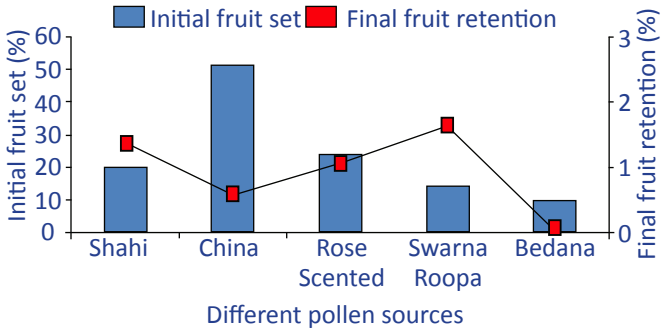

Figure 1: Pollen source (current season) effect on the initial fruit set and final fruit retention of the cultivar 'Bedana'. Data are means of 15 panicles per treatment (5 panicles×3 trees) of male parents 'Shahi', 'China', 'Rose Scented', 'SwarnaRoopa' and 'Bedana'

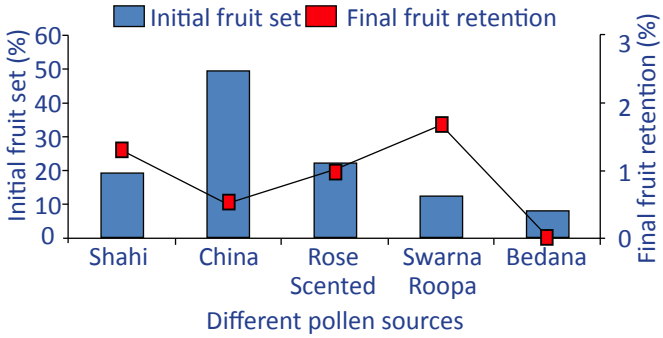

Figure 2: Pollen source (one year old) effect on the initial fruit set and final fruit retention of the cultivar 'Bedana'. Data are means of 15 panicles per treatment (5 panicles×3 trees) of male parents 'Shahi', 'China', 'Rose Scented', 'SwarnaRoopa' and 'Bedana'

14.62 and 12.45%) was found with pollen sources parents 'Shahi', 'China' 'Rose Scented' and 'SwarnaRoopa'respectively (Figure 1 and 2) in both current season's pollen and one year old pollen. Kumari et al. (2018) found higher fruit set in cross pollination as compared to self-pollination. In contrary to this result Brijwal et al. (2016) had reported that initial fruit set under self-pollination was significantly higher than all crosses and open-pollination methods. Forneman et al. (2012) also reported the lower initial fruit set in all cross-pollination as compared to self-pollination in "WaiChee" litchi cultivar.

The final fruit retention was maximum in Bedana (1.64% and 1.69 %) with pollen source 'SwarnaRoopa' of current season's pollen and one year old pollen. Although, the initial fruit set was least in 'Bedana' with pollen source 'SwarnaRoopa' under cross pollination. The lower numbers of initial fruit set efficiently used food materials which resulted in high retention of fruits at harvest. Others sources resulted with higher initial fruit set where more competition occurs among more numbers of fruitlets resulted more fruit drop and low retention of fruit at harvest. However, there was no fruit retention at harvest in self-pollination with source 'Bedana' and cross pollination with other sources enhanced fruit set and fruit retention. Kumar and Kumar (2014) and Srivastava et al. (2017) also reported that cross pollination enhanced fruit set than bagged panicle/self-pollination. Degani et al. (1995) reported that in-bred fruit often abscise early, supporting the findings of this study. The better fruitlet retention with cross-pollination may also be explained by embryo degeneration and abortion found in self-pollinated fruit due to inbreeding depression (Sedgley and Griffin, 1989). A great number of fruit drop prematurely reduces the crop potential. This fruit drop pattern was also clear in 'Bedana' after hand pollination of female flowers. The significant effect of pollen source on litchi fruit set and retention in 'Bedana' became evident as the number of fruits that survived throughout the development period was monitored. Results in this study showed that self-pollinating 'Bedana' gave initial fruit set but fruitlets emanating from these self-pollinations abscised at a higher rate than the fruitlets resulting from cross-pollination and there was no fruit retention in self- pollination at harvest. The significant increases in fruit retention obtained with all sources pollen may be an indication of potential enhancing effects of cross pollinators on yield in 'Bedana'. The actual fruit set is considered in litchi two weeks after pollination and during second week, compared to self-pollination with 'Bedana' pollen, a significantly higher (p<0.05) initial fruit set (2.31 and 3.12%, 6.45 and 2.99%, 3.52 and 4.62%, 4.26 and 4.08%, 0.75 and 1.23%) was found in all cross pollinating treatments with current season's and one year old pollens, respectively (Figure 3 and 4).

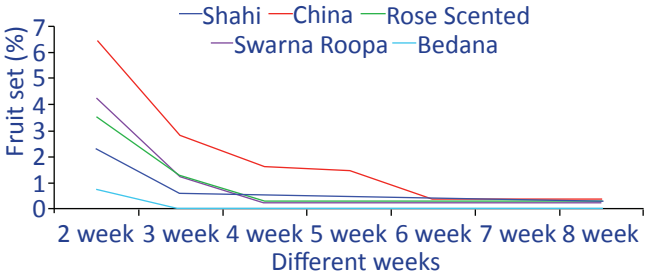

Figure 3: Trend of pollen source (current season) effect on % of fruit set weekly on 'Bedana' panicles from fruit set (2 week) to harvest (8 week). Data are means of 15 panicles per treatment (5 panicles×3 trees) of male parents 'Shahi', 'China', 'Rose Scented', 'SwarnaRoopa' and 'Bedana'

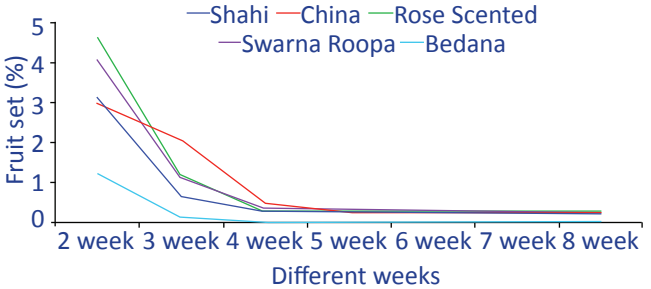

Figure 4: Trend of pollen source (one year old) effect on % of fruit set weekly on 'Bedana' panicles from fruit set (2 week) to harvest (8 week). Data are means of 15 panicles per treatment (5 panicles×3 trees) of male parents 'Shahi', 'China', 'Rose Scented', 'SwarnaRoopa' and 'Bedana'

In order to determine the significance of pollen source between 2 and 8 weeks, the % fruit retained on each week relative to initial fruit set was analyzed. Compared to self-pollination with 'Bedana' pollen, final fruit retention varied from 0.58 to 1.64% with current season's pollens (Figure 5) and 0.50 to 1.69% with one year pollens (Figure 6). All cross pollination

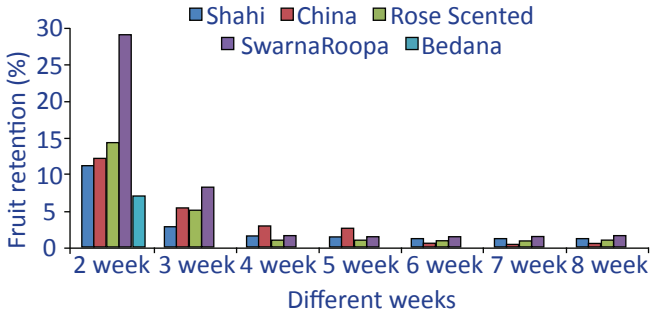

Figure 5: Effect of pollen source (current season) on % fruit retained in 'Bedana' relative to the initial fruit set. The % was calculated as the number of fruit retained relative to the initial fruit set on week 1. This was done on a weekly basis until harvest (week 8). Data are means of 15 panicles per treatment (5 panicles×3 trees) of male parents 'Shahi', 'China', 'Rose Scented', 'SwarnaRoopa' and 'Bedana'

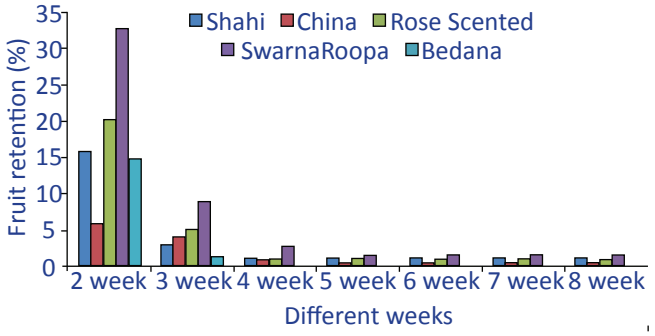

Figure 6: Effect of pollen source (one year old) on % fruit retained in 'Bedana' relative to the initial fruit set. The % was calculated as the number of fruit retained relative to the initial fruit set on week 1. This was done on a weekly basis until harvest (week 8). Data are means of 15 panicles per treatment (5 panicles×3 trees) of male parents 'Shahi', 'China', 'Rose Scented', 'SwarnaRoopa' and 'Bedana'

treatments resulted in more fruit retention at harvest and no fruit retention in self-pollination condition. Fruit retention deceased with the passes of time till 4 weeks and afterwards become constant. When the % fruit retained relative to initial fruit set was analysed, it was revealed that pollen source had a statistically significant effect on fruit retention during certain stages of fruit development. Fruit retention started to decrease after first week, but after a pronounced fruit drop period of three weeks, cross-pollinating sources had a significantly higher influence on fruit retention during the later stages of fruit development. Degani et al. (1995) reported that in-bred fruit often abscise early, supporting the findings of this study. The better fruitlet retention with cross pollination may also be explained by embryo degeneration and abortion found in self-pollinated fruit due to inbreeding depression (Sedgley and Griffin, 1989). Final fruit retention at harvest was higher in all cross-pollinating sources, demonstrating the potential ability of cross-pollinated fruitlets to outcompete self-pollinated fruitlets for available tree resources.

4. Conclusion

Results have shown a positive response of 'Bedana' towards different pollen source uses aiming to enhance fruit set and fruit retention in the cultivar but 'Swarna Roopa' showed good compatibility resulted maximum fruit retention at harvest. The limited numbers of initial fruit set resulted in final high retention of fruits. Final fruit retention with cross-pollinating sources was higher. Results therefore indicate that the inclusion of pollen sources to encourage cross-pollination in litchi orchards may have beneficial effects on production.

5. Acknowledgement

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