EFFECT OF POLLEN GRAIN SOURCES ON FRUIT SET AND RETENTION IN 'SHAHI' LITCHI

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Abstract

The effect of self- and cross-pollination on fruit set and fruit retention in 'Shahi' litchi was investigated. The enclosed flower panicles were hand pollinated with male (M_2) pollen from 'Rose Scented', 'Swarna Roopa', 'Bedana', 'China' and 'Shahi' flowers. The current season's pollen and one year old pollen stored at 4 °C were used for pollination. The number of fruit set and fruit retention per panicle was determined throughout the fruit development period from fruit set to harvest on a weekly basis. Initial fruit set in 'Shahi' was lower with sources 'Swarna Roopa' and 'Bedana' compared to the self-pollination with 'Shahi'. However, final fruit retention in 'Shahi' was higher with all sources used for cross-pollination whereas there was no fruit retention in self pollination. Results indicated that cross-pollination in 'Shahi' litchi is essential for fruit set and fruit retention. The limited number of initial fruit set resulted in high retention of fruits (19.29 % and 15.30%) in 'Shahi' with current season and one year old pollen of 'Swarna Roopa'.

Key Words: *Self and cross pollination, fruit set, fruit retention, current season pollen, one year old pollen*

Introduction

Litchi (*Litchi chinensis* Sonn.) is an important commercial fruit crop grown extensively in Bihar, West Bengal, Assam, Jharkhand, Uttarakhand and Odisha states of India. 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. Litchi flowers are borne on multi-branched terminal inflorescences, which are generally referred as panicles. A panicle can have up to 3,000 flowers (Lal, 2018), although only about 200 are pollinated and of these only 5 to 60 will develop into mature fruit. 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 to produce by some cultivars of litchi mostly during young stage of plants and only two flowers M_2 and F flower are produced. 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. The male flowers in the first and third stages release pollen to fertilize the female flowers. Most of the pollen used for fertilization is usually supplied by the third stage of male hermaphrodite flowers (M_2) and staining results revealed that M_2 pollen were more viable than M_1 (Gupta *et al.*, 2018). Thus, there needs to be an overlap of the male stages with the female stage to promote self-pollination. The success of fruit set depends upon male parents irrespective of cultural and environmental condition. 'Shahi', a early and high yielding commercial litchi cultivar grown in major parts of India. However, the cultivar is harvested at a time in India when there is a gap in worldwide litchi production, thereby increasing its profitability. The fruit drop in one of the major detrimental factor which lowers the production (Lal *et al.*, 2017). Therefore, retention of fruit is very important for high production in any crops. An obvious field of study would therefore be to investigate ways of improving fruit set and retention to enhance the appeal of 'Shahi' 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 flowering and male flowers enables pollination among flowers on the same tree, or among trees of the same cultivar, thereby providing an opportunity for self-pollination (Stern and Gazit, 1996; Lal, 2018). Litchi is considered to be self-fertile, since single cultivar litchi orchards are capable of producing good yields. Many researchers from South Africa (Fivaz and Robbertse, 1995), Israel (Stern and Gazit, 1998), and Australia (Batten and McConchie, 1992) confirmed the self-compatibility of several litchi cultivars. However, some pollen parents increased fruit set in certain cultivars (Stern and Gazit, 2003). The opening of female flower overlaps with the male flowers which increases chances of self-pollination (Lal, 2018) but cross pollination is very important in litchi for higher production. 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 shown 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 'Shahi' litchi.

Materials and Methods

An experiment was conducted during 2017 and 2018 in Field Gene Bank at ICAR-NRC on Litchi, Muzaffarpur to assess the effect of pollen sources on fruit set and fruit retention in 'Shahi' litchi. The trial was laid out as a randomised complete block design (RCBD). Five panicles for each pollen source were marked on 'Shahi' 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 'Rose Scented, 'Swarna Roopa', ' Bedana' 'China' and 'Shahi' were applied to the stigma of female flowers (Shahi) 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 'Shahi'. 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 'Shahi' litchi. Data from 'Shahi' 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)

Results and Discussion

The initial fruit set and final fruit retention are presented in Figure 1 & 2 and a trend of pollen source effect on fruit set and subsequent fruit retention of 'Shahi' on 15 flower panicles per treatment is demonstrated in Figure 3 & 4. Initial fruit set in 'Shahi' panicles were higher in all cross-pollinating treatments compared to self-pollination with 'Shahi' except 'Swarna Roopa' and 'Bedana'. However, final fruit retention was higher in all the cross-pollinating treatments as opposed to self-pollination with 'Shahi'. Compared to self-pollination with 'Shahi' pollen, a significantly lower ($P<0.05$) initial fruit set (10.42, 20.71 and 4.38, 19.46 %) was found with pollen sources 'Swarna Roopa' and 'Bedana' respectively (Fig. 2) in both current season's pollen and one year old pollen. Kumari *et al.* (2018) found higher fruit set in cross pollination as compare 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 "Wai Chee" litchi cultivar.

The maximum fruit retention in Shahi (19.29% and 15.30 %) was found with source 'Swarna Roopa' of current season's pollen and one year old pollen. Although, the initial fruit set was least in Shahi with source 'Swarna Roopa'. The lower numbers of initial fruit set efficiently used food materials which resulted in high retention of fruits. Others sources resulted with higher initial fruit set where more competition occurs among more numbers of fruitlets resulting more fruit drop and low retention of fruit at harvest. However, there was no fruit retention at harvest in self-pollination with source 'Shahi' 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 'Shahi' after hand pollination of female flowers. The significant effect of pollen source on litchi fruit set and retention in 'Shahi' became evident as the number of fruits that survived throughout the development period was monitored. Results in this study showed that self-pollinating 'Shahi' gave the highest initial fruit set compare to source Swarna Roopa' and 'Bedana', 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 'Shahi'. The actual fruit set is considered in litchi two weeks after pollination and during second week, compared to self-pollination with 'Shahi' pollen, a significantly lower ($P<0.05$) initial fruit set (2.31%) was found with pollen sources 'Bedana' when current season's pollens were used (Fig 3). However, 'Shahi' as pollen source retained significantly less fruit set than current sesason pollen sources 'Rose Scented', 'Swarna Roopa', and 'China' while all sources retained more fruit set with one year old pollens (Fig 4).

In order to determine the significance of pollen source between 2 and 8 weeks, the percentage fruit retained on each week relative to initial fruit set was analysed. Compared to self-pollination with 'Shahi' pollen, a significantly lower ($P<0.05$) final fruit retention (9.39%) was found with pollen sources 'Rose Scented' when current season's pollens were used (Fig 5). However, 'Shahi' as pollen source retained significantly less fruit retention than cross-pollinating treatments 'Swarna Roopa, China and Bedana' with current season' pollens while all sources retained more fruit retention with one year old pollens (Fig 6). Fruit retention deceased with the passes of time till 7 weeks and afterwards become constant. When the percentage fruit retained relative to initial fruit set was analysed, it was found that pollen source had a statistically significant effect on fruit retention during certain stages of fruit development. Retention of fruit started 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.

Conclusion

Results obtained in this study have shown a positive response of 'Shahi' towards different pollen source applications aiming to enhance fruit set and fruit retention in the cultivar. The limited numbers of initial fruit set resulted in final high retention of fruits. Final fruit retention with cross-pollinating sources was all higher than with self-pollination. Results therefore indicate that the inclusion of pollen sources to encourage cross-pollination in litchi orchards may have beneficial effects on production. Work in this study was mainly focused on the 'Shahi' cultivar. However, it would be worthwhile to include some other litchi cultivars in future investigations to determine the effect of cross-pollination on these cultivars. Due to environmental effects it could also be worthwhile to repeat this trial over consecutive seasons to determine the economic impact of the pollen source on various fruit characteristics over a period of time.

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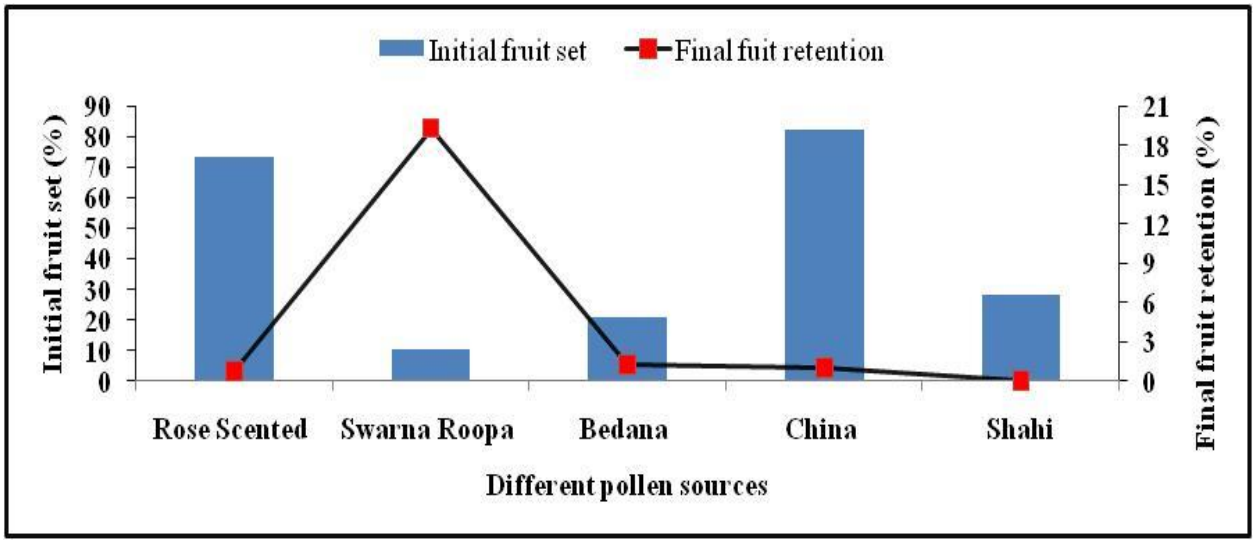

Fig 1: Pollen source (Current season) effect on the initial fruit set and final fruit retention of the cultivar 'Shahi'. Data are means of 15 panicles per treatment (5 panicles x 3 trees) of male parents 'Rose Scented', 'Swarna Roopa', 'Bedana', 'China' and 'Shahi'.

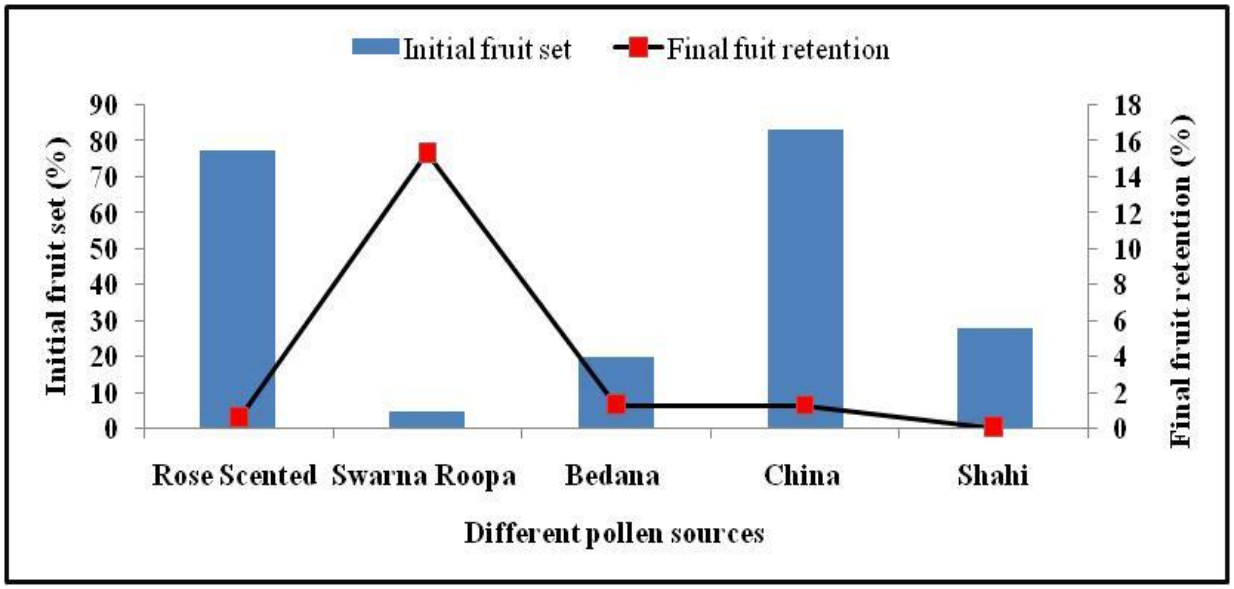

Fig 2: Pollen source (One year old) effect on the initial fruit set and final fruit retention of the cultivar 'Shahi'. Data are means of 15 panicles per treatment (5 panicles x 3 trees) of male parents 'Rose Scented', 'Swarna Roopa', 'Bedana', 'China' and 'Shahi'.

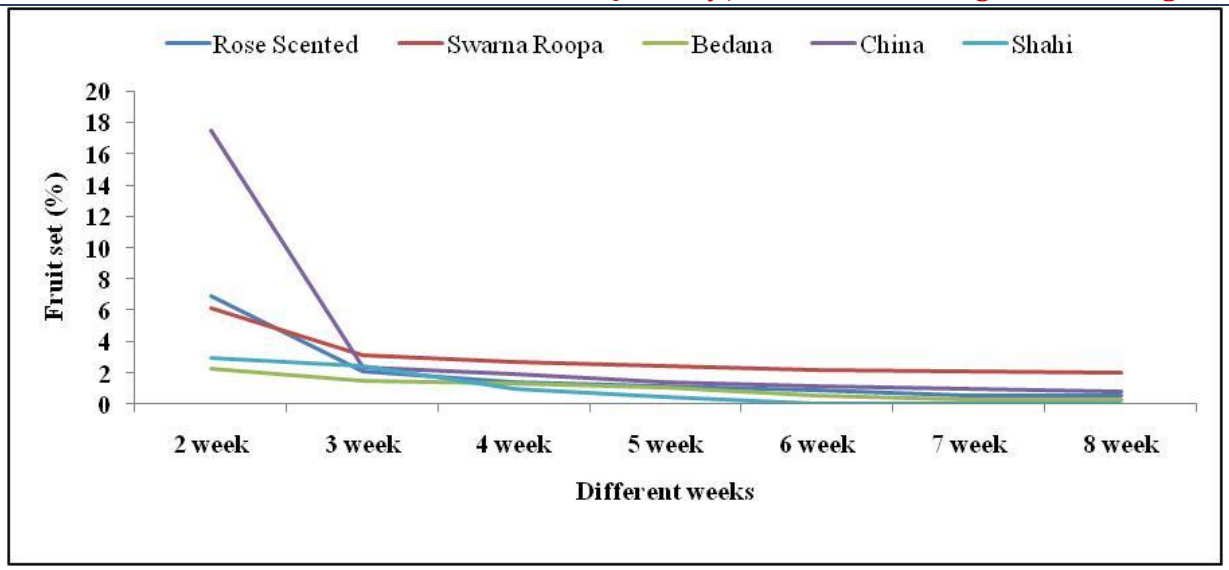

Fig 3: Trend of pollen source (Current season) effect on per cent of fruit set weekly on 'Shahi' panicles from fruit set (2 week) to harvest (8 week). Data are means of 15 panicles per treatment (5 panicles x 3 trees) of male parents 'Rose Scented', 'Swarna Roopa', 'Bedana', 'China' and 'Shahi'.

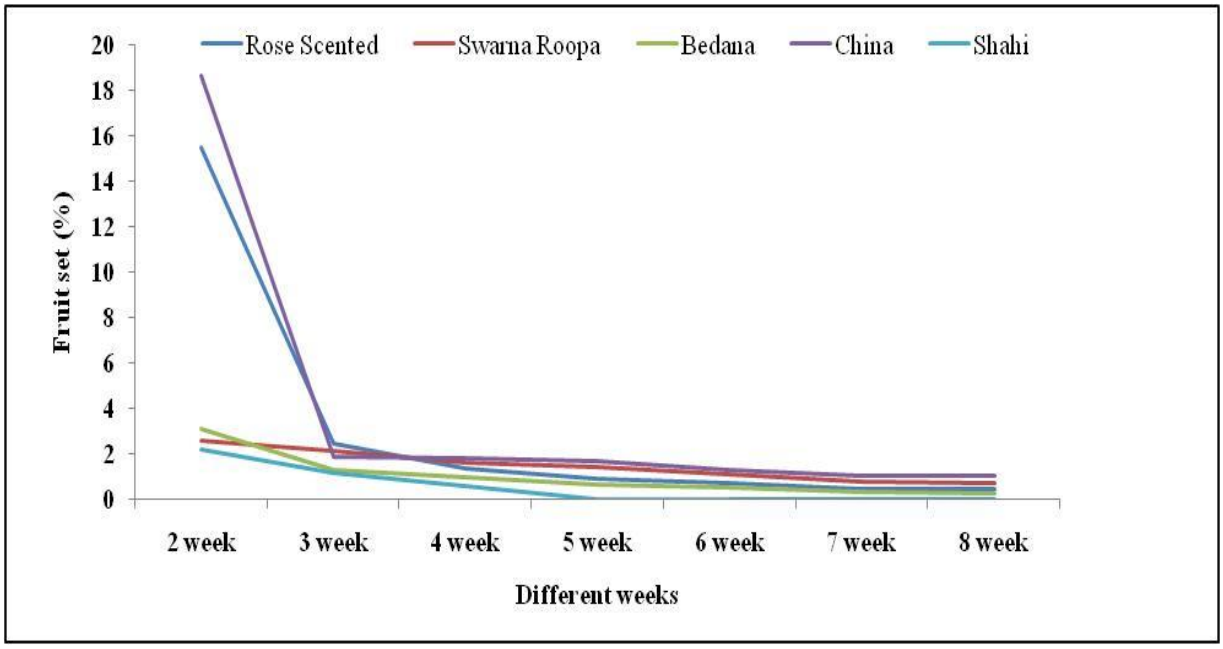

Fig 4: Trend of pollen source (One year old) effect on per cent of fruit set weekly on 'Shahi' panicles from fruit set (2 week) to harvest (8 week). Data are means of 15 panicles per treatment (5 panicles x 3 trees) of male parents Rose Scented', 'Swarna Roopa', 'Bedana', 'China' and 'Shahi'.

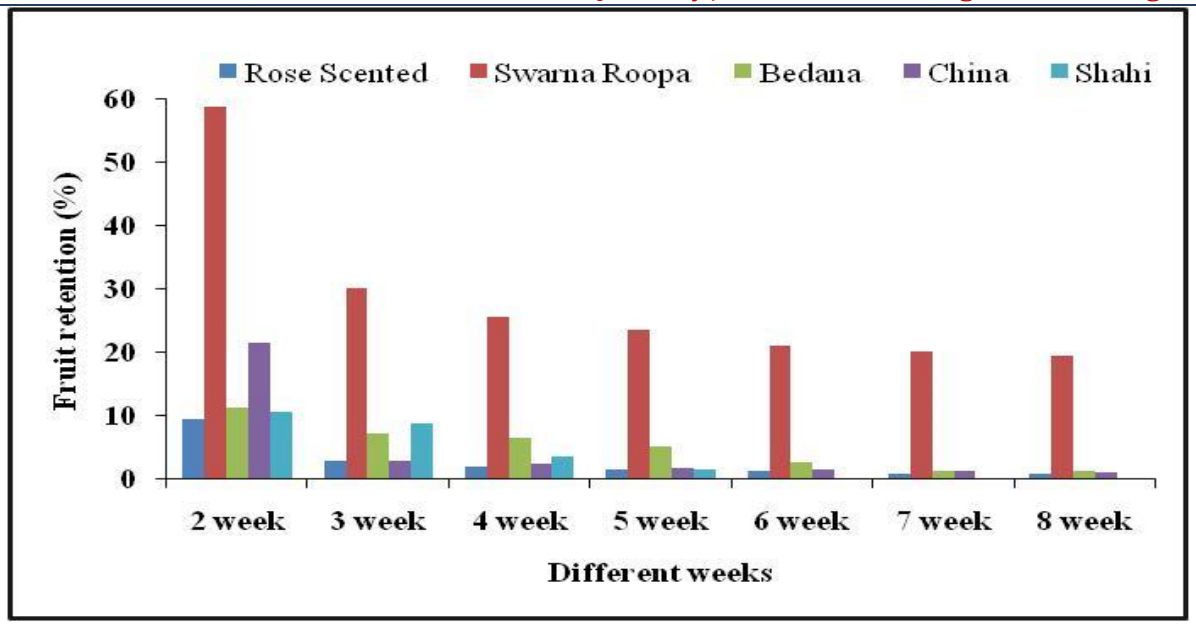

Fig 5: Effect of pollen source (Current season) on percentage fruit retained in 'Shahi' relative to the initial fruit set. Percentages were calculated as the number of fruit retained relative to the initial fruit set on week 1. This was done on a weekly basis until harvest (week 8). Data are means of 15 panicles per treatment (5 panicles x 3 trees) of male parents Rose Scented', 'Swarna Roopa', 'Bedana', 'China' and 'Shahi'.

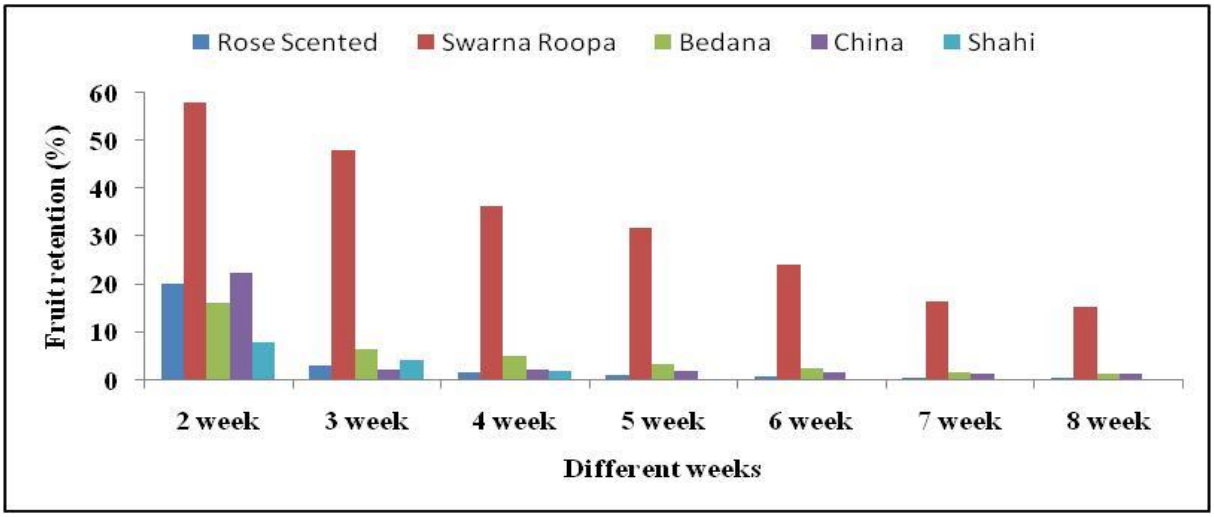

Fig 6: Effect of pollen source (One year old) on percentage fruit retained in 'Shahi' relative to the initial fruit set. Percentages were calculated as the number of fruit retained relative to the initial fruit set on week 1. This was done on a weekly basis until harvest (week 8). Data are means of 15 panicles per treatment (5 panicles x 3 trees) of male parents Rose Scented', 'Swarna Roopa', 'Bedana', 'China' and 'Shahi'.