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Effect of temperature, flowering time and inflorescence length on yield and productivity of litchi (*Litchi chinensis*) cv. 'Shahi'

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ABSTRACT

The present study was carried out in 2017–18 at ICAR-NRC on Litchi, Muzaffarpur to assess the effect of temperature, flowering time and inflorescence length on yield of litchi (*Litchi chinensis* Sonn.) cv. Shahi. The study revealed that the temperature, flowering stage as well as length of inflorescence were positively correlated with florescence width (0.98) while fruit set was negatively correlated with temperature (-0.863). There was a strong correlation between fruit set and size of the inflorescence. Early-season flowering had higher fruit set (8.56%) as compared to mid (7.58%) and late-season (4.05%) flowering. Fruit set was critically reduced by 50% in late flowering plants resulting in drastic reduction in the total fruit yield. A strong positive correlation (0.84) was found between inflorescence thickness and fruit weight. Fruit and pulp weight were influenced by stage of flowering, as early flowering exhibited highest fruit weight (24.56 g) compared to mid and late flowering in which fruit weight was reduced by 35.42% and 50%, respectively.

Keywords: Flowering stage, Fruit set, Fruit weight, Inflorescence, Temperature

Litchi (*Litchi chinensis* Sonn.) is a subtropical evergreen fruit tree and its cultivation is restricted to a few states in India. The total production of litchi in India is 668,000 metric tonnes from 92,000 ha (Anonymous 2018). Earlier, it was being grown mainly in northern parts of the country, but presently, it is being grown in southern parts also (Kerala, Karnataka, Tamil Nadu) where it is available in off-season during December-January (Nath *et al.* 2015). Emergence of inflorescence starts during February-March under Bihar conditions. Many genotypes bear either loose or compact panicles depending on prevailing weather conditions. The number of flowers on a single inflorescence varies from few hundred to several thousands. There are three types of flowers in the inflorescence: male, pseudo-hermaphrodite female and pseudo-hermaphrodite male flowers, which open in sequential order and each stage of flowers extends for a period of 7–10 days (Lal *et al.* 2019). Bihar's litchi cv. Shahi has the Geographical Indication (GI) tag. Shahi is the leading cultivar being grown in India with highest area and is highly popular for its taste. The productivity of litchi varies from 1.8 to 15.1 tonnes in India (Anonymous 2014). This huge variation in productivity might be due to poor cultural practices, but prevailing weather conditions and climate changes may also be responsible for augmenting this problem. Shahi is among the early cultivars, which commence flowering during February-March and the fruits are available in the market during late May. The inflorescence of litchi is panicle and its fruiting body and characteristics ensure the final fruit yield of litchi. The size of inflorescence affects competition for the nutrients during flowering and early fruit-set (Teng 1996). In the cv. 'Shahi', inflorescence is much larger than that of other cultivars leading to strong competition among the flowers and the developing fruits. Therefore, the objective of this study was to assess the effect of temperature and inflorescence length on yield of litchi. Further, the effect of flowering stage in relation to temperature on fruit set was explored.

MATERIALS AND METHODS

The study was conducted in 2017 and 2018, at the National Active Germplasm Site (NAGS) of ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar located at 26°5'87" N latitude, 85°26'64" E longitude at an elevation of 210 m amsl, to assess the relationship between panicle size and fruit traits of Shahi cultivar of litchi. The soil of the site is alluvial with sandy loam texture and calcareous nature along with *p*H 7.5–8.0. The temperature varies

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from 30–43°C (May) in summers and 5–10°C in winters (December). The region is characterized by dry and hot summers and cold winters with heavy rainfall during rainy season. The onset of monsoon usually occurs in the second or third week of June and continues in appreciable amount up to mid of September. Ten years old plants of litchi cv. Shahi were selected and the experiment was laid out in randomized block design (RBD) with eight replications. The uniform cultural practices (weeding and irrigation) were provided to all of the selected plants. Twenty shoots around each tree were labeled at about the shoulder height for measuring the length and width of inflorescence and fruit number. The length and width of the longest and widest part of each inflorescence and the time of initiation of opening of first flower were recorded. The observations on number of fruits per shoot were also recorded at the time of harvest for two consecutive years. The time of anthesis of female flowers was recorded in tagged branches in four directions and flowering was considered as early, mid and late stage. Numbers of female flowers were counted in each stage of flowering and fruit retention was recorded till harvesting. The correlation and regression of inflorescence data were analyzed by SAS software (Lee and Chang 2019).

RESULTS AND DISCUSSION

Relationship between the length of inflorescence and fruit set: There was a strong and positive correlation (0.98) between the length and width of inflorescence (Fig 1). Lal *et al.* (2020) also recorded a strong positive correlation between the length and width of panicle over the times in the three cultivars of litchi, viz. Rose Scented (0.989), Mandaraji (0.970) and Seedless Late (0.771). Panicle width increased with an increment in length. Further, a strong relationship between the number of fruits set and the length of the inflorescence was observed, with optimum length around 37 cm. A strong relationship between the number of fruits and the length of the inflorescence in litchi was also observed in earlier studies (Lee 2006, Chen *et al.* 2013). This information is very important as the inflorescence governs the number of flowers produced and is also responsible for success of fruit set in litchi. Large size panicle carried a greater number of flowers, and ultimately higher number of fruits. This indicated clearly that an optimum size of panicle is required for higher production of litchi fruits. The panicle length also exerts a great impact on litchi production by affecting the behavior of pollinators as their attraction is dependent only on the number of flowers open at a given time and not on the total number of flowers produced (Lal *et al.* 2020). Suetsugu *et al.* (2015) also found a positive correlation between the proportion of flowers developing into fruit and the number of flowers per inflorescence. Fruit set was reported as directly correlated with lower sex ratio in ber (Adhikary *et al.* 2019). These observations clearly revealed that the panicle length development should be allowed to the maximum possible extent (37 cm) for higher fruit set.

In 2017 and 2018, the female flower of early inflorescences flowered from 22nd March to 29th March, while the flowers on mid-season inflorescence flowered from 30th March to 5th April and those on the late season inflorescence flowered from 6thApril to 12thApril. All the inflorescences bore flowers from 22nd March to 12thApril. There was a strong correlation between fruit set and the size of the inflorescence in the early, mid- and late-season inflorescences (Fig 2). Results exhibited that early flowering showed maximum length of inflorescence (21.56 to 47. 65 cm) followed by mid flowering (16.45 to 46.53 cm) and late

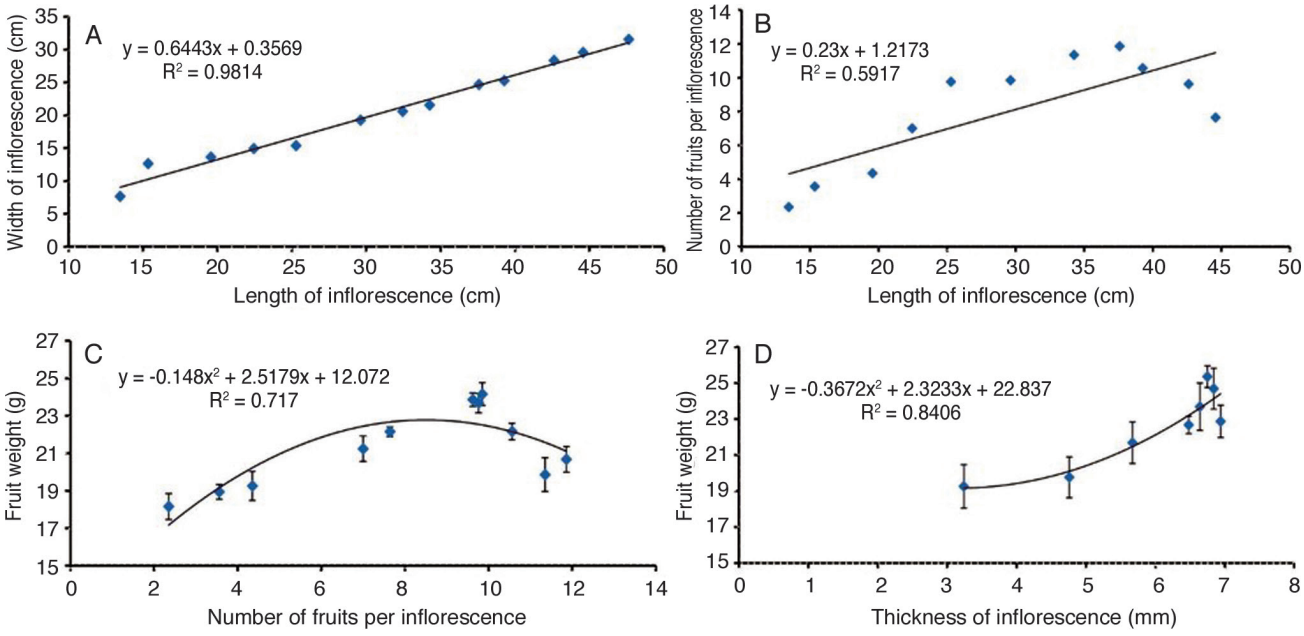

Fig 1 Relationship between the length and width of inflorescences (A), length of inflorescence and number of fruit set per inflorescence (B), number of fruit set per inflorescence and fruit weight (C), and thickness of inflorescence and fruit weight (D) in 'Shahi' cultivar of litchi.

flowering (13.45 to 38.25 cm). Early flowering had higher fruit set (8.56%) as compared to mid (7.58%) and late (4.05%) flowering. These results clearly exhibited that the fruit set was reduced by 50% in late flowering plants, which might be responsible for drastically reducing the total yield and also lowering of the productivity. The variation in fruit set is entirely based on pollen fertility and prevailing temperature (Kumari *et al.* 2016). Chen and Weng (2000), Lee (1992) and Lin (1994) indicated that the temperature can influence pollen germination and fertilization, resulting in different yield potential across different flowerings. The increase in temperature during the late flowering may be responsible for lower fruit set and ultimately reduced fruit yields. This is why the litchi plant is considered to be very specific in its climatic requirements and is grown in very limited countries.

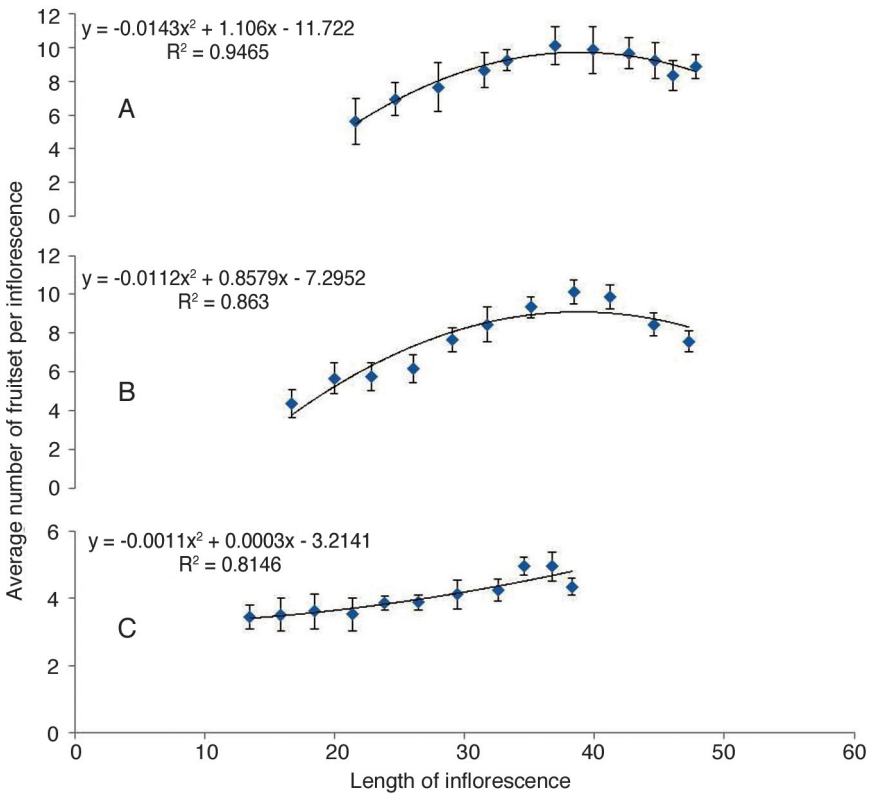

Fig 2 Relationship between fruit set and length of inflorescence across early (A), mid- (B) and late flowering (C) in 'Shahi' cultivar of litchi.

Number of fruit set per inflorescence was negatively correlated (-0.863) with temperature which exhibited maximum fruit set in early stage of flowering followed by mid and late stage and this might be due to comparatively low temperature during early stage of flower opening that favoured good pollination and fertilization. The size of the inflorescence in litchi cv. 'Shahi' decreased with delayed flowering resulting in reduction of the rate of fruit set (4.05%). This might be due to a direct effect of hot weather on the fertility of the late flowers, and weak development of inflorescence leading to least number of fruits. Early inflorescence develops very strongly and carries enough water, nutrients and photosynthates to the developing fruits from other parts of plants because growing fruit are a high demanding sink. Menzel *et al.* (1995) reported that a proportion of the carbohydrate produced from photosynthesis is used immediately in the growth of developing fruit. Early emergence of inflorescence might have helped early development of fruit as temperature was low at the time of early flowering which ensured proper pollination and fertilization, and promoted fruit development. Fruit produced in early flowering inflorescence took more days to mature as compared to mid and late. Pure leafless inflorescence develops in early season due to low temperature while leafy inflorescence in late season. Leaves are strong competitors for tree resources against flowers (Huang and Chen 2014). It is generally assumed that the fruit set on leafless inflorescences is better than that on leafy inflorescences (Chang *et al.* 2009, Davenport and Stern 2005, Lee and Chang 2019). The early and mid-season flushing influence the yield whereas, the late season flushing does not have any contribution towards yield (Kumar *et al.* 2016). Early flush becomes mature enough and produces early inflorescence which is strong and ensures proper pollination and fertilization due to low temperature.

Effect of fruit set per inflorescenceon fruit weight: There was a positive correlation (0.71) between number of fruits set per inflorescence and fruit weight (Fig 1). The fruit weight was highest (24.16 g) when number of fruits per inflorescence was 9.85. Fruit weight might not only be influenced by number of fruits per inflorescence, but also thickness of inflorescence and orientation of fruit (Waseem *et al.* 2002). On the other hand, Nagraj *et al.* (2019) reported that fruit load has negative relationship with fruit weight in litchi cv. China. These results clearly give an idea about the number of fruits to be retained on individual inflorescence to have good sized fruits.

Effect of thickness of inflorescence on fruit weight: A very strong positive correlation (0.84) was found between thicknesses of inflorescence and fruit weight (Fig 1). The highest fruit weight (25.35 g) was recorded when inflorescence thickness was 6.75 mm. Inflorescence size and girth thickness strongly determines fruit weight. A positive relationship has also been reported between inflorescence development and fruit set (Lauri *et al.* 1996), and panicle girth and fruit set (Lal *et al.* 2020). Higher value of auxin:gibberellin ratio promotes flower bud initiation, which was associated with higher cambial activity of higher girth of inflorescence (Luo *et al.* 2005). This reflects that an adequate active xylem and pith cell is capable to transport food materials to the developing fruits which resulted in

maximum growth of fruits. The significance of fruit tree reserves in influencing fruit set and weight has also been reported in olive (Bustan *et al.* 2011).

From the study, it can be concluded that early flowering trees had higher fruit set and yield compared to mid and late flowering trees. This can be due to congenial temperature experienced by early flowering trees which has a favourable influence on inflorescence development, fruit set and yield. Comparatively, early flowering trees produced healthy and better-quality panicles in terms of length and girth which are capable of supporting fruit growth till maturity. This information can provide the basis for assessing the yield performance of litchi at the initial stage of fruiting which can be useful in deciding the required orchard practices to be executed.

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