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Evaluation of arabica coffee cultivars under Pulney hill conditions of Tamil Nadu

Mallikarjun G. Awati*, C.G. Anand and Y. Raghuramulu****

Regional Coffee Research Station, Dindigul, Thandigudi 624 216, Tamil Nadu

ABSTRACT

A study was conducted to assess the vegetative and reproductive growth in field in four arabica coffee cultivars. The data revealed an improvement in production of more number of leaves after receipt of summer showers, which continued up to May-June and thereafter started defoliating. The formation of maximum number of nodes per tertiary branch was noticed at the initial stage of fruit ripening during October in Chandragiri (43.22%) followed by Sln.5B (43.03%), Sln.9 (35.77%) and Sln.7.3 (30.42%). Among the cultivars, Chandragiri produced highest cropping node/ branch of 8.35 Nos., flower buds/ branch of 90.24 Nos. and fruit set of 95.09% compared to other cultivars. However, production of flower buds/cropping node was more in Sln.5B (11.59) on par with Chandragiri (11.03) followed by Sln.9 (10.39) and Sln.7.3 (8.09). The average of four season's recorded data on total fruit drop was 28.95, 31.74, 39.47 and 42.73 per cent in Chandragiri, Sln.\5B, Sln.\7.3 and Sln.\9, respectively. Assessment of fruit drop at monthly interval indicated maximum fruit drop during June-July in Sln.\5B, Sln.\9 and Chandragiri and in July-August in Sln.\7.3. Chandragiri (semi-dwarf) and Sln.5B (tall) arabica cultivars were found better physiological efficient genotypes for Pulney hill region of Tamil Nadu.

Keywords: Arabica coffee, vegetative growth, reproductive growth, fruit set, pre-mature fruit drop.

INTRODUCTION

Arabica and robusta coffee are important commercially cultivated species and arabica is cultivated at higher elevations, robusta at lower elevations and mainly confined to southern states of India. Besides elevation and temperature, the coffee growth is influenced by rainfall, relative humidity, soil conditions and shade pattern (Anand *et al.*, 2; Anon, 3; Barros *et al.*, 7; Ramaiah and Venkataramanan, 16). Coffee being a perennial crop, its pattern of vegetative and reproductive growth and development is controlled by a combination of physiological and environmental factors. The yearly production pattern of fruits and seeds in coffee is also depends upon the extent of variability in seasonal, genetic as well as physiological factors prevailing during floral bud formation and their development, flowering, fruit set and their retention. The carbohydrate reserve status has a vital role in flower bud formation, successful fruit set and berry growth and development and growth of new shoots besides maintenance of plant vigour. In general, the floral buds starts initiating from August-September, continue till December-January. Initiated floral buds grow slowly and after attaining a size of 7 to 8 mm, they stops further growing and remains at stagnated stage. Flower bud enlargement and anthesis occurs within next 8 to 10 days on receipt of blossom shower (rainfall or irrigation) and further for fruit-set and berry growth and development, backing shower (rainfall/ irrigation) is necessary. Hence, for better prospects of coffee in a given year is dependent on good blossom shower in March/ April and a backing shower (rainfall/ irrigation) within 15 to 30 days after blossom is important for fruit set and further berry growth and development. Normally, 80 to 85% fruit set occur in arabica coffee and failure of fruit set to an extent of 15 to 20% is mainly due to floral abnormalities, non-fertilization, failure in dehiscence of anthers, misty-cloudy weather and heavy showers on the day of blossom (Venkataramanan *et al.*, 25; Anand *et al.*, 2; Anon, 3).

Fruit drop occurs at greater extent during berry development before maturity and fruit drop is absent in coffee at the time maturity and referred to pre-mature fruit drop. The severity of pre-mature fruit drop depends upon internal factors such as depletion of carbohydrate at reproductive phase and competition among the berries for their growth and development and imbalance in auxin/ carbohydrate as well as environmental factors such as excessive wetness and water logging conditions. Pre-mature fruit drop ranges from 10 to 50% under south Indian conditions and maximum drop occurs between 90 to 120 days after fruit set and is pronounced during June-July at peak of south-west monsoon, because of soil saturation leading to less uptake of nutrients, auxin/

*Present address of corresponding author: Dept. of Biotechnology and Crop Improvement, College of Horticulture, Udyanagiri, UHS, Bagalkot 587 104, Karnataka; E-mail: mgawati@rediffmail.com

**Central Coffee Research Institute, Coffee Research Station, Chikmagalur 577 117, Karnataka

carbohydrate imbalance and poor aeration in the root zone (Ramaiah and Venkataramanan, 16; Anand and Prathima, 1; Anon, 3; Kumar and Tieszen, 13; Cannell, 8); defoliation along with fruit drop at greater extent in arabica coffee (Sadananda, 18; Anand *et al*., 2) as well as hormonal imbalance with increase in ABA content and reduction in cytokinin level at continuous heavy rainfall (Awati *et al*., 5). The fruit load also showed large impact on dry matter production and partitioning in apple (Palmer, 15) and peach (Genard *et al*., 9).

High fruit load decreases shoot growth and results in strong alternate bearing and production patterns in coffee. At high fruit loads, there is competition for carbohydrates among berries that strongly affects coffee bean size, biochemical composition and beverage quality (Vaast *et al*., 23). Wormer and Ebagole (26) and Cannell (8) have shown the association of these phenomena with the high carbohydrate demand of berries and the depletion of reserves, notably starch in storage organs like branch, stem and thick roots. Keeping above points in view and the varied rainfall pattern in Pulney hills of Tamil Nadu, this study was carried out to assess the physiological efficiency of four different arabica cultivars and find out better cultivars for North-East monsoon experiencing areas.

MATERIALS AND METHODS

A field trial was conducted for four seasons from 2008-09 to 2011-12 at Regional Coffee Research Station, Thandigudi located in the Pulney hills, Tamil Nadu. The pattern of total rainfall and rainy days of four seasons are presented in Fig. 1&2. The experiment was conducted in four arabica cultivars, *viz*. Sln.\5B and Sln.9 (talls), Sln.7.3 (dwarf) and Chandragiri (semi-dwarf). The age of Sln.\5B and Sln.\9, Sln.\7.3 cultivars were about 25 to 27 years and about 12 years of Chandragiri. These cultivars were grown at an altitude ranging from 1,250 to 1,300 m from above msl with maintenance of optimum filtered natural shade and following standard package of practices. The observations recorded were on morphological and yield parameters such as number of leaves, flower buds, cropping nodes and berries per tertiary branch at monthly intervals for four seasons from 63 plants per cultivar in each season. In each cultivar, nine plants (4-tertiary branch/ plant) were considered as one replication and each replication was repeated for seven times. The plants and branches tagged for observations were different for each season in each cultivar and initial flower numbers were recorded at candle stage (after receipt of blossom showers and before flower opening); fruit-set after 40 days of blossom and the fruit retention continued till the fruit maturity.

The preliminary data were used to compute the per cent fruit set branch^{-1} (No. of berries branch^{-1} ÷ No. of flower buds branch^{-1}) × 100); monthly interval of fruit drop ((Initial No. of berries branch^{-1} - first month No. of berries branch^{-1} ÷ Initial No. of berries branch^{-1}) × 100); (Second month No. of berries branch^{-1} - first month No. of berries branch^{-1} ÷ Initial No. of berries branch^{-1}) × 100); accordingly recorded in subsequent months; total fruit drop (total of individual month's per cent fruit drop) and fruit retention [(Final No. of fruits branch^{-1} ÷ Initial No. of berries branch^{-1}) × 100] in all cultivars. The meteorological and rainfall data were collected at monthly intervals for 2008-09

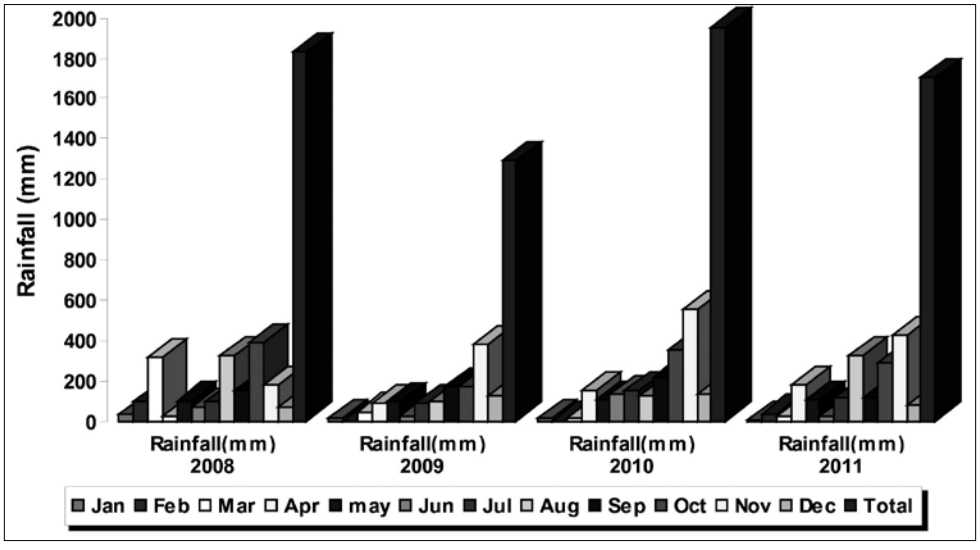

Fig. 1. Rainfall pattern at RCRS, Thandigudi, Pulney hills, Tamil Nadu.

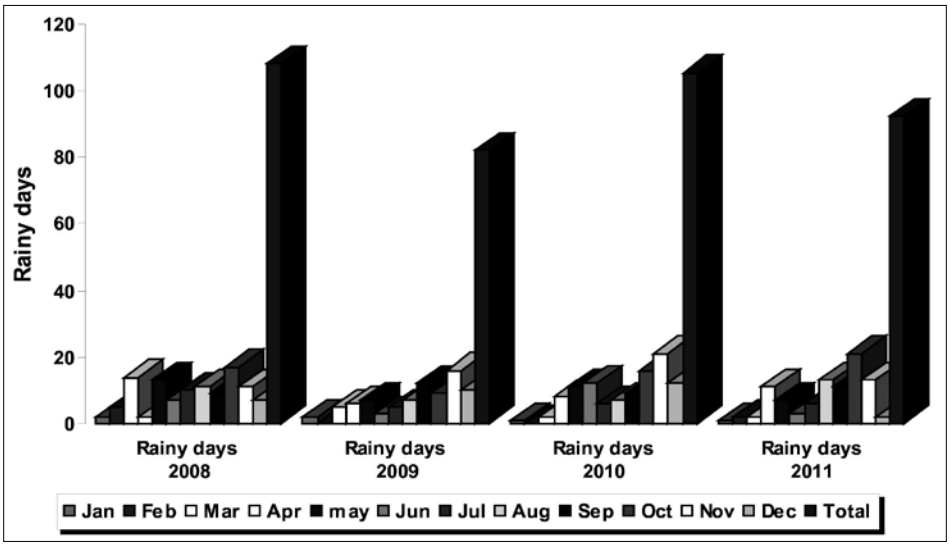

Fig. 2. Number of rainy days at RCRS, Thandigudi, Pulney hills.

to 2011-12. The data were subjected to statistical analysis adopting Randomized Block Design (RBD) specified by Sundararaj *et al.* (20).

RESULTS AND DISCUSSION

The rainfall distribution at Regional Coffee Research Station (RCRS) in North-East monsoon in Pulney hills prevailed during experimental period revealed variation between the years considerably (Fig. 1&2). The morphological and yield component data revealed maximum production of leaves after receipt of blossom showers and sustained up to May-June and there after started defoliating. The extent of defoliation at the initiation of fruit ripening during October month varied from 15.95 to 26.84%. High defoliation at commencement of fruit ripening and harvest could be due to strong sink effect of fruits coupled with production of senescence hormone (Fig. 3). However, significantly higher leaf production was recorded in Chandragiri followed by Sln.5B, Sln.9 and Sln.7.3 (Table 1). Vasudeva and Ramaiah (24); Barros *et. al.* (7); and Anand and Prathima (1) also pointed that a rapid vegetative growth occurs during mid March to the end of May or early June on receipt of first rains; this growth falls off by the end of May, and ceased earlier in the years of heavy crop.

The improvement observed on growth of leaves along with higher total nodes and cropping nodes per branch in Chandragiri followed by Sln.7.3, Sln.9 and Sln.5B. The increase in total nodes started after blossom showers up to October in all cultivars. The maximum increase in nodes was 43.22, 43.03,

Table 1. Number of leaves, nodes, cropping nodes, flower buds, per cent fruit set, fruit drop and fruit retention in coffee cultivars.

Cultivar	Leaves/ tertiary branch	Total nodes/ tertiary branch	Cropping nodes/ tertiary branch	Flower buds/ tertiary branch	Flower buds/ cropping node	Fruit set (%)	Fruit drop (%)	Fruit retention (%)
Sln.5B	14.37^{a}	12.80^{c}	6.96^{c}	81.73^{b}	11.59^{a}	88.97^{b}	31.74^{b}	68.14^{a}
Sln.9	13.74^{a}	13.40^{b}	7.25^{bc}	75.73^{b}	10.39^{b}	94.01^{a}	42.73^{a}	56.76^{b}
Chandragiri	14.24^{a}	14.95^{a}	8.35^{a}	90.24^{a}	11.03^{a}	95.09^{a}	28.95^{b}	70.76^{a}
Sln.7.3	12.54^{b}	13.40^{b}	7.55^{b}	61.80^{c}	8.09^{c}	89.79^{b}	39.47^{a}	60.42^{b}
Mean	13.72	13.64	7.53	77.38	10.28	91.97	35.72	64.02
F-test	*	*	*	*	*	*	*	*
CD at 5%	1.025	0.507	0.377	6.77	0.598	1.612	4.423	4.438

Each value is the mean of seven replications. In a column, means followed by the same letter(s) are not significantly different as per DMRT (p = 0.05). *Significant at 5% level, **Significant at 1% level, ^{NS}Non-significant

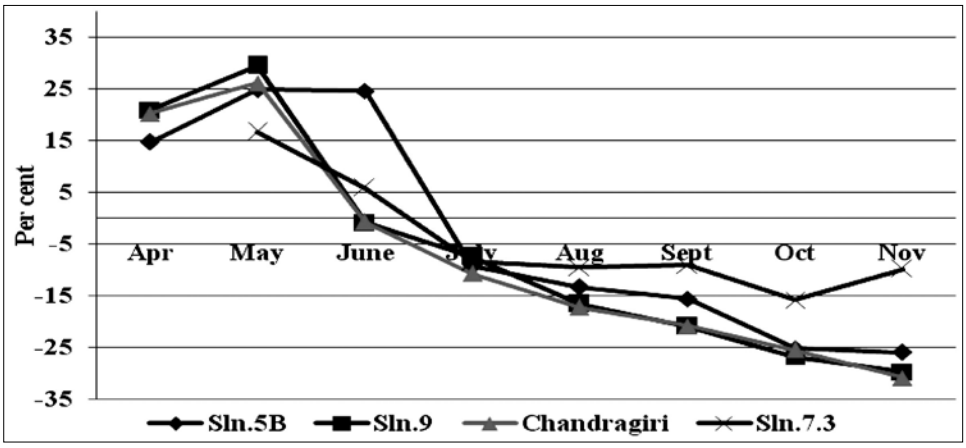

Fig. 3. Pattern of defoliation in coffee cultivars (mean of 4 seasons).

35.77 and 30.42 per cent on Chandragiri, Sln.5B, Sln.9 and Sln.7.3, respectively (Fig. 4). The four season's data indicated maximum production of cropping node of 8.35 and flower bud of 90.24 per branch was in Chandragiri. Highest formation of flower buds/ cropping node was in Sln.5B (11.59), Chandragiri (11.03), Sln.9 (10.39) and least in Sln.7.3 (8.09) (Table 1). Similarly, highest total flower buds formation per tertiary branch was in Chandragiri, Sln.5B, Sln.9 and Sln.7.3. A significant difference in production of flower buds with maximum fruit set and fruits retention at harvest with lowest fruit drop was in Chandragiri and Sln.\5B than Sln.\9 and Sln.\7.3 (Table 1). The difference in vegetative growth, flower bud initiation, fruit set and final fruit retention could have been mainly due to maintenance of carbohydrate reserve status, plant vigour, photosynthetic efficiency, biomass partitioning efficiency and external factors. The carbohydrate reserves play a vital role in flower bud formation, successful fruit set and development and growth of new shoots (Vasudeva and Ramaiah, 24; Rizwan *et al.*, 17).

The fruit set in coffee varies from year to year in the same locality on account of variation in weather prevailed at particular year. In the present study, variation of fruit set ranged between 88.97 to 95.09% with final fruit retention of 56.76 to 70.76% in all cultivars. Among the four cultivars, Chandragiri showed the highest fruit set of 95.09% and final fruit retention of 70.76% with minimum fruit drop of 28.95% than rest of the cultivars (Table 1). Maximum flower bud production, fruit set and final fruit retention in Chandragiri might be due to its prime yielding age as it was 12-year-old; whereas other cultivars were of about 25 to 27 years. Thimma Reddy and Srinivasan (22) explained about detrimental effects of irregular weather conditions and coffee plant's physiological efficiency and variability in flower bud production fruit

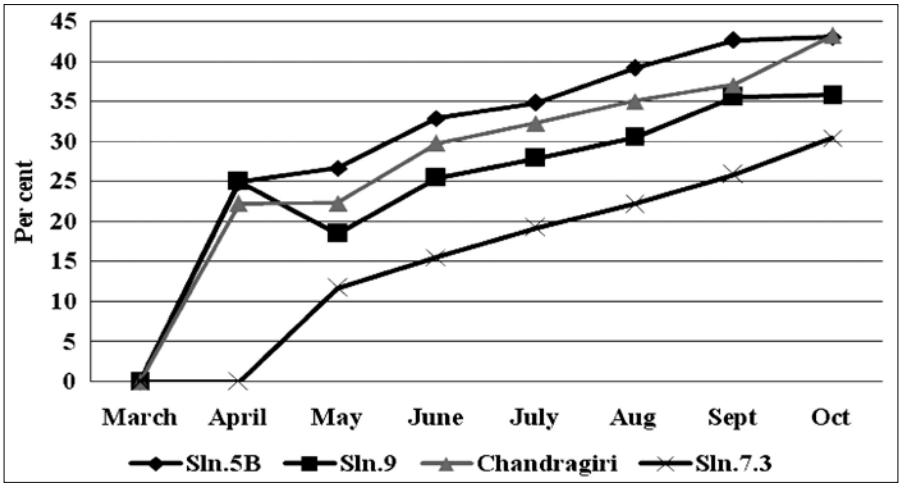

Fig. 4. Per cent increase in total nodes/ tertiary branch in coffee cultivars (mean of 4 seasons).

set, fruit drop and final retention. Generally, the fruit set in coffee under South-West monsoon is about 85% but final retention remains only 40 to 45% at maturity (Anon, 3; Anand *et al.*, 2). Often the final fruit yield goes down to 25 to 35% (Gopal, 12).

The fruit drop occurs, in general, before maturity during the berry development stage under South-West monsoon conditions of India as the fruit drop at maturity in coffee is absent. Similarly, month-wise variation in fruit drop under North-East monsoon area indicated highest drop in June-July month. Higher fruit drop in Sln.9 and Chandragiri was during June, whereas in Sln.5B and Sln.7.3, the maximum fruit drop was in July (Fig. 5) but total fruit drop varied between the years (Fig. 6). The variation in extent of fruit drop depends on internal factors such as carbohydrate depletion, auxin to carbohydrate imbalance as well as environmental factors. Hence, high berry drop during June-July at adverse edaphic and environmental conditions might be leading to competition for carbohydrates among the berries resulting short supply of food reserve, which coincides with rapid berry growth in arabica coffee (Ramaiah and Venkataramanan, 16; Anand and Prathima, 1; Anon, 3; Vaast *et al*., 23); defoliation along with greater extent of fruit drop in arabica coffee (Sadananda, 18; Anand *et al*., 2) as well as hormonal imbalance with increase in ABA content and reduction in cytokinin level at continuous heavy rainfall (Awati *et al*., 5) and (Kumar and Tieszen, 13; Cannell, 8). Similarly, various stresses leading to cause increase in abscisic acid and ethylene levels in plant associated with fruit drop (Bangerth, 6). The fruit drop in other crops on account of various factors also has been noticed by different researchers such nutritional imbalance and physiological factors in mandarin citrus (Asraf *et al*., 4; Saleem *et al.*, 19; Gonzalez-Carranza *et al*., 11); competition between large number of small fruits

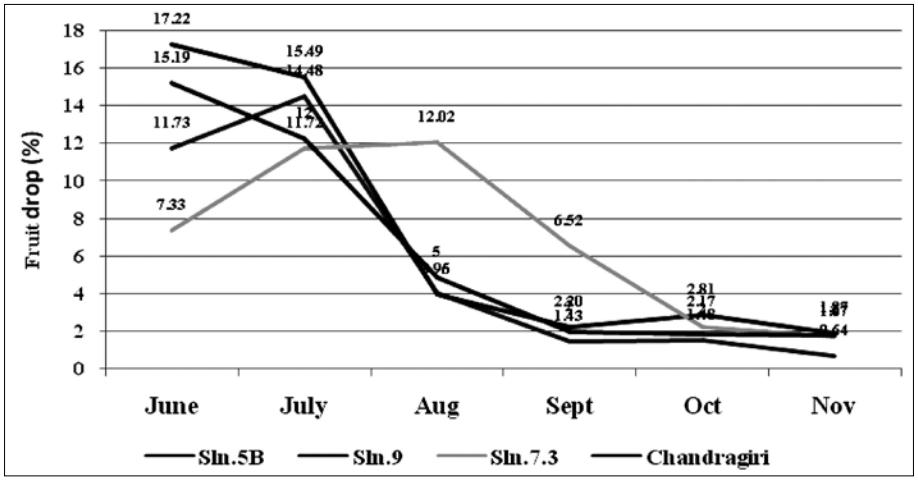

Fig. 5. Pattern of fruit drop in coffee cultivars under North-East monsoon conditions (mean of 4 seasons).

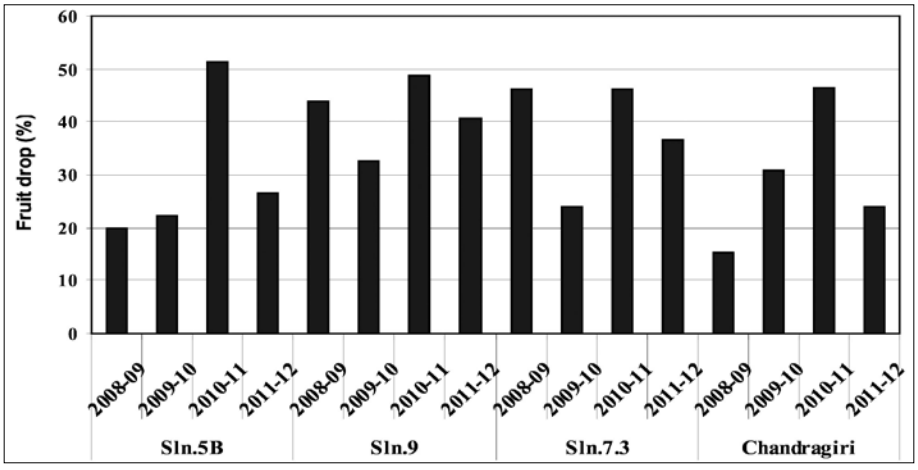

Fig. 6. Seasonal variation of total fruit drop in coffee cultivars.

initially formed and some incompletely unfertilized ovules in mango (Thimmappaiah and Suman, 21); insufficient carbohydrates, auxin content and other physiological factors in apple (Leopold, 14; Palmer, 15); hormonal imbalance in citrus by Gomez *et al.* (10) and fruit load has a big effect on dry matter production and partitioning of peach (Genard *et al.*, 9).

Under South-West monsoon conditions the berry drop ranges from 10 to 50% and maximum fruit drop occurs between 90 to 120 days after fruit set and is pronounced during the months of June-July because of soil saturation leading to less uptake of nutrients, auxin to carbohydrate imbalance and poor aeration in the root zone under South-West monsoon conditions (Ramaiah and Venkataramanan, 16; Anand *et al.*, 2; Anon, 3). The average of four season's data on per cent fruit drop from fruit set to final retention revealed that a total drop of 28.95, 31.74, 39.47 and 42.73% were recorded in Chandragiri, Sln.\5B, Sln.\7.3 and Sln.9, respectively (Table 1). The fruit drop under South-West monsoon conditions of South India occurs between 90 to 120 days after fruit set, however, under North-East monsoon conditions, the fruit drop extend to nearly 90-150 days after fruit set. Thus, it was observed that the initial fruit set to the final fruit retention might be controlled mainly by fruit drop in coffee. In general, high fruit load decreases the shoot growth and results in strong alternate bearing and production patterns in coffee.

In conclusion, it was found that there was maximum production of vegetative parameters, *viz.* leaves, total nodes, cropping nodes, flower buds, fruit-set, fruit retention with less fruit drop in Chandragiri and Sln.5B compared to Sln.9 and Sln.7.3 cultivars. The maximum fruit drop in June-July month under environmental conditions of North-East monsoon in Pulney hills region could be due to competition for carbohydrates reserves among the berries combined with vegetative growth and immobilization of nutrients. Hence, the physiological performance of semi-dwarf Chandragiri and tall Sln.5B arabica was found to be better for cultivation in the region.

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