Journal of Crop and Weed, 15(2): 58-64 (2019) ISSN- O : 2349 9400 ; P : 0974 6315

http://cwssbckv.org
www.cropandweed.com

Studies on planting geometry and pruning methods for improving productivity and reduce labour drudgery in Arabica coffee cv. Chandragiri

N. GOKAVI, D. S. MUKHARIB, K. MOTE, A. N. MANJUNATHA AND Y. RAGHURAMULU

Central Coffee Research Institute
Coffee Research Station Post - 577 117, Chikmagaluru District, Karnataka

Received : 14.02.2019 ; Revised : 11.06.2019 ; Accepted : 15.06.2019

ABSTRACT

A field experiments was initiated to standardize suitable planting designs and pruning methods to get sustainable yield in Arabica coffee at Central Coffee Research Institute, Coffee Research Station, Balehonnur, Karnataka during the year 2006-07. Bush management practices such as pruning and handling, centering and desuckering had shown positive effect over last three years. Results from the pooled data showed that, among the different pruning treatments, treatment T_4 (Square system at close spacing (5'x5') + training on multiple stem without topping + cyclic pruning after each harvest (1742 plants/acr.) took less number of man days (26) to carry out bush management operations per hectare unit area compared to control (63 man days per hectare). Data also indicated that, about 32 to 59 per cent of labour saving could achieve by adopting modified pruning methods over the traditional pruning method on pooled data basis. Significantly higher clean coffee yield per hectare (2195 kg ha^{-1}) was recorded in T_3 (Square system of planting (6'x 6' Quincunx) + training on single stem + multiple stem on middle plant) on pooled basis. Coffee is a labour intensive crop and pruning is a skilled process. Hence, modified pruning methods such as cyclic and rock-n-roll pruning could be a option for overcoming the labour scarcity and reduce the labour drudgery in coffee plantation as these systems facilitates easy and no skilled involved in pruning operations. Adaption of high density planting system such as Square system of planting (6'x 6' Quincunx) + training on single stem + multiple stem on middle plant) could helps to achieve significantly higher clean coffee yield per hectare.

Keywords **:** Arabica coffee, cyclic pruning, labour drudgery, planting geometry, rock-n-roll pruning and clean coffee yield.

Coffee (*Coffea arabica*) is the one of the most important traded commodities in the world after petroleum products. A native to the tropical rain forests of Ethiopia and Central Africa, this stimulating beverage crop was introduced into India during 1600 ad from Yemen and planted in the high hills in Chikmagalur district of Karnataka. However, it was only during 18th century that the British entrepreneurs established commercial coffee plantations in south India. Arabica is a small tree, a shrub or even a bush when properly trained and pruned. Pruning is an important operation in coffee which is essentially a thinning process of branches in order to balance the vegetative and reproductive wood as the crop is produced on second year wood in coffee. Regular pruning facilitates the removal of old unproductive, criss-cross, lean, lanky and whippy wood, diseased and damaged branches and branches going toward main stem, for encouraging the growth of new branches that would become subsequent years cropping wood. Further, pruning permits entry of sunlight and air to bushes, thereby minimizing the pest/disease incidence and improving efficiency of spraying, swabbing, harvesting (Hand Book of Horticulture, 2012). Canopy architecture may also indirectly minimize the build-up of pests and diseases (Basu, 2014 and Boorah, *et al.*, 2016).

A different density of planting has been used in coffee plantations in order to increase yield. Several studies (Braccini *et al*., 2005 and Pereira *et al*., 2007) have shown that greater yields per unit area are achieved due to the increase in the number of plants per unit area. Under reduced spacing conditions, plants produce thinner stems and smaller canopy diameters when compared to plants grown on a wider spacing (Martinez *et al*., 2007 and Boorah *et al.*, 2016). Recently, modified pruning methods (multiple stem system) such as cyclic and rock-n-roll pruning are practiced by few innovative planters (Raghuramulu, 2009 and Biradar *et al.,* 2012). The multiple stem system is generally practiced for coffee plants in open conditions, as in some countries of Africa, Latin and South America. In this type of bush training, multiple or more than one stem is allowed. Generally the plants trained on multiple stems are left untopped and pruning in such case usually restricted to stumping of multiple stems in a cycle of three or four years either by cyclic pruning or Rock-n-roll pruning. Since, pruning is being practiced in India is a labour intensive and skilled process so as to minimize the labour requirement and to increase the labour use efficiency for carrying out simple and easy pruning operations like, multiple system is yet to be standardized. Hence, this study was initiated to assess the influence of planting geometry and pruning methods on labour requirement and yield performance of *Coffea arabica.*

Email : sanvinagaraj17@gmail.com

MATERIALS AND METHODS

A long term field experiment was initiated to standardize the suitable planting designs and pruning methods to get sustainable yield and reduce labour requirement per unit area to carry out easy and simple pruning operations in Arabica coffee at Central Coffee Research Institute, Coffee Research Station, Balehonnur, Karnataka during the year 2006-07. In this experiment Arabica coffee cv. Chandragiri was used and laid out in randomized complete block design (RCBD) with 7 treatments and 3 replications. The treatment details are as follows-

T_1 Square system of planting (62 ×62) + training on single stem + regular light pruning (Control) (1210 plants acre^{-1})

T_2 Square system at close spacing (52 ×52) + training on single stem + Rock-n-roll pruning of alternate rows once 3-4 crops (1742 plants acre^{-1})

T_3 Square system of planting (62 ×62 Quincunx) + training on single stem + multiple stem on middle plant (2652 plants acre^{-1})

T_4 Square system at close spacing (52 ×52) + training on multiple stem without topping + cyclic pruning after each harvest (1742 plants acre^{-1})

T_5 Hedge row system on single stem (62 ×32) + Rock-n-roll pruning of alternate rows (2420 plants acre^{-1})

T_6 Hedge row system on multiple stem without topping (62 ×32) + Cyclic pruning after each harvest (2420 plants acre^{-1})

T_7 Paired row system 62 ×32 ×72 for tall Arabica + single stem training + Rock-n-roll pruning alternate rows (1452 plants acre^{-1})

The experimental plot was established during the year 2006-07 with four different levels of spacing (Square system, hedge row system, quincunx system and paired row system of planting) and treatment imposition was carried out for three year old plantation with three different pruning levels (light pruning, cyclic pruning and rock-n-roll pruning) as per the treatments. The brief information regarding different pruning treatments and their method of imposition are discussed below,

Traditional pruning (Planters practice)

It is a thinning process of branches which involves the removal of old unproductive, criss-cross, lean, lanky and whippy wood, diseased and damaged branches and branches going towards main stem, for encouraging the growth of new branches that would become subsequent years cropping wood. Light Pruning is recommended after harvesting and continued till the onset of monsoon. When dry conditions prevail, it is better to commence the pruning after few summer showers.

Modified plant wise pruning method

It is practiced after establishing the 1st tier by topping the main stem at about 0.3 m height. After topping one sucker is allowed from topping wood during 1st year, 2nd new sucker will be allowed to grow in the 2nd year and 3rd sucker in the 3rd year as shown in the figure 1. Similarly, 1st sucker will be removed during 4th year by allowing one new sucker, 2nd sucker in the 5th year and 3rd sucker in 6th year. Every removed sucker will be substituted by one new sucker. Like this pruning will be practiced in cyclic manner after the harvest of the crop (Fig. 1).

Modified row wise pruning method

It is practiced after establishing the 1st tier by topping the main stem at a height of about 0.3 m. Subsequently, during the 1st year, 2 to 3 suckers are allowed to grow in the 1st, 4th, 7th rows etc., during the 2nd year 2nd, 5th, 8th row etc., and during the 3rd year 3rd, 6th, 9th row etc. during the 4th year all suckers in the 1st, 4th, 7th rows *etc*., will be pruned and replaced with new suckers. The cycle will be continued in the subsequent years (Fig. 2).

Handling

Handling is a thinning process carried out after the main pruning, in one or two rounds in a year, depending upon the growth habit of the plants. The handling operation is suggested mainly to thin out the new flush to a desired level. During this process, the criss-cross, inward growing branches (towards main stem) and semi-erect growing (gormandizers) should be removed irrespective of their vigor.

Centering

At the time of handling, all the new flush arising within 10 to 15 cm radius of the main stem should be removed. This operation is called 'centering', which helps in penetration of light and aeration to the lower branches of the coffee bushes.

Desuckering

It is done periodically by removing all suckers on the main stem from time to time.

Observations on growth parameters, yield and yield attributing parameters, quality parameters and labour requirement per unit area were recorded as per the treatments. The data were subjected to statistical analysis as per the method of Gomez and Gomez (1984). Other cultural operations like fertilization, weed management and plant protection measures were practiced as per the recommendations of Coffee Guide (2014).

RESULTS AND DISCUSSION

Bush spread (North-South and East-West)

The results pertaining to plant spread (NS & EW) due to influence of planting geometry and pruning methods on bush spread are illustrated in the figure 3. During the year 2015-16, no significant variation was noticed in plant spread (N-S) due to treatments. The maximum plant spread (N-S) of 198 cm was recorded in T_6 (Hedge row system on multiple stem without topping (62 × 32) + Cyclic pruning after each harvest). While minimum (175 cm) was recorded in T_4 (Square system at close spacing (52 × 52) + training on multiple stem without topping + cyclic pruning after each harvest). The results also had shown no significant variations among the treatments during 2016, 2017 and in pooled data. However, Hedge row system on single stem (62 ×32) + Rock-n-roll pruning of alternate rows (T_5) recorded higher bush spread of 199, 200 and 196 cm, respectively over the years. This could be attributed to the fact that, better utilization resources like solar energy and space in wider spacing could help in increase of plant spread. On other hand, this might be a response to the enhanced light penetration in the canopies favoring the development of vegetative as well as reproductive structures (DaMatta *et al*., 2007). While the minimum bush spread of 174, 175 and 169 cm was recorded during 2016, 2017 and in pooled data, respectively. Bush spread (E-W) did not show influence on different planting geometry and pruning methods. Maximum plant spread of 195, 195, 197 and 196 cm was observed in T_4 (Square system at close spacing (52 × 52) + training on multiple stem without topping + cyclic pruning after each harvest) during 2015, 2016, 2017 and pooled results, respectively. Whereas Paired row system 62 ×32 ×72 for tall Arabica + single stem training + Rock-n-roll pruning alternate rows (T_7) (169 cm) and Square system of planting (62 ×62 Quincunx) + training on single stem + multiple stem on middle plant (T_3) (165, 171 & 172 cm) was recorded minimum plant spread during 2015 and 2016, respectively.

Labour requirement for bush management

The data on labour requirement for bush management operations *viz*; pruning and handling, centering and desuckering as influenced by different planting designs and pruning methods on labour use efficiency for bush management are presented in table 1. Among the different pruning treatments, square system at close spacing (5'x5') + training on multiple stem without topping + cyclic pruning after each harvest (1742 plants/ acr.) took less man days (23, 28, 25 and 26) per hectare unit area during the year 2015, 2016, 2017 and pooled mean, respectively. Whereas control (square system of planting (62 ×62) + training on single stem + regular light pruning (1210 plants acre^{-1}) showed large number of labour requirement 62 (2015), 63 (2016), 65 (2017) and 63 (pooled mean) during all the years of study over the rest of the treatments. Data from the study also indicated that, per cent labour saving had shown promising results due to influence of different planting designs and pruning systems. Highest per cent labour saving was achieved in the treatment T_5 (Hedge row system on single stem (62 ×32) + Rock-n-roll pruning of alternate rows (2420 plants acre^{-1}) which saved 39, 27, 31 and 32 percentage during all the years of the study 2015, 2016, 2017 and pooled data, respectively. Whereas percent labour saving was lowest during 2015 (63), 2016 (56), 2017 (61) and pooled data (59) over rest of the modified pruning methods. However, about 39 to 63, 27 to 56, 31 to 61 and 32 to 59 per cent of labour saving could achieve by adopting modified pruning methods over the traditional pruning method during all the years of study 2015, 2016, 2017 and pooled mean, respectively. There are costs savings associated with pruning systems that can increase grower profitability. Pruning systems reduced the cost associated with pruning by 32% to 59%, depending on the methods of pruning. These results are in the tune of Bates and Morris, (2009).

Percent fruit set and clean coffee yield (kg ha^{-1})

Data from table 2 indicated that different planting geometry and pruning methods had no significant effect on fruit set percentage. Results showed that treatments did not show influence over the years. However the fruit set percentage was recorded highest in T_4 (Square system at close spacing (52 ×52) + training on multiple stem without topping + cyclic pruning after each harvest) (91.75, 94.44 & 87 % during 2015, 2016 & pooled, respectively) and T_7 (Paired row system 62 ×32 ×72 for tall Arabica + single stem training + rock-n-roll pruning alternate rows) (83.56 %) during 2017. While the treatments such as T_6 (74.95 %, 77.30 % and 77 % during 2015, 2016 and pooled, respectively.) and T_1 (70.84 %) in 2017 recorded lowest fruit set percentage. Pruning restores the balance between vegetative and reproductive growth of plant. There by decreases in competition among the flower for nutrient and plant hormone; and increases the auxin content in flowering shoot pruned tree, may be the probable reason of high flower set %. This finding is well supported by Salem *et al.* (2008) and Shaban A.E.A. (2009). It is evident from the above table that planting designs and pruning methods had significant effect on clean coffee yield per hectare over the year. During 2015, 2016 and pooled analysis, significantly highest clean coffee yield per hectare (3627, 2127 and 2195 kg, respectively) was registered in T_3 (Square system of planting (62 ×62 Quincunx) + training

Table 1: Influence of planting designs and pruning methods on labour requirement for bush management in Arabica coffee cv. Chandragiri

Treatments	2015-16		2016-17		2017-18		Pooled	
	Total man days ha^{-1} saving	Percent labour	Total man days ha^{-1} saving	Percent labour	Total man days ha^{-1} saving	Percent labour	Total man days ha^{-1} saving	Percent labour
T_1: Square system of planting (62 ×62) + training on single stem + regular light pruning (Control) (1210 plants $acre^{-1}$)	62	-	63	-	65	-	63	-
T_2: Square system at close spacing (52 ×52) + training on single stem + Rock-n-roll pruning of alternate rows once 3-4 crops (1742 plants $acre^{-1}$)	28	56	33	47	31	51	31	51
T_3: Square system of planting (62 ×62 Quincunx) + training on single stem + multiple stem on middle plant (2652 plants $acre^{-1}$)	142	-128	136	-115	148	-129	142	-124
T_4: Square system at close spacing (52 ×52) + training on multiple stem without topping + cyclic pruning after each harvest (1742 plants $acre^{-1}$)	23	63	28	56	25	61	26	59
T_5: Hedge row system on single stem (62 ×32) + Rock-n-roll pruning of alternate rows (2420 plants $acre^{-1}$)	38	39	46	27	45	31	43	32
T_6: Hedge row system on multiple stem without topping (62 ×32) + Cyclic pruning after each harvest (2420 plants $acre^{-1}$)	34	46	35	44	35	46	35	45
T_7: Paired row system (32 x62 x72 for tall Arabica and 32 ×52 × 62 for semi dwarf Arabica) + single stem training + Rock-n-roll pruning (1452 plants $acre^{-1}$)	25	60	31	51	27	58	27	57

Table 2: Influence of planting geometry and pruning methods on per cent fruit set and clean coffee yield of Arabica coffee cv. Chandragiri

Treatments	Fruit set (%)				Clean coffee yield (kg ha^{-1})			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T_1	82.23	84.84	70.84	79	1311	1126	830	1123
T_2	85.45	88.28	80.80	85	1919	1367	1799	1695
T_3	84.35	86.11	79.58	83	3627	2127	933	2195
T_4	91.75	94.44	73.47	87	1514	1476	933	1308
T_5	87.24	89.74	80.86	86	1351	1420	1408	1393
T_6	74.95	77.30	79.47	77	972	1671	922	1188
T_7	85.82	88.25	83.56	86	1948	1988	1366	1767
SEm (±)	**6.25**	**6.28**	**9.56**	**7.36**	**214.60**	**112.83**	**103.41**	**143.61**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**661.00**	**347.66**	**318.65**	**442.44**

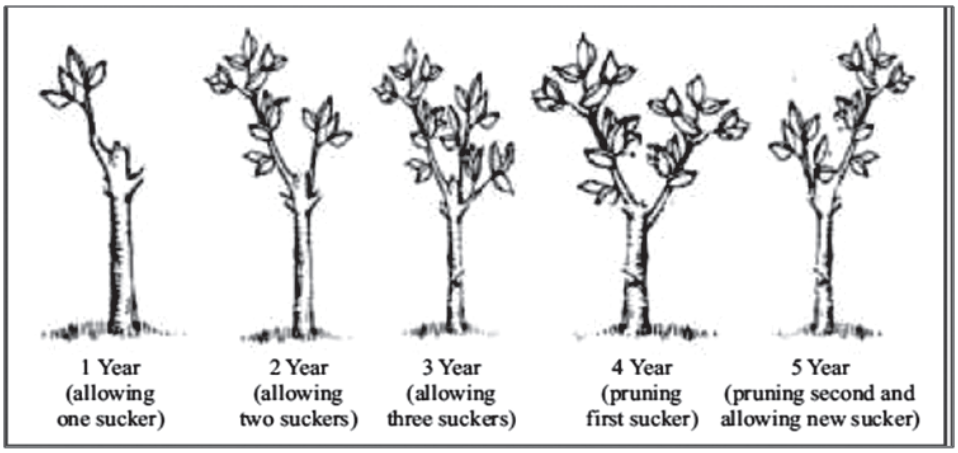

Fig. 1: Cyclic pruning in Arabica coffee cv. Chandragiri

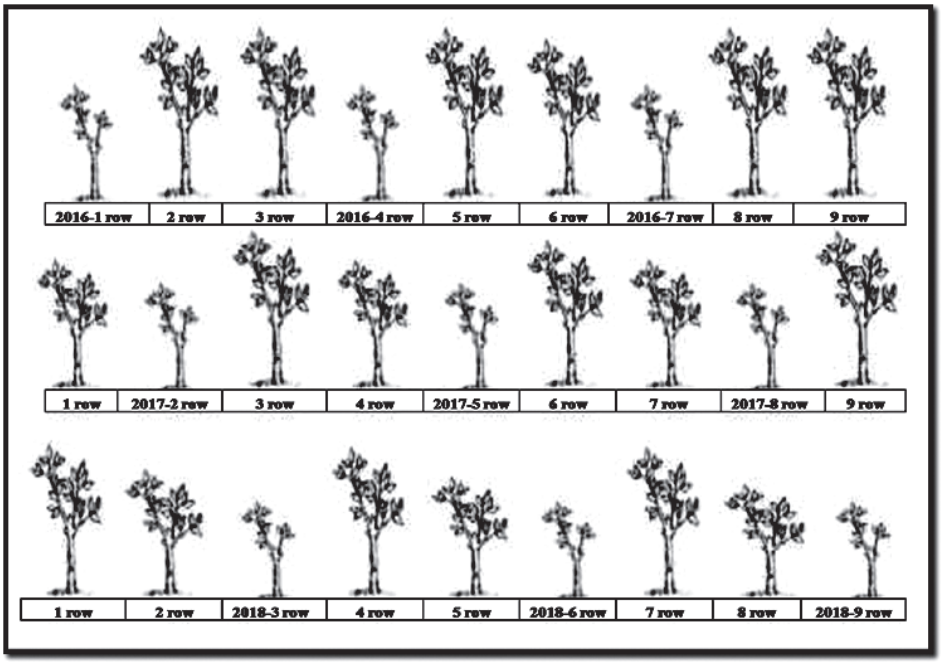

Fig. 2: Rock-n-roll pruning in Arabica coffee cv. Chandragiri

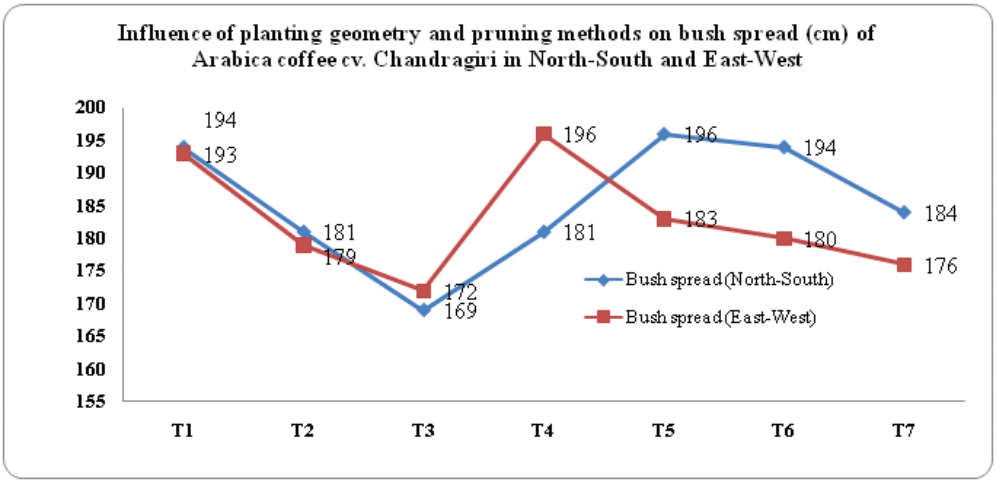

Fig. 3: Influence of planting geometry and pruning methods on bush spread (North-South and East-West) of Arabica coffee cv. Chandragiri

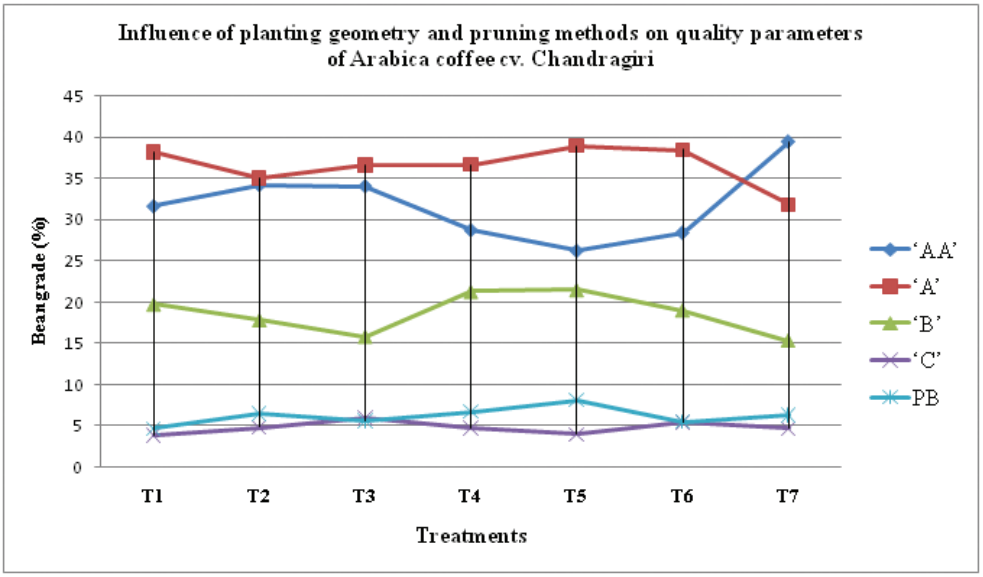

Fig. 4: Influence of planting geometry and pruning methods on quality parameters of Arabica coffee cv. Chandragiri

on single stem + multiple stem on middle plant) and T_2 (1799 kg) Square system at close spacing (5'x5') + training on single stem + Rock-n-roll pruning of alternate rows once 3-4 crops. Increase in yield might be due to higher plant population per unit area and it is more amenable for farm operations as each plant can be reached easily and more utilization of air and sunlight from the natural system. The high density of plants in a unit area helps in assured higher production levels (Dalal *et al.*, 2013; Pratibha and Goswami, 2013; Pandey *et al*., 2015). Whereas the lowest clean coffee yield per hectare (972 and 1126, 830 and 1123 kg) was observed in T_6 during 2015 and $T_{1,}$ during the year 2016, 2017 and pooled results, respectively.

Quality parameters

The results pertaining to quality parameters due to influence of planting geometry and pruning methods are illustrated in fig. 4. Coffee beans grades were did not show influence on different planting geometry and pruning methods. However, higher "AA" (39.42) and "A" (38.9) beans grade observed in Paired row system 62 ×32 ×72 for tall Arabica + single stem training + Rock-n-roll pruning (T_7) and Hedge row system on single stem (6'x3') + Rock-n-roll pruning of alternate rows (T_5), respectively. While the treatments T_5 (Hedge row system on single stem (62 ×32) + Rock-n-roll pruning of alternate rows) and T_6 (Hedge row system on multiple stem without topping (62 ×32) + Cyclic pruning after

each harvest) recorded least bean grade quality of 26.22 % and 31.88 %, respectively. This might be due to the fact that shelf shading of branches results in slower maturation of beans and accumulation of higher carbohydrates due to vertical growth of the stem in modified pruning systems, which leads the beans become bigger and gives highest grade quality. Similarly, more number of fruits in case of unpruned trees resulting in lesser availability of nutrients which lead to smaller sized fruits while more availability of metabolites under the trees pruned lead to increase in fruit size. Similar results with respect to fruit size were also reported by Kumar *et al.* (2002).

Coffee is a labour intensive crop and pruning is a skilled process. Hence, modified pruning methods such as cyclic and rock-n-roll pruning could be an option for overcoming the labour scarcity and reduce labour drudgery in coffee plantation as these systems facilitates easy and no skilled involved in pruning operations. Further, Coffee beans grades were did not show significant influence on different planting geometry and pruning methods. However, higher "AA" and "A" beans grade observed in Paired row system 62 ×32 ×72 for tall Arabica + single stem training + Rock-n-roll pruning and Hedge row system on single stem (62 ×32) + Rock-n-roll pruning of alternate rows.

REFERENCES

Babou, C., Kamalabai, S., Venkatesha M. M., Raghuramulu, Y. and Jayarama 2013. Preliminary experiences with different planting designs and pruning methods in Arabica coffee under Indian conditions. *J. Coffee Res.,* **41**(1&2): 31-39.

Basu, A. 2014. Influence of canopy management practices to reduce the severity of anthracnose disease of grapes. *Bioscan,* **9**(3): 997-1000.

Bates, T. and Morris, J. 2009. Mechanical Cane Pruning and Crop Adjustment Decreases Labor Costs and Maintains Fruit Quality in New York 'Concord' Grape Production, *Hortitechnology,* **9**(2): 247-253.

Biradar, I. B., Kamalabai, S., Venkatesha, M. M., Raghuramulu, Y. and Jayarama. 2012. Mechanization of farm operations in Indian coffee. *Indian Coffee,* **LXXVI** (7): 4.

Braccini, A. L., Scapim, C. A., Vidigal Filho, P. S., Braccini, M. C. L., Borges, S. C. and Albrecht, L. P. 2005. Características agronômicas eprodução de frutos e grãos em resposta ao aumento na densidade populacional do cafeeiro. *Acta Scien.Agron.,* **27**:269-279.

Boorah, R. S., Dhaliwal, H. S. and Aror, N. K. 2016. Crop regulation in guava-A review. *Agric. Rev.,* **37**(1): 1-9.

Coffee Guide. 2014. Central Coffee Research Institute, Coffee Research Station, Government of India, Chikmagalur district, Karnataka, India.

Dalal, R. P. S., Sangwan, A. K., Beniwal, B. S. and Sharma, S. 2013. Effect of planting density on canopy parameter, yield and water use efficiency of Kinnow mandarin. *Indian J. Hort.,* **70**(4): 587-590.

Damatta, F. M, Ronchi, C. P, Maestri, M. and Barros, R. S. 2007. Ecophysiology of coffee growth and production. *Brazilian J. Pl. Physiol*., **19(4)**:485-510.

Gomez, K. A. and Gomez, A. A.1984. *Statistical Procedures for Agricultural Research*. A Wiley Inter Science Publication, John. Wiley and Sons, New York. pp. 680.

Hand book of Horticulture 2012. Indian Council Agricultural Research, IARI, New Delhi.

Kumar, S., Ram, S. N. and Baig, M. J. 2002. Effect of pruning levels on yield and quality of ber (*Zizyphus mauritiana* L.) cultivars. *Range Manag Agroforest.,* **23**(1): 59-62.

Martinez, H. E. P., Augusto, H. S. and Sampaio, N. F. 2007. Crescimento vegetativo de cultivares de café (*Coffea arabica* L.) e sua correlação com a produção em espaçamentos adensados. *Acta Scientiarum Agron.,* **29**: 481-489.

Pandey, S. D., Amrendra Kumar, R. K. Patel, R. R. Rai and Vishalnath, 2015. Influence of planting densities on plant growth, yield and quality of litchi cv. Shahi. *Ecoscan,* **7**: 397-401.

Pereira, S. P., Guimaraes, R. J., Bartholo, G. F., Guimarães, P. T. G. and Alves, J. D. 2007. Crescimento vegetativo e produção de cafeeiros (*Coffea arabica* L.) recepados em duas épocas, conduzidos emespaçamentos crescentes. *Ciência e Agrotecnologia,* **31**: 643-649.

Pratibha Lal, S. and Goswami, A. K. 2013. Effect of pruning and planting systems on growth, flowering, fruiting and yield of guava cv. Sardar. *Indian J. Hort.* **70**(4): 496-500.

Raghuramulu, Y. 2009. Prospectus of mechanization in Indian coffeeplantations. *Indian Coffee*. **LXXIII** (5): 4-10.

Salem, A.T., Hasseb, G.M. and Kamel, H.M. 2008. Effect of pruning severity on vegetative growth, flowering and fruit setting of Balady mandarin trees. *Egypt. J. Appl. Sci.,* **23** : 285-296.

Shaban, A.E.A. and Haseeb, G.M.M. 2009. Effect of pruning severity and spraying some chemical substances on growth and fruiting of guava trees. *American-Eurasian J. Agric. Env. Sci*., **5**(6) : 825-831.