

# PLANTING DESIGN FOR MECHANIZATION OF COFFEE PLANTATIONS IN INDIA

The productivity of coffee farms depends largely on the availability and judicious use of farm facilities and infrastructure by the coffee growers. Agricultural tools and machines enable the farmers to use the farm facilities efficiently including the farm workers judiciously for production purposes. Agricultural machines increase productivity of land and labour by meeting timeliness of farm operations and increase work out-put per unit time. Besides its paramount contribution to the multiple cropping and diversification of agriculture, mechanization also enables effective utilization of available land and inputs such as plant materials, agro inputs, spray solutions, fertilizers and irrigation water.

In India, coffee is grown in slope lands in the hilly tracts under shade trees. Majority of the farm work has been carried out manually, since there has been no suitable machinery. Nowadays, there is a severe shortage of skilled and experienced farm workers. Thus, there is a great need to develop mechanized farming system for coffee cultivation. Use of improved machinery and farm implements to carry out different cultural operations and to increase the productivity of land and labour is the need of the hour in many agricultural crops including coffee. The concept of mechanization is relatively new in Indian coffee cultivation and it still remains primarily as a labour intensive crop.

In some countries like Brazil, USA (Hawaii) and Australia, where coffee is grown in almost flat to gentle sloping lands in open conditions and the coffee cultivation has been mechanized to a great extent to bring down dependence on human labour which is very expensive in these countries. While in other coffee producing countries including India, coffee is essentially grown in hilly, undulating terrain and the operations are carried out mainly by human labour. In India, apart from growing in undulating terrain, coffee is grown under shade trees, which makes it further difficult to mechanize the farm operations.

For the effective maintenance of coffee plantations in India, the annual requirement of labour for undertaking regular cultural operations is about 456 man days per ha in case of Arabica, 266 man days per ha in case of rain-fed Robusta and 326 man days per ha in case of irrigated Robusta coffee. The cost of labour alone constitutes about 60 to 70 percent of the total cultivation costs in case of Arabica and about 55 to 65 percent in the case of Robusta coffee depending on whether irrigated or not.

In recent years, shortage of labourers in coffee plantations is acute due to migration of workers to urban areas in search of better living. The old generation of workers employed on the farms is retiring due to aging and the non availability of young workers, especially skilled workers for carrying out certain critical operations like shade lopping, weeding, tracing of white stem borer affected plants, pruning etc. is affecting the coffee plantations seriously. Thus there is an imperative need to introduce mechanization to the possible extent to

carry out field operations for improving the efficiency and productivity of labour and to reduce the cost of production. The mechanization, though difficult to each one, remains a viable option to overcome the scarcity of labourers in the plantation sector. Coffee Board is evolving long-term strategies and programmes to accelerate mechanization of coffee cultivation in India. One of the critical factors which help to introduce farm mechanization is to develop suitable planting design to suit the smooth operation of machines. The ultimate objective of farm mechanization is to enhance the overall productivity and production without sacrificing the quality.

### **Development of mechanized coffee estates**

Mechanization of a coffee estate does not refer to driving a tractor or large machinery in an estate. It is rather finding the means to carry out the farm operations smoothly and effectively utilizing minimum energy which is economic to the planter and improves the efficiency of the farm worker by reducing the drudgery. Further, mechanization in Brazil cannot be correlated with that in India because in Brazil, there is no shade and fields are located in plain. Indian coffee plantations are different. The various tasks that have to be performed in a coffee estate at different stages are plenty in number like the identification of suitable site for planting, clearing the land by removal of excess trees and bushes, line marking, planting temporary and permanent shade trees in suitable places, pitting and preparing them for planting, planting coffee seedlings etc. Similarly to maintain an estate in good condition the farm operations like soil, weed, shade, bush and nutrient

management have to be attended scrupulously in time. Pest and disease management related activities are also need to be attended meticulously. Use of mechanical technology of various power source, improved farm tools and equipments for timely completion of the various farm operations implies mechanization in coffee farms. The challenge is to ensure gradual mechanization with novel technologies to replace the traditional cultivation practices that have endured for centuries. To ensure efficient use of farm machinery, certain modifications are needed in the existing coffee fields.

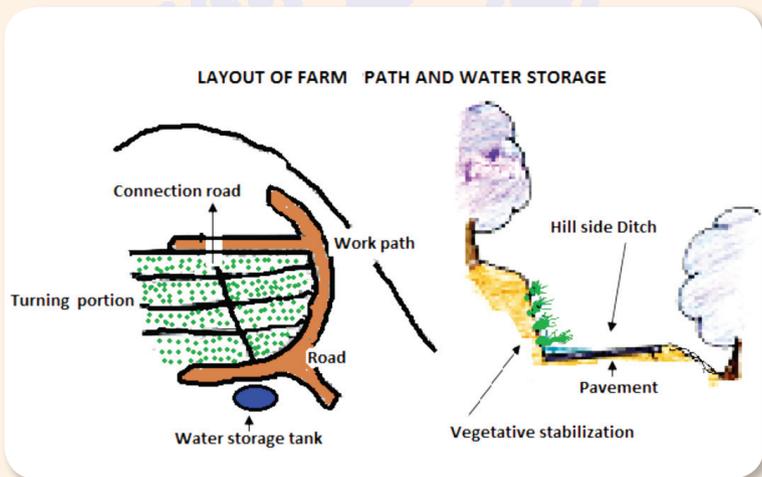
### **Japanese Experiment**

New farm path system developed by the farmers of steep slope-land citrus orchards of Japan seems to be a viable immediate solution for the development of mechanized coffee estates in India. Professor Masahiro Miyazaki of Shikoku of National Agricultural Experiment Station, Japan reports that the mechanization of farm operations had lagged behind in the citrus orchards of Japan due to the steep gradients and high-density planting made the use of machinery difficult, and sometimes even dangerous. In steep slope-lands construction of wide farm roads to facilitate large farm machines is not desirable due to the high cost involved, the danger of land slide and also the reduction in yield due to the removal of plants while constructing the roads and other needed infrastructure.

### **Development of estate pathways**

New estate/farm path system developed in citrus orchards of Japan has three components, namely (i) creation

of farm paths (ii) designing small machines specially for movement in such paths and (iii) mechanization of farm operations like management of weeds, shade regulation, spraying, fertilizer application, pest and disease control etc. The farm paths constructed for the movement of small machines include two kinds of path, a work path which is one meter wide and a connection road with a width of more than 1.3 meter. The connection road is like a back bone and to this back bone, work paths are laterally joined. To make sure that the machines travel safely along the paths, the slope (gradient) of the connection road should be less than 27%. The path should have a turning circle with a diameter of 2 m, where the machine can turn round. Fig.1 is the schematic diagram of the new path system being used by farmers of citrus orchards of Japan. These



**Fig.1. New Farm Path System practiced in steep-slope land citrus orchards of Japan**

(Courtesy Prof. M.Miyazaki, Shikoku National Agricultural Experiment Station, Japan)

farm paths also function as hillside ditches, intercepting run-off water. It is important to lay them to prevent erosion and to allow machines to travel smoothly.

### **Development of Water storage tanks for water conservation**

Normally a water storage tank is constructed at the lower end of the connection road to collect runoff water which runs down the farm paths. The water is used for irrigation or for the preparation of spray solutions. In order to protect the side slope of the work path from soil erosion, the soil surface is stabilized vegetatively. Pelleted grass seeds are planted on the slope and this gives effective protection while the grass grows over the soil surface. This farm path system not only permits the use of small machines, but also improves light conditions in the lower and inner tree canopy and promotes soil conservation in orchards.

### **Relevance of development of path ways in Indian Coffee Estates**

Creation of farm paths and water conservation is very relevant to Indian coffee plantations for taking up mechanization activities as the coffee fields are located in gentle to very steep slope areas and under the canopy of shade trees. The new farm path system development technology with certain modifications can be extended to the Indian coffee plantations where preservation of permanent shade trees is as important as introducing mechanization in plantations. The first and foremost step involved in introducing mechanization of farm operations in

to the coffee estate is creating farm paths for movement of small machines. The farm paths have to be planned through proper land shaping/scaping and based on the slope of the land, contour or terrace farming practiced without more than required damage to the shade trees. The working path is for moving small machines with crawler treads rather than wheels having a very small turning circle and the operator not riding the machine but walking behind the machine. The connecting road interconnects all the working rows thus making it easy to take up continuous farm operations.

Once land terrain is made amenable for movement of small machinery like Mini Tractors or Rubberized Track carriers, a suitable planting design which provides adequate space for the movement of machinery in between the rows should be chosen.

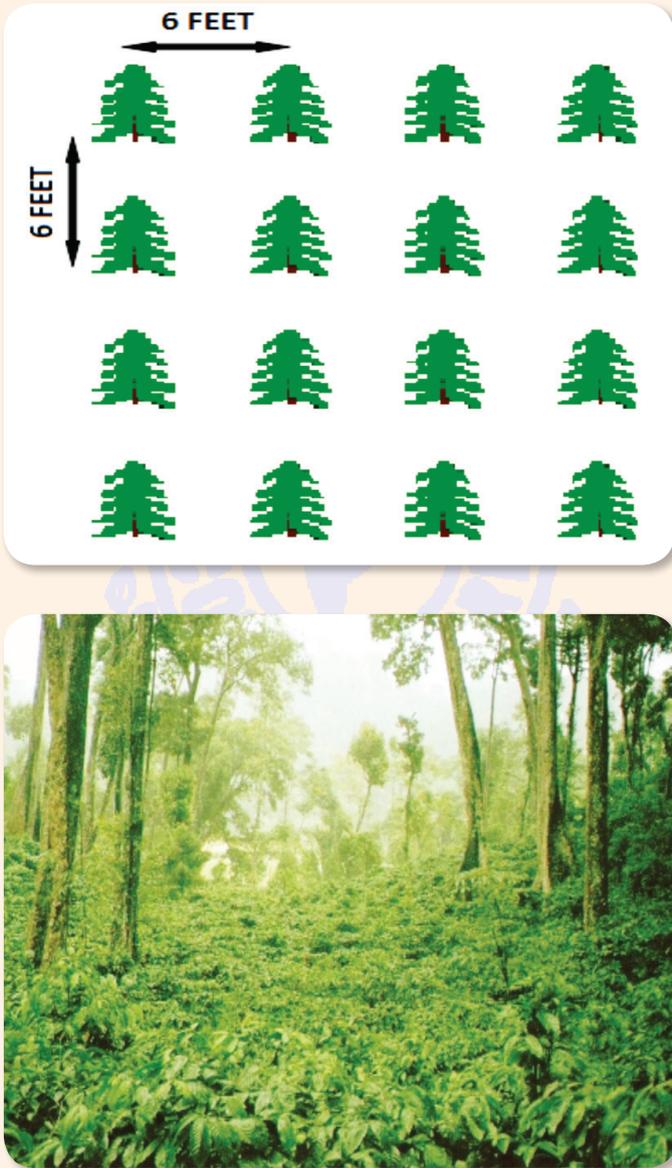
### **Generally adopted planting designs in India:**

Three types of planting designs are generally practiced in Indian coffee plantations, viz., square, hedge row and paired row planting.

#### **Square system:**

Generally square system of planting is found to be ideal in flat to gentle slope areas. The distance between the rows and spacing of plants would depend upon the type of planting material. In general, the recommended optimum spacing for planting the tall Arabica varieties (Sln. 5, Sln. 9, Sln. 795) are 6 x 6 feet or 7 x 6 feet or 7 x 7 feet while that for dwarf Arabica varieties is 5 x 5 feet. The ideal spacing recommended for planting the Robusta variety CXR is 8 x 8 feet and for the other two varieties, viz., S.274, Old

Robusta at 10 x 10 feet; 12 x 12 feet respectively. The square planting design is shown in Fig. 2.

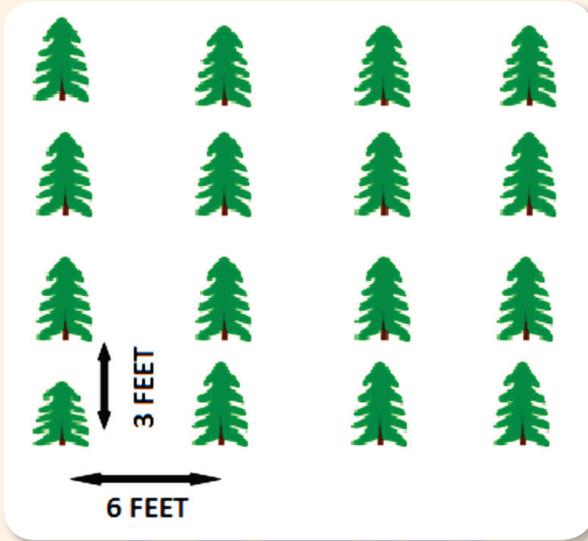


**Fig. 2. Square planting design**

The square planting design accommodates 1742 plants at 5 ft X 5 ft spacing and 1210 plants at 6 ft X 6 ft spacing per acre. Once the plants are established in the field the space between the rows are well covered reducing the accessibility to each plant. Hence this planting design is not a very ideal one for mechanizing the farm operations especially the free movement of the machine.

### **Hedge row planting:**

In hedge row method, the spacing within the row is less than the spacing between the rows, thus making a provision for wider working space between the rows. In Latin American and African countries for Arabica coffee 7 x 3 feet is the most commonly adopted spacing for hedge-rows. The hedge row planting is shown in Fig. 3. In this planting design a plant population of 2420 can be accommodated in one acre area and it is more amenable for mechanization of farm operations as each plant can be reached easily. The high density of plants in a unit area helps in assured higher production levels.

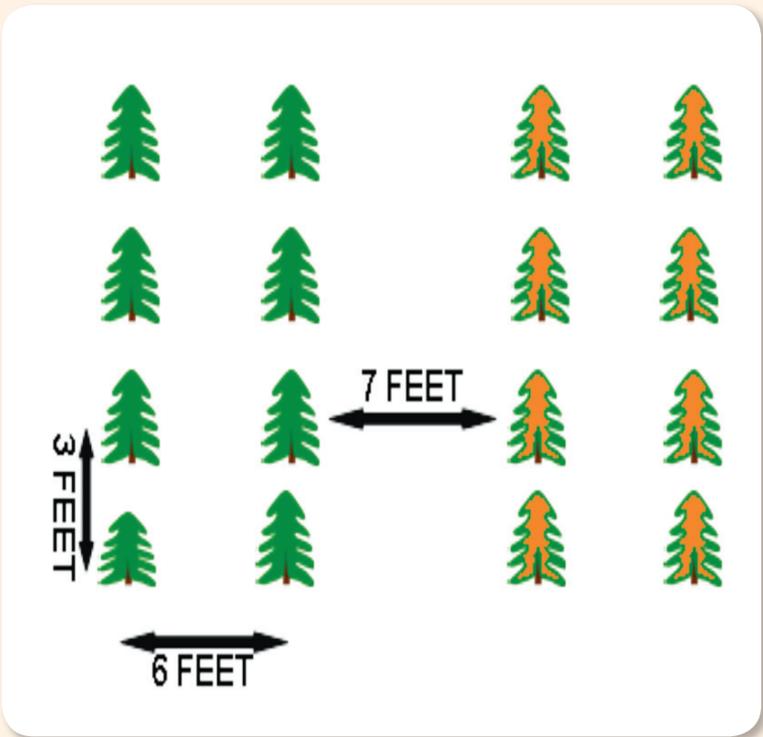


**Fig. 3. Hedge row planting**

**Paired row planting:**

Paired row system of planting is also practiced in coffee. In this planting design, two rows are brought together followed by a wide gap before the next set of two

rows. The spacing between inter rows is 6 feet and between intra rows 3 feet, with 7 feet spacing between next set of two rows (Fig.4). The advantages of this kind of planting design is that wide spacing is available between any two sets of paired rows and that can be utilized for movement of small tractors or rubberized track carriers. This system also permits better light interception by the crop and thus can give higher yields. By adopting this planting design about 2234 number of plants can be grown in one acre.





**Fig.4. Paired row system of planting design**

### **Planting designs based on condition and slope of land for mechanization**

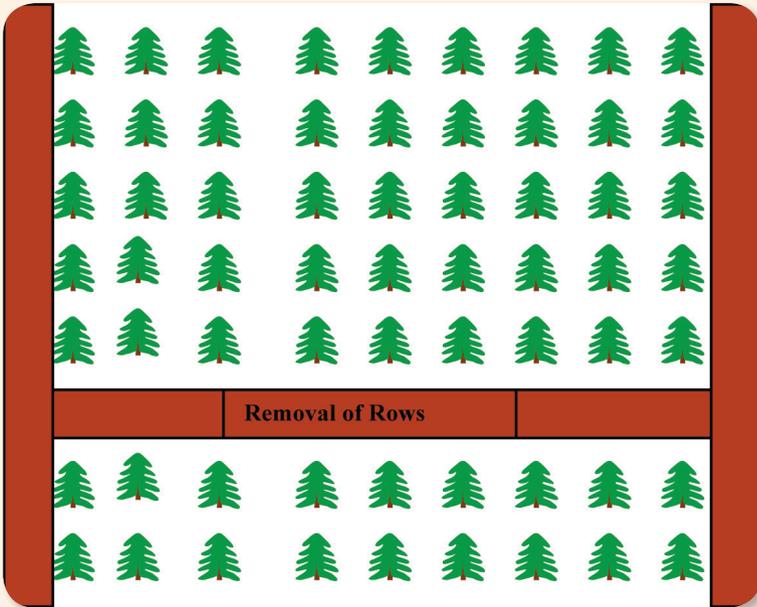
#### **a) In Existing Plantations:**

The present situation of coffee cultivation in undulating terrain under the shade trees at irregular interval coupled with square system of planting is not ideally suited for introduction of many types of machinery that could be driven / moved in between the coffee rows. Only small, handheld type of machinery like weed/ brush cutters, pit diggers, handheld battery operated harvesters could be used under the existing conditions.

It has to be noted that, majority of existing planting design is square planting design in India. The hedge

row and paired row system are recently introduced in the plantations by planters based on the experience of Prof. Miyazaki in citrus orchards where mechanization is introduced either by using mini tractors or walk behind machines. If the existing blocks are to be made amenable for mechanization, it is necessary to create working space, narrow farm paths in between the existing planted rows. These working space or farm paths should be of about 1.5 meter width and formed along the contour lines. While forming the working space, removal of coffee bushes which fall in the row marked for creation of farm path may be required (Fig. 5) Shade trees which are in the way of working row need not be removed; instead, the farm paths can be laid around the shade tree trunks.

The farm paths should be connected with each other at the end of the plot, so as to facilitate turning of small machinery from one working row to another. Once this is done, the Mini Tractors or Rubberized Track carriers can be used for operations like spraying and transportation of inputs or harvested fruits. These newly created farm paths help in improving the accessibility to every plant in the block and in turn the efficiency of all the field operations. Thus a substantial savings in the farm inputs (like fertilizers, manures, plant protection materials etc.) and also labour can be achieved without sacrificing the production levels of the block.



**Fig. 5. Creating farm path by removal of a row in existing plantation**

**b) Replanting a Block/New plantation:**

Whenever there is an opportunity to completely (clean) replant a block or to bring a new land under coffee cultivation, efforts have to be made to modify the terrain of the land and planting designs to suit the movement of small tractors or rubberized track carriers. In certain cases the number of plants per unit area may slightly decrease compare to traditional planting. The modifications to the land terrain and planting designs would primarily depend on the slope of the land.

## The suggested methods of land modifications and planting designs for different field situations to enable mechanization

### Flat land to gentle slopes:

Flat lands and gentle sloping lands do not require any land modification or land shaping. In such areas, adopting hedge row method of planting across the slope would be highly desirable (Figs.6 & 7). The most commonly adopted spacing for hedge-rows is 2m x 1m (6 X 3 ft) for Arabica coffee. Because of closer spacing of plants within a row, stems of the plants are covered more and thus reduce the chances of white stem borer attack. When planted in hedge rows, it is advised to construct farm paths (about 3 m wide) between 4 and 6 hedge rows for facilitating movement of small tractors or walking behind type of Rubberized Track Carriers etc.



**Fig. 6. Flat lands**



**Fig. 7. Gentle slope**

#### **Moderate slopes:**

In gentle to moderate slopes, contour farming/ bunding is recommended at suitable intervals for minimizing erosion of top soil. Contour farming is the technique of growing crops “on the level” across or perpendicular to a slope rather than up and down the slope. The rows running across the slope are designed to be as level as possible to facilitate planting operations on the contour. Contour farming is most effective on slopes above 10 percent. Contour farming is not well suited to rolling topography having a higher slope with maximum irregularity. The contour bunds fortified with earthen embankment can act as narrow farm path for facilitating movement of small tractors or walking behind type Rubberized Track Carriers etc. These farm paths can be fortified by planting soil binding grasses like Vetiver, Paspalum etc., on the lower side. At the end of

each farm path there should be a provision for connecting the farm paths, taking care that the slope of connecting path not exceeding 15 percent. The area between two contour bunds can be planted with coffee either in hedge row design or paired row design of planting. In paired row system, the coffee plants within a paired row can be planted in a zig-zag fashion, forming a triangle (Triangle method).



**Fig:8. Paired row- triangular design**



**Fig:9.Narrow farm paths in steep slopes**

### **Steep slope:**

In steep slopes, it is suggested to construct bench terraces across the slope to minimize soil erosion as well as to improve the working conditions within the plot. Bench terracing involves transforming of relatively steep to very steep slope land into a series of steps running across the slope separated by vertical risers or terraces. The vertical risers (bench terraces) act as platform to plant coffee. In bench terraces coffee can be planted either in hedge row or paired row- triangular design (Fig 8). In very steep slopes (25% and above) coffee can be cultivated by bench terracing or by contour planting but introducing any large scale mechanization may not be possible because farm-paths required for movement of machinery have to be constructed at very close spacing (Fig.9).

Development of new suitable farm path system depending on the slope and shade tree population, selection of right planting design for the easy and convenient movement of small machinery to improve easy access to each plant or planted rows is the important step for mechanization of the farm operations which would improve the efficiency of the farm labourers and thereby mitigate the labour constraint. It also helps in implementation of farm operations in a timely manner and ultimately reduces the cost of cultivation substantially.

