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Gopichand
Department of High Altitude Biology, CSIR - Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh, India

RL Meena
Department of High Altitude Biology, CSIR - Institute of Himalayan Bioresource Technology, Palampur, Himachal, Pradesh, India

RD Singh
Department of High Altitude Biology, CSIR - Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh, India

Correspondence
Gopichand
Department of High Altitude Biology, CSIR - Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh, India

Effect of different tree shading on the growth and yield of *Curcuma aromatica* salisb

Gopichand, RL Meena and RD Singh

Abstract

Curcuma aromatica is a wild species, mostly distributed in hilly regions of India from North western to north eastern of Indian Himalaya. The studies were conducted in CSIR-IHBT, Palampur during 2002 to 2005 to monitor the effect of different shade tree species (*Grevillea robusta, Morus alba* and *Jacaranda acutifolia*), FYM application, plant spacing and in open field conditions on growth and yield of rhizomes. Observations were recorded on number of leaves, number of plantlets (side tillers), plant height, rhizome yield of second and third years of trials. The crop *Curcuma* responded significantly in number of leaves per plant and plant height, under shade trees and in open conditions. However, number of tillers per plants was not statistically significant. In the application of FYM 30 t/ha was produced highest statistically significant yield of rhizomes. In the same way regarding plant spacing, in all used spacing, all growth parameters were not statistically significant, in terms of number of leaves and number of plantlets (side tillers) per plant. However, in the case of plant height it was statistically significant. It has been recorded, that the yield of rhizomes after second and third years were statistically significant in all used tree shades by different species and in open conditions also. In the same manner, different plant spacing also influenced on the yield of rhizomes after second and third year's harvest.

Keywords: shading, growth, Observations, responded significantly

Introduction

Medicinal plants contribute an important chemical constituent to all the systems of medicines being highest in Ayurvedic followed by Unani and Allopathic. The varies agro-climatic conditions, ranging from sub-tropical to alpine. This part allows a long number of medicinal and aromatic plants including some plants of very high medicinal commercial value. Since, last 50 years, the medicinal plants wealth has been eroded at a very high rate, mainly because of unscientific extraction from natural habitats. Unlike agricultural crops, cultivation of medicinal and aromatic plants is not in vogue and these are after exploited as a common property resource. Recently a scientist visited London (UK) for research purpose. He told in his seminar lecture that you can easily purchase many medicinal plants in the form of raw material from London (UK) market. These materials was carried from Nepal, Pakistan, Bangladesh and different parts of India, like Northeast, Srinagar, Manali, Kullu, Lahaul-Spiti, Kinnaur, Bharmour (H.P.) etc. places. The recent trend of people on reverting towards herbal products, these may be drinks, health medicine, soaps or creams etc. The WTO policies on plant genetic resources including patients have further increased the pressure on these valuable resources. As per the Govt. of India polices, including different financial agencies, National Medicinal Plants Board, Department of Biotechnology, Ministry of Forest and Environment, realizing this fact and has sanction different mega project to develop a comprehensive package of practices of important medicinal plants of India. Under the project BDU (Bioresource Development Unit) at IHBT, Palampur (H.P.), Biodiversity division has been conducted different experiments on domestication and cultivation of various medicinal crops. *Curcuma aromatica* is one of them; we have developed whole package and practices, agronomical trials, FYM application, plant spacing, different rhizome size, different sowing time, using different tree crops as shading crops or inter cropping system, and cultivation in open field also.

C. aromatica is a highly commercial valued crop, it has ethnobotanical value, in India used as a tonic (Tiwari *et al*., 2003) [19], carminative an antidote to snake bite, astringent (Jain *et al*., 1991) [5]. Its rhizome paste along with milk is used in blood dysentery and stomachache (Kulkarni *et al*., 2003) [8]. The rhizome juice of *C. aromatica* is used for curing indigestion, rheumatism and dysentery. Plant parts are also used for healing wounds (Santhanam and

Nagarajan, 1990) [13] and fractured bones (Kumar, 2002) [9]. *C. aromatica* have wide range of activities like antifungal (Rao, 1976; Venkataraman *et al*., 1978) [12, 20], antimicrobial (Singh *et al*., 2000a) [16], mosquito repellent (Das *et al*., 1999) [3], anti-inflammatory (Jangde *et al*., 1998) [6], the oil has inhibitory effect on sarcoma.

C. aromatica is wildly available is Dhauladhar ranges of Western- Himalaya (H.P.). This plant has high yielding potential and could be used for crop diversification from the traditional cereal or routine cropping system, prevailing in the mid hills of Himachal Pradesh to generate additional income. In the present paper, we have emphasized on using different tree shade and open conditions, and using different plant spacing to evaluate the different growth parameters and ultimate yield of rhizomes of second and third years after planting the crop of *Curcuma aromatica*.

Materials and Methods

The field trial was laid out with two factor factorial completely randomized block design, one factor plant spacing and second was FYM application, it was replicated thrice. The experiment was conducted at Biodiversity Garden of CSIR-Institute of Himalayan Bioresource Technology, Palampur (1325 m above msl, $32^0$06'05"N, $76^0$34'10"E) situated in the mid-hills of Himachal Pradesh, India. The experiment was laid out in December 2002 and harvested in 2005. At the time of laying the experiment, soil samples from 0 to 15 and 15 to 30 cm depth were collected and analysed for physic-co-chemical properties. The soil was silty clay loam in texture, normal to slightly acidic in soil reaction. The average of top and sub-soil organic carbon was 2.25 in open conditions. While in *Morus* 1.90, in *Grevillea* it was 2.92 available N, P and K was 197, 22.5, 459.5 in open field and 175, 6.25 and 180 in *Morus* and in *Grevillea*, it was 192.5, 6.50 and 110; In the *Jacaranda*, the average of pH was 5.83, organic matter 2.55, available NPK was 140.5, 13.75 and 90 respectively.

The average rainfall during the period of study 92.5 cm minimum and 210.5 cm maximum respectively of which more than 80% was received from July to September. Average maximum and minimum temperatures were 29^0C and 12.6^0C respectively. December to February was the coolest spell when maximum and minimum temperature was 17.8 and 3.9^0C, respectively. Average relative humidity was 56% during the crop season. The field experiment was conducted as two factor factorial completely randomized block design having three plant spacing and four FYM doses, 15 t/ha, 22.5 t/ha, 30 t/ha and 37.5 t/ha and three number spacing 25 cm x 25 cm, 50 cm x 25 cm and 50 cm x 50 cm. The land was prepared very well by manually. The rhizomes of uniform size about 5 - 6 cm length and 3 to 4 cm width. Hardly 2 to 3 no. irrigation was given per year.

A- Plantation under tree shade

B- Plantation in open field

C- Rhizome of *C. aromatica* after harvesting (daughter and mother rhizomes)

Fig 1: Field view of *C. aromatic* crop, A- Plantation under tree shade. B- Plantation in open field. C- Rhizome of *C. aromatica* after harvesting (daughter and mother rhizomes)

Observations

The trial was laid out in the month of December 2002. The observations were recorded after sprouting the rhizomes in middle month of May 2003. Number of leaves per plant, plant height, number of plantlets (side tillers) per plant, dormancy period, rhizome yield kg/sqm and total yield t/ha of consecutive after second and third years. The growth parameters were given only final year i.e. after 2 and 3 years period (Table-1). As the three plant species *Grevillea, Morus* and *Jacaranda* were selected for shading (Figure-1A). The statistically significant number of leaves (8.0 numbers) was recorded in *Jacaranda* shade followed by in open field. While the maximum number of side plantlets (side tillers) was recorded under the shade of *Grevillea robusta*. In the case of plant height all the plant species used including in open field, the plant height was statistically significant (Figure-1B). However, the maximum height was recorded in open field i.e. 166 cm. It is clear-cut indication that the maximum growth was recorded in open field about three times more in comparison to used shade trees. It means that the light requirement was more for the overall growth and cultivation of *C. aromatica*.

In the case of rhizomes yield, the crop harvesting was done in December 2004 and 2005 respectively. The statistically significant yield of rhizomes was recorded in open trial i.e. 5.84 kg/sqm and 58.44 t/ha. However, all growth parameters and yield including all shade were statistically significant. It is very evident from rhizome yield (Table-1) that in the open field, rhizomes yield was four times more in comparison to shade of *Grevillea* and *Morus* species after two and three years of harvest. All the used tree shade was statistically significant. However, the statistically maximum significant rhizome yield was recorded in open field 6.28 kg/sqm and 62.78 t/ha in the third year (Table-1). This yield was about four times more in comparison to the yield of other species (Figure-1C).

In the case of FYM application, most of the growth parameters were statistically non-significant. In the same way in the case of rhizome yield both the years, the first order (daughter rhizome) and the second order (mother rhizomes) and over all rhizome yield was statistically significant (Table-3). It was recorded that the application of 30 t/ha FYM level was the best and produced 113.333 t/ha rhizome yield (table-3), statistically significant and optimum doses for the yield of *C. aromatic* rhizome yield.

In the case of different plant spacing (25 cm x 25 cm, 50 cm x 25 cm and 50 cm x 50 cm), the number of leaves per plant and the plantlets (side tillers) were statistically non-significant. However, it is clear that there was a trend as the spacing was increased side plantlets were decreased (Table - 2). In the case of plant height all the used shade, including open field, all are statistically significant. However, the pattern was same as in the case of plantlets (side tillers) per plant, i.e. the narrow spacing producing statistically maximum plant height. In terms of rhizome yield, it was statistically significant in the narrow spacing (25 cm x 25 cm), the rhizome yield was recorded 2.8 kg/sqm and 28 t/ha over all. As the plant spacing were increased the rhizome yield were decreased in second and third years respectively.

Discussion

In the modern time, as the world is running towards "Herbals", a phenomenon which storming the globe with scientific rationale and leads that are fast emerging to provide better health and convenient life through plants and plant derived products (Stone, 2002) [18]. Herbal medicine is still the mainstay of about 75 - 80% of the world population, mainly in the developing countries. In India, about 80% of medicinal and aromatic plants are collected from 17 million ha of Indian forest (Chatterjee, 2002) [1]. Generally, the plant or its part is collected from wild. This natural collection from wild is unsuitable and immature, resulting rapidly depleting the bio-resource base, this species may be under threat of extinction. Keeping in mind an intercropping system was proposed on the basis of agrotechniques for the cultivation and ultimately commercialization of *C. aromatica*.

Three plant species has been selected as shading for the cultivation of *C. aromatica* along with open field. As the growth parameters and the yield data was recorded in three years. It is clearly indicating that the number of leaves per plant and plant height were statistically significant. It means the provided tree shades were good for the growth and yield of rhizomes. It is very evident from the second and third years' rhizome yield, that all the shades used for the cultivation of *C. aromatica* were statistically significant in terms of growth and yield of rhizomes. In the case of plant height, it was significant in open field, just double from the others; it means that *C. aromatica* requires more light intensity. It means the crop produced statistically significant yield of rhizomes, in second and third year more than four times rhizome yield was recorded (Table-1). It means the crop was preferred maximum photoperiod. However, physiological studies have not been recorded in this trial, because the studies were proposed for the benefit of local population and foresters to adopt these package and practices of the cultivation of *C. aromatica*. Because due to the partial shade of the used trees, prohibited light due to its plant canopy. It means accumulation or the synthesis of food or carbon assimilation will be decreased in comparison to open field, where the sunshine is bright. Due to the partial shade of used tree species, the photosynthesis rate is decreased, less food formation, possibly less growth were performed by the crop. It means the low rhizome yield was also recorded in shade trees in comparison to open field. It is well documented that the upper leaves of a tree get more light, more carbon assimilation, but lower leaves or the lower canopy of the tree and the crop *C. aromatica* receive low light intensity, resultant low carbon assimilation. Because *C. aromatica* is lower storey crop, receive low light, means formation of food material was also low as per the rhizome yield performance. In case we may use some tree shade for its cultivation, there is no harm, because the overall results of growth and rhizome yield obtained were statistically significant. However, the crop prefers open cultivation. In terms of plant spacing, close spacing produced statistically significant growth, especially plant height and rhizome yield after second and third years. Close spacing (25 cm x 25 cm), means more plants in a space producing more yield. Wider spacing (50 cm x 50 cm) means less no. of plants, low rhizome yield. The R&D trials were laid out keeping in view that this crop is wild and available in Dhauladhar mid- hills of Himachal Pradesh. In the forest system, the package and practices of cultivation of this crop may be adopted for future conservation and upliftment of local society. Otherwise, the rate of exploitation is very high and the species may be extinct very soon. If no necessary measure would be taken in order to conserve it.

It is very well evident that in the third year, the first order, second order and over all rhizome yield was statistically significant in terms of FYM levels (Table-3). However in the case of plant spacing the results was non-significant. At commercial point of view, it is clear, that in case we will increase the FYM levels the rhizome yield were significantly increased in due course of time. It is also clear that 30 t/ha, FYM level was the best optimum dose of the crop rhizome yield, above and below this level, the results are lower yield. It is understood that in first and second years rhizome yield was significantly increased in course of time i.e., in three years. Rana *et al*. (2004) [11], has also studied the same type of rhizomatous crop on *Hedychium spicatum* and reported the same type of rhizome yield.

In the detail study lot of growth and yield parameters were very well recorded and explained in the research article by (Gopichand *et al*. 2006) [4]. (Rana *et al.* 2004) [11] Has suggested the apple plantation for the cultivation of *Hedychium spicatum* crop as intercropping system. It is same type of rhizomatous crop and found at the same altitude 1,000 to 2,800 m at msl and climatic conditions. In the same crop, we have used some tree species for its cultivation as *Grevillea, Morus,* Kinnow etc., and recorded very significant yield in *H. spicatum.* Plants at 25 cm x 25 cm spacing showed significantly higher plant than 50 cm x 25 cm and 50 cm x 50 cm spacing, thus 50 cm x 50 cm spacing recorded lowest plant height. (Shashidhar *et al*. 1997) [14], also recorded similar results in case of *Curcuma longa*. In fact, at closer spacing, crop plants complete for resources as sunlight, and thereby grow taller to harness solar energy. Thus, with increase in spacing the plant height decreased. In the same way the lower spacing producing more side plantlets, statistically non- significant, but producing more rhizome no. means more rhizome yield per plant or t/ ha.

The co-relation between field productivity and net photosynthesis rate is well documented (Ledig, 1969) [10]. The lower rate of photosynthesis or less light intensity received by ground level leaves or lower storey crop. This can be probably explained by ‘Sunflecks’ (Yin and Johanson, 2000) [21]. The fact that low rates of photosynthesis is also exhibited by broad leaves species (Koike *et al*., 2001) [7], the temperature of leaf was found 2-3ºC less in comparison to narrow leaf species. (Sobrado 1994) [17] Have reported that the photosynthetic capacity of individual leaf is species specific and may facilitate the scaling of biomass production to the stand level. It is very well establish fact and reported (Cromer and Jarvis, 1990 and Sigurdsson *et al*., 2001) [2, 15] that the poor aerial growth is a reflection of photosynthetic partitioning towards roots. In case of rhizome yield, it may be assumed that the low light intensity received by *C. aromatica* leaves, resultant low photosynthetic activity, low growth in comparison to open trial, i.e. low level of biomass (underground) production. All these parameters are interlinked with each other. It may be concluded that the light requirement of *C. aromatica* is more in comparison to other species. It is species specific.

Table 1: Influence of Shade Trees on the Growth parameters and Yield of *C. aromatica*.

Shade tree species	No. of leaves/ plant	No. of Tiller/ plant	Plant height (cm)	Rhizome weight (kg/sqm) After Two year	Rhizome weight (t/ha) After Two year	Rhizome weight (kg/sqm) After Three year	Rhizome weight (t/ha) After Three year
Grevillea	5.56	3.11	64.78	1.33	13.33	1.62	16.22
Morus	5.78	2.89	59.56	1.46	14.56	1.66	16.56
Jacaranda	6.00	2.83	69.78	1.73	17.33	1.68	16.78
Open	7.67	2.44	166.00	5.84	58.44	6.28	62.78
LSD (p=0.5)	0.22	NS	1.44	0.09	0.94	0.08	0.77

Table 2: Influence of plant spacing on growth parameters and yield of *C. aromatica*.

Spacing (sq cm)	No. of leaves/ plant	No. of Tiller/ plant	Plant height (cm)	Rhizome weight (kg/sqm) After Two year	Rhizome weight (t/ha) After Two year	Rhizome weight (kg/sqm) After Three year	Rhizome weight (t/ha) After Three year
25x25	6.417	2.875	93.083	2.800	28.000	3.108	31.083
50x25	6.250	2.833	90.583	2.617	26.167	2.800	28.000
50x50	6.083	2.750	86.417	2.358	23.583	2.517	25.167
LSD (p=0.5)	NS	NS	1.25	0.08	0.82	0.07	0.67

Table-3: Influence of different FYM level on rhizome production of *C. aromatica*.

FYM (t/ha)	Mother rhizome weight (t/ha)	Daughter rhizome weight (t/ha)	Total rhizome weight (t/ha)
15.0	39.556	0.018	79.333
22.5	46.444	0.020	92.667
30.0	56.889	0.015	113.333
37.5	51.556	0.021	100.000
Sem± (0.5)	2.592	0.001	4.459

Conclusion

In the present studies, it is stated that the importance of tree shade is required or not for cultivation of medicinal and aromatic plants in the natural climatic conditions. Because it was observed that most of the medicinal and aromatic plants were growing under shade in forest of Himachal Pradesh. In keeping view, the above experiment was laid out to understand, the importance of tree shade. For this conclusion to compare the yield of rhizomes in shade and in open conditions. However, it was recorded that all the used partial tree shade proved that the growth and yield of rhizome was statistically significant. But it is evident that the experiment was conducted in open conditions was produced more than four time yield t/ha of rhizomes of *Curcuma aromatica*. FYM application and spacing was not proved a effective role in the yield of rhizome. It means it is absolutely clear that this crop would not required any type of partial shade by using tree species.

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