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Assessment of shade adaptation and spacing on growth and yield of wild turmeric (*Curcuma aromatica* Salisb.)

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ABSTRACT

Curcuma aromatica (common name: wild turmeric), well known for antibacterial, antifungal, and cosmetic properties, is a member of the genus Curcuma belonging to the family Zingiberaceae. A study was undertaken at the Department of Agronomy farm, College of Agriculture, Vellanikkara, Thrissur, Kerala from May to December 2021 to study the effect of shade and spacing on the growth, yield and, quality of Curcuma aromatica. The experiment was laid out in a two factorial completely randomized block design with three replications. Shade was taken as the first factor, and spacing was taken as the second factor. Two levels of the first factor (open and 25% shade) and three levels of the second factor (60 cm x 40 cm, 40 cm x 25 cm, and 25 cm x 25 cm) were evaluated. Plants grown under shaded conditions were taller (142.50 cm) and had more leaf area (453.42 cm^2) than plants grown under open (92.17 cm and 377.36 cm^2 respectively) conditions. Open conditions resulted in a greater number of leaves (10.41) and tillers (2.02) compared to shade (7.38 and 1.44 respectively). But yield and yield characters except number of fingers were not statistically different in both the treatments. The number of fingers was higher in open (36.26) condition and it was lower in shaded condition (30.31). Essential oil content was higher in shade (3.32%) compared to open (3.06%). Concerning the effect of spacing on growth and yield, 25 cm x 25 cm spacing (123.79 cm) had produced taller plants followed by 40 cm x 25 cm (118.93 cm) and 60 cm x 40 cm (109.30 cm) spacing. The treatment 60 cm x 40 cm significantly resulted in higher number of leaves, tillers and leaf area and lowest was produced by 25 cm x 25 cm. The yield and yield characters (rhizome length and number of rhizomes) were significantly higher under 60 cm x 40 cm spacing compared to other treatments. But per hectare yield was higher at 25 cm x 25 cm spacing since plant population is more in this treatment. The treatment combination 25 cm x 25 cm spacing with shade had produced maximum plant height and lowest was produced by 60 cm x 40 cm spacing under open conditions. Number of leaves, number of tillers, number of rhizomes were found to be higher at 60 cm x 40 cm under open conditions. There is no statistical difference between treatments for leaf area, rhizome yield of single plant, rhizome yield (kg ha^{-1}) and essential oil content. The results acknowledge that Curcuma aromatica is a shade tolerant crop. It can be grown in either open or shaded areas. To achieve a higher yield, it is preferable to use a 25 cm x 25 cm spacing.

Keywords: Shade, spacing, Curcuma aromatica, wild turmeric, growth, yield

INTRODUCTION

Curcuma aromatica (common name: wild turmeric), well known for antibacterial, antifungal, and cosmetic properties, is a member of the genus Curcuma belonging to the family Zingiberaceae. C. aromatica Salisb. is commonly found in South Asia, China, New Guinea, India and Northern Australia (Ravindran *et al.*, 2007). Although it grows naturally throughout India, the plant is primarily grown in Kerala and West Bengal (Ahmad *et al.*, 2011). Its anti-cancerous properties make it an essential plant in the pharmaceutical industry (Asolkar *et al.*, 1992). Aquaous extract of Curcuma aromatica may be useful as an anti-proliferative herb for colon cancer (Hu *et al.*, 2011). It has anti-inflammatory, wound healing, anti-melanogenic, antioxidant and free radical scavenging, anti-tumor, anti-cancer, anti-repellent, antitussive, anti-platelet and antinephrotoxic activity (Sikha *et al.*, 2015). Numerous substances was found in C. aromatica have been shown to have antioxidant and anti-diabetic activities, including 1,8-cineole, ar-turmerone, curcumin, curcumol, demethoxycurcumin, germacrone, and xanthorrhizol (Umar *et al.*, 2020). Many people have misinterpreted other Curcuma sp, especially Curcuma zedoaria, as Curcuma aromatica. This encourages vendors to profit by selling other commonly occurring Curcuma spp. as Curcuma aromatica. Habitat destruction and deforestation make the plant more vulnerable to extinction (Kumar and Sikarwar, 2002). Wide

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range of medicinal properties of the plant makes it difficult to ignore the fact that its existence is being threatened. Therefore, It is imperative that, urgent measures to be taken to popularise Curcuma aromatica cultivation. The demand for the crop will rise as more people become aware of its therapeutic benefits, which will result in higher profits for the farmers.

Crops like ginger and turmeric can tolerate a certain degree of shade. Since Curcuma aromatica belongs to the same genus of turmeric, it is expected that it can also tolerate shade. Then, it could be recommended as a component of homestead farming by conducting further studies. It will increase the acceptability of wild turmeric cultivation. Plant population and productivity are influenced by spacing. When plants are spaced properly, they can absorb sufficient light, nutrients, and water (Abdel-Rahman *et al.*, 2012). In this background, a study was conducted at the Department of Agronomy, College of Agriculture, Vellanikkara, to evaluate the influence of shade and spacing on the growth and yield of Curcuma aromatica.

MATERIALS AND METHODS

The present study was undertaken at the Department of Agronomy farm, College of Agriculture, Vellanikkara, Thrissur, Kerala (13° 32'N latitude and 76° 26'E longitude, 40 m above mean sea level) from May to December 2021. At the experimental site, the soil was sandy clay loam in texture, acidic in reaction (pH 4.7), low in available N (145 kg ha^{-1}), high in available P (25 kg ha^{-1}) and medium in available K (220 kg ha^{-1}). The crop received a total annual rainfall of 6605.6 mm throughout its growing period. The experiment was laid out in a two-factorial, completely randomized block design with three replications. The first factor studied was shade, and the second was spacing. Two levels of the first factor (open and 25% shade) and three levels of the second factor (60 cm x 40 cm, 40 cm x 25 cm, and 25 cm x 25 cm) were evaluated. The experimental site was ploughed with a disc plough and made into fine tilth using a cultivator. Lime was applied to correct the pH of the experimental field. According to spacing treatments, rhizomes of a local variety with one or two buds and of uniform weight were planted on raised beds both in open and shaded conditions. After that, the beds were mulched with dried leaves. Application of farmyard manure at 15 t ha^{-1} was done as basal. Fertilizer NPK @ 100 kg N + 50 kg P + 50 kg K ha^{-1} was applied. Total phosphorus was applied as basal. N and K were applied in two equal split doses, one at basal and another two months after planting, along with weeding and earthing up (KAU PoP, 2016). Irrigation was not required since the crop had gotten enough rainfall throughout its growth period. Observations on plant height, number of leaves, number of tillers and leaf area were taken six months after planting when plants had reached full maturity.

The following formula was used for calculating leaf area in turmeric (Randhawa *et al.*,1985).

Y = 4.09 + 0.564 (Length x Breadth)

Y = Leaf area

Length = Length of leaf in cm

Breadth = Breadth of leaf in cm

Plants were harvested seven months after planting when the leaves had dried completely. Observations on yield such as rhizome length, number of fingers, weight of single rhizome and rhizome yield (kg ha^{-1}) were taken on the day of harvest. The essential oil content of rhizomes was also estimated by the hydrodistillation method using the Clevenger apparatus as per AOAC (1975). The data obtained from the experiment were analyzed using analysis of variance (ANOVA) with the statistical package 'WASP 2' (ICAR Goa, https://ccari.icar.gov.in/waspnew.html).

RESULTS AND DISCUSSION

Biometric characters

The growth characteristics of *Curcuma aromatica* were significantly influenced by levels of shade and spacing as well as their interaction. There were recorded significant differences in plant height due to shade. Plants recorded a maximum height of 142.50 cm under shaded conditions compared to those under open conditions (92.17 cm). Reduced light intensity at the base of the plant under shady conditions might have accelerated the elongation of lower internodes resulting in increased plant height (Srikrishnah *et al.*, 2015). When it comes to spacing, 25 cm x 25 cm significantly resulted in tallest plants (123.79 cm), followed by 40 cm x 25 cm (118.93 cm) and 60 cm x 40 cm (109.3

cm), respectively. Closer-spaced plants had more plant height than wider-spaced plants. Kumar and Gill (2010) reported the same for turmeric from an experiment conducted in Punjab. There might be competition from neighbouring plants for getting adequate sunlight. As a result, the plants grown in closer spacing might have increased their height to get sufficient sunlight. A combination of 25% shade with 25 cm x 25 cm plant spacing produced the tallest plants (157.56 cm). It was 17.65 cm taller than 40 cm x 25 cm under 25% shade. Plant spacing of 60 cm x 40 cm under open conditions resulted in the lowest plant height (88.57 cm). It was on par with 25 cm x 25 cm under open conditions (90.01 cm).

Table 1: Effect of shade and spacing on growth and yield of *Curcuma aromatic*

Treatment	Plant height (at 6 MAP) (cm)	No. of leaves (at 6 MAP)	No. of tillers (at 6 MAP)	Leaf area (cm^2)	Rhizome length (at harvest) (cm)	No. of rhizome (at harvest)	Rhizome yield $plant^{-1}$ (g)	Rhizome yield (kg ha^{-1})	Essential oil content (%)
Shade									
Open	92.17	10.41	2.02	377.36	18.10	36.26	217.40	15627	3.06
25% shade	142.50	7.38	1.44	453.42	18.70	30.31	229.50	16566	3.32
CD (p=0.05)	3.98	0.56	0.17	26.75	NS	2.34	NS	NS	0.16
SEm+	1.383	0.193	0.058	9.309	0.394	0.814	5.081	482.441	0.057
Spacing									
60 cm x 40 cm	109.30	10.75	2.04	449.81	19.75	40.93	286.82	9560	3.07
40 cm x 25cm	118.93	8.81	1.77	432.22	18.19	32.08	215.86	17269	3.24
25 cm x 25 cm	123.79	7.12	1.38	364.14	17.28	26.85	167.67	21461	3.25
CD (p=0.05)	4.87	0.68	0.21	32.77	1.39	2.87	17.88	1698	NS
SEm+	1.694	0.236	0.072	11.401	0.483	0.997	6.223	590.868	0.069

The number of leaves was significantly higher in open (10.41) conditions than in shaded (7.38) conditions. Kumar *et al.* (2018) also had similar findings when they cultivated turmeric in harad-based agroforestry system. Treatment with 60 cm x 40 cm spacing (10.75) significantly resulted in a higher number of leaves, followed by 40 cm x 25 cm (8.81) and 25 cm x 25 cm (7.12), respectively. A similar trend was observed in an experiment conducted by Gopichand and Singh (2017) in *Curcuma aromatica.*The treatment combination, open with 60 cm x 40 cm spacing (13.34), significantly produced the maximum number of leaves, followed by open with 40 cm x 25 cm spacing (10.58). The lowest number of leaves was recorded by treatment combination, with 25 cm x 25 cm spacing (6.93).

Identical performance was recorded in the number of tillers and the number of leaves. The number of tillers was significantly higher under open conditions (2.02) than in shaded conditions (1.44). Latha *et al.* (1995) also reported a significant increase in the number of tillers in some turmeric varieties under open conditions compared to shade. The plants also exhibited significant variations in the number of tillers due to spacing differences. The maximum number of tillers recorded at the wider spacing was 60 cm x 40 cm (2.04), followed by 40 cm x 25 cm (1.77) and 25 cm x 25 cm (1.38), respectively. Closely spaced plants might have fewer leaves and tillers because there was not enough space for them to develop.The interaction effect of shade and spacing significantly influenced the production of tillers. Among interactions, 60 cm x 40 cm spacing under open conditions (2.49) resulted in the highest number of tillers, followed by 40 cm x 25 cm under open conditions (2.13). The lowest number of tillers was recorded by 25 cm x 25 cm under shaded conditions (1.33).

The leaf area differed strikingly under open and shaded conditions. The data indicated that the plants grown in shady conditions (453.42 cm^2) had a higher leaf area than those grown under open conditions (377.36 cm^2). Light capture and distribution are maintained in plants under shade by larger leaves. This result was in agreement with Srikrishnah and Sutharsan, (2015). It shows that *Curcuma aromatica* requires shading to develop leaves properly. Among different spacings evaluated, 60 cm x 40 cm (449.81 cm^2) resulted in a higher leaf area. It was on par with a spacing 40 cm x 25 cm (432.22 cm^2). The lowest leaf area was produced by spacing 25 cm x 25 cm (364.14 cm^2). Interaction between shade and spacing did not bring any significant variation in leaf area.

Table 2: Interaction effect of shade and spacing on growth and yield of *Curcuma aromatica*

Treatment (Shade x Spacing)		Plant height (at 6 MAP) (cm)	No. of leaves (at 6 MAP)	No. of tillers (at 6 MAP)	Leaf area (cm^2)	Rhizome length (at harvest) (cm)	No. of rhizome (at harvest)	Rhizome yield plant^{-1} (g)	Rhizome yield (kg ha^{-1})	Essential oil content (%)
Open	60 cm x 40 cm	88.57	13.34	2.49	396.73	19.28	47.86	282.43	9,414	2.96
	40 cm x 25cm	97.94	10.58	2.13	397.99	17.36	35.10	205.57	16,445	3.04
	25 cm x 25 cm	90.01	7.30	1.43	337.37	17.78	25.84	164.23	21,021	3.17
25% shade	60 cm x 40 cm	130.03	8.17	1.60	502.90	20.22	34.00	291.20	9,707	3.19
	40 cm x 25cm	139.91	7.04	1.40	466.45	19.02	29.07	226.15	18,092	3.43
	25 cm x 25 cm	157.56	6.93	1.33	390.92	16.79	27.87	171.1	21,900	3.32
CD (p=0.05)		6.89	0.96	0.29	NS	NS	4.05	NS	NS	NS
SEm+		2.395	0.334	0.101	16.123	0.682	1.41	8.8	835.61	0.098

Yield and yield parameters

The data presented in Tables 1 and 2 indicated that yield and yield parameters, except the number of rhizomes, were significantly affected by spacing. The number of rhizomes was influenced considerably by spacing as well as shade. Plants grown under shaded and open conditions did not exhibit significant variations in rhizome length, weight of a single rhizome (g plant^{-1}), and rhizome yield (kg ha^{-1}). However, all these parameters were slightly higher under shaded conditions. The production of rhizomes was significantly higher under open (36.26) than the shaded (30.31) condition. In shady conditions, it was compensated by the production of extensive rhizomes. Though it did not produce any significant variation in yield, the yield was slightly higher under shaded conditions. This result proved that *Curcuma aromatica* could be classified as a shade tolerant crop and can be recommended as a component in homestead farming. Spacing 60 cm x 40 cm had significantly higher rhizome length (19.75), number of rhizomes (40.93), and weight of a single rhizome (286.82 g plant^{-1}), followed by 40 cm x 25 cm and 25 cm x 25 cm. In an experiment conducted in *Curcuma longa*, Kumar and Gill (2010) also reported higher yield under broader spacing. However, due to the increased plant population under closer spacing, the yield of closer spacing per hectare was higher. Per hectare yield of rhizomes under 25 cm x 25 cm was 21461 kg ha^{-1}, which was significantly higher than 40 cm x 25 cm (17269 kg ha^{-1}) and 60 cm x 40 cm (9560 kg ha^{-1}). The highest essential oil content was registered under shade (3.32%) compared to open (3.06%) conditions. The result was in concordance with Padmapriya *et al.* (2007). There was no significant variation in essential oil content according to spacing.

It may be concluded that *Curcuma aromatica* is a shade tolerant crop. It can be grown in either open or shaded areas. To achieve a higher yield, it is preferable to use a 25 cm x 25 cm spacing. *Curcuma aromatica* can be recommended as a component of homestead farming.

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