Original Research Article

GROWTH AND YIELD OF THREE TURMERIC VARITIES (*Curcuma longa* L.) UNDER MANGO BASED AGROFORESTRY

ABSTRACT

An experiment was conducted at the Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during 24 March 2018 to 10 January 2019, to investigate the growth and yield of different turmeric varieties under mango trees and open control. The experiment consisted of two factors with three replications. Among the two factors, one factor was two production systems: T_1 =Mango + Turmeric and T_2=Open control + Turmeric; the second factor was three turmeric local varieties: V_1=Thailand, V_2= Malshira and V_3= Debipat. Interaction treatments between factor A and factor B were T_1V_1, T_1V_2, T_1V_3, T_2V_1, T_2V_2 and T_2V_3 combinations. The experiment was laid out following a Randomized Complete Block Design with three replications. Findings of the study revealed that growth and yield of turmeric significantly varied in the main effect of different agroforestry production systems. The highest fresh weight of rhizome (11000 kg/ha) was obtained in T_2 and lowest (7055 kg/ha) in T_1. The highest dry weight of rhizome (2126 kg/ha) was found in T_2 and lowest (1456 kg/ha) was in T_1.on the other hand the highest fresh weight of rhizome was 9777 kg/ha found with (V_2) and lowest 8055 kg/ha with (V_3), the highest dry weight of rhizome was 2013kg/ha found in V_1.In case of interaction, the highest fresh rhizome weight (13611 kg/ha) and dry rhizome weight (2631 kg/ha) were recorded in T_2V_2 and T_2V_2, respectively. However, the lowest were found in T_1V_2 (5944 kg/ha) and T_1V_2 (1208 kg/ha).

Keywords: Turmeric, Varieties, Suitability, Mango, Agroforestry System, Sole Cropping

1.INTRODUCTION

Turmeric (*Curcuma longa*L.), belongs to the Zingiberaceae family which is one of the most useful herbal medicinal plants (Ref). Turmeric is n spice and a medicinal plant frequently used in Bangladesh. Common Bangladeshi people traditionally use various spices in their daily life. Among them is turmeric (*Curcuma longa*) which is the most important one. Besides using as a spice, it is also used for medicine as a carminative and aromatic stimulant (Purseglove*et al.,* 1981). In addition, turmeric is a valued crop having local as well as export potentials (Siddique, 1995). Total production of turmeric is 117000 metric tons from 21.41 thousand hectors land (BBS, 2011). The demand for turmeric as domestic use is increasing daily with theever increasing population of Bangladesh and global demand is also increasing.Turmeric has been known as shade loving spices crop of Bangladesh. It can be cultivated in most areas of the tropics and subtropics, provided that in case of inadequate rainfall, facilities for irrigation are available. It is usually grown in regions with an annual rainfall of 1000-2000 mm. Cultivation has been extended into moist areas with rainfall above 2000 mm per annum. It can be grown up to an altitude of 1220 m in the Himalayan foothills (Purseglove*et al.,* 1981). Humus-rich virgin soil of hills and forests is also suitable for turmeric production. All the above conditions for turmeric production is available in Bangladesh.

Agroforestry, the integration of tree and crop/vegetables in the same area of land is a promising production system for maximizing yield (Nair, 1990). Multi-storey crops (including vegetables) can be integrated with forestry, orchard, or other agroforestry systems, but farmers face problems of growing crops after 4-5 years of tree plantations and even sometimes fail to grow under storey crops under and around trees because in agroforestry systems, among different production limitations, light availability may be the most important limitation to the performance of the understory crops/vegetables, particularly where an upperstorey perennial forms a continuous overstorey canopy (Miah*et al*., 1995). This problem may be overcome by introducing shade tolerant crops likeginger, and turmeric.

Mango is a tropical fruit and belongs to the genus *Mangifera* of the family Anacardiaceae. Mango is a major fruit in the northern part of Bangladesh, especially in the Dinajpur region due to its edaphic-climatic adaptability. In the Dinajpur region, mango is an integral component of homestead gardening. However, day by day mango gardens is increasing. Nowadays growing of different annual crops in association with mango is practiced by farmers, but without many scientific considerations. A protocol was therefore developed and findings which are beneficial for growers. Keeping this view in mind, research on mango based agroforestry system was conducted in order to select compatible ground storey crops as well as to work out the economic viability of the systems. Hence, attempts were taken to boos-up mango turmeric culture through appropriate techniques. Under these conditions, the present study was undertaken to assess the effects of mango shade on the germination, growth and yield of turmeric varieties.

2.Materials and Methods:

2.1 Experimental site description

The research work was carried out in a field (Under Mango trees and open control) adjacent to the HSTU Research Farm, Dinajpur during 24 March 2018 to 10 January 2019 the upland conditions, The site lies between 25˚13' 13 latitude and 88˚23' longitudes at the elevation of 38m above sea level.

2.1.1 Soil characteristics

The experiments were laid out in a medium high land belonging to the AEZ of Himalayan piedmont plain area. The soil texture was sandy loam with a pH of 5.0.The structure of soil was fine and the organic matter, total N, P, K, S, Zn and B contents were 1.20%, 0.06%, 29.35μ/g soil, 0.21μ/100g soil, 6.13μ/g soil, 0.73μ/g soil and 0.27μ/g soil respectively. The soil characteristics were determined at the Regional Laboratory, SRDI, Dinajpur.

2.1.2. Climate

The climate of the study area is characterized by a heavy rainfall during the Kharif season (April to September, 2018), while a scanty rainfall during the rest period, i.e. during the Rabi season (October to March, 2018). The mean annual rainfall was 1822mm most of which occurred in during June-September and light showers occurs during the Rabi season (October, 2018 to January, 2019).

The mean maximum temperature in the summer (March to September, 2018) was 35℃ and the mean maximum temperature in the winter (November, 2018 to January, 2019) was 11.9℃. The humidity was 87% in January and 88% in July.

2.2 Experimental designs

The experiments were laid out in a randomized complete block design (RCBD). There were two treatments in the experiment, first experiment was set with three varieties of turmeric under mango shade and second was set with three varieties under open space (control). There were three replications in each study. The size of plot was 3m x 3m.But for data analysis, the plot size was measured as 3mx 0.6m as necessary.The experiment consisted of 2(two) factors:Factor A: (Two production systems), T_1=under mango shade+ turmeric,T_2=Open space+ Turmeric.Factor B: (Three local turmeric varieties)V_1=Thailand,V_2=Malshira,V_3=Debipat and the treatment combination wasT_1V_1=Turmeric Thailand var. under mango shade,T_1V_2=Turmeric Malshira var. under mango shade,T_1V_3=Turmeric Debipat var. under mango shade,T_2V_1=Turmeric Thailand var. under open field,T_2V_2=Turmeric Malshira var. under open field,T_2V_3=Turmeric Debipat?var. under open field.

2.3 Crop establishment

The seed-rhizomes/fingers of the turmeric were planted, maintaining a line to line distance of 60 cm, plant to plant with distance 20cm and a depth of 10cm under mango trees and open field/space (control). Weight of each seed/rhizome of Thailand was 20g,Malshira was 18 and Debipat turmeric was 17g.

2.4 Weeding and irrigation

Weeding was done whennecessary. Ear thing up was done thrice; the first one after 60, the second one after 90 and the final one after 110 days of planting. Some plants were rotten by water logging condition. This condition was controlled by drainage.

2.5 Application of fertilizer

Recommended doses of fertilizers were used as urea (N at 135 kg/ha), TSP (P_2O_5 at 30 kg/ha), MP (K_2O at 90 kg/ha), Gypsum (S at10 kg/ha), zinc sulfate (Zn at 2 kg/ha), Borax (B at1.5 kg/ha), andcow dung (5 tons/ha).

2.6Data collection

2.6.1 During germination period

Germination data:The number of plants was counted after 10 days aftergermination of turmeric plants within 140 days after planting (DAP). Germination speedwascalculated as followed (Zhang and Fu, 2010). Germination speed wascalculated as under (Chiapusio*et al.,* 1997):

S= (N1*1) + (N2–N1)*1/2 + (N3- N2)*1/3 + … + (Nn- Nn-1)*1/n:

Where, N1, N2, N3,…, Nn-1, Nn refers to the proportion of germinated rhizomes on 10 days, 20 days, 30 days, and 140 days.

Data were collected of the following parameters:

1. Number of plants, plant height (cm).
2. Length of leaf blade (cm).
3. Width of leaf (cm).

2.6.2 Duringharvesting period:

1. Number of plants per plot. Total number of fingers per plot.
2. Number of fingers per plant.
3. Length of largest rhizome (cm).
4. Width of largest rhizome (cm).
5. Number of total nodes per rhizome.
6. Total length of internodes per rhizome (cm).
7. Fresh weight of rhizomes per plot.
8. Fresh weight of rhizomes per hectare.
9. Dry weight of rhizomes per plot/100g.
10. Dry weight of rhizomes per hectare.

2.7 Light intensity

Light intensity were measured by aLUX meter (Hanna company) before the harvesting at 10 am, 1pm and 4 pm.

2.8 Data analysis

Means of each parameter were separated by TUKEY HSD - multiple comparison method. A two way interaction were obtained by factorial analysis of variance (ANOVA) .All data were analyzed usingSTATISTIX 10.

4. Result and discussion

4.1 Interaction effect of different agroforestry production systems and turmeric varieties on growth and quality contributing characters of turmeric at different DAP

4.1.1 Plant height (cm)

The interaction effect of the different agroforestry production systems and turmeric varieties on plant height was significantly different between certain treatments at different DAP (Table 1). The tallest plant was recorded in the T_1V_2 combination (28.22 cm) at 60 DAP and the shortest plant was found in T_2V_3 combination (20.77 cm). At 90 DAP, the tallest plant was observed in T_1V_3 combination (70.88 cm), and shortest T_2V_1 combination (31.55 cm). Then, at 120 DAP, the tallest plant was recorded in T_1V_3 combination (97.00 cm) and the shortest plant was found in T_2V_1 combination (45.44 cm).Furthermore, at 180 DAP ,the tallest plant was in T_1V_3 combination (131.33 cm), and the shortest plant was recorded in the T_2V_3 combination (85.56 cm) at 180 DAP.

Table1: Interaction effect of different agroforestry production systems and turmeric varieties on plant height at different DAP

Interaction treatments	Plant height			
	60 DAP (cm)	**90 DAP (cm)**	**120DAP (cm)**	**180 DAP (cm)**
Mango x Thailand (T_1V_1)	24.94a*	59.77ab	80.00ab	103.44bc
Mango x Malshira (T_1V_2)	28.22a	68.22a	91.00ab	114.33ab
Mango x Debipat (T_1V_3)	25.66a	70.88a	97.00a	131.33a
Open x Thailand (T_2V_1)	21.66a	31.55c	45.44c	119.11ab
Open x Malshira (T_2V_2)	21.66a	62.66ab	84.66ab	127.67a
Open x Debipat (T_2V_3)	20.77a	50.11b	74.22b	85.56c
CV%	30.74	18.63	15.9	13

*In a column different letters indicate significantdifferences at *p* ≤ 0.05, 0.01 and 0.001 byTukey HSD test

4.1.2 Length of leaf (cm)

The length of the leaf of turmeric varied significantly by the interaction effect of different agroforestry production systems, and turmeric varieties at differentDAP (Table 2). The longest leaf blade was observed in T_1V_3 combination (27.66 cm) and the shortest was found in T_2V_1 combination (16.55 cm) at 60 DAP. At 90 DAP, the longest leaf was observed in T_1V_3 combination (36.00 cm) and the shortest was recorded in T_2V_1 combination (16.33 cm). Again the longest leaf was observed in T_1V_3 combination (51.00 cm) and the shortest was found in T_2V_1 combination (25.22 cm) at 120 DAP. Moreover, at 180 DAP, the longest leaf was found inT_1V_3 combination (63.88 cm) and the shortest was observed in T_2V_3 combination (41.44 cm). Garrity*et al.* (1992) observed that the number of leaves per plantswas minimally affected byshading condition in mixed cropping of turmeric.

Table 2: Interaction effect of different agroforestry production systems and turmeric varieties on length of leaf

Interaction treatments	Length of leaf			
	60DAP (cm)	**90DAP (cm)**	**120DAP (cm)**	**180DAP (cm)**
Mango x Thailand (T_1V_1)	21.33bc*	28.55bc	39.77b	55.00a
Mango x Malshira (T_1V_2)	25.66ab	33.44ab	48.22a	58.66a

Mango x Debipat (T_1V_3)	27.66a	36.00a	51.00a	63.88a
Open x Thailand (T_2V_1)?				
Open x Malshira (T_2V_2)	26.88ab	20.44de	33.00b	59.66a
Open x Debipat (T_2V_3)	25.94ab	24.11cd	37.55b	41.44b
CV%	18.27	15.92	14.12	14.7

*In a column different letters indicate significant differences at $p \leq 0.05$, 0.01 and 0.001 byTukey HSD test

4.1.3 Width of leaf (cm)

Width of leaf of turmeric plants varied significantly by the interaction effect of different agroforestry production systems, and turmeric varieties at different DAP (Table 3). The maximum width of leaf was observed in T_1V_1 (4.11 cm) and T_2V_2 (4.00 cm) combinations, which were statistically similar at 60 DAP. The minimum width of leaf was recorded in T_1V_2 (3.88 cm), T_1V_3 (3.66 cm), T_2V_1 (3.77 cm) and T_2V_3 (3.33 cm) combinations, which were statistically similar. At 90 DAP, the maximum width of leaf was in T_1V_1 (6.88 cm), T_1V_2 (6.33 cm), T_1V_3 (6.22 cm), T_2V_1 (6.33 cm) andT_2V_2 (6.55 cm) combinations, which were also statistically similar; and the minimum width of leaf was observed in T_2V_3 (5.66 cm).Then, at 120 DAP, maximum width of leaf was in T_1V_1 (11.88 cm), T_2V_1(11.11 cm) and T_2V_2(11.22 cm) combinations, they were also statistically similar, the minimum was observed in T_2V_3 (9.33 cm).Moreover, the maximum weight of leaf was recorded in T_1V_1 (17.11 cm) combinations and the minimum was found in T_2V_3 (13.77 cm) combinations at 180 DAP. Similar results were found by Chowdhury*et al.* (1992).

Table 3: Interaction effect of different agroforestry production systems and turmeric varieties on width of leaf

Interaction treatments	Width of leaf			
	60DAP (cm)	**90DAP (cm)**	**120 DAP (cm)**	**180 DAP (cm)**
Mango x Thailand (T_1V_1)	4.11a*	6.88a	11.88a	17.11a
Mango x Malshira (T_1V_2)	3.88a	6.33a	10.33ab	15.77ab
Mango x Debipat (T_1V_3)	3.66a	6.22a	10.00ab	15.66ab
Open x Thailand (T_2V_1)	3.77a	6.33a	11.11ab	16.00ab
Open x Malshira (T_2V_2)	4.00a	6.55a	11.22ab	16.33ab
Open x Debipat (T_2V_3)	3.33a	5.66a	9.33b	13.77b
CV%	19.14	17.46	15.89	11.64

*In a column different letters indicate significant differencesat $P \leq 0.05$, 0.01 and 0.001 byTukey HSD test

4.1.4 Number of finger and size of turmeric varieties

The number of fingers is an important quality contributing parameter. The interaction effect of different agroforestry production systems and turmeric varieties on number of finger and size was significantly varied (Table 4). The highest total number of fingers per plot during harvesttime was observed in T_2V_2 (59.22) combination and the lowest total number of fingers was found in T_2V_1 (37.55) combination. The total number of fingers per plot were converted into number of fingers per plant. The highest number of fingers per plant were recorded in T_2V_2 (4.66) and T_2V_3 (4.43) combinations, they were statistically similar. On the other hand the lowest number of fingers per plant were found in T_1V_1 (3.39), T_1V_2 (3.92), T_1V_3 (3.86) and T_2V_1 (3.32) combinations, they were also statistically similar. Length of the largest rhizome and width of the largest rhizome are important quality contributing parameters. The longest length of the largest rhizome was found in T_1V_2 (28.66 cm) combination and the shortest length of the largest rhizome was observed in T_1V_3 (25.24 cm) combination.

Longest width of largest rhizome was observed in T_2V_2(23.77 cm) combination, and the shortest width of largest rhizome was found in T_1V_3 (17.94 cm) combination. Similar resultswere found by Pushkaran*et al.* (1985).

Table 4: Interaction effect of different agroforestry production systems and turmeric varieties on the number of fingers and size of rhizome

Interaction treatments	**No. of fingers/plot**	**No. of fingers/plant**	**Length of largest rhizome (cm)**	**Width of largest rhizome (cm)**
Mango x Thailand (T_1V_1)	42.00a*	3.39a	27.38a	19.84ab
Mango x Malshira (T_1V_2)	53.33a	3.92a	28.66a	20.50ab
Mango x Debipat (T_1V_3)	53.66a	3.86a	25.24a	17.94b
Open x Thailand (T_2V_1)	37.55a	3.32a	27.11a	20.27ab
Open x Malshira (T_2V_2)	59.22a	4.66a	26.97a	23.77b
Open x Debipat (T_2V_3)	56.11a	4.43a	27.22a	19.38b
CV%	35.08	31.65	10.73	14.76

*In a column different letters indicate significant differences at $p \leq 0.05$, 0.01 and 0.001 byTukey HSD test

4.1.5 Quality parameters of turmeric varieties

The number of plants per plot, number of node of fingers per rhizome, length of inter-nodes per finger (cm) and number of shoots per plot are importantquality parameters of turmeric. These varied significantly by different agroforestry production systems (Table 5).The highest number of plants per plot were observed T_1V_2 (13.22) and T_1V_3 (13.77) combinations, which were statistically similar. The lowest number of plants per plot was found in T_2V_1 (11.33) combination.None of the treatments were statistically different.

The highest number of nodes of fingers per rhizome were recorded in T_1V_2 (19.66), T_2V_1 (19.22), T_2V_2 (19.33) and T_2V_3 (19.88) combinations, and lowest was found in T_1V_1 (17.77). However they were statistically similar, on the other hand the lowest was found in T_1V_1 (17.77). The maximum length of internode per finger was recorded in T_1V_1 (4.28 cm), T_2V_1 (4.20 cm), T_2V_2 (4.21 cm) and T_2V_3 (4.44 cm) combinations, they were statistically similar and the minimum was found in T_1V_2 (3.66 cm) and T_1V_3 (3.65 cm) combinations which were also statistically similar. At the number of shoots per plot.,the maximum number of shoots were observed in T_2V_2 (6.77) and T_2V_3 (6.11) combinations which were statistically similar. The minimum were observed in T_1V_1 (5.88), T_1V_2 (5.77), T_1V_3 (5.00) and T_2V_1 (5.44) combinations, and werealso statistically similar. Similar result found by Pushkaran*et al*. (1985).

Table 5: Interaction effect of different agroforestry production systems and turmeric varieties on the quality parameters

Interaction treatments	No. of plants/plot	No. of nodes offinger/rhizome	Length ofinternode/finger(cm)	No. ofshoots/plot
Mango x Thailand (T_1V_1)	12.44ab*	17.77a	4.28a	5.88a
Mango x Malshira (T_1V_2)	13.22a	19.66a	3.66a	5.77a
Mango x Debipat (T_1V_3)	13.77a	18.66a	3.65a	5.00a
Open x Thailand (T_2V_1)	11.33b	19.22a	4.20a	5.44a
Open x Malshira (T_2V_2)	12.77a	19.33a	4.21a	6.77a
Open x Debipat (T_2V_3)	12.77a	19.88a	4.44a	6.11a
CV%	7.83	9.94	18.8	28.03

*In a column different letters indicate significant differences at $p\leq 0.05$, 0.01 and 0.001 byTukey HSD test

4.1.6 Fresh rhizome weight (kg) per plot and dry rhizome weight (g) per plot

Total fresh weight of rhizome of turmeric varieties varied significantly by the effect of different agroforestry production systems (Table 6). The highest total fresh weight of rhizomes were observed in T_2V_2 (2.45 kg) and T_2V_1 (2.09 kg) combinations but were not statisticallysignificantly different. The lowest were observed in T_1V_1 (1.24 kg), T_1V_2 (1.07 kg), T_1V_3 (1.50 kg) and T_2V_3 (1.40 kg) combinations and were also not statistically significantly different from oneanother, however, “mango” treatments were significantly different from “Open” treatments, except for “Open x Debipat (T_2V_3).

Dry weight of rhizome of turmeric varieties per plot varied significantly by the effect of different agroforestry production systems (Table 6). The highest dry weight of rhizome was observed in T_1V_1 (22.33 g) combination, and the lowest dry weight of rhizome was found in T_2V_3 (17.33 g) combination.

Similar results were reported by Srikrishnah and Sutharsan (2015) who found that 50 % shade level is suitable for the cultivation of turmeric.

Table 6: Interaction effect of different agroforestry production systems and turmeric variety on fresh rhizome weight and dry rhizome weight

Interaction treatments	Total fresh weight ofrhizomes(kg/plot)	Dry weight of rhizomes (100g/plot)
Mango x Thailand (T_1V_1)	1.24bc*	22.33a
Mango x Malshira (T_1V_2)	1.07c	20.33c
Mango x Debipat (T_1V_3)	1.50bc	18.33e
Open x Thailand (T_2V_1)	2.09ab	21.33b
Open x Malshira (T_2V_2)	2.45a	19.33d
Open x Debipat (T_2V_3)	1.40bc	17.33f
CV%	38.30	2.23

*In a column different letters indicate significant differencesat *p*≤ 0.05, 0.01 and 0.001 byTukeyHSD test

4.1.7 Fresh rhizome weight (kg) per hectare and dry rhizome weight (kg) per hectare

Fresh weight (kg) of rhizome was converted per plant to per hectare. Therefore, maximum fresh rhizome weight per hectare was recorded in T_2V_2 (13611 kg) combination and minimum fresh weight of rhizome per hectare was found in T_1V_2 (5944 kg) combination.Dry weight of rhizome of turmeric per plot varied significantly by the interaction effect of different agroforestry production systems and turmeric varieties. The maximum dry weight of rhizome was found in T_2V_2 (2631 kg) combination. Moreover, the minimum dry weight of rhizome was observed in T_1V_2 (1208 kg) combination. Similar resultswere reported by Hossain*et al.* (2005).

Table 7: Interaction effect of different agroforestry production systems and turmeric varieties on fresh rhizome weight and dry rhizome weight per hectare

Interaction treatments	Fresh weight of rhizomes (kg/ha)	Dry weight of rhizomes (kg/ha)
Mango x Thailand (T_1V_1)	6888	1538
Mango x Malshira (T_1V_2)	5944	1208
Mango x Debipat (T_1V_3)	8333	1527
Open x Thailand (T_2V_1)	11611	2476
Open x Malshira (T_2V_2)	13611	2631
Open x Debipat (T_2V_3)	7777	1348
CV%	38.30	2.23

*In a column different letters are significantly different at P≤ 0.05, 0.01 and 0.001 byTukey HSD test

Conclusion

From the results it can be concluded that between the two production systems, the growth and quality of turmeric with germination speed was better under mango shade than open conditions. On the other hand,a higher yield was found in open control plants than mango shade plants. Between turmeric varieties, Malshira performed better than Thailand and Debipat varieties. Fresh rhizome turmeric yield increased with an increasing rate of light intensity.

Reference:

Purseglove, J.W.G., Brown, C.L. and Robbins, S.R.J. (1981). Spices. Longman scientificTechnical Co-published in the United States with John Wiley& sons, Inc., New York. Vol., 2:457.

Nair, P.K.R. (1990). An Introduction to Agroforestry. Kluwer Academy Publishers, ICRAF. pp: 37-54.

Miah, M.G., Garriry, D.P. and Agron, M.L. (1995). Light availability to the understorey annual crops in an agroforestry system. In: Sinoquet, H. and P. Cruz (ed). Ecophysiology of tropical inter cropping. IRNA Editions, Paris, France. pp. 265-274.

Siddique, A.B. (1995). Importance of vegetables and spices production. Horticulture Research and Development project, Dhaka.

Garrity, D.P., Akinnifesi, F.K., Ajayi, O.C., Weldesemayat, S.G., Mowo, J.G., Kalinganire, A., Larwanou, M. and Bayala, J. (2010). Evergreen agriculture: a robust approach to sustainable food security in Africa. Food Secur. 2(3):197-214.

Chowdhury, M.K. and Satter, M.A. (1992). Agroforestry practice in traditional farming system of Bangladesh. A report prepared for BARC/Winrock Intl., Dhaka, Bangladesh.

Pushkharan, K., Babylatha, A.K. and George, K.M. (1985). Comparative performance of turmeric varieties in coconut gardens. South Indian Hort. 33:269-270.

Srikrishnah, S. and Sutharsan, S. (2015). Effect of different shade level on growth and tuber yield of turmeric (*Curcuma longa* L.) in the Batticaloa district of Sri Lanka. American-Eurasian J. Agric. & Environ. Sci. 15:813-816.

Hossain, M. A., Ishimine, Y., Akamine, H. and Motomura, K. 2005. Effects of seed rhizome size on growth and yield of Turmeric (*Curcuma longa* L.). Plant Prod. Sci. 8:86-94.