Original Research Article

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

ABSTRACT

An experiment was conducted in the research field of the Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur during 24 March 2018 to 10 January 2019, in order to investigate the growth and yield of different turmeric varieties under mango tree and open control. The experiment was 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; another 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 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). And the highest dry weight of rhizome 2126 kg/ha was found in (T_2) and lowest 1456 kg/ha was observed 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, on the other hand 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*), belonging to the Zingiberaceae family is one of the most useful herbal medicinal plants. Turmeric is a very important spices as well as a medicinal plant in Bangladesh. Common Bangladeshi people traditionally use various spices in curry in their daily life. Among them, turmeric (*Curcuma longa*) is the most important one. Besides making curries, it is also used for medicine as a carminative and aromatic stimulant to be the gastrointestinal tract (Purseglove *et al.,* 1981) and many other purposes. In addition, turmeric is a highly valued crop having good local as well as export potentials (Siddique, 1995). But total production of turmeric is 117 thousand metric tons from 21.41 thousand hectors land (BBS, 2011). The demand of turmeric for home consumption is increasing day by day with the over increasing population of Bangladesh and demand is worldwide also increasing.Turmeric has been traditionally known as shade loving spices crops of Bangladesh. It can be cultivated in most areas of the tropics and subtropics provided that rainfall inadequate or 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 rain above 2000 mm per annum. It can be grown up to an altitude of 1220 m in the Himalayan foothills (Purseglove *et al.,* 1981). The humus-rich virgin soil of hill and forest 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 on the same area of land is a promising production system for maximizing yield (Nair, 1990) and maintaining friendly environment all over the world including Bangladesh. Under 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 like ginger, turmeric, etc.

Again, mango is the king of oriental fruits belongs to the genus Mangifera of the family Anacardiaceae. Again Mango is a major fruit in the northern part of Bangladesh especially in the Dinajpur region due to its edaphic-climatic adaptability. In Dinajpur region, the 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. So, we should develop some protocol and findings which are beneficial for growers. Keeping this view in mind, we want to conduct the research on mango based agroforestry system 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 local techniques. In this condition, 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 present research work was carried out at a farmer's 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 & 88˚23' longitudes at the elevation of 38m above the 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 (very acidic).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 tested at the Regional Laboratory, SRDI, Dinajpur.

2.1.2. Climate

The climate of the study area is characterized by a heavy rainfall during 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 maximum temperature in the summer (March to September, 2018) was 35℃ and the mean maximum temperature in the winter (November, 2018 to January, 2019) 11.9℃. The humidity was 87% in January and 88% in July. The mean annual rainfall was 1822mm most of which occurred in during June-September and light showers occurs during the Rabi season (October, 2018January, 2019).

2.2 Experimental Designs

The experiments were laid out in the 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×3m.But for data analysis, the plot size was measured as 3m×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 place+ 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 variety of turmeric were planted maintaining a line to line distance of 60 cm, plant to plant 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 is done as felt necessary. 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 Manure,

Fertilizer Recommended doses of fertilizers were used as Urea (N@135 kg/ha), TSP (P2O5@30 kg/ha), MP (K2O@90 kg/ha), Gypsum (S@10 kg/ha), Zinc Sulfate (Zn@2 kg/ha), Borax (B@1.5 kg/ha), Cowdung (5 ton/ha).

2.6 Data Collection

- **During germination period**

Germination data: Number of plants was counted after 10 days by turns after germination of turmeric plants within 140 days after planting (DAP). Germination speeds were calculated as followed by (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 the 10 days, 20 days , 30 days,…. 140 days.

Data were collected to the following parameters

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

- **During harvesting period**

1. Number of plant per plotTotal number of fingers per plot:
2. Number of finger per plant:
3. Length of biggest rhizome (cm):
4. Width of biggest 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 an LUX meter (Hanna company) before the harvesting at the time of 10 am, 1pm and 4 pm.

2.8 Data analyses

Means of each parameter were separated by TUKEY HSD - multiple comparison method. A two way interaction were obtained by factorial analysis of anova (AOV).All data were analyzed by the help of computer system STATISTIX 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 the plant height of turmeric was found significantly different at different days after planting (DAP) .The tallest plant was recorded in T_1V_2 (28.22 cm) combination at the 60 DAP and the lowest plant height was found in T_2V_3 (20.77 cm) combination. Again, at 90 DAP, the tallest plant height was observed in T_1V_3 (70.88 cm) combination, which was followed by T_2V_1 (31.55cm) combination. Then, at 120 DAP, the tallest plant height was recorded in T_1V_3 (97.00 cm) combination and the lowest plant height was found in T_2V_1 (45.44 cm) combination.
Moreover, the tallest plant height was observed in T_1V_3 (131.33 cm) combination, and the shortest plant height was recorded in T_2V_3 (85.56 cm) combination at 180 DAP.

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

Interaction treatments	Plant height	Plant height	Plant height	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 are significantly different at P≤ 0.05, 0.01 and 0.001 by Tukey HSD test

4.1.2 Length of leaf (cm)

The length of leaf blade of turmeric varied significantly by the interaction effect of different agroforestry production systems, and turmeric varieties at diffferent days after planting (DAPs). The longest length of leaf blade was observed in T_1V_3 (27.66 cm) combination and the shortest was found in T_2V_1 (16.55 cm) combination at 60 DAP. Then, at 90 Dap, the longest length of leaf blade was observed in T_1V_3 (36.00 cm) combination and the shortest was recorded in T_2V_1 (16.33 cm) combination. Again the longest length of leaf blade was observed in T_1V_3 (51.00 cm) combination and the shortest was found in T_2V_1 (25.22 cm) combination at 120 DAP. Moreover, at 180 DAP, the longest length of leaf blade was found inT_1V_3 (63.88 cm) combination and the shortest was observed in T_2V_3 (41.44 cm) combination. Garrity *ET AL.* (1992) observed number of leaf per plant affected minimum due to shadding condition in mixed cropping of turmeric.

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

Interaction treatments	Length of leaf 60DAP (cm)	Length of leaf 90DAP (cm)	Length of leaf 120DAP (cm)	Length of leaf 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 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 are significantly different at P≤ 0.05, 0.01 and 0.001 by Tukey 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 days after planting (DAPs).The maximum width of leaf were 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 were recorded in T_1V_1 (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 almost statistically similar. At 90 DAP, the maximum width of leaf were found 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 almost 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 were found in T_1V_1 (11.88 cm), T_2V_1(11.11 cm) and T_2V_2(11.22 cm) combinations, they were almost 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 variety on width of leaf

Interaction treatments	Width of leaf 60DAP (cm)	Width of leaf 90DAP (cm)	Width of leaf 120 DAP (cm)	Width of leaf 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 are significantly different at P≤ 0.05, 0.01 and 0.001 by Tukey HSD test

4.1.4 Number of finger and size of turmeric varieties

Number of finger is an important quality contributing parameter. The interaction effect of different agroforestry production systems and turmeric varieties on number of finger and size of turmeric varieties were significantly varied. The highest total number of finger per plot during harvesting time was observed in T_2V_2 (59.22) combination and the lowest total number of finger was found in T_2V_1 (37.55) combination. Then the total number of finger per plot were converted into number of finger per plant, the highest number of finger per plant were recorded in T_2V_2 (4.66) and T_2V_3 (4.43) combinations, they were almost statistically similar. On the other hand the lowest number of finger per plant were observed 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 almost statistically similar. Length of the biggest rhizome and width of the biggest rhizome are important quality contributing parameters. The highest length of biggest rhizome was found in T_1V_2 (28.38 cm) combination and the shortest length of the biggest rhizome was observed in T_1V_3 (25.24 cm) combination. Again, longest width of biggest rhizome was observed in T_2V_2(23.77 cm) combination, on the other hand, the lowest width of biggest rhizome was found in T1V3 (17.94 cm) combination. Similar result found by Pushkaran *ET AL.* (1985).

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

Interaction treatments	Total no.of finger per plot	No.of finger per plant	Length of the biggest rhizome(cm)	Width of the biggest 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 are significantly different at P≤ 0.05, 0.01 and 0.001 by Tukey HSD test

4.1.5 Quality parameters of turmeric varieties

The Number of plant per plot, number of node of finger per rhizome, length of inter-node per finger (cm) and number of shoot per plot are importantquality parameters of turmeric. Those were varied significantly by different agroforestry production systems.

The tallest number of plant per plot were observed T_1V_2 (13.22) and T_1V_3 (13.77) combinations which were statistically similar, The lowest number of plant per plot was found in T_2V_1 (11.33) combination and the moderate were recorded in T_1V_1 (12.44), T_2V_2 (12.77) and T_2V_3 (12.77) combinations which were almost statistically similar.

Then, the highest number of node of finger 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, they were statistically almost similar, on the other hand the lowest was found in T_1V_1 (17.77) and the moderate wasobserved in T_1V_3 (18.66) combination. Again, the maximum length of internode per finger were 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 almost 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 shoot per plot, The maximum number of shoot 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, they also were almost statistically similar. Similar result found by Pushkaran *ET AL.* (1985).

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

Interaction treatments	No. of plant per plot	No. of node of finger per rhizome	Length of internode per finger(cm)	No. of shoot per 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 are significantly different at P≤ 0.05, 0.01 and 0.001 by Tukey HSD test

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

Fresh weight of rhizome of turmeric varieties was varied significantly by the effect of different agroforestry production systems. The highest total fresh weight of rhizome were observed in T_2V_2 (2.45 kg) and T_2V_1 (2.09 kg) combinations, those data were almost statistically similar and 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, those data were also statistically similar.

Again dry weight of rhizome of turmeric varieties per plot was also varied significantly by the effect of different agroforestry production systems. The highest dry weight of rhizome was observed in T_1V_1

(22.33 g) combination, the lowest dry weight of rhizome was found in T_2V_3 (17.33 g) combination. Similar results have been also reported by Srikrishnah and Sutharsan (2015) who reported 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 of rhizome kg/plot	Dry weight of rhizome 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 are significantly different at P≤ 0.05, 0.01 and 0.001 by Tukey HSD test

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

Fresh weight (kg) of rhizome was converted per plant to per hectare. So, 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.

Again, dry weight of rhizome of turmeric per plot was also 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 result found in Hossain *ET AL*., 2005a.

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

Interaction treatments	Fresh weight of rhizome kg/ha	Dry weight of rhizome 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 by Tukey HSD test

Conclusion

From the above results and discussion it can be concluded that among the two production systems, the growth and quality of turmeric with it is germination speed was better under mango shade than open condition. On the other hand the highest yield was found better in open control than mango shade. Between turmeric varieties, malshira did better performance than thailand and debipat varieties. Surprisingly that fresh rhizome turmeric yield was increased with the increasing rate of light intensity.

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