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Varietal Performance of Turmeric under Mango Based Agroforestry System

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Abstract

An experiment was carried out at the Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, during April, 2014 to January 2015. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. Among the two factors, one factor like A was two production systems: S_1 = Mango + Turmeric and S_2 = Turmeric (sole crop); another factor like B was three turmeric variety: V_1 = BARI Holud-1, V_2 = BARI Holud-2 and V_3 = BARI Holud-3. So, the treatment combinations were: S_1V_1 = Mango + BARI Holud-1, S_1V_2 = Mango + BARI Holud-2, S_1V_3 = Mango + BARI Holud-3, S_2V_1 = sole cropping of BARI Holud-1, S_2V_2 = sole cropping of BARI Holud-2 and S_2V_3 = sole cropping of BARI Holud-3. The result of the experiment revealed that interaction effect of production systems and variety was found significant on plant height, number of leaf per plant, length of leaf blade, breadth of leaf blade, number of finger per rhizome, fresh and dry yield per hectare. The higher fresh yield of turmeric (34.75 t/ha) and dry yield (6.10 t/ha) was found from S_1V_1 treatment (Mango + BARI Holud-1). Whereas the lowest fresh yield (33.41 t/ha) and dry yield (4.93 t/ha) was found from S_2V_2 treatment (sole cropping of BARI Holud-2). However, the suitability of the cultivation of different turmeric variety under mango based agroforestry systems may be ranked as $S_1V_1 > S_2V_1 > S_1V_3 > S_2V_3 > S_1V_2 > S_2V_2$. Finally it may be concluded that, BARI Holud-1 would be the best variety to be grown under mango based agroforestry.

Keywords

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

1. Introduction

Turmeric is 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 the gastrointestinal tract [1] and many other purposes. In addition, turmeric is a high valued crop having good local as well as export potentials [2]. But total production of turmeric is 117 thousand metric tons from 21.41 thousand hectors land [3]. The demand of turmeric for home consumption is increasing day by day with the over increasing population of Bangladesh and their demand is worldwide also increasing. Tropics and subtropics provided that rainfall is adequate or facilities for irrigation are available. It is usually grown in regions with an annual rainfall of 1000 - 2000 mm. But its' 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 [1]. Turmeric has been traditionally known as shade loving spices crops of Bangladesh. These spices crops are grown under partial shade condition but their degrees of shade tolerance and which variety is good under shade have not yet been standardized from the scientific point of view.

Again, mango is the king of oriental fruits belongs to the genus *Mangifera* of the family Anacardiaceae. The genus *Mangifera* contains several species that bear edible fruit. Mango has become naturalized and adapted throughout the tropics and subtropics. Mango plays an important part in the diet and cuisine of many diverse cultures. This delicious fruit is particularly rich in nutrients such as protein, vitamin A, fiber, thiamine, ascorbic acid etc. The fruit is eaten as green, processed pickles, pulps, jams and is frozen or dried. Mango trees are usually between 3 and 10 m (10 - 33 ft) tall but can reach up to 30 m (100 ft) in some forest situation. The canopy is evergreen. Mango trees are recognized as national tree of Bangladesh, and eaten throughout the world. Mango covered 78,196 acres area under garden having total production of 304,187 metric tons in 2007-2008 [4]. Now a day's turmeric is grown in association with mango by farmers but without much scientific consideration. Many modern varieties of turmeric have been released by Spices Research Centre, BARI in Bangladesh. But the varietal performance under mango based agroforestry is not tested scientifically. Keeping this view in mind, this research has been conducted on mango based agroforestry system in order to evaluate the performance of three turmeric varieties and identify the best variety under mango based Agroforestry system.

2. Materials and Methods

2.1 Experimental Site Description

The experimental site was selected in the existing Mango orchard of the Agroforestry & Environment Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. The geographical location of the

site was between 25˚13' latitude and 88˚23' longitude.

2.1.1. Soil Characteristics

The experimental plot was situated in a medium high land belonging to the old Himalayan Piedmont Plain area (AEZ 01). Land was well-drained as drainage system was well developed. The soil texture was sandy loam in nature. The soil contains Sand = 65%, Silt = 30%, Clay = 5%, CEC (meq/100g) = 8.07, pH = 5.35, Organic matter = 1.06%, Total nitrogen = 0.10%, Sodium (meq/100g) = 0.06, Calcium (meq/100g) = 1.30, Magnesium (meq/100g) = 0.40, Potassium (meq/100g) = 0.26, Phosphorus (µg/g) = 24.0, Sulphur (µg/g) = 3.2, Boron (µg/g) = 0.27, Iron (µg/g) = 5.30 and Zinc (µg/g) = 0.90

2.1.2. Climate

The experimental site was situated under the tropical climate characterized by heavy rainfall from July to August and scanty rainfall the rest period of the year. In April, May, June, July, August, September, October, November, December 2014 and January 2015 maximum air temperature was (32.8˚C, 13.9˚C, 33.2˚C, 32.0˚C, 32.4˚C, 32.0˚C, 31.6˚C, 28.70˚C, and 27.20˚C) and Minimum (21.1˚C, 21.5˚C, 23.2˚C, 25.8˚C, 26.2˚C, 25.0˚C, 21.0˚C, 19.68˚C, 18.45˚C, and 16.10˚C), RH (83%, 77%, 82%, 85%, 84%, 89%, 90%, 24.77%, 23.56% and 21.65%) and total Rainfall (54, 213, 333, 369, 466, 97, 10, 5, 18 and 12 mm).

2.2. Experimental Period

Duration of the experiential period was from April 2014 to February 2015.

2.2.1. Seed Collections

Turmeric rhizome was collected from spices research center, Bangladesh Agriculture Research Institute, Bogra.

BARI Holud-1: Plant height long, life cycle 270 - 280 days, fresh Rhizome weight 400 - 420 g/plant, number of finger/rhizome 7 - 8, Yield 35 - 40 T/h.

BARI Holud-2: Plant height medium, life cycle 270- 290 days, fresh Rhizome weight 375 - 380 g/plant, number of finger/rhizome 7 - 8, Yield 30 - 35 T/h, color deep yellow.

BARI Holud-3: Plant height medium, life cycle 270 - 290 days, fresh Rhizome weight 400 - 420 g/plant, number of finger/rhizome 7 - 8, Yield 30 - 35 T/h, color deep yellow.

2.2.2. Experimental Design

The experiment was laid out following a two factorial Randomized Complete Block Design (RCBD) with three replications. Total number of experimental plot was 9. The size of each unit plot was 5 m × 5 m. Among the two factors, factor A was two production systems; S_1 = Mango + Turmeric, S_2 = Turmeric on sole cropping. Another factor B was three Turmeric varieties; V_1 = BARI Holud-1, V_2 = BARI Holud-2, V_3 = BARI Holud-3. So there were 6 treatments combinations and these were; S_1V_1 = Mango + BARI Holud-1, S_1V_2 = Mango + BARI Holud-2,

S_1V_3 = Mango + BARI Holud-3, S_2V_1 = sole cropping of BARI Holud-1, S_2V_2 = sole cropping of BARI Holud-2, and S_2V_3 = sole cropping of BARI Holud-3.

2.2.3. Structural Description of the Treatments

1st layer (upper layer): Mango tree, Scientific name: *Mangifera indica* L., Variety: Amropali, Family: Anacardiaceae, Spacing: 5 m × 5 m, Establishment: 2008, Planting direction: East-West, 2nd layer was turmeric.

2.2.4. Crop Establishment

The seed rhizome of turmeric was planted maintaining a row to row distance of 50 cm, a plant to plant distance of 25 cm and a depth of 10 cm. The weight of each seed-rhizome was of 15 - 20 g.

2.2.5. 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.

2.2.6. Application of Manure, Fertilizer

Recommended doses of fertilizers were used as Urea (N@135 kg/ha), TSP (P_2O_5@30 kg/ha), MP (K_2O@90 kg/ha), Gypsum (S@10 kg/ha), Zinc Sulfate (Zn@2 kg/ha), Borax (B@1.5 kg/ha), Cowdung (5 ton/ha).

2.3. Data Collection

The heights were measured from the ground level to the tip of the longest shoot at an interval of 30 days starting from 90, 120, 150, 180 and 210 DAP. The number of tillers per plant, number of leaves per plant, length of leaf blade and breath of leaf blade data are collected at an interval of 30 days starting from 90, 120, 150, 180 and 210 DAP. The number of finger per selected plant was counted at harvest time. The weight of fresh rhizome per selected plant was recorded with the help of a balance at the time of harvest. After harvest, rhizome of 10 selected plants were weighed and dried in an oven for 24 hours at 70˚C till constant weight. After drying the dry rhizome weighed and mean weight was calculated.

2.4. Data Analysis

Data were statistically analyzed using the "Analysis of variance" (ANOVA) technique with the help of computer package MSTAT-C. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT) [5].

3. Results

The tallest plant of turmeric (66.63 cm, 83.44 cm, 109.40 cm 129.10 cm and 102.8 cm at 90 DAP, 120 DAP, 150 DAP, 180 DAP and 210 DAP) was recorded in S_1V_1 (Mango + BARI Holud-1) treatment combination. On the other hand,

the shortest plant of turmeric (49.60 cm, 64.53 cm, 71.23 cm, 94.47 cm and 68.20 cm at 90 DAP, 120 DAP, 150 DAP, 180 DAP and 210 DAP) was recorded in S_2V3 (Sole cropping of BARI Holud-3) (Table 1). Again, the highest number of tiller per plant (2.33, 2.73 3.26 and 4.03, respectively at 90 DAP, 120 DAP, 150 DAP, 180 DAP and 210 DAP) was recorded in S_1V_1 (Mango + BARI Holud-1) treatment and lowest number of tiller per plant (1.53, 1.86, 2.43 and 2.86 at 90 DAP, 120 DAP, 150 DAP, 180 DAP and 210 DAP) was recorded in S_2V_2 (Sole cropping of BARI Holud-2) (Table 1). Consequently, the maximum number of leaves per plant (8.03, 10.03, 14.73, 15.73 and 12.03 at 90 DAP, 120 DAP, 150 DAP, 180 DAP, 210 DAP) was recorded in S_1V_1 (Mango + BARI Holud-1) treatment. On the other hand, minimum number of leaves per plant (6.16, 8.16, 12.13, 12.53 and 9.33 at 90 DAP, 120 DAP, 150 DAP, 180 DAP, 210 DAP) was recorded in S_2V_1 (Sole cropping of BARI Holud-3) treatment (Table 2). Similarly, the longest length of leaf blade of turmeric (45.83 cm, 54.10 cm, 62.07 cm, 68.47 cm and 60.40 cm, respectively at 90, 120, 150, 180 and 210 DAP) was recorded in S_2V_1 (Mango + BARI Holud-1) treatment. On the other hand, the shortest length of leaf blade of turmeric (28.37 cm, 38.03 cm, 46.87 cm, 54.10 cm and 46.17 cm at 90, 120, 150, 180 and 210 DAP) was recorded in S_2V_3 (Sole cropping of BARI Holud-3) treatment combination (Table 2). Once more, the widest leaf blade of turmeric (11.03 cm, 13.67 cm, 16.40 cm, 18.80 cm and 15.13 cm at 90, 120, 150, 180 and 210 DAP) was recorded in S_1V_1 (Mango + BARI Holud-1) treatment. On the other hand, the leaf blade with minimum breadth (8.067 cm, 10.83 cm, 13.17 cm, 14.97 cm and 12.57 cm at 90, 120, 150, 180 and 210 DAP) was recorded in S_2V_3 (Sole cropping of BARI Holud-3) treatment (Table 3). Significantly, the highest number of finger per plant (25.0) was recorded in S_1V_1 (Mango + BARI Holud-1) treatment combination. On the other hand the lowest (16.67) was recorded under S_2V_3 (Sole cropping of BARI Holud-3) treatment (Table 4). Again, the highest fresh weight of rhizome per plant

Table 1. Interaction effect of production systems and turmeric variety on plant height and number of tiller/plant at different DAP.

Treatments	Plant height					Number of tiller/plant				
	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP
S_1V_1	66.63a	83.44a	109.40a	129.10a	102.80a	2.33a	2.73a	3.26a	4.03a	4.03a
S_1V_2	61.17c	70.65c	86.27c	106.50c	81.60c	1.73ab	2.13ab	2.56ab	3.06bc	3.06bc
S_1V_3	56.40d	67.30d	83.57c	101.40d	74.53d	2.03ab	2.33ab	2.76ab	3.26bc	3.26bc
S_2V_1	63.37b	77.57b	103.00b	116.10b	95.07b	2.13ab	2.53ab	3.13ab	3.73ab	3.73ab
S_2V_2	53.73e	65.14de	78.63d	100.50d	72.40d	1.53b	1.86b	2.43b	2.86c	2.86c
S_2V_3	49.60f	64.53e	71.23e	94.47e	68.20e	2.13ab	2.53ab	2.73ab	3.23bc	3.23bc
CV (%)	1.52	2.11	2.15	1.92	1.43	15.38	14.53	13.38	11.02	11.02

(Note: Means with similar letter (s) in column of the table do not differ significantly by DMRT at P > 5% level).

Table 2. Interaction effect of production systems and turmeric variety on Number of leaf/plant and Length of leaf blade at different DAP.

Treatments	Number of leaf/plant					Length of leaf blade				
	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP
S_1V_1	8.03a	10.03a	14.73a	15.73a	12.03a	45.83a	54.10a	62.07a	68.47a	60.40a
S_1V_2	6.96b	8.83c	12.60c	13.63b	10.57bc	34.67c	42.80c	52.07c	59.33c	50.33c
S_1V_3	6.73b	8.33d	12.17c	13.13b	9.733c	31.23e	40.63d	49.93d	55.83d	48.77d
S_2V_1	7.16ab	9.56b	14.23b	15.17a	11.63ab	43.67b	52.23b	60.20b	66.03b	58.23b
S_2V_2	6.33b	8.53cd	12.20c	12.73b	9.333c	32.60d	40.03d	49.77d	56.57d	48.47d
S_2V_3	6.16b	8.16d	12.13c	12.53b	9.533c	28.37f	38.03e	46.87e	54.10e	46.17e
CV (%)	7.72	2.81	2.06	1.65	6.22	1.58	1.64	1.37	1.00	4.8

(Note: Means with similar letter (s) in column of the table do not differ significantly by DMRT at P > 5% level).

Table 3. Interaction effect of production systems and turmeric variety on breadth of leaf blade of turmeric at different DAP.

Treatments	Breadth of leaf blade				
	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP
S_1V_1	11.03a	13.67a	16.40a	18.80a	15.13a
S_1V_2	9.13b	11.77b	14.87bc	16.23c	13.20c
S_1V_3	8.43cd	11.17bc	13.47de	15.63cd	12.83c
S_2V_1	10.60a	13.13a	15.37b	18.07b	14.23b
S_2V_2	8.73bc	11.30bc	14.07cd	15.57cd	12.87c
S_2V_3	8.06d	10.83c	13.17e	14.97d	12.57c
CV (%)	3.61	2.70	3.04	2.16	3.40

(Note: Means with similar letter (s) in column of the table do not differ significantly by DMRT at P > 5% level).

of turmeric (434.30 g) was recorded in S_1V_1 (Mango + BARI Holud-1) treatment. On the other hand the lowest fresh weight of rhizome per plant of turmeric (356.70 g) was recorded in S_2V_2 (Sole cropping of BARI Holud-2) treatment combination (Table 4). Similarly the highest dry weight of rhizome per plant of turmeric (75.13 g) was recorded in S_1V_1 (Mango + BARI Holud-1) treatment. On the other hand the lowest fresh weight of rhizome per plant of turmeric (61.63 g) was recorded in S_2V_2 (Sole cropping of BARI Holud-2) treatment combination (Table 4). Consequently, the highest fresh yield (34.75 t/ha) was recorded in S_1V_1 (Mango + BARI Holud-1) treatment and the lowest yield (28.53 t/ha) was recorded in S_2V_2 (Table 4). Similar trend was recorded in case of dry yield. The highest dry yield (6.01 t/ha) was recorded in V_1S_1 (Mango + BARI Holud-1) treatment and the lowest yield (4.93 t/ha) was recorded in S_2V_2 (Sole cropping of BARI Holud-2) treatment combination (Table 4).

Table 4. Interaction effect of production systems and turmeric variety on fresh and dry yield of turmeric (tha^{-1}).

Treatments	No. of finger/plant	Fresh wt. of rhizome/plant	Dry wt. of rhizome/plant	Fresh yield (t/ha)	Dry yield (t/ha)
S_1V_1	28.00a	434.30a	75.13a	34.75a	6.01a
S_1V_2	23.33cd	370.00de	63.98de	30.80c	5.11de
S_1V_3	24.67bc	408.30bc	69.68bc	32.53bc	5.56bc
S_2V_1	26.33ab	417.70ab	72.10ab	33.41ab	5.76ab
S_2V_2	21.67d	356.70e	61.63e	28.53d	4.93e
S_2V_3	21.33d	389.00cd	66.20cd	31.12c	5.28cd
CV (%)	5.67	3.23	3.06	3.03	2.98

(Note: Means with similar letter (s) in column of the table do not differ significantly by DMRT at P > 5% level).

4. Discussion

The research revealed that the highest plant height, number of tillers per plant, number of leaves per plant, length of leaf blade and breath of leaf blade were found on BARI Holud-1of Turmeric variety under mango tree. It may be due to that this variety may have high efficiency of using space, air, water and sunlight. It also may have high genetic vigor than other variety. The present study revealed that the plant height increased with the decrease of light levels. Plant height depends on a number of factors such as availability of required quality of water, mineral nutrients, quantity, quality and duration of light, temperature, area of growing space and genetic set-up of the plants. Hillman [6] reported that, plant grown in low light levels was found to be more apical dominant than those grown in high light environment resulting in taller plants under shade. Similar result was mentioned by [7] and [8]. In case of number of leaf per plant, the finding was in agreement with the findings of [9] who stated that, cooler temperatures promote lower number of total leaf and numbers of branches. Again in case of, length of leaf blade of turmeric due to the situation of cellular expansion and cell division of leaves under shaded condition [10] Similar result was also found by [7] for breadth of leaf blade of turmeric. The reason of maximum yield of turmeric in Agroforestry system might be that the early stage of mango tree canopy did not affect much the lower story turmeric crop whereas turmeric is a shade loving crop. Similar result was obtained by some researchers such as [11] and [12]. On the other hand crop growth is mainly affected by light and nutrient availability. Leaf litter inputs from agro-forestry trees could provide sufficient nutrients and organic matter to sustain crop growth that may improve crop yield. Similar results were observed by [13].

5. Conclusion

The findings of the present investigation indicate that diversification of farming

system and growing turmeric as ground layers crops in mango tree orchard is a viable option for increasing income of farmers. One turmeric variety like BARI Holud-1 has been grown successfully as intercrops in the floor of mango tree orchard. The presence of tree canopies did not influence on the growth and yield of turmeric variety so much. Moreover, among the three turmeric varieties, BARI Holud-1 gave the better yield both in the mango based agroforestry systems as well as in sole cropping. However, the suitability of the cultivation of different turmeric variety under mango based agroforestry systems may be ranked as $S_1V_1 > S_2V_1 > S_1V_3 > S_2V_3 > S_1V_2 > S_2V_2$. Finally it may be concluded that, BARI Holud-1 would be the best variety to be grown under mango based agroforestry.

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