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Influence of Planting Methods, Intercrop and Integrated Weed Management Practices on Yield of Turmeric (*Curcuma domestica Val.*)

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Abstract

A field experiment was conducted during 2013-14 and 2014-15 to study the effect of planting methods, intercropping and integrated weed management practices on yield of turmeric. Two planting methods of turmeric *viz*., paired row of 80/20 cm and paired row 70/30 cm; two intercrops viz., baby corn and greengram and three weed management practices *viz*., non-chemical i.e. mulching followed by four hand weeding at 35, 65, 95 and 140 days after planting (DAP), pre-emergence application of metribuzin @ 500 g ha^{-1} followed by five hand weeding at 35, 65, 95, 140 and 185 DAP and pre-emergence application of oxadiargyl @ 90 g ha^{-1} followed by five hand weeding at 35, 65, 95, 140 and 185 DAP along with one weedy check (control) were evaluated. Turmeric planting in paired row 70/30 cm and intercropping greengram in between paired rows with non-chemical weed management practice by mulching followed by four hand weeding at 35, 65, 95 and 140 DAP ($M_2I_2W_2$) proved superior in most of the attributes studied, followed by paired row 70/30 cm and intercropping baby corn with non-chemical weed management practice by mulching followed by four hand weeding at 35, 65, 95 and 140 DAP ($M_2I_1W_2$).

Keywords: Turmeric; Intercrop; Integrated weed management; Weeds; And yield.

1. Introduction

Turmeric has been famed and valued for its attractive colour and medicinal properties. The virtue of turmeric gives it the name "golden spice" and "spice of life". India is the largest producer, consumer and exporter of turmeric in the world. Turmeric occupies about 6% of the total area under spices and condiments in the country. Because of high curcumin content of Indian turmeric, it is regarded as the best in the world. Though India is in dominant position as far as production; trade etc. of turmeric is concerned, its mean productivity is quite low in comparison to the competitor countries.

There are many factors responsible for low productivity of turmeric in the country. The two such major factors are use of marginal or low productive land for turmeric cultivation and weed infestation. As turmeric is a long duration crop, the marginal and small farmers can hardly spare their land for cultivation of turmeric without a mid-term income. On the other hand, being a rainy season crop and characterized by delayed emergence, slow initial growth, poor canopy development, turmeric encounters severe competition from weeds for production factors. Yield losses of turmeric due to weeds vary from 30-75 per cent [1]. Short duration and price fetching suitable intercrop with turmeric may result in sustainable turmeric cultivation. Simultaneously, suitable integrated weed management practice will check the yield losses. Keeping these in view, the present investigation was undertaken to develop a suitable intercropping and weed management system in turmeric.

2. Materials and Methods

A field experiment was conducted during 2013-14 and 2014-15 in the Instructional-cum- Research Farm of Assam Agricultural University, Jorhat, Assam, India. The soil of the experimental site belonged to order of inceptisol with sandy loam texture. The surface soil, in both the years of experimentation was acidic in reaction, low in organic carbon, medium in available nitrogen and potassium, and low in phosphorus. The experiment was laid out in a factorial randomized block design with three replications and it consisted of twenty treatment combinations including four controls (sole crops) *viz.* $M_1I_1W_1$-80/20 cm; Baby corn; weedy check, $M_1I_1W_2$ -80/20 cm; baby corn;

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straw mulching + 4HW at 35, 65, 95, 140 DAP, $M_1I_1W_3$ -80/20 cm; baby corn; metribuzine (PE) + 5HW at 35, 65, 95, 140 and 185 DAP, $M_1I_1W_4$ -80/20 cm; baby corn; oxadiargyl (PE) + 5HW at 35, 65, 95, 140 and 185 DAP, $M_1I_2W_1$ -80/20 cm; greengram; weedy check, $M_1I_2W_2$ -80/20 cm; greengram; straw mulching + 4HW at 35, 65, 95 and 140 DAP, $M_1I_2W_3$ -80/20 cm; greengram; metribuzine (PE) + 5HW at 35, 65, 95, 140 and 185DAP, $M_1I_2W_4$ -80/20 cm; greengram; oxadiargyl (PE) + 5HW at 35, 65, 95, 140 and 185 DAP, $M_2I_1W_1$ -70/30 cm; baby corn; weedy check, $M_2I_1W_2$ -70/30 cm; baby corn; straw mulching + 4HW at 35, 65, 95 and 140 DAP, $M_2I_1W_3$ -70/30 cm; baby corn; metribuzine (PE) + 5HW at 35, 65, 95, 140 and 185 DAP, $M_2I_1W_4$ -70/30 cm; greengram; oxadiargyl (PE) + 5HW at 35, 65, 95, 140 and 185 DAP, $M_2I_2W_1$ -70/30 cm; greengram; baby corn; weedy check, $M_2I_2W_2$ -70/30 cm; greengram; straw mulching + 4HW at 35, 65, 95 and 140 DAP, $M_2I_2W_3$ -70/20 cm; greengram; metribuzin (PE) + 5HW at 35, 65, 95, 140 and 185 DAP, $M_2I_2W_4$ -70/30 cm; greengram; oxadiargyl (PE) + 5HW at 35, 65, 95, 140 and 185 DAP. Turmeric variety *Lakadong*, baby corn variety G 5414 and greengram variety *Pratap* (SG-1) were planted same day according to the planting method adopted. The recommended production practices of Assam Agricultural University were followed to raise the crops. The data on weed count and dry weight was subjected to square root $\sqrt{(x + 0.5)}$ transformation before statistical analysis to normalize their distribution.

3. Results and Discussion

3.1. Effect on Weeds

During both the years of experimentation, *Elusine indica* (L.) Gaertn., *Digitaria setigera* Roth., *Panicum repens* L., *Cyperus iria* L., *Fimbristylis aestivalis* (Retz.) Vahl., *Borreria articularis* (L.f.) Will, *Commelina diffusa* Burm.f., *Ageratum houstonianum* Mill, *Mimosa diplotricha* C Wright. and *Mimosa pudica* L. were the dominant weed flora. In 2013, the relative density of grasses was higher in initial growth stages of the crops but at later growth stages, broad leaved weeds dominated over other types. However, in 2014, both grasses and broad leaved weeds dominated equally in all the growth stages of turmeric. This result was in conformity with the findings of Bhuvaneswari [2] and Sathiyavani and Prabhakaran [3] who reported that higher population of grass and broad leaved weed flora occurred due to high rainfall. Higher weed continuum recorded during both the years might be due to sufficient rainfall received during cropping period which resulted in ideal field environment for weed growth. All the weed control treatments recorded significantly lower weed density and dry weight (Table.1 and 2) than unweeded check. The paired row planting 70/30 cm compared to 80/20 cm recorded lower weed density and weed dry weight. Intercropping greengram compared to baby corn resulted lower weed density and weed dry weight. Non-chemical weed control method *i.e.* mulching along with four hand weeding at 35, 65, 95 and 140 DAP as compared other weed management treatments recorded lower weed density and weed dry weight.

Table-1. Total weed density at 150 and 180 DAP as influenced by planting methods, intercropping and weed management practices in turmeric

Treatments	Total weed density (No. m^{-2})			
	150 DAP		180 DAP	
	2013	2014	2013	2014
Planting Methods (M)				
M_1 : Paired row 80/20 cm	3.8 (42.8)	3.6 (37.8)	9.9 (102.1)	9.4 (94.8)
M_2 : Paired row 70/30 cm	3.6 (39.5)	3.5 (34.1)	9.5 (96.3)	9.2 (89.2)
SEd (±)	0.013	0.329	0.073	0.037
CD (P=0.05)	0.03	0.07	0.15	0.07
Intercropping (I)				
I_1 : Baby corn	3.7 (40.3)	3.6 (36.3)	9.8 (100.6)	9.4 (93.5)
I_2 : Greengram	3.7 (40.7)	3.5 (35.6)	9.6 (96.3)	9.3 (91.2)
SEd (±)	0.013	0.032	0.073	0.037
CD (P=0.05)	NS	NS	NS	0.07
Weed management (W)				
W_1 : Weedy check (Control)	12.7 (162.0)	12.0 (143.7)	12.8 (164.2)	11.5 (132.0)
W_2 : Non-chemical (mulching + hand weeding at 35, 65, 95 and 140 DAP)	0.7 (0.0)	0.7 (0.0)	6.2 (38.0)	4.9 (24.3)
W_3 : Pre-emergence application of metribuzin @ 500 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	0.7 (0.0)	0.7 (0.0)	9.6 (91.0)	10.1 (101.8)
W_4 : Pre-emergence application of oxadiargyl @ 90 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	0.7 (0.0)	0.7 (0.0)	10.2 (102.8)	10.6 (111.2)

SEd (±)	0.02	0.05	0.10	0.05
CD (P=0.05)	0.04	0.09	0.21	0.11
Treatment Mean	3.7	3.5	9.7	9.3
Control (C)				
C_1 : (Sole turmeric-recommended)	5.4 (28.7)	5.7 (32.0)	6.4 (40.7)	7.3 (52.7)
C_4 : (Sole turmeric-weed free)	0.7 (0.0)	0.7 (0.0)	3.6 (12.7)	2.8 (7.3)
SEd (±)	0.061	6.88E-08	0.125	0.186
CD (P=0.05)	0.26	2.96E-07	0.54	0.80
SEd (±) between				
Treatment mean vs. C_1	0.062	0.024	0.096	0.093
Treatment mean vs. C_4	0.009	0.024	0.122	0.123
CD (P=0.05) between				
Treatment mean vs. C_1	0.17	0.07	0.27	0.25
Treatment mean vs. C_4	0.03	0.07	0.34	0.34

Figures in parenthesis are mean of original values; Data subjected to square root transformation

Table-2. Dry weight of total weed at 150 and 180 DAP as influenced by planting methods, intercropping and weed management practices in turmeric

Treatments	**Dry weight of total weed (g m^{-2})**			
	150 DAP		**180 DAP**	
	2013	**2014**	**2013**	**2014**
Planting Methods (M)				
M_1 : Paired row 80/20 cm	11.3 (128.1)	11.1 (122.9)	12.9 (166.8)	12.6 (158.4)
M_2 : Paired row 70/30 cm	10.8 (116.3)	10.9 (119.4)	12.7 (160.5)	12.3 (151.8)
SEd (±)	0.01	0.01	0.02	0.01
CD (P=0.05)	NS	0.03	0.04	0.02
Intercropping (I)				
I_1 : Baby corn	11.3 (127.1)	11.2 (121.6)	12.9 (164.7)	12.5 (156.4)
I_2 : Greengram	10.8 (117.2)	11.0 (120.6	12.8 (162.6)	12.4 (153.9)
SEd (±)	0.01	0.01	0.02	0.01
CD (P=0.05)	NS	0.03	0.04	0.02
Weed Management (W)				
W_1 : Weedy check (Control)	22.1 (488.7)	22.0 (484.5)	23.2 (538.2)	22.7 (513.7)
W_2 : Non-chemical (mulching + hand weeding at 35, 65, 95 and 140 DAP)	0.7 (0.0)	0.7 (0.0)	3.8 (13.8)	3.6 (12.2)
W_3 : Pre-emergence application of metribuzin @ 500 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	0.7 (0.0)	0.7 (0.0)	6.7 (44.8)	6.8 (45.2)
W_4 : Pre-emergence application of oxadiargyl @ 90 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	0.7 (0.0)	0.7 (0.0)	7.6 (57.8)	7.1 (49.3)
SEd (±)	0.01	0.02	0.03	0.01
CD (P=0.05)	0.03	0.04	0.05	0.03
Treatment Mean	11.1	11.0	12.8	12.5
Control (C)				
C_1 : (Sole turmeric-recommended)	4.1 (16.5)	4.1 (16.5)	5.1 (25.9)	2.5 (29.3)
C_4 : (Sole turmeric-weed free)	0.7 (0.0)	0.7 (0.0)	1.7 (2.3)	1.7 (2.4)
SEd (±)	4.87E-08	4.87E-08	0.16	0.08
CD (P=0.05)	2.09E-07	2.09E-07	0.70	0.33
SEd (±) between				
Treatment mean vs. C_1	0.01	0.01	0.04	0.07
Treatment mean vs. C_4	0.01	0.01	0.15	0.01
CD (P=0.05) between				
Treatment mean vs. C_1	0.01	0.01	0.12	0.20

Treatment mean vs. C_4	0.01	0.01	0.42	0.30

Figures in parenthesis are mean of original values; Data subjected to square root transformation

Table-3. Number of tillers per plant at 140 and 185 DAP of turmeric as influenced by planting methods, intercropping and weed management practices

Treatments	**Number of tillers**			
	140 DAP		**185 DAP**	
	2013	**2014**	**2013**	**2014**
Planting Methods (M)				
M_1 : Paired row 80/20 cm	3.87	4.01	4.70	4.68
M_2 : Paired row 70/30 cm	4.16	4.12	5.05	4.84
SEd (±)	0.08	NS	0.08	0.14
CD (P=0.05)	0.16	NS	0.17	NS
Intercropping (I)				
I_1 : Baby corn	3.78	3.78	4.73	4.73
I_2 : Greengram	4.25	4.35	5.02	4.79
SEd (±)	0.08	0.10	0.08	0.14
CD (P=0.05)	0.16	0.20	0.17	NS
Weed Management (W)				
W_1 : Weedy check (Control)	2.06	1.96	2.67	2.24
W_2 : Non-chemical (mulching + hand weeding at 35, 65, 95 and 140 DAP)	5.81	5.91	6.34	6.32
W_3 : Pre-emergence application of metribuzin @ 500 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	4.26	4.29	5.37	5.38
W_4 : Pre-emergence application of oxadiargyl @ 90 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	3.93	4.10	5.08	5.09
SEd (±)	0.11	0.14	0.12	0.20
CD (P=0.05)	0.23	0.29	0.24	0.40
Treatment Mean	4.02	4.07	4.88	4.76
Control (C)				
C_1 : (Sole turmeric-recommended)	5.90	5.80	7.00	6.80
C_4 : (Sole turmeric-weed free)	6.40	6.27	7.40	7.13
SEd (±)	0.27	0.12	0.06	0.13
CD (P=0.05)	NS	0.52	NS	NS
SEd (±) between				
Treatment mean vs. C_1	0.17	0.12	0.31	0.09
Treatment mean vs. C_4	0.18	0.20	0.26	0.20
CD (P=0.05) between				
Treatment mean vs. C_1	NS	0.34	NS	0.26
Treatment mean vs. C_4	NS	0.57	NS	0.56

Table-4. Leaf area index of turmeric at 140 and 185 DAP as influenced by planting methods, intercropping and weed management practices

Treatments	**Leaf area index**			
	140 DAP		**185 DAP**	
	2013	**2014**	**2013**	**2014**
Planting Methods (M)				
M_1 : Paired row 80/20 cm	14.14	14.47	21.66	26.63
M_2 : Paired row 70/30 cm	15.43	15.43	23.33	23.16
SEd (±)	0.34	0.20	0.06	0.17
CD (P=0.05)	0.69	0.42	0.12	0.34
Intercropping (I)				
I_1 : Baby corn	14.39	14.72	22.05	22.04
I_2 : Greengram	15.18	15.18	22.93	22.74
SEd (±)	0.34	0.20	0.06	0.17
CD (P=0.05)	0.69	0.42	0.12	0.34
Weed Management (W)				
W_1 : Weedy check (Control)	5.64	5.65	7.73	7.62
W_2 : Non-chemical (mulching + hand weeding at 35, 65, 95 and 140 DAP)	22.65	22.67	32.87	32.86
W_3 : Pre-emergence application of metribuzin @ 500 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	16.72	16.68	35.90	25.93
W_4 : Pre-emergence application of oxadiargyl @ 90 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	14.12	14.79	23.56	23.16

SEd (±)	0.48	0.29	0.08	0.24
CD (P=0.05)	0.98	0.58	0.17	0.49
Treatment Mean	14.78	14.95	22.49	22.39
Control (C)				
C_1 : (Sole turmeric-recommended)	29.91	29.89	40.70	39.41
C_4 : (Sole turmeric-weed free)	35.38	35.15	46.86	46.79
SEd (±)	0.10	0.03	0.46	0.07
CD (P=0.05)	0.45	0.15	1.96	0.29
SEd (±) between				
Treatment mean vs. C_1	0.16	0.01	0.43	0.12
Treatment mean vs. C_4	0.18	0.04	0.04	0.10
CD (P=0.05) between				
Treatment mean vs. C_1	0.45	0.03	1.19	0.33
Treatment mean vs. C_4	0.50	0.11	0.11	0.28

Table-5. Number of rhizome and weight of rhizome per plant of turmeric at harvest as influenced by planting methods, intercropping and weed management practices

Treatment	**Number of rhizome per plant**		**Weight of rhizome (g per plant)**	
	2013	**2014**	**2013**	**2014**
Planting Methods (M)				
M_1 : Paired row 80/20 cm	17.88	18.11	340.53	342.58
M_2 : Paired row 70/30 cm	18.56	19.19	355.61	357.59
SEd (±)	0.14	0.25	0.38	0.67
CD (P=0.05)	0.29	0.50	0.78	1.37
Intercropping (I)				
I_1 : Baby corn	17.07	17.75	339.32	340.52
I_2 : Greengram	18.68	19.55	356.83	359.65
SEd (±)	0.14	0.25	0.38	0.67
CD (P=0.05)	0.29	0.50	0.78	1.37
Weed Management (W)				
W_1 : Weedy check (Control)	12.93	14.03	192.30	195.59
W_2 : Non-chemical (mulching + hand weeding at 35, 65, 95 and 140 DAP)	24.36	24.80	460.37	462.35
W_3 : Pre-emergence application of metribuzin @ 500 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	16.89	16.72	388.78	390.58
W_4 : Pre-emergence application of oxadiargyl @ 90 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	17.33	19.06	350.84	351.82
SEd (±)	0.20	0.35	0.54	0.95
CD (P=0.05)	0.41	0.71	1.10	1.94
Treatment Mean	18.22	18.65	348.07	350.08
Control (C)				
C_1 : (Sole turmeric-recommended)	28.06	26.60	551.83	546.77
C_4 : (Sole turmeric-weed free)	29.70	28.00	580.86	579.93
SEd (±)	0.13	0.47	0.94	1.12
CD (P=0.05)	0.57	NS	4.03	4.81
SEd (±) between				
Treatment mean vs. C_1	0.49	0.16	0.45	0.99
Treatment mean vs. C_4	0.41	0.58	0.85	1.32
CD (P=0.05) between				
Treatment mean vs. C_1	1.34	0.43	1.24	2.74
Treatment mean vs. C_4	1.13	1.61	2.36	3.67

Table-6. Fresh and dry yield (t ha^{-1}) of turmeric as influenced by planting methods, intercropping and weeds management practices

Treatments	Rhizome yield (t/ha)			
	Fresh		Dry	
	2013	2014	2013	2014
Planting Methods (M)				
M_1 : Paired row 80/20 cm	23.70	24.04	5.45	5.48
M_2 : Paired row 70/30 cm	24.25	24.63	5.55	5.61
SEd (±)	0.07	0.08	0.02	0.02
CD (P=0.05)	0.14	0.16	0.04	0.04
Intercropping (I)				
I_1 : Baby corn	23.63	23.97	5.43	5.48
I_2 : Greengram	24.33	24.7	5.57	5.62
SEd (±)	0.07	0.08	0.02	0.02
CD (P=0.05)	0.14	0.16	0.04	0.04
Weed Management (W)				
W_1 : Weedy check (Control)	12.11	12.52	2.57	2.51
W_2 : Non-chemical (mulching + hand weeding at 35, 65, 95 and 140 DAP)	32.05	32.42	7.66	7.14
W_3 : Pre-emergence application of metribuzin @ 500 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	26.55	26.78	6.04	6.19
W_4 : Pre-emergence application of oxadiargyl @ 90 g ha^{-1} + hand weeding at 35, 65, 95, 140 and 185 DAP	25.2	25.62	5.71	5.87
SEd (±)	0.10	0.11	0.03	0.03
CD (P=0.05)	0.20	0.23	0.06	0.05
Treatment Mean	23.98	24.33	5.50	5.54
Control (C)				
C_1 : (Sole turmeric-recommended)	37.13	36.8	8.61	8.99
C_4 : (Sole turmeric-weed free)	39.43	38.9	9.12	9.50
SEd (±)	0.21	0.15	0.11	0.14
CD (P=0.05)	0.89	0.66	0.46	NS
SEd (±) between				
Treatment mean vs. C_1	0.09	0.14	0.08	0.08
Treatment mean vs. C_4	0.18	0.19	0.07	0.07
CD (P=0.05) between				
Treatment mean vs. C_1	0.25	0.38	0.21	0.21
Treatment mean vs. C_4	0.49	0.52	0.20	0.19

3.2. Effect on Crop

Planting method of paired row 70/30 cm produced higher leaf area index (15.43 and 23.25 cm at 140 and 185 DAP, respectively) and number of tillers (4.14 and 4.95 at 140 and 185 DAP, respectively) than paired row 80/20 cm. This might be due to the fact that wider intra-row spacing i.e. 30 cm in paired row 70/30 cm reduced intra-row competition thereby enhancing higher tillering than that in 80/20cm. Similarly, intercropping turmeric with greengram (I_2) recorded significantly higher leaf area index and tillers per plant of turmeric over that in baby corn (I_1). This might be due to the synergistic effect of leguminous intercrop greengram on turmeric that enhanced tillering and number of leaves in turmeric, while on the contrary, baby corn being a highly exhaustive crop might have exploited more soil resources thereby affecting the tillering of base crop.

Weed management practices had significant effect on LAI and number of tillers. The highest value of LAI and number of tillers was achieved in non-chemical weed control treatment (W_2) which was statistically superior to all other weed management practices which might due to reduced the crop-weed competition causing higher number of tillers and leaves per plant that eventually led to significantly higher value of LAI. Similar results were also reported by Hashim, *et al.* [4] and Jan, *et al.* [5].

Number of rhizomes/plant, weight of rhizome/plant, fresh and dry rhizome yields were significantly influenced by the different planting methods, intercrops and weed management practices (Table.5 and 6). The treatment combination of paired row planting 70/30 cm, intercropping greengram and weed control method by non-chemical *i.e.* mulching along with four hand weeding at 35, 65, 95 and 140 DAP recorded significantly lower weed density, weed dry weight and higher number of rhizomes/plant which could have resulted higher fresh and dry rhizome yields under this treatment.

4. Conclusion

1. The work carried out concludes that turmeric intercropping with greengarm and following planting method of 70/30 cm along with integrated weed management practices with mulching and hand weeding at 35, 65, 95 and 140 DAP can give better yield of turmeric.

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