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Integrated weed management in turmeric

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ABSTRACT

Field experiments were conducted during *Kharif* 2012-13 and 2013-14 at the Research farm of Rajendra Agricultural University Bihar, Pusa to find out effective and economical approaches for weed management in turmeric. The grassy weeds present in the experimental field were *Cynodon dactylon, Echinocloa colona* and *Dactyloctenium aegyptium*. *Cyperus rotundus* was only sedge and *Chenopodium album, Cannabis sativa, Parthenium hysterophorus, Phyllanthus niruri* and *Caesulia auxillaris* were the broad-leaved weeds. The lowest weed count, weed dry weight and the highest number of tillers per plant, number of leaves per plant and rhizome yield of turmeric were recorded by the weed free (hand weeding at 25 and 45 DAS). The highest rhizome yield (52.05 t/ha) was recorded under weed free which was statistically at par with atrazine 0.75 kg/ha *fb* fenoxaprop 67 g/ha+ metsulfuron 4 g/ ha (50.65 t/ha). The highest weed control efficiency (84.62%) was recorded under the treatment weed free which was closely followed by atrazine 0.75 kg/ha *fb* fenoxaprop 67 g/ha+ metsulfuron 4 g/ha (78.9%) and pendimethalin 1.0 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4 g/ha (78.6%). The highest B:C ratio was recorded with application of atrazine 0.75 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha, which was statistically at par with weed free, pendimethalin 1.0 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha and metribuzin 0.7 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4g/ ha.

Key words: Herbicide, Integrated weed management, Straw mulch, Turmeric

Turmeric (*Curcuma longa* L.) is a major spice crop, occupying 6% of the total area under spices and condiments in India. It is grown for its rhizomes, which are mainly used as a spice for flavouring and colouring many foods.Turmeric is one of the second most important spice crops after chilli. India accounts for 78% in world production and 60% in world export share (Angles *et al*. 2011). Its cultivation provides avenues for crop diversification, value addition and revenue generation. Though India leads in production of turmeric with 75% of global production, its average productivity is quite low, mainly due to the competition offered by weeds which reduce yield by 30-75% (Krishnamurthy and Ayyaswamy 2000). Slow initial growth and its poor canopy development provide an ideal environment for weeds to grow and compete with the crop. Heavy infestation of weeds comprising of grasses, sedges and broad-leaved weeds poses a big challenge for turmeric production in India. Farmers have to go for sequential weeding, which adds to the cost of weed management. Non-availability of labour hinders the timely removal of weeds. Pre-emergence herbicides *viz.* pendimethalin (Anil Kumar and Reddy 2000), atrazine (Singh and Mahey 1992) and metribuzin (Gill *et al.* 2000) help save the crop from severe weed competition at an early age. Straw mulch is another approach adopted by the farmers that conserves soil moisture and modifies soil temperature for benefit of crop, besides controlling weeds (Mahey *et al.* 1986). Mulching suppresses weed growth and improves crop yield (Hossain 2005). This necessitates developing effective and economically better integrated weed-control practices for realizing high productivity of turmeric.

MATERIALS AND METHODS

Field experiment was conducted during *Kharif* 2012-13 and 2013-14 at the Research farm of Rajendra Agricultural University Bihar, Pusa. The experiment was carried out in randomized block design with three replications. The variety used was '*Rajendra Sonia*'. The soil of experimental field was sandy loam and low in organic carbon (0.42%) and available nitrogen (208 kg/ha), available phosphorus (18.9 kg/ha) and potassium (108.5 kg/ha) with pH 8.3. The experiment comprised of 10 weed management treatments. The treatments were metribuzin 0.7 kg/ha *fb* two hoeing, metribuzin 0.7 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4g/ha, metribuzin 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one

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HW, pendimethalin 1.0 kg/ha *fb* two hoeing, pendimethalin 1.0 kg/ha *fb* fenoxaprop 67 g/ha+ metsulfuron 4 g/ha, pendimethalin 1.0 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, atrazine 0.75 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha, atrazine 0.75 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, weed-free and weedy check. Meribuzin, pendimethalin and atrazine were applied as pre-emergence and fenoxaprop + metsulfuron were applied at 3-4 leaf stages of weeds. The paddy straw mulch was applied immediately after planting as per treatment. The recommended dose of fertilizer *i.e.* 150-60-120 kg N-P_2O_5-K_2O/ha along with 30 t/ha well decomposed FYM were applied during both the years. During both the years of study, healthy rhizomes were planted on 18th June at 30 x 20 cm spacing. Light irrigations were applied frequently till the crop sprouted. The recommended package and practices of turmeric cultivation was adopted. Herbicides were applied with the help of knapsack sprayer fitted with flat fan nozzle. Two hand weedings were given at 25 and 45 days after sowing. The weed population and weed dry weight were recorded at 60 days after sowing.

RESULTS AND DISCUSSION

Effect on weeds

The major weed flora observed in the experimental field predominantly consisted of three grass species, five species of broad leaved weed and a sedge weed. The grassy weeds present in the experiment were *Cynodon dactylon, Echinocloa colona* and *Dactyloctenium aegyptium. Cyperus rotundus* was only sedge and *Chenopodium album, Cannabis sativa, Parthenium hysterophorus, Phyllanthus niruri* and *Caesulia auxillaris* were the broad-leaved weeds. The lowest weed count was recorded by weed free and the lowest weed dry weight was recorded by the weed free, which was statistically at par with atrazine 0.75 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha and pendimethalin 1.0 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha. Effective control of weeds in turmeric has been reported with application of atrazine 0.62 kg/ha (Singh and Mahey 1992), pendimethalin 1.0 kg/ha (Anil Kumar and Reddy 2000) and metribuzin 0.70 kg/ha (Gill *et al.* 2000). The highest weed control efficiency (84.6%) was recorded under the treatment weed free (HW at 25 and 45 DAS), which was closely followed by application of atrazine 0.75 kg/ha *fb* fenoxaprop 67 g/ ha + metsulfuron 4 g/ha, (78.9%) and pendimethalin 1.0 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4 g/ha (78.6%).

Effect on crop

Growth attributes like plant height, number of tiller per plant and leaf area development are the reflective process of effective utilization of resources in a better crop production environment. Conducive crop growth environment with minimum stresses due to biotic factors like less weed competition reflects further on better yield attributes of crops. Dramatic variations in growth and yield attributes of turmeric was noticed due to different weed control methods primarily associated with change in weed flora

Table 1. Effect of different weed management treatments on weed parameters, yield attributes and yield of turmeric (mean data of two years)

Treatment	Weed count (no./m^2) 60 DAS	Weed dry wt. (g/m^2) 60 DAS	WCE (%) 60 DAS	Plant height (cm)	No of tillers/ plant	No of leave/ plant	Rhizome yield (t/ha)
Metribuzin 0.7 kg/ha *fb* two hoeing	12.76	22.9	65.2	127.1	3.54	13.4	41.3
Metribuzin 0.7 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4 g/ ha	7.11	15.6	76.2	127.5	4.27	16.3	47.8
Metribuzin 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one HW	10.87	21.8	66.8	126.1	3.71	14.3	44.9
Pendimethalin 1.0 kg/ha *fb* two hoeing	12.38	23.1	64.8	128.8	3.65	13.5	42.7
Pendimethalin 1.0 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4 g/ha	6.79	14.1	78.6	129.5	4.37	15.9	48.1
Pendimethalin 1.0 kg/ha *fb* straw mulch 10 tones /ha *fb* one HW	10.65	19.4	70.5	130.9	3.85	15.3	46.0
Atrazine 0.75 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha	6.28	13.9	78.9	129.4	4.60	16.4	50.6
Atrazine 0.75 kg/ha *fb* straw mulch 10 tones/ha *fb* one HW	9.63	17.2	73.8	125.8	4.25	15.7	47.9
Weed-free	4.21	10.1	84.6	133.9	4.71	18.0	52.0
Weedy check	36.30	65.8	-	118.8	2.62	11.3	29.8
LSD (P= 0.05)	1.30	4.9	-	8.1	0.64	3.4	3.5

composition with varying weed density and weed dry weight. The highest plant height was observed in the weed free treatment which was statistically at par with all the treatments except weedy check, which may be attributed to better weed control with favourable soil environment that might have resulted in reduced crop-weed competition for the growth factors such as light, space and nutrients which in turn helped in efficient photosynthetic activity recording taller plants. Decreasing weed density result in increased plant growth was supported by Hashim *et al.* (2003) and Jan *et al.* (2004). Weedy check showed significant reduction in plant height. This was attributed to suppressing effect of uncontrol weeds by weedy check on crop plants similar findings have been reported by Chander *et al*. (1997). From the experimental results, it is evident that high competition of weeds reduced the input availability to plants, thus reduced the plant height to a greater extent. The highest number of tillers per plant and number of leaves per pant were recorded by weed free treatment which was statistically at par with application of atrazine 0.75 kg/ha *fb* straw mulch 10 t/ha *fb* one HW, atrazine 0.75 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4 g/ha, pendimethalin 1.0 kg/ha *fb* fenoxaprop 67 g/ha+ metsulfuron 4 g/ha and metribuzin 0.7 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4g/ha and significantly superior over rest of the treatments. However, in case of number of leaves per plant, application of pendimethalin 1.0 kg/ha *fb* straw mulch 10 t/ha *fb* one hand weeding was also at par with weed free. This might be due to very effective suppression of weed flora by the pre-emergence application of herbicide at early stage of the crop and subsequent removal of late emerging weeds by weed free and post emergence application of herbicides and eventually resulted in higher number of tiller and higher number of leaves per plant. This finding is in conformity with the results of Channappagoudar *et al.* (2007). The highest rhizome yield (52.05 t/ha) was recorded under the treatment weed free which was statistically at par with atrazine 0.75 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4 g/ha (50.65 t/ha) and significantly superior over rest of the treatments. The lowest rhizome yield was recorded under weedy check. Kuar *et al*. (2008) found that uncontrolled weed growth resulted in 63.9% reduction in average rhizome yield of turmeric. Weedy check reduce the rhizome yield by 80 per cent due to severe weed competition, particularly due to the presence of grasses and broad leaved weeds as weed competition could lower the number of rhizome per plant and rhizome weight considerably in turmeric.(Ratnam *et al.* 2012).

Nutrient depletion by weeds

Weeds in the weedy check remove 117.8, 21.2 and 175.3 kg/ha N, P and K respectively, which were the highest, and 63.6, 62.7 and 73.9% of total N, P and K removed by both crop and weeds. The corresponding figures were only 4.7, 5.2 and 9.6% for weed free which was closely followed by 8.8, 6.9 and 10.7% for atrazine at 0.75 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron at 4 g/ha at 20 DAS, pendimethalin at 1.0 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron at 4 g/ha at 20 DAS and metribuzin at 0.7 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron at 4 g/ ha at 20 DAS. This indicates that where the removal of nutrients by weeds was more, the corresponding uptake by the crop was less and *vice versa*. Nutrient uptake by weeds followed a similar trend as that of dry weight of weeds.

Table 2. Nutrient uptake (kg/ha) by crop and nutrient depletion by weeds (kg/ha) under different weed control treatments (mean data of two years)

Treatment	Nutrient uptake by crop						Nutrient depletion by weed		
	Rhizome			Above-ground part					
	N	P	K	N	P	K	N	P	K
Metribuzin 0.7 kg/ha *fb* two hoeing	162.4	24.2	170.9	70.3	9.1	36.5	44.2	15.6	41.1
Metribuzin 0.7 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha	169.3	30.2	175.6	75.2	11.1	40.9	33.2	7.50	32.8
Metribuzin 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one HW	165.4	26.8	172.6	73.4	9.70	37.5	39.3	12.1	37.9
Pendimethalin 1.0 kg/ha *fb* two hoeing	164.2	25.5	172.0	72.5	9.30	37.2	41.7	13.2	38.5
Pendimethalin 1.0 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha	170.7	30.8	176.4	75.8	11.3	41.6	28.6	5.10	29.3
Pendimethalin 1.0 kg/ha *fb* straw mulch 10 t/ha *fb* one HW	167.6	28.4	174.5	74.2	10.1	38.7	38.8	11.2	37.5
Atrazine 0.75 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4 g/ha	172.4	31.7	178.8	77.4	12.6	42.4	24.2	3.30	26.4
Atrazine 0.75 kg/ha *fb* staw mulch 10 tone/ha *fb* one HW	168.2	29.1	175.3	74.9	10.7	39.8	35.4	9.10	34.6
Weed-free (hand weeding at 25 and 45 DAS)	175.2	34.8	180.3	178.7	14.2	43.6	17.4	2.70	23.8
Weedy check	37.7	6.5	45.3	29.6	6.10	16.7	117.8	21.2	175.3
LSD (P= 0.05)	13.6	4.8	32.7	7.6	2.2	3.3	3.10	4.20	8.90

Table 3. Economics of different weed control treatments (mean data of two years)

Treatment	Net returns (x10^3 `/ha)	B:C ratio
Metribuzin 0.7 kg/ha *fb* two hoeing	175.10	1.54
Metribuzin 0.7 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha	230.93	2.23
Metribuzin 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one HW	191.65	1.56
Pendimethalin 1.0 kg/ha *fb* two hoeing	185.40	1.63
Pendimethalin 1.0 kg/ha *fb* fenoxaprop 67 g/ha + metsulfuron 4 g/ha	233.53	2.26
Pendimethalin 1.0 kg/ha *fb* straw mulch 10 tone/ha *fb* one HW	199.50	1.63
Atrazine 0.75 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha	252.28	2.47
Atrazine 0.75 kg/ha *fb* staw mulch 10 tones/ha *fb* one HW	213.70	1.76
Weed-free (hand weeding at 25 and 45 DAS)	252.35	2.25
Weedy check	108.60	1.09
LSD (P= 0.05)	22.55	0.28

Nutrient uptake by crop

Weed free recorded the highest utilization of 175.2 kg N, 34.8 kg P and 180.3 kg K/ha by the rhizomes (Table 2). In the weedy check plots, rhizomes utilized 37.7 kg N, 6.5 kg P and 45.3 kg K/ha, which were only 21.5, 18.7 and 25.1% when compared with weed free treatment. Effective control of weeds over a longer period with herbicides combination and herbicide with straw mulch combination helped the crop to produce more dry matter and grab a major share of nutrients, leaving very less for the weeds. As the nutrient content did not vary among different weed control treatments, the utilization of nutrients followed a trend similar to that of rhizome yield. Nutrient uptake by above ground parts of the crop showed a trend similar to that recorded for rhizomes.

Economics

The highest net return was recorded by the weed free treatment which was statistically at par with pre-emergence application of atrazine 0.75 kg/ha followed by application of fenoxaprop at 67 g/ha + metsulfuron 4 g/ha at 3-4 leaves stage, pendimethalin 1.0 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha and metribuzin 0.7 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha. However, the highest B:C ratio was recorded with atrazine 0.75 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha which was statistically at par with weed free, pendimethalin 1.0 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4 g/ha and metribuzin 0.7 kg/ha *fb* fenoxaprop at 67 g/ha + metsulfuron 4g/ha.

It may be concluded that pre-emergence application of atrazine at 0.75 kg/ha or pendimethalin 1.0 kg/ha or metribuzin 0.7 kg/ha followed by application of fenoxaprop 67 g/ha + metsulfuron 4 g/ha at 3-4 leaves stage was adjudged very effective for controlling weeds and for attaining highest productivity and profitability in turmeric.

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