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Integrated weed management in turmeric

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ABSTRACT

A field experiment was conducted during *Kharif* 2014 and 2015 at Agriculture and Horticulture Research Station, Kathalagere, Davanagere district of Karnataka state, to study the effect of various weed management practices on weed density, weed dry weight, growth, yield and economics of turmeric. Pre-emergence (PE) application of pendimethalin at 1.0 kg/ha *fb* two hand weeding on 45 and 75 DAP recorded the highest rhizome yield, weed control efficiency, net returns and B:C ratio (23.2 t/ha, 89.2%, ` 1,45,309/ha and 2.50, respectively) in 2014. Whereas, PE application of oxyflourfen at 0.30 kg/ha *fb* 2 hand weeding on 45 and 75 DAP recoded the highest rhizome yield, weed control efficiency, net returns and B:C ratio (21.9 t/ha, 89.1%, ` 133236/ha and 2.60, respectively) in 2015. Integrated weed management using a broad-spectrum PE herbicide like pendimethalin or oxyflourfen *fb* 2 hand weedings on 45 and 75 DAP was effective in controlling weeds and obtaining higher yield and economic returns in turmeric.

Key words: Hand weeding, Integrated weed management, Oxyflourfen, Pendimethalin, Turmeric

Turmeric (*Curcuma longa* L.), is an herbaceous perennial plant, belonging to the family Zinziberaceae, native to tropical South-east Asia. It is one of the most-valuable spices all over the world. Turmeric, an ancient and sacred spice of India, is a major rhizomatous spice produced and exported from India. In India, it is grown over an area of 1,94,000 ha with an average production of 9,71,000 MT and productivity of 5 MT/ha (Indian Horticulture data base 2014). Turmeric forms an important adjuvant in Indian culinary as it gives colour and aromatic flavour to various dishes. Turmeric is widely used as an important condiment in the preparation of pickles and curries and as a colouring agent in textiles, food and confectionary industries. Turmeric has long been used in India for the treatment of sprains and inflammatory conditions. Turmeric, largely grown as a rainfed crop during *Kharif* (rainy) season, takes long time span of about 8–9 months (Barla *et al*. 2015). Delayed emergence, slow initial growth, poor canopy development of turmeric provides ideal environment for weeds to grow and cover the ground quickly and compete with the crop for nutrients, moisture and space causing considerable yield reduction of about 30-75% (Krishnamurthi and Ayyaswamy 2000). Weed control by hand weeding becomes expensive, time consuming and laborious. Sometimes, due to scarcity of labour specially during critical stages of crop growth, the yield may be reduced drastically. Hence, the use of herbicides in turmeric production becomes essential. The effectiveness of each herbicide is determined by the factors like type of weed flora, soil type, organic matter content of the soil, weather conditions *etc*. Turmeric requires a weed free condition of 70 to 160 days after planting (DAP) for better production of rhizomes. This necessitates development of an effective and economically better integrated weed control strategy for realizing higher productivity of turmeric. Keeping these in view, the present investigation was conducted with an objective to find the best weed management practice for effective control of weeds.

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MATERIALS AND METHODS

A field experiment was conducted at Agriculture and Horticulture Research Station, Kathalagere during *Kharif* season of 2014 and 2015. The experiment comprised 15 treatments, *viz*. metribuzin 0.7 kg/ha at 0-5 days after planting (DAP) followed by (*fb*) 2-hand weeding (HW) at 45 and 75 DAP, metribuzin 0.7 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP, metribuzin 0.7 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW 75 DAP, pendimethalin 1.0 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP, pendimethalin 1.0 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP, pendimethalin 1.0 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha at 10 DAP *fb* HW 75 DAP, atrazine 0.75 kg/ha at 0-5 DAP *fb* 2 HW 45 and 75 DAP, atrazine 0.75 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP, atrazine 0.75 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW at 75 DAP, oxyfluorfen 0.30 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP, oxadiargyl 0.25 kg/ha at 0-5 DAP *fb* 2 HW at

45 and 75 DAP, glyphosate 5.0 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP, glyphosate 7.5 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP, hand weeding at 25, 45 and 75 DAP, un-weeded check, tested in a Randomized Complete Block Design with three replications. The crop was planted at a spacing of 45 x 30 cm and 150:125:250 kg N: P_2O_5:K_2O/ha, were applied. The data on weed density and weed dry weight were recorded at 75 DAP using a quadrant of 50 x 50 cm. The data on weed density and dry weight were subjected to square root transformation using the formula square root of x + 1. When the leaves turned yellow and dry, the crop from net plots was harvested. The rhizomes were dug taking care that they were not cut or damaged, then cleaned to remove soil and weighed for fresh weight. Economics of the treatments was computed based on the prevalent market prices of the inputs used and rhizomes produced.

RESULTS AND DISCUSSION

Weed flora

The major weed flora observed in the experimental plots were *Cyperus rotundus* and *Scirpus* sp. (among sedges); *Cynadon dactylon* and *Echinochloa colona* (among grasses); *Spillanthus acmella, Portulaca oleracia, Parthenium hysteroporus, Phyllanthus niruri* and *Euphorbia geniculata* (among broad-leaf weeds). Among different categories, grasses were recorded in higher number *fb* broad-leaf weeds and sedges at 75 DAP in turmeric.

Weed density and weed dry weight

All the weed management practices significantly reduced the weed density and dry weight in turmeric (**Tables 1** and **2**). Among the various integrated weed management practices, PE application of pendimethalin at 1.0 kg/ha, oxyflourfen at 0.30 kg/ha and atrazine at 0.75 kg/ha *fb* 2 HW at 45 and 75 DAP had recorded the lowest density and dry weight of grasses, broad-leaf weeds and sedges during both the years of experimentation. PE application of pendimethalin, oxyflourfen, atrazine had broad spectrum effect on weeds *fb* 2 HW on 45 and 75 DAP had reduced the major weed flora in turmeric and resulted in lower weed density and dry weight. Similar indications of weed control by integrated weed management had been observed by Ashok and Sanjay (2014), Nidhi *et al*. (2015), Ratnum *et al*. (2012) and Barla *et al*. 2015.

Growth and rhizome yield

Effect of different weed management practices on plant height and number of leaves in turmeric at 75 DAP is presented in **Table 3**. In 2014, the highest plant height and number of leaves were recorded in pre-emergence application of pendimethalin at 1.0 kg/ ha *fb* 2 HW on 45 and 75 DAP. Whereas in 2015, PE application of oxyflourfen at 0.30 kg/ha *fb* 2 HW at 45 and 75 DAP recoded the highest plant height and number of leaves. Reduced competition between the crop and weeds resulted in higher plant height and number of leaves in turmeric. Channappagoudar *et al*. (2013) also noticed similar results.

Table 1. Effect of weed management practices on weed density (no./m^2) in turmeric at 75 days after planting

Treatment	Weeds density (no./m^2)							
	Sedges + 2014	Sedges + 2015	Grasses+ 2014	Grasses+ 2015	Broad-leaf # 2014	Broad-leaf # 2015	Total # 2014	Total # 2015
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	3.2(9.7)$^+$	3.45(11.0)$^+$	3.4(10.3)$^+$	2.6(6.3)$^+$	1.5(27.7)$^\#$	1.4(29.8)$^\#$	1.7(47.7)$^\#$	1.6(47.1)$^\#$
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP	3.7(12.7)	3.83(13.7)	4.3(17.7)	3.5(12.0)	1.6(35.7)	1.7(51.2)	1.8(66.0)	1.8(76.8)
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW 75 DAP	3.2(9.3)	3.56(11.7)	3.7(12.7)	3.2(10.0)	1.5(33.3)	1.5(38.8)	1.7(55.3)	1.7(60.5)
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	2.7(6.7)	3.27(9.7)	2.8(7.0)	2.5(5.3)	1.3(18.0)	1.4(28.2)	1.5(31.7)	1.6(43.1)
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP	3.8(13.7)	4.12(16.0)	3.9(14.7)	4.2(17.3)	1.7(43.7)	1.7(54.8)	1.9(72.0)	1.9(88.2)
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha at 10 DAP *fb* HW 75 DAP	3.2(10.3)	3.56(13.0)	3.9(14.0)	3.2(10.0)	1.6(34.7)	1.6(42.8)	1.8(59.0)	1.8(65.8)
Atrazine 0.75 kg/ha at 0-5 DAP *fb* 2 HW 45 and 75 DAP	2.8(7.3)	3.32(10.3)	3.3(10.0)	2.9(8.0)	1.4(25.7)	1.5(30.8)	1.6(43.0)	1.7 (49.2)
Atrazine 0.75 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP	3.8(14.7)	4.03(15.3)	4.2(17.0)	4.4(18.7)	1.7(44.7)	1.7(58.3)	1.9(76.3)	1.9 (92.3)
Atrazine 0.75 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW at 75 DAP	3.2(9.7)	3.60(12.0)	4.0(14.7)	3.4(11.0)	1.6(36.0)	1.6(47.5)	1.8(60.3)	1.8(71.3)
Oxyfluorfen 0.30 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	2.9(7.3)	3.16(9.3)	3.1(8.7)	2.7(6.3)	1.4(22.0)	1.4(24.7)	1.6(38.0)	1.6(40.3)
Oxadiargyl 0.25 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	3.1(9.7)	3.44(11.3)	3.4(11.0)	3.1(9.0)	1.5(29.3)	1.5(32.5)	1.7(50.0)	1.7(52.9)
Glyphosate 5.0 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP	3.4(10.7)	3.77(13.3)	4.1(16.7)	3.5(11.7)	1.6(37.3)	1.6(47.5)	1.8(64.7)	1.8(72.6)
Glyphosate 7.5 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP	3.3(10.3)	3.55(11.7)	3.7(12.7)	3.1(8.7)	1.5(30.0)	1.5(35.8)	1.7(53.0)	1.7(56.2)
Hand weeding at 25, 45 and 75 DAP	3.2(9.7)	3.41(11.0)	3.9(14.0)	3.1(9.0)	1.5(32.3)	1.6(40.4)	1.8(56.0)	1.7(60.4)
Un-weeded check	6.2(37.7)	6.40(41.3)	5.6(31.0)	5.8(34.0)	1.9(86.0)	1.9(100.1)	2.2(154.7)	2.2(175.5)
LSD (p=0.05)	1.29	1.07	0.84	0.95	0.17	0.22	0.21	0.16

Data within the parentheses are original values; Transformed values - # = log ($\sqrt{x+2}$), + = square root of ($\sqrt{x+1}$)

Weed control treatments significantly influenced the rhizome yield of turmeric (**Table 3**). Pre-emergence application of pendimethalin at 1.0 kg/ha *fb* 2 HW on 45 and 75 DAP had recorded the highest rhizome yield (23.2 t/ha) in 2014 followed by pre-emergence application of oxyflourfen at 0.30 kg/ha or atrazine at 0.75 kg/ha *fb* 2 HW on 45 and 75 DAP (22.5 and 22.3 t/ha, repectively). In 2015, pre-emergence application of oxyflourfen at 0.30 kg/ha *fb* 2 HW on 45 and 75 DAP recoded the highest rhizome yield (21.9 t/ha). Unweeded check recorded the lowest yield during both the years. Increased growth parameters and reduced weed pressure on crop has led to increase in yield. The results are in conformity with to results obtained by Gill *et al*. (2000), Ashok and Sanjay (2014) and Barla *et al*. (2015).

Weed control efficiency

Integrated weed management practices registered higher weed control efficiency during both

Table 2. Effect of weed management practices on major weed dry weight in turmeric crop at 75 days after planting

Treatment	Weed dry weight (g/m^2)							
	Sedges + 2014	Sedges + 2015	Grasses+ 2014	Grasses+ 2015	Broad-leaf # 2014	Broad-leaf # 2015	Total # 2014	Total # 2015
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	2.4(4.7)$^{+}$	2.3(4.7)$^{+}$	2.5(5.3)$^{+}$	1.9(2.9)$^{+}$	1.2(15.5)$^{+}$	1.2(16.9)$^{\#}$	1.4(25.5)$^{\#}$	1.4(24.6)$^{\#}$
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP	3.0(8.2)	3.2(9.6)	3.6(12.5)	3.0(8.8)	1.4(26.8)	1.6(40.6)	1.7(47.5)	1.7(58.9)
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW 75 DAP	2.5(5.4)	2.7(6.3)	2.9(7.7)	2.5(5.8)	1.3(21.3)	1.4(25.6)	1.5(34.5)	1.5(38.0)
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	1.9(2.7)	2.2(4.1)	2.0(3.3)	1.8(2.4)	1.0(9.2)	1.2(15.0)	1.2(15.2)	1.3(21.5)
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP	3.2(9.7)	3.5(11.8)	3.4(10.9)	3.7(13.2)	1.6(34.5)	1.6(44.3)	1.8(55.1)	1.8(69.3)
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha at 10 DAP *fb* HW 75 DAP	2.5(6.1)	2.8(7.8)	3.1(8.8)	2.6(6.5)	1.4(22.9)	1.4(29.4)	1.6(37.8)	1.6(43.7)
Atrazine 0.75 kg/ha at 0-5 DAP *fb* 2 HW 45 and 75 DAP	2.1(3.4)	2.3(4.9)	2.2(4.9)	2.1(3.8)	1.2(13.9)	1.2(17.8)	1.4(22.1)	1.4(26.4)
Atrazine 0.75 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67 + 4 g/ha at 45 DAP	3.4(11.0)	3.5(12.0)	3.7(13.3)	3.9(14.9)	1.6(36.6)	1.6(49.0)	1.8(60.9)	1.8(75.9)
Atrazine 0.75 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW at 75 DAP	2.6(5.9)	3.0(8.0)	3.2(9.5)	2.9(7.8)	1.4(24.8)	1.5(36.7)	1.6(40.3)	1.7(52.6)
Oxyfluorfen 0.30 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	2.0(3.2)	2.1(3.8)	2.1(4.2)	1.9(2.8)	1.1(11.4)	1.1(13.1)	1.3(18.8)	1.3(19.7)
Oxadiargyl 0.25 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	2.4(4.9)	2.4(5.4)	2.6(5.9)	2.3(4.7)	1.2(17.0)	1.3(19.6)	1.5(27.9)	1.4(29.7)
Glyphosate 5.0 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP	2.8(6.7)	3.1(8.8)	3.5(11.3)	2.9(8.1)	1.4(26.9)	1.5(35.0)	1.7(44.9)	1.7(51.9)
Glyphosate 7.5 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP	2.5(5.4)	2.5(5.7)	2.8(7.1)	2.3(4.7)	1.3(18.0)	1.3(22.1)	1.5(30.5)	1.5(32.5)
Hand weeding at 25, 45 and 75 DAP	2.4(5.1)	2.6(6.3)	3.0(8.3)	2.4(5.4)	1.3(20.0)	1.4(27.4)	1.5(33.4)	1.6(39.1)
Un-weeded check	5.7(32.4)	6.1(37.6)	5.3(28.8)	5.8(33.3)	1.9(85.1)	2.0(110.0)	2.2(146.4)	2.2(180.9)
LSD (p=0.05)	0.98	0.84	1.46	0.76	0.31	0.22	0.20	0.17

Data within the parentheses are original values; Transformed values - # = log ($\sqrt{x+2}$), + = square root of ($\sqrt{x+1}$)

Table 3. Effect of weed management practices on plant height, number of leaves, fresh rhizome yield and weed control efficiency in turmeric

Treatment	75 DAP				Fresh rhizome yield (t/ha) 2014	Fresh rhizome yield (t/ha) 2015	Weed control efficiency (%) 2014	Weed control efficiency (%) 2015
	Plant height (cm) 2014	Plant height (cm) 2015	No. of leaves/ plant 2014	No. of leaves/ plant 2015				
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	80	78	19	19	21.4	20.6	82.6	86.4
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67+4 g/ha at 45 DAP	65	63	15	13	13.8	12.6	67.5	67.5
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW 75 DAP	74	73	17	17	19.7	18.1	76.4	79.0
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	87	79	20	20	23.2	21.7	89.6	88.1
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67+4 g/ha at 45 DAP	65	63	14	13	12.0	11.4	62.4	61.7
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha at 10 DAP *fb* HW 75 DAP	73	71	17	16	17.4	16.9	74.2	75.8
Atrazine 0.75 kg/ha at 0-5 DAP *fb* 2 HW 45 and 75 DAP	81	80	19	19	22.3	20.3	84.9	85.4
Atrazine 0.75 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67+4 g/ha at 45 DAP	61	60	14	13	11.5	11.1	58.4	58.1
Atrazine 0.75 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW at 75 DAP	69	69	16	16	15.6	14.1	72.5	70.9
Oxyfluorfen 0.30 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	83	80	20	20	22.5	21.9	87.2	89.1
Oxadiargyl 0.25 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	79	75	18	19	21.1	19.7	80.9	83.6
Glyphosate 5.0 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP	66	71	15	15	14.8	14.2	69.3	71.3
Glyphosate 7.5 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP	78	76	19	18	20.7	18.5	79.2	82.0
Hand weeding at 25, 45 and 75 DAP	77	72	18	17	19.9	17.4	77.2	78.4
Un-weeded check	58	58	11	10	6.4	6.1	0.0	0.0
LSD (p=0.05)	10.9	8.8	4.7	2.5	5.8	2.6	NA	NA

NA: Not analyzed

Table 4. Effect of weed management practices on economics of turmeric production

Treatment	Cost of cultivation (x10^3 `/ha) 2014	Cost of cultivation (x10^3 `/ha) 2015	Gross returns (x10^3 `/ha) 2014	Gross returns (x10^3 `/ha) 2015	Net returns (x10^3 `/ha) 2014	Net returns (x10^3 `/ha) 2015	B:C Ratio 2014	B:C Ratio 2015
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	86.25	86.25	214.00	205.67	127.75	119.42	2.5	2.4
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67+4 g/ha at 45 DAP	79.38	79.38	138.00	125.67	58.62	46.29	1.7	1.6
Metribuzin 0.7 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW 75 DAP	81.75	81.75	197.06	181.00	115.31	99.25	2.4	2.2
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	86.74	86.74	232.04	216.67	145.301	129.93	2.7	2.5
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67+4 g/ha at 45 DAP	79.86	79.86	120.00	114.33	40.14	34.47	1.5	1.4
Pendimethalin 1.0 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha at 10 DAP *fb* HW 75 DAP	82.24	82.24	173.72	168.67	91.49	86.43	2.1	2.1
Atrazine 0.75 kg/ha at 0-5 DAP *fb* 2 HW 45 and 75 DAP	84.90	84.90	223.00	203.33	138.10	118.43	2.6	2.4
Atrazine 0.75 kg/ha at 0-5 DAP *fb* fenoxaprop + metsulfuron 67+4 g/ha at 45 DAP	78.03	78.03	115.33	111.00	37.31	32.97	1.5	1.4
Atrazine 0.75 kg/ha at 0-5 DAP *fb* straw mulch at 5 t/ha *fb* at 10 DAP *fb* HW at 75 DAP	80.40	80.40	156.31	140.67	75.91	60.27	1.9	1.7
Oxyfluorfen 0.30 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	85.76	85.76	224.87	219.00	139.11	133.24	2.6	2.6
Oxadiargyl 0.25 kg/ha at 0-5 DAP *fb* 2 HW at 45 and 75 DAP	86.82	86.82	210.89	197.33	124.06	110.51	2.4	2.3
Glyphosate 5.0 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP	84.45	84.45	148.00	142.33	63.54	57.88	1.8	1.7
Glyphosate 7.5 ml/l at 25 DAP *fb* 2 HW at 45 and 75 DAP	84.45	84.45	206.98	185.00	122.53	100.54	2.5	2.2
Hand weeding at 25, 45 and 75 DAP	88.50	88.50	198.99	174.00	110.49	85.50	2.2	2.0
Un-weeded check	75.00	75.00	64.33	61.00	-10.67	-14.00	-0.9	0.8

Cost of herbicides: metribuzin = ` 180/100 g, pendimethalin = ` 700/lit, atrazine = ` 300/kg, oxyfluorfen = ` 515/250ml, oxadiargyl = ` 760/100 g, glyphosate = ` 380/lit, fenoxaprop= ` 417/250 ml, metsulfuron= ` 217/10 g, Men Labour: ` 200 per day; Women Labour: ` 150 per day price of turmeric= ` 10/kg.

the years (**Table 3**). Pre-emergence (PE) application of pendimethalin at 1.0 kg/ha *fb* 2 HW on 45 and 75 DAP recorded higher weed control efficiency (89.6%) in 2014. Closer results were obtained in PE application of oxyflourfen at 0.30 kg/ha or atrazine at 0.75 kg/ha *fb* 2 HW at 45 and 75 DAP (87.2 and 84.9%, respectively). In 2015, higher weed control efficiency was observed in PE application of oxyflourfen at 0.30 kg/ha *fb* 2 HW on 45 and 75 DAP (89.1%). The higher weed control efficiency in these treatments was due to lower weed dry weight.

Economics

Economics is the ultimate criteria for acceptance and wider adoption of any technology. Among different indicators of economics efficiency in any production system, net returns and B:C ratio have greater impact on the practical utility and acceptance of the technology by the farmers. In the present study, PE application of pendimethalin at 1.0 kg/ha *fb* HW on 45 and 75 DAP recorded higher net returns and B:C ratio (` 1,45,309/ha and 2.7, repectively) in 2014. Whereas in 2015, higher net returns and B:C ratio was observed in PE application of oxyflourfen at 0.30 kg/ha *fb* 2 HW on 45 and 75 DAP (` 1,33,236/ha and 2.6, respectively). Integrated management of weeds reduced the cost of weed management, improved the yield and thus led to higher net returns and B:C ratio. Similar findings have been reported by Roy and Dharminder (2015).

The findings of present investigation conclusively inferred that weeds in turmeric can be effectively managed along with higher yield and profit by PE application of pendimethalin (1.0 kg/ha) or oxyflourfen (0.30 kg/ha) *fb* 2 HW on 45 and 75 DAP.

REFERENCES

Ashok J and Sanjay P. 2014. Integrated weed management in turmeric. *Indian Journal of Weed Science* **46**(3): 294-295.

Barla S, Upasani RR and Puran AN. 2015. Growth and yield of turmeric (*Curcuma longa* L.) under different weed management. *Journal Crop and Weed* **11**: 179-182.

Channappagoudar BB, Babu V, Naganagoudar YB and Santosha Rathod. 2013. Influence of herbicides on morpho-physiological growth parameters in turmeric (*Curcuma longa* L.). The Bioscan. **8**(3): 1019-1023.

Gill BS, Randhawa GS and Saini SS. 2000. Integrated weed management studies in turmeric (*Curcuma longa* L.). *Indian Journal of Weed Science* . 32. 114-115.

Indian Horticulture data base, 2014.

Krishnamurthi VV and Ayyaswamy M. 2000. Role of herbicide on yield of turmeric. *Spice India* **13**: 9-11.

Nidhi S, Kumar S. and Rana SS. 2015. Integrated weed management in turmeric. *Indian Journal of Weed Science*, **47**(1): 50-54.

Ratnum M, Rao AS and Reddy TY. 2012. Integrated weed management in turmeric (*Curcuma longa*). *Indian Journal of Agronomy* **57**(1): 82-84.

Roy DK and Dharminder. 2015. Integrated weed management in turmeric. *Indian Journal of Weed Science* **47**(4): 393-396.