Indian Journal of Weed Science (2023) **55**(2): 190–192
http://dx.doi.org/10.5958/0974-8164.2023.00034.5

RESEARCH ARTICLE

Integrated weed management to manage complex weed flora in turmeric

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Received: 10 August 2022 | Revised: 10 April 2023 | Accepted: 13 April 2023

ABSTRACT

A field experiment was carried out during two consecutive *Kharif-Rabi* seasond of 2019-20 and 2020-21 at AICRP Weed Management Farm, B. A. College of Agriculture, Anand Agricultural University, Anand to evaluate the effect of pre-emergence application (PE) (next day after planting) of atrazine 750 g/ha, metribuzin 500 g/ha, pendimethalin 750 g/ha and atrazine 500 g/ha + pendimethalin 500 g/ha (tank-mix) followed by (*fb*) rice straw mulch 5 t/ha (one day after application of PE) *fb* hand weeding (HW) at 75 days after planting (DAP) and interculturing (IC) *fb* HW at 20, 40 and 60 DAP and earthing up at 75 DAP on weed control, rhizome yield and economics of turmeric on loamy sand soil. Atrazine 500 g/ha + pendimethalin 500 g/ha (tank-mix) PE *fb* rice straw mulch 5 t/ha (0-3 DAP) *fb* HW at 75 DAP provided effective control of weeds with higher weed control efficiency and higher rhizome yield with better economic returns. The next best treatment was metribuzin 750 g/ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP during both the years.

Keywords: Atrazine, Economics, Integrated weed management, Metribuzin, Mulching, Pendimethalin, Turmeric

INTRODUCTION

Turmeric (*Curcuma longa* L.) is widely used as a spice, cosmetic and natural medicine in many countries. Turmeric is a rhizomatous herbaceous perennial plant of the ginger family (Priyadarsini 2014). Curcumin is being recognized and used worldwide in many different forms for multiple potential health benefits (Gupta *et al*. 2013). Turmeric is the second most important spice crops after chilli and India accounts for 78% in world production and 60% in world export share (Angles *et al*. 2011). India is the largest turmeric producer, consumer and exporter of this crop where it is cultivated on an area of 253.35 thousand hectare with total production of 976.97 thousand tons (Anonymous 2019). The major turmeric producing states in India are Andhra Pradesh, Orissa, Tamil Nadu, Assam, Gujarat and Maharashtra (Patel *et al*. 2012). Being a long duration crop with delayed emergence, slow initial growth and planted in wider space permit more sunlight to reach the soil provides congenial condition for rapid weed growth during initial stage which leads to enormous damage to the crop in terms of quality and quantity. It is essential to the crop free of weeds during 70 to 160 days after planting for higher yield of turmeric (Hossain *et al*. 2008). Farmers rely on manual weeding for the control of weeds but with increase in labour cost and scarcity of labour, manual weed control has become difficult and also damage to the rhizome during mechanical weeding. Thus, adoption of herbicides for weed control is the best alternative to manual weeding. Due to long duration of the crop, use of pre-emergence herbicides alone does not provide the season-long weed control. Hence, the integration of other alternatives to manage the weeds during growing period is needed. Use of mulch after pre-emergence application of herbicide is another approach adopted by the farmers as it helps in conserving soil moisture and modifies soil temperature for benefit of crop, besides controlling weeds. However, inadequate research work was carried out on use of herbicides in integration with mulch. Hence, a study was carried out to assess the efficacy of integrated weed management for the management of complex weed flora in turmeric.

MATERIALS AND METHODS

The experiment was carried out during two consecutive *Kharif-Rabi* season of the year 2019-20 and 2020-21 on loamy sand soil of AICRP Weed Management Farm, B.A. College of Agriculture, Anand Agricultural University, Anand. The soil of the experimental field was low in available nitrogen and medium in available phosphorous and high in potassium. Six different weed management treatments tested consisted of: pre-emergence application (PE) of atrazine 750 g/ha followed by (*fb*) rice straw mulch 5 t/ha at 0-3 days after planting (DAP) *fb* hand weeding (HW) at 75 DAP; metribuzin 500 g/ha PE *fb* rice straw mulch 5 t/ha (0-3 DAP) *fb* HW at 75 DAP; pendimethalin 750 g/ha PE *fb* rice

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straw mulch 5 t/ha (0-3 DAP) *fb* HW at 75 DAP; atrazine 500 g/ha + pendimethalin 500 g/ha (tank-mix) PE *fb* rice straw mulch 5 t/ha (0-3 DAP) *fb* HW at 75 DAP; inter cultivation (IC) *fb* HW at 20, 40 and 60 DAP and earthing-up at 75 DAP and weedy check were laid out in the randomized block design with four replications. Turmeric cv. GNT 2 was planted on 07 June 2019 and 29 May 2020 keeping the distance of 45 cm x 20 cm by using 2500 kg/ha rhizomes. The crop was harvested on 7 March 2020 and 19 February 2021. The crop was fertilized with recommended rate of fertilizer (100-50-50 NPK kg/ha) applied using urea, single super phosphate and muriate of potash, respectively during both the years of experimentation. The recommended package of practices was adopted to raise the crop. Weed management practices were adopted as per the treatment wherein, mulching treatment was imposed after application of pre-emergence herbicides. Weed biomass of monocot, dicot and sedges were recorded from randomly selected four spots in net plot by using 0.25 m^2 iron quadrat by destructive sampling method. Weed control efficiency (WCE) was calculated using standard formula as suggested by Maity and Mukherjee (2011). Other observations were also recorded from net plot area following standard procedures.

RESULTS AND DISCUSSION

Effect on weeds

Monocot weeds dominated (76.5%) the experimental period. Major weeds observed in the experimental field were: *Eleusine indica* (32.0%), *Dactyloctenium aegyptium* (17.4%), *Digitaria sanguinalis* (12.5%) and *Eragrostis major* (5.7%) amongst monocot weeds and *Trianthema monogyna* (8.1%), *Oldenlandia umbellata* (4.9%), *Boerhavia erecta* (3.2%) and *Phyllanthus niruri* (3.0%) amongst dicot weeds (**Table 1**).

All the weed management treatments resulted in significant reduction in dry biomass of monocot, dicot and total weeds as compared to weedy check during both the years of experimentation at harvest (**Table 1**). Dry biomass of monocot (8.71 and 5.94 g/m^2) and total (10.1 and 8.86 g/m^2) weeds was observed significantly lower with atrazine 500 g/ha + pendimethalin 500 g/ha (tank-mix) PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP as compared to weedy check during both the years, respectively. The lower dry biomass might be due to effective control of germinating weeds by tank-mix herbicide application while mulches restricted the penetration of solar radiation to soil surface, hampering the germination and emergence of weeds thereby reduced the dry biomass of weeds (Choudhary *et al*. 2020 and Rana *et al*. 2017) in turmeric. However, metribuzin 500 g/ha PE *fb* rice straw mulch 5 t/ha (0-3 DAP) *fb* HW at 75 DAP provided excellent control of dicot weeds (5.02 and 6.75 g/m^2) during both the years, confirming findings of Jadhav and Pawar (2014). Hand weeding thrice and earthing up at 75 DAS provided maximum weed control efficiency of 75.37 and 70.79% during both the years, due to repeated removal of weeds resulting in the lowest weed growth during critical crop weed competition period and highest weed control efficiency, amongst all the treatments tested. Among integrated treatments, atrazine 500 g /ha + pendimethalin 500 g/ha (tank-mix) PE *fb* rice straw mulch 5 t/ha (0-3 DAP) *fb* HW at 75 DAP or metribuzin 70% WP 500 g ha *fb* rice straw mulch 5 t/ha (0-3 DAP) *fb* HW at 75 DAP recorded maximum weed control efficiency due to reduction in density of weeds which lead to reduced the dry biomass of weeds and thereby higher weed

Table 1. Weed biomass at harvest and weed control efficiency as influenced due to different weed management treatments

Treatment	Weed biomass (g/m^2)						WCE (%)	
	Monocot		Dicot		Total			
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Atrazine 750 g/ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP	10.6 (111)	8.14 (66.5)	5.52 (29.8)	7.63 (57.9)	11.9 (141)	11.2 (124)	65.61	53.21
Metribuzin 500 g/ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP	9.03 (81.2)	6.13 (37.2)	5.02 (24.6)	6.75 (45.0)	10.3 (106)	9.08 (82.2)	74.15	68.98
Pendimethalin 750 g/ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP	9.66 (92.9)	8.01 (64.9)	6.07 (37.2)	8.16 (66.0)	11.4 (130)	11.5 (131)	68.29	50.57
Atrazine 500 g/ha + pendimethalin 500 g/ha (tank- mix) PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP	8.71 (75.2)	5.94 (35.2)	5.13 (25.9)	6.53 (42.2)	10.1 (101)	8.86 (77.4)	75.37	70.79
Intercultivation (IC) *fb* HW at 20, 40 and 60 DAP and earthing-up at 75 DAP	11.7 (138)	8.00 (63.5)	6.02 (36.4)	6.12 (36.6)	13.2 (174)	10.0 (100)	57.56	62.26
Weedy check	15.9 (254)	11.2 (125)	12.5 (156)	11.7 (139)	20.2 (410)	16.3 (265)	-	-
LSD (p=0.05)	2.37	2.19	1.88	2.54	2.03	2.22	-	-

Note: Data subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values. *PE = pre-emergence application; DAP = days after planting; *fb* = followed by, HW = hand weeding, DAP=days after planting

Table 2. Rhizome yield and economics of turmeric as influenced by weed management treatments

Treatment	Rhizome yield (t/ha)		WI (%)		Gross returns (x10^3 `/ha)		Net returns (x10^3 `/ha)		B:C	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Atrazine 750 g /ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP	19.4	13.6	19.83	35.24	291.0	204.0	112.5	25.5	1.63	1.14
Metribuzin 500 g/ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP	23.7	20.6	2.07	1.90	355.5	309.0	175.6	129.1	1.98	1.72
Pendimethalin 750 g/ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP	19.6	14.8	19.01	29.52	294.0	222.0	115.4	43.4	1.65	1.24
Atrazine 500 g/ha + pendimethalin 500 g/ha (tank- mix) PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP	24.2	21.0	-	-	363.0	315.0	184.1	136.1	2.03	1.76
Intercultivation (IC) *fb* HW at 20, 40 and 60 DAP and earthing-up at 75 DAP	20.7	17.3	14.46	17.62	310.5	259.5	130.4	79.4	1.72	1.44
Weedy check	5.00	3.70	79.34	82.38	75.0	55.5	-78.9	-98.4	0.49	0.36
LSD (p=0.05)	3.67	4.71								

*PE = pre-emergence application; DAP = days after planting; *fb* = followed by, HW = hand weeding, DAP=days after planting

control efficiency. Beneficial effect of reducing the dry biomass of weeds due to integration of herbicides and mulches was also observed by Dhillon and Bhullar (2014) in turmeric.

Effect on crop

None of applied herbicide showed phytotoxic effect on turmeric at all the growth stages. All the treatments were significantly superior than weedy check in increasing rhizome yield. Atrazine 500 g/ha + pendimethalin 500 g/ha (tank-mix) *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP recorded significantly higher rhizome yield and it was at par with metribuzin 750 g/ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP during both the years of experimentation. The higher yield might be owing to control of complex weed flora due to integration of herbicide, mulching and hand weeding which provides congenial weed free environment to the crop resulted in significantly higher rhizome yield over other treatments. Thus, the integration of herbicides with mulching and hand weeding provided an effective weed management in a long duration crop like turmeric than sole dependence on any single method as reported by Rana *et al.* (2017) and Kumar *et al.* (2014). Among all the treatments, weedy check recorded significantly the lowest rhizome yield during both the years. Yield reduction due to weeds was minimum with metribuzin 500 g/ha PE *fb* rice straw mulch 5 t/ha *fb* hand weeding at 75 DAS while maximum yield reduction was observed under weedy check as observed by Patel *et al.* (2022); Roy and Dharminder (2015) and Rana *et al.* (2017).

Economics

Economics of various weed management treatments indicated that atrazine 500 g/ha + pendimethalin 500 g/ha (tank-mix) PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP recorded higher gross returns, net returns and benefit cost ratio which was followed by application of metribuzin 750 g /ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP during both the years of experimentation. Jadhav and Pawar (2014) also noticed higher net returns and B:C with integration of herbicide with mulching and hand weeding in turmeric.

It can be concluded that atrazine 500 g/ha + pendimethalin 500 g/ha (tank-mix) PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP or metribuzin 750 g/ha PE *fb* rice straw mulch 5 t/ha *fb* HW at 75 DAP provides effective control of weeds, increases rhizome yield as well as benefit cost ratio in turmeric.

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