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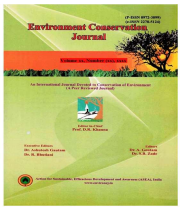

Effect of integrated weed management on turmeric under mid hill conditions of Himachal Pradesh

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ABSTRACT

A field experiment was carried out on silty clay loam soil, acidic in reaction, high in available phosphorus, medium in available potassium and low in available N during *kharif* 2017 at the Research Farm of Department of Agronomy, CSKHPKV, Palampur to study effective weed control strategy for this important crop. The results revealed that *Alternanthera philoxeroides* was the major weed constituting 16% of the total weed flora. This was followed by *Cynodon dactylon* and *Echinochloa colona* with 14 and 12% of total weed population, respectively. The count of *Echinochloa colona, Alternanthera philoxeroides, Commelina benghalensis, Digitaria sanguinalis* and *Ageratum conyzoides* was maximum at 120 DAP and there after it gradually decreased. All herbicide treatments brought significant reduction in the count on *Echinochloa, Alternanthera* and *Ageratum* over weedy check. The lowest count of these weeds was recorded in metribuzin fb straw mulch fb hand weeding and the maximum count was in case of weedy check. All the weed control treatments significantly reduced the total weed count and dry weight of weeds as compared to the weedy check. Amongst different herbicide treatments application of metribuzin @ 0.70 kg/ha fb straw mulch fb hand weeding resulted in significantly lowest weed count at all stages of observation as well as at harvest though this treatment was at par with metribuzin @ 0.70 kg/ha fb two hand weedings and treatments in which atrazine 0.75 kg/ha and hand weedings were applied with or without the use of straw mulch resulted in significantly lower dry matter accumulation by weeds as compared to other herbicide treatments. Weed index calculated at 120 DAP was highest with use of metribuzin @ 0.70 kg/ha and atrazine @ 0.75 kg/ha used along with straw mulch and one or two hand weedings proving effective as compared to other herbicides tested. From the present study it seems that mulching must be included in any effective weed management strategy for turmeric. Also among different herbicides metribuzin and atrazine are effective and their integration with mulching and/or hand weeding gave good control of weeds in turmeric.

Introduction

Turmeric (*Curcuma longa* L.) is one of the most valuable species cultivated all over the world. It is the ancient and sacred spice of India and is also known as “Indian Saffron” or “Golden Spice” or “Spice of Life”. This wonder spice contains various constituents like curcumin (1.8-5.4%), essential oil (2.5-7.2%), fat (5%), minerals (3.5%) and carbohydrates (69.4%) (Barrero and Carreno 1999). Curcumin, the principal component of turmeric rhizome, has immense medicinal

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properties as anti-inflammatory, anti-mutagenic, anti-carcinogenic, anti-tumour, anti-bacterial, anti-fungal, anti-oxidant, anti-parasitic and detoxifying agent. It is used as blood purifier, antiseptic and cures problems like indigestion, throat infection, common cold, treating wounds along with anticancer and antiviral activities. It is also useful in treating dropsy, wounds and inflammations (Khanna 1999)

Turmeric is grown during rainy season, under low and mid hills of Himachal Pradesh. It is a slow growing crop having long duration. It is finding an important place in *kharif* as an alternative to maize particularly in wild boars, monkey, stray animals and porcupines infested areas. Weeds like in other crops , also compete with turmeric for nutrients, moisture and space and cause considerable yield reduction to the extent of 35-75 per cent (Krishnamurthy and Ayyaswamy 2000). Rana *et al.* (2017) have also reported 55 per cent reduction in turmeric rhizome yield due to weeds in turmeric under Palampur conditions of Himachal Pradesh. Slow initial growth and poor canopy development of the turmeric crop provide an ideal environment for weeds to grow and compete with the crop, and managing these weeds add to the cost of production of this crop.

Different methods *viz*. physical, cultural and chemical are followed to control weeds in turmeric crop fields. Farmers usually perform hand weeding in turmeric crop but due to unavailability of labour during critical stages of crop growth, the yield reduces drastically. Mulching suppresses the weed growth and improves crop yield (Hossain, 2005). Chemical method of weed control is not only cheaper but also feasible for timely application; however, it requires more care with reference to appropriate selection of herbicide, its dose and time of application. Efficiency of herbicides also depends on several factors like type of weed flora, soil type, organic matter content of the soil and weather condition. Keeping these points in view, the present investigation was planned to develop an effective weed management strategy for controlling weeds in turmeric.

Material and Methods

The field experiment was carried out at Research Farm of Department of Agronomy CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experimental site was located at $32^0 6'$ N latitude and $76\ ^0 3'$ E longitude and at an altitude of 1290.8 m above mean sea level. The site falls in sub-humid subtropical mid-hills zone of Himachal Pradesh which is characterized by mild summers, severe winters and experiences occasional snowfall during winters. The area receives an annual rainfall of about 2500 mm of which about 80 % is received during monsoon months of July to September while the remaining rainfall is received during winter months. The soil of the experimental site was silty-clay loam in texture, acidic in reaction and low in available nitrogen, high in available phosphorus and medium in available potassium.

The field experiment was laid out in randomised block design with 12 weed control treatments *viz.* metribuzin @ 0.70 kg/ha followed by (fb) hand weeding at 45 and 75 days after planting (DAP), metribuzin @ 0.70 kg/ha fb straw mulch @ 10 t/ha fb hand weeding at 75 DAP, pendimethalin @ 1.0 kg/ha fb two hand weedings at 45 and 75 DAP, pendimethalin @ 1.0 kg/ha fb straw mulch @ 10 t/ha fb hand weeding at 75 DAP, atrazine @ 0.75 kg/ha fb two hand weedings at 45 and 75 DAP, atrazine @ 0.75 kg/ha fb straw mulch @ 10 t/ha fb hand weeding at 75 days, oxyfluorfen @ 0.30 kg/ha fb two hand weedings at 45 and 75 DAP, glyphosate @ 1.23 kg/ha fb two hand weedings at 45 and 75 days, glyphosate @ 1.85 kg/ha fb two hand weedings at 45 and 75 DAP, hand weeding thrice at 25, 45 and 75 DAP, weed control with organic practices (mulch) and unweeded check. The rhizomes of turmeric variety *Palam Pitamber* were planted in rows 45 cm apart using seed rate of 20 q/ha. Rows were opened with the help of hand plough and after putting rhizomes in the rows at 25 cm distance were covered with the soil properly. The crop was fertilized with 30 kg N, 30 kg P_2O_5, and 60 kg K_2O per hectare. The herbicides and intercultural operations were carried out as per the treatments to different plots. Rice straw was used as mulch material after the herbicides were sprayed on second day as per treatment. On maturity, the crop from net plots was harvested when the leaves turned yellow or dry. The rhizomes were dug taking care that they were not cut or damaged. The rhizomes were then cleaned to remove soil and weighed for fresh weight. The weed count was recorded at 90, 120, 150 DAP and at harvest by randomly throwing a quadrat in the plot and counting the weeds of different species which were than dried to get total dry

matter accumulation by weeds. The total dry matter accumulation of weeds per square metre was recorded by multiplying it with factor 16.
The weed control index was calculated by formula given by (Mishra and Tosh 1979)

$$\textbf{Weed Control Index} = \frac{DWc-DWt}{DWc} x\ 100$$

Where DWc – Dry weight of weeds in weedy check

DWt – Dry weight of weeds in treated plot

For measuring the plant height, five plants were selected at random from each plot and were tagged. The height was measured from base of the plant up to top most leaf tip at 30 days interval. The average of these plants was taken as mean plant height in centimetres. The number of leaves per plant was recorded manually from tagged five plants and their average was worked out. The number of shoots per plant was recorded from tagged five plants in each plot and their average was taken out.
The rhizomes from net plot were dug and weighed. The produce was recorded in kilograms and was converted to t/ha. The rhizomes were then subjected to curing and cured rhizome yield was also recorded.
The data obtained were subjected to statistical analysis as per Gomez and Gomez (1984) and were tested at 5 per cent level of significance to interpret the treatment differences. The count and weed biomass data were analysed after subjecting the original data to square root transformation *i.e* $\sqrt{x+0.5}$), and the treatments effects were compared using transformed means.

Results and Discussion

Data on effect of different herbicide treatments on the species wise weed count, recorded at 120 days after planting (DAP) in turmeric (Table 1), revealed significant differences among treatments. Significantly lowest count of *Echinochloa colona* was recorded with the pre-emergence application of metribuzin 0.70 kg/ha followed by (fb) straw mulch fb one hand weeding at 75 DAP though this treatment was at par with all other herbicide treatments except post emergence application of glyphosate at lower dose of 1.23 kg/ha fb two hand weedings at 45 and 75 DAP. Significantly highest count of *Echinochloa colona* was recorded in the weedy check treatment though it was also at par with the treatment in which lower dose of glyphosate (1.23 kg/ha) was applied fb two hand weedings.The population of *Alternanthera philoxeroides* also showed a similar trend with application of metribuzin fb straw mulch fb one hand weeding recording significantly lowest count though this treatment was at par with application of metribuzin fb two hand weedings at 45 and 75 DAP as well as treatments in which atrazine was applied alone with hand weeding and with or without the use of straw mulch. Significantly highest population of *Alternanthera philoxeroides* was recorded in weedy check though it was at par with the application of lowest dose of glyphosate. The treatment in which three and weedings were done (25, 45 and 75 DAP) was not as effective as the treatments in which either metribuzin or atrazine was used. Also pendimethalin was found to be effective for controlling this weed in turmeric.
Contrary to this significantly lowest population of *Commelina benghalensis* was recorded with the post emergence application of glyphosate (1.85 kg/ha) though this treatment was at par with all other herbicide treatments except treatments in which atrazine was applied alone with straw mulch and one hand weeding and application of lower dose of glyphosate (1.23 kg/ha) fb two hand weedings. Weedy check recorded significantly highest count of *Commelina benghalensis* though this treatment was also at par with treatment in which only mulch was applied.Regarding count of *Digitaria sanguinalis* all the herbicide treatments as well as treatments in which hand weedings alone or mulch alone was used were at par with each other while weedy check recorded significantly highest count of this weed at 120 DAP. All the herbicide treatments except pre-emergence application of pendimethalin (1kg/ha) fb straw mulch fb hand weeding at 75 Dap were equally effective in reducing the count *Ageratum conyzoides* at 120 DAP though the significantly lower count was recorded with the application of metribuzin 0.70 kg/ha fb straw mulch fb hand weeding at 75 DAP. The hand weeding treatment as well as organic practice of using mulch alone was also equally effective in reducing count of this weed while significantly higher value was observed in the weedy check treatment.

Table 1: Effect of weed control treatments on count (No./m^2) of *Echinochloa colona*, *Alternanthera philoxeroides, Commelina benghalensis, Digitaria sanguinalis and Ageratum conyzoides* at 120 DAP

Treatment	Dose (kg/ha, t/ha)	*Echinochloa*	*Alternanthera*	*Commelina*	*Digitaria*	*Ageratum*
T_1 Metribuzin fb hand weeding twice	0.70	5.4 (29.3)	5.7 (32.0)	5.1 (26.7)	5.0 (25.1)	5.2 (26.7)
T_2 Metribuzin fb straw mulch fb hand weeding	0.70 + 10	4.6 (21.3)	5.1 (26.7)	4.6 (21.3)	4.6 (21.3)	4.9 (23.5))
T_3 Pendimethalin fb hand weeding twice	1.0	5.3 (28.3)	6.9 (48.0)	4.8 (24.0)	5.7 (32.0)	5.4 (29.3)
T_4 Pendimethalin fb straw mulch fb hand weeding	1+ 10	5.7 (32.0)	7.6 (58.7)	5.0 (25.1)	5.5 (29.3)	6.1 (37.3)
T_5 Atrazine fb hand weeding twice	0.75	4.9 (24.0)	6.1 (37.3)	5.1 (26.7)	5.2 (26.7)	5.2 (26.7)
T_6 Atrazine fb straw mulch fb hand weeding	0.75 + 10	5.2 (26.7)	5.7 (32.0)	5.7 (32.0)	5.6 (30.4)	5.7 (31.5)
T_7 Oxyfluorfen fb hand weeding twice	0.30	5.4 (29.3)	7.3 (53.3)	4.6 (21.3)	5.2 (26.7)	5.6 (30.9)
T_8 Glyphosate fb hand weeding twice	1.23	6.1 (37.3)	7.6 (58.7)	5.7 (32.0)	5.4 (28.8)	5.7 (32.5)
T_9 Glyphosate fb hand weeding twice	1.85	5.2 (26.7)	6.4 (42.7)	4.4 (19.7)	5.6 (30.4)	5.6 (30.4)
T_{10} Hand weeding thrice	--	5.1 (26.6)	6.9 (48.0)	5.7 (33.1)	5.1 (25.6)	5.7 (32.0)
T_{11} Weed management with organic practice (Mulch)	--	5.9 (34.7))	6.9 (48.0)	6.1 (37.3)	4.6 (21.3)	5.2 (26.7)
T_{12} Weedy check	--	7.3 (53.3)	8.6 (74.7)	6.9 (48.0)	6.5 (42.7)	7.0 (48.0)
SEm±		0.5	0.3	0.4	0.4	0.3
LSD (P=0.05)		1.3	1.0	1.1	NS	1.0

Values given in parentheses are the means of original values; Data transformed to square root transformation ($\sqrt{x+0.5}$)

Table 2: Effect of weed control treatment on total weed count, total dry matter accumulation and weed control index (%) at 120 DAP

Treatment	Dose (kg/ha, t/ha)	Total weed count (No./m^2)	Total dry matter accumulatiom (g/m^2)	Weed control index (%)
T_1 Metribuzin fb hand weeding twice	0.70	14.1 (198.4)	9.0 (80.0)	81.3
T_2 Metribuzin fb straw mulch fb hand weeding	0.70 + 10	13.4 (183.5)	8.7 (74.7)	82.5
T_3 Pendimethalin fb hand weeding twice	1.0	16.8 (284.3)	12.9 (165.3)	61.3
T_4 Pendimethalin fb straw mulch fb hand weeding	1+ 10	17.0 (289.1)	14.3 (203.2)	52.4
T_5 Atrazine fb hand weeding twice	0.75	15.8 (248.5)	9.3 (85.3)	80.0
T_6 Atrazine fb straw mulch fb hand weeding	0.75 + 10	15.9 (253.3)	9.4 (88.0)	79.4
T_7 Oxyfluorfen fb hand weeding twice	0.30	16.4 (268.3)	12.0 (144.0)	66.3
T_8 Glyphosate fb hand weeding twice	1.23	16.9 (283.2)	12.9 (165.3)	61.3
T_9 Glyphosate fb hand weeding twice	1.85	16.1 (261.9)	12.2 (149.3)	65.0
T_{10} Hand weeding thrice	--	16.4 (268.3)	12.2 (149.3)	65.0
T_{11} Weed management with organic practice (Mulch)	--	17.0(290.7)	12.9 (165.3)	61.3
T_{12} Weedy check	--	21.4 (458.7)	20.7 (426.7)	0.0
SEm±			0.4	
LSD (P=0.05)		2.1	1.2	

Data transformed to square root transformation ($\sqrt{x+0.5}$), values given in parenthesis are the means of original value

Table 3: Effect of weed control treatment on plant height (cm), leaves, shoots per plants, fresh and cured rhizome yield (q/ha) of turmeric

Treatment	Dose (kg/ha, t/ha)	Plant height (cm)	Leaves/ plant (No.)	Shoots/ plant (No.)	Fresh rhizome yield (q/ha)	Cured rhizome yield (q/ha)
T_1 Metribuzin fb hand weeding twice	0.70	41.6	4.7	1.3	89.17	54.84
T_2 Metribuzin fb straw mulch fb hand weeding	0.70 + 10	42.7	5.6	1.8	90.19	55.46
T_3 Pendimethalin fb hand weeding twice	1.0	40.4	4.9	1.4	75.46	46.41
T_4 Pendimethalin fb straw mulch fb hand weeding	1+ 10	41.0	5.6	1.8	71.81	44.17
T_5 Atrazine fb hand weeding twice	0.75	41.5	4.4	1.4	86.94	53.47
T_6 Atrazine fb straw mulch fb hand weeding	0.75 + 10	41.1	5.2	1.7	86.20	53.02
T_7 Oxyfluorfen fb hand weeding twice	0.30	41.0	4.9	1.6	62.87	38.67
T_8 Glyphosate fb hand weeding twice	1.23	39.1	4.9	1.4	79.63	48.97
T_9 Glyphosate fb hand weeding twice	1.85	39.8	4.8	1.6	75.37	46.35
T_{10} Hand Weeding thrice	--	41.2	5.0	1.3	77.78	47.83
T_{11} Weed control with organic practice (Mulch)	--	40.6	5.2	1.4	77.78	47.83
T_{12} Weedy check	--	38.8	4.2	1.4	42.59	26.19
SEm±		0.5	0.3	0.1	6.98	4.29
LSD (P=0.05)		1.4	0.7	NS	20.59	12.66

The data on effect of different herbicide treatments on the weed count at 120 DAP (Table 2) shows significant differences amongst various treatments. Significantly lowest weed count at 120 DAP was recorded in the treatment in which pre-emergence application of metribuzin 700 g/ha was followed by application of straw mulch fb one hand weeding at 75 DAP though this treatment was at par with application of metribuzin 0.70 kg/ha fb two hand weedings at 45 and 75 DAP and treatments in which atrazine 0.75 kg/ha and hand weedings were applied with or without the use of straw mulch. These treatments were followed by all other herbicide treatments except treatment in which pendimethalin (1 kg/ha) was applied fb straw mulch fb one hand weeding at 75 DAP and organic mulch. Significantly highest total weed dry matter was recorded in the weedy check.

The data on effect of different herbicide treatments on the weed dry matter at 120 DAP (Table 2) revealed significant differences amongst various treatments. Significantly lowest total weed dry matter at 120 DAP was recorded in the treatment in which pre-emergence application of metribuzin 0.70 kg/ha was followed by application of straw mulch fb one hand weeding at 75 DAP though this treatment was at par with application of metribuzin 0.70 kg/ha fb two hand weedings at 45 and 75 DAP and treatments in which atrazine 0.75 kg/ha and hand weedings were applied with or without the use of straw mulch. These treatments were followed by all other herbicide treatments except treatment in which pendimethalin (1 kg/ha) was applied fb straw mulch fb one hand weeding at 75 DAP, hand weeding thrice as well as use of organic mulch. Significantly highest total weed dry matter was recorded in the weedy check. Since the weed control index is based on the dry matter accumulated by weeds the treatments in which metribuzin or atrazine were used along with hand weeding and with or without straw mulch give higher weed control index indicating better efficacy of these two herbicides in managing weeds in turmeric. Lower values of weed control index was recorded in the treatments in which pendimethalin was used indicate the ineffectiveness of this herbicide for controlling weeds in turmeric. Similarly oxyfluorfen as well as glyphosate were found to be less effective in controlling weeds in turmeric as compared to metribuzin and atrazine.

The plant height of turmeric was significantly influenced (Table 3) by different herbicide treatments with significantly shortest plants recorded in weedy check treatment though this treatment was at par with treatments in which glyphosate was used at both the doses. The result so indicate the adverse effect of glyphosate application on turmeric. Similar results have also been reported by Sachdeva et. al 2015. Significantly taller plants were observed with the application of metribuzin 0.70 kg/ha fb straw mulch fb one hand weeding at 75 DAP though this treatment was at par with application of metribuzin as well as atrazine fb two hand weedings at 45 and 75 DAP which in turn were at par with treatments in which either pendimethalin or oxyfluorfen were used as well as with hand weeding thrice and use of straw mulch alone.

The data on effect of different herbicide treatments on number of leaves per plant (Table 3) revealed that the value of this parameter was significantly higher in treatments in which mulch was applied either alone with herbicides or alone. Significantly lower number of leaves per plant were recorded in weedy check. Also the treatments in which the crop wasw subjected to hand weeding lower number of leaves per plant. The number of shoots per plant also behaved in a similar manner as number of leaves % with treatments in which herbicides were applied alone with mulch application recording higher number of shoots per plant while the lowest were recorded in the weedy check. In the weedy check treatment the availability of all the essential resources including light, water and nutrients is limited to the crop, owing to their competition by weeds, which inturn resulted in poor and stunted growth leading to lower number of shoots per plant. Also the use of mulch, besides controlling weeds, helps in moderative the soil condition resulting in better growth and higher number of shoots per plant. Also treatments in which hand weeding was done resulted in lower values of shoots per plant which may be due to slight injury caused to the crop as a result of hand weeding.

The herbicides treatments brought about significant variation in rhizome yield (Table 3) of turmeric. Significantly highest fresh rhizome yield was

recorded with the pre emergence application of metribuzin 0.70 kg/ha fb straw mulch fb hand weeding at 75 DAP, though this treatment was at par with all other herbicide treatments except weedy check and oxyfluorfen fb hand weedings at 45 and 75 DAP. Similar trend was also observed in case of cured rhizome yield. Weeds in weedy check reduced turmeric fresh and cured rhizome yield by about 53 per cent. Mulching appeared to be an important practice in turmeric as the weed control treatment in which only mulch was used was as effective as other herbicidal treatments in increasing fresh and cured rhizome yield. The results so obtained also indicated that weed control in turmeric is an essential requirement for obtaining higher productivity of this crop. Also combined use of herbicides with the use of mulch as well as one or two hand weedings also helped in achieving higher yield. Similar results have been reported by several workers all over the world (Singh and Mahey, 1991; Gill *et al.,* 2000; Singh *et al.,* 2002; Ishimine *et al.,* 2003; Kaur *et al.,* 2008; Ratnam *et al.,* 2012; Kumar *et al.,* 2014; Bharty *et al.,* 2016; Singh *et al.,* 2017).

Conclusion

Based on our findings, it was concluded that weeds inflict huge losses in rhizome yield of turmeric and need to be managed with an integrated approach. Satisfactory yield and profit can be obtained by use of either metribuzin (0.70 kg/ha) or atrazine (0.75 kg/ha) fb straw mulch (10 t/ha) fb one hand weeding at 75 DAP.

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