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Response of non-chemical approaches of weed management in potato (*Solanum tuberosum)* crop under organic cultivation mode

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ABSTRACT

A field experiment was conducted during 2016-17 and 2017-18 at Gwalior, Madhya Pradesh, to study the effect of integrated weed management on weed species, yield and economics of potato (*Solanum tuberosum* L.) grown under chemical and non-chemical approaches of weed management. The treatments were white plastic mulch, black plastic mulch, straw mulching 5 t/ha (5 DAP), hand weeding (20 DAP) + straw mulching (25 DAP), two hand weedings (20 and 40 DAP), hand hoeing (20 DAP), hand hoeing (20 DAP) + hand weeding (40 DAP), metribuzin 500g/ha alone, metribuzin 500g/ha followed by hand weeding (40 DAP) and weedy check. Based on results, twice hand weeding deceased the weed density up to 86%, however one hand weeding with straw mulching 75%. At harvest, weed biomass under white and black plastic mulch compared to the weed infested treatment had highest around 46% in both but the lowest was observed where twice hand weeding was applied (19.20%) compared to weedy check. It can be concluded that twice hand weeding (20 and 40 DAP) resulted in better control of weeds with 78% WCE and maximum tuber yield (27.32 t/ha) followed by one hand weeding (20 DAP) + straw mulching (25 DAP) with 76% WCE and tuber yield 25.39 t/ha.

Key words: Metribuzin, Non-chemical, Potato, Straw mulch, Weed management

Potato (*Solanum tuberosum* L.) is one of the most important commercial vegetable crops widely grown in India. There are several constraints in potato production, of which the weeds often pose a serious problem. Potato has robust growing and quick spreading nature but it turns as a weak competitor with weeds. The critical period of crop-weed competition in potato is 20 - 66 days after emergence when the crop should be kept free from weeds (Monteiro *et al.* 2011). The yield reduction due to weeds in potato is estimated to be as high as 7 to 48% (Gupta *et al.* 2019). Singh and Bhan (1999) reported that the presence of weeds throughout the growing period of crop caused 62% reduction in tuber yield. Therefore, weed control in the initial stages plays an important role in maximizing the tuber production. Farmers in Gwalior, Madhya Pradesh region usually grow potato without having proper knowledge on use of herbicide.

Metribuzin is the most popular herbicide used in potato to control weeds (Zand *et al.* 2007; Zaki *et al.* 2014). Chemical weed control appears to hold a great promise for effective, timely and economic weed suppression. Besides beneficial effects of chemical weed control it may create environmental hazards and develops herbicide resistance and weed shift. Weed interference with the crop reduces marketable yield by decreasing number and size of potato tuber. Weeds may also create the problem in mechanical harvesting (Pandey 2000). The use of tillage or cultivator along with herbicide, controls the weeds effectively in potato crop (Mohammaddoust *et al.* 2011).

Mulches are used as an effective method for weed management. Integration of non-chemical methods of weed control also decreases the crop-weed competition and resulting less utilization of chemicals to control weeds. This experiment was planned to find out suitable non-chemical and economically viable weed management practices for potato crop.

MATERIALS AND METHODS

Field experiment was conducted during *rabi* 2016-17 and 2017-18 at Research Farm, College of Agriculture, RVSKVV, Gwalior, Madhya Pradesh, India of 412 m altitude from sea level, 79º 54' E longitude and 23º 10' N latitude. No rainfall was received both the years during crop growing period. Although the humidity ranged from 93% in the morning to 28% in the evening which was good to crop growth and the temperature ranged from 4^0C-32^0C during both the years. The soil was sandy clay loam in texture, low in available N (237 kg/ha), medium in P (19.7 kg/ha) and K (277.1 kg/ha).

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Table 1 Density of narrow- leaved weeds as infuenced by different weed management practices (pooled data 2016-17 and 2017-18)

Treatment	*C. rotundus*		*P. minor*		*S. arvensis*		*C. dactylon		*R. dentatus	*H. spontaneum		*P. monspeliensis	**A. fatua
	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	30 DAP	60 DAP	30 DAP	60 DAP
White plastic mulch	9.00 (80.67)	8.90 (80.67)	6.53 (44.67)	7.34 (61.33)	1.88 (3.33)	2.96 (8.67)	2.67 (6.67)	2.11 (4.00)	0.71 (0.00)	2.67 (6.67)	2.11 (4.00)	2.41 (5.33)	2.90 (8.00)
Black plastic mulch	7.00 (49.33)	8.60 (75.33)	5.88 (36.00)	6.73 (54.00)	2.65 (6.67)	2.29 (5.33)	2.12 (4.00)	1.76 (2.67)	1.34 (1.33)	2.26 (4.67)	2.67 (6.67)	2.68 (6.67)	1.29 (1.33)
Straw mulching	8.42 (72.00)	7.43 (55.33)	5.79 (36.00)	6.37 (42.67)	1.94 (3.33)	2.90 (8.00)	2.40 (5.33)	1.34 (1.33)	2.67 (6.67)	2.26 (4.67)	2.39 (5.33)	2.90 (8.00)	2.11 (4.00)
HW + Straw mulching	7.53 (58.67)	7.19 (51.33)	4.13 (18.83)	4.90 (24.00)	1.94 (3.50)	1.98 (4.00)	1.34 (1.33)	1.22 (1.00)	1.76 (2.67)	1.22 (1.00)	1.77 (2.67)	1.77 (2.67)	2.39 (5.33)
Two hand weeding	4.92 (27.17)	4.81 (22.83)	4.71 (27.67)	4.12 (17.00)	1.45 (1.67)	1.32 (1.33)	1.76 (2.67)	0.88 (0.33)	1.34 (1.33)	1.76 (2.67	1.47 (2.00)	2.41 (5.33)	0.71 (0.00)
One hand hoeing	7.81 (60.67)	9.39 (89.33)	5.69 (36.67)	5.90 (34.67)	1.56 (2.00)	2.82 (8.33)	1.34 (1.33)	1.76 (2.67)	1.74 (2.67)	2.11 (4.00)	1.95 (3.33)	2.11 (4.00)	2.11 (4.00)
Hoeing + hand weeding	9.52 (99.33)	6.20 (42.67)	6.56 (47.33)	6.15 (40.67)	2.82 (8.00)	1.65 (2.67)	2.11 (4.00)	1.77 (2.67)	0.71 (0.00)	1.76 (2.67)	1.68 (2.33)	1.76 (2.67)	0.71 (0.00)
Metribuzin 0.5 kg/ha	12.38 (160.67)	11.15 (127.33)	6.64 (45.33)	7.97 (64.00)	2.77 (7.33)	1.70 (2.67)	2.39 (5.33)	2.11 (4.00)	0.71 (0.00)	0.71 (0.00)	1.76 (2.67)	2.11 (4.00)	0.71 (0.00)
Metribuzin 0.5 kg/ha + HW	10.73 (116.67)	9.84 (100.00)	4.41 (32.67)	6.63 (46.00)	2.15 (4.17)	1.36 (1.50)	2.67 (6.67)	1.29 (1.33)	0.71 (0.00)	0.71 (0.00)	1.34 (1.33)	2.20 (4.33)	0.71 (0.00)
Weedy check	16.50 (272.00)	14.51 (210.67)	10.05 (112.67)	10.72 (118.00)	4.02 (16.17)	3.42 (11.33)	3.34 (10.67)	2.91 (8.00)	2.91 (8.00)	3.71 (13.33)	4.53 (20.00)	4.22 (17.33)	2.80 (7.33)
SEm ±	0.501	0.372	0.359	0.390	0.162	0.363	0.152	0.166	0.130	0.141	0.197	0.135	0.160
LSD(P=0.05)	1.467	1.089	1.051	1.142	0.475	1.063	0.444	0.486	0.380	0.414	0.576	0.395	0.469

*Weeds emerged in 2016-17 only. **Weed emerged in 2017-18 only. Transform values of $\sqrt{x+0.5}$ was used. Figures in parentheses indicate original values

Table 2 Density of broad-leaved weeds as influenced by different weed management practices (pooled data of 2016-17 and 2017-18)

Treatment	*C. album*		*C. arvensis*		**M. hispida*		*A. arvensis*		**R. dentatus*
	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	60 DAP	*30 DAP	60 DAP	60 DAP
White plastic mulch	6.47 (56.00)	9.98 (106.00)	1.77 (2.67)	2.40 (5.33)	2.68 (1.67)	2.40 (5.33)	4.38 (18.67)	2.62 (8.00)	2.11 (4.00)
Black plastic mulch	7.22 (60.00)	8.36 (79.33)	1.94 (3.33)	1.94 (3.33)	2.41 (5.53)	2.09 (4.00)	4.22 (17.33)	2.46 (8.67)	1.29 (1.33)
Straw mulching	6.61 (50.00)	8.81 (81.33)	0.71 (0.00)	1.73 (2.67)	2.41 (5.33)	2.07 (4.00)	4.06 (16.00)	3.80 (14.00)	2.12 (4.00)
HW + Straw mulching	5.24 (34.33)	6.42 (42.00)	2.11 (4.00)	2.26 (4.67)	2.40 (5.33)	1.92 (3.50)	3.12 (9.33)	1.92 (4.67)	0.71 (0.00)
Two hand weeding	5.38 (37.33)	5.12 (28.00)	1.03 (0.67)	1.11 (0.83)	2.11 (4.00)	1.28 (1.17)	3.13 (9.33)	1.81 (4.00)	0.71 (0.00)
One hand hoeing	7.98 (65.33)	7.93 (62.67)	1.50 (1.83)	1.73 (2.67)	2.67 (6.67)	2.03 (3.67)	2.91 (8.00)	2.40 (5.33)	2.41 (5.33)
Hoeing + hand weeding	8.10 (66.00)	5.74 (36.67)	1.55 (2.00)	1.73 (2.67)	3.34 (10.67)	1.94 (3.33)	3.12 (9.33)	1.56 (2.67)	1.76 (2.67)
Metribuzin 0.5 kg/ha	2.46 (8.67)	4.86 (27.33)	1.98 (3.83)	1.82 (3.17)	0.71 (0.00)	1.51 (1.83)	1.34 (1.33)	1.45 (2.17)	0.71 (0.00)
Metribuzin 0.5 kg/ha + HW	2.29 (7.33)	3.93 (16.67)	0.88 (0.33)	1.64 (2.50)	0.71 (0.00)	1.20 (1.00)	0.71 (0.00)	1.19 (1.17)	0.71 (0.00)
Weedy check	11.78 (160.67)	11.74 (147.33)	2.54 (6.33)	3.33 (10.67)	4.66 (21.33)	4.02 (16.83)	5.21 (26.67)	4.33 (18.67)	3.34 (10.67)
SEm ±	0.389	0.361	0.137	0.180	0.121	0.222	0.132	0.164	0.123
LSD(P=0.05)	1.139	1.058	0.402	0.527	0.354	0.650	0.386	0.479	0.359

*Weeds emerged in 2016-17 only. Transform values of $\sqrt{x+0.5}$ was used. Figures in parentheses indicate original values

Experimental design and treatments

Ten treatments were executed in the experiment and replicated thrice under randomized block design. The experiments were white plastic mulch, black plastic mulch, straw mulch 5 t/ha, one hand weeding after 20 days of planting (20 DAP) followed by straw mulching, two hand weeding at 20 and 40 DAP, one hand hoeing at 20 DAP, one hand hoeing at 20 DAP followed by one hand weeding at 40 DAP, metribuzine 500g/ha as pre-emergence, metribuzine 500g/ha as pre-emergence with one hand weeding at 40 DAP and weedy check (no weed removal). The thickness of white and black plastic mulches was 50 microns which was used to cover the space between rows and then potato planting was done with making a whole in the plastic sheet immediately. For straw mulching wheat straw was used as 5 t/ha with thickness of 15 cm after 5 days of planting.

Field was prepared to a fine tilth by one deep ploughing followed by two cross disc harrowing followed by planking. Variety Kufri Sindoori was planted in the first week of November with seed rate 3 t/ha in plot size 5.0 m × 3.6 m with spacing of 60 cm × 20 cm after harvesting of greengram in the month of October both the years. Seed treatment was done with phosphate solubilising bacteria (PSB) @ 5 ml/kg of seed by dipping tubers for 30 min. Application of 10 tonnes FYM and 5 tonnes vermicompost were made during field preparation. Vermicompost @ 5 t/ha with 5 kg/ha gram flour (*besan*) was also applied before planting. To control the termites neem cake 250 kg/ha was also incorporated in soil. Foliar spray of *panchagavya* (3% solution) at 10 days interval was applied 5 times during crop growth period. During first irrigation PSB+KSB+*Azotobacter* (100 ml each/ha) was applied to provide enzymes, vitamins and hormones to the plants.

Weed sampling was done in each plot with 1.0 m × 1.0 m quadrate. After counting the weeds, dried in oven for 72 hr at 75^0C. Yield of tuber was recorded after excluding two border rows.

RESULTS AND DISCUSSION

Weed flora

Major weed flora of experimental site were: *Cyperus rotundus* (38.3%), *Phalaris minor* (18.5%), *Spergula arvensis* (2.2%), *Polypogon monspeliensis* (2.3%), *Rumex dentatus* (1.5%), *Avena fatua* (0.6%), *Hordium spontaneum* (2.7%), and *Cynodon dactylon* (1.5%) as grasses, *Medicago polymorpha* (3.0%), *Chenopodium album* (24.6%), *Convolvulus arvensis* (1.4%) and *Anagallis arvensis* (3.6%) as major broad-leaved weeds (BLW's). *Cynodon dactylon* and *Rumex dentatus* were not seen in 2017-18. Some weeds like *Avena fatua, Medicago polymorpha, Polypogon monspeliensis* and *Anagallis arvensis* were emerged only after 60 DAP.

Effect on weeds

Density and dry matter accumulation of weeds were significantly affected by weed management practices. At

Fig 1 The images of the experimental site at RVSKVV, Gwalior, MP, India. 30 days crop (*Left*) and 60 days crop (*Right*)

initial stage of crop growth, minimum weed density was observed where two hand weeding was applied followed by one hand weeding along with application of straw mulch. However, after 60 days of planting, the density of weeds was effectively controlled by two hand weeding followed by one hoeing supplemented with one hand weeding at 40 DAP.

After 30 days of planting the density of *Cynodon dactylon, Hordium spontaneum* and *Polypogon monspeliensis* was observed very low as compared to other grasses (Table 1 and Fig 2). While the density of *Cyperus rotundus* was found maximum in the experimental plot followed by *Phalaris minor* where the density of *Chenopodium album* was recorded maximum compared to other broad leaved-weeds (Table 2). *Cyperus rotundus* effectively controlled by twice hand weeding at 20 and 40 DAP followed by hoeing at 20 DAP supplemented with one hand weeding at 40 DAP and this treatment was at par with one hand weeding at 20 DAP along with the application of straw mulch 5 t/ha at 60 DAP. *Phalaris minor* was controlled by two hand weeding but it was at par with hand weeding at 20 DAP with the application of straw mulch as 5 t/ha.

After 60 days of planting among broad-leaved weeds the minimum density of *Polypogon monspeliensis*, *Medicago hispida* and *Anagallis arvensis* was achieved under twice hand weeding and these weeds were also at par with one hand weeding along with application of straw mulch 5 t/ha. However *Convolvulus arvensis* was effectively controlled by twice hand weeding and it was at par with straw mulch 5 t/ha applied alone. Metribuzin 500 g/ha was also effectively prevented the germination of weeds and found good to control the narrow and broad-leaved weeds both.

Dry weight of weeds was significantly influenced by different treatments. After 30 days of planting the minimum dry matter accumulation of weeds was found under one hand weeding with application of straw

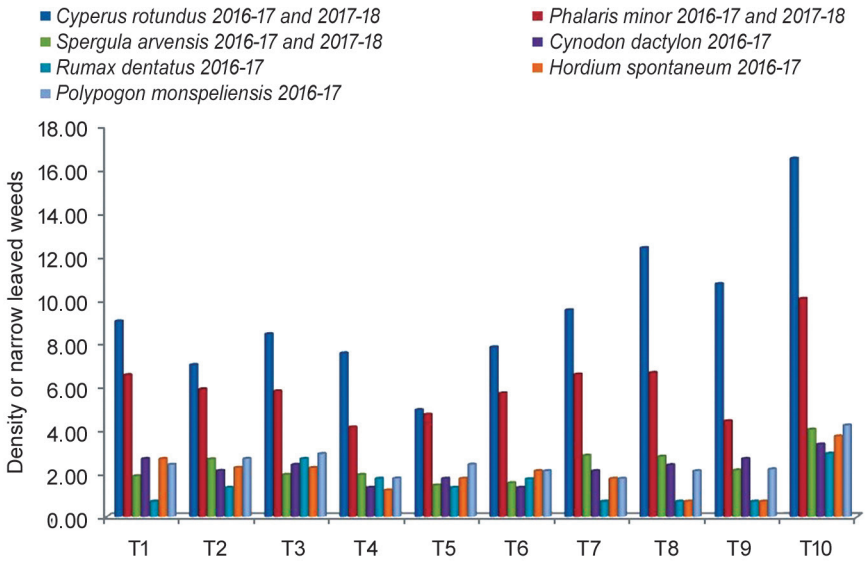

Fig 2 Effect of different weed management practices on density of NLWs at 30 DAS.

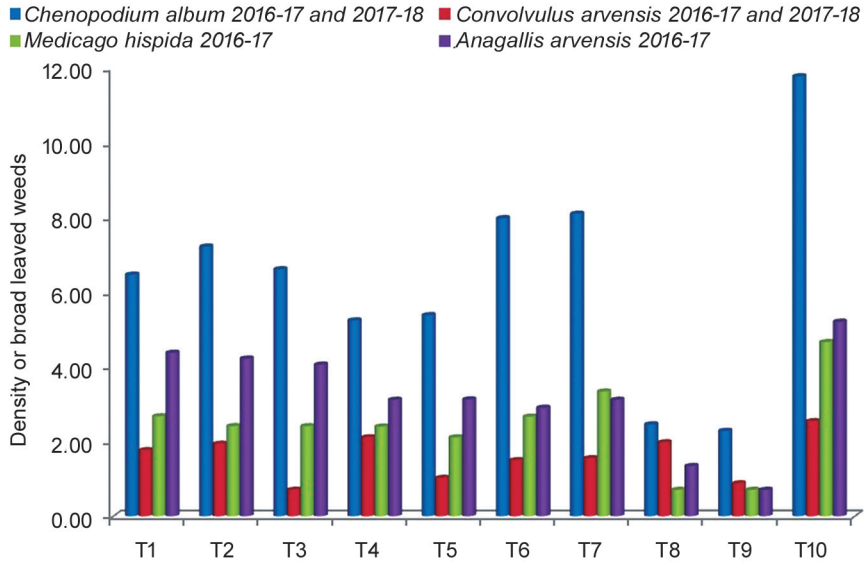

Fig 3 Effect of different weed management practices on density of BLWs at 30 DAS.

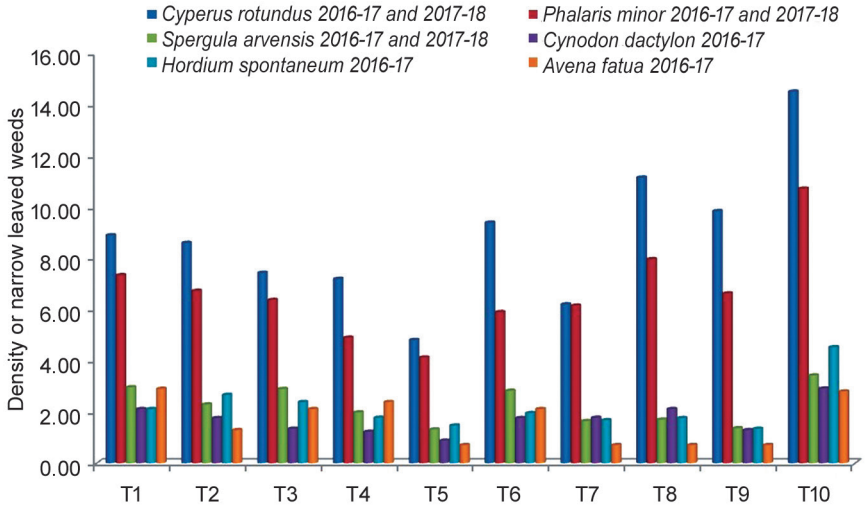

Fig 4 Effect of different weed management practices on density of NLWs at 60 DAS.

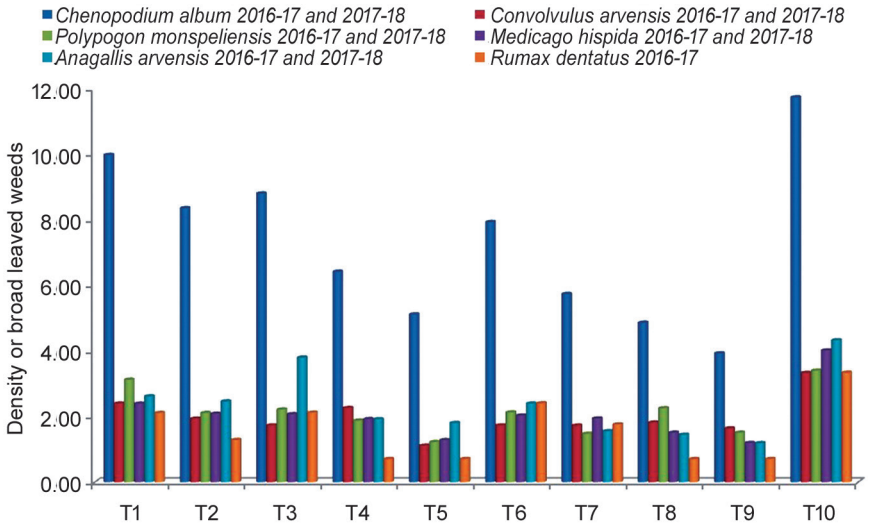

Fig 5 Effect of different weed management practices on density of BLWs at 60 DAS.

mulch 5 t/ha which was closely followed by twice hand weedings. The minimum dry matter at 60 DAP was found where twice hand weedings was done followed by one hand weeding with application of straw mulch 5 t/ha. After 30 days of planting the maximum weed control efficiency (73.46%) was recorded where one hand weeding was done with application of straw mulch followed by twice hand weedings (72.45%) and minimum weed control efficiency was found where white plastic mulch was used as compared to black plastic mulch (Table 3). It might be due to light passes through white plastic mulch and its stimulate the germination of weeds but because of the low temperature during the crop growth period it could not prevent weeds germination and the result, may be stimulated weed species and causes of weed germination. This was reported by Azadbakht *et al.* (2017) and Majd *et al.* (2014).

Potato yield

The maximum potato tuber yield 27.32 t/ha was recorded with execution of twice hand weeding followed by application of one hand weeding with supplementation of straw mulch (25.39 t/ha) and straw mulch applied alone (22.96 t/ha) which were 92%, 79% and 62% higher over weedy check (14.20 t/ha). Whereas the application of white plastic mulch recorded 18.69 t/ha yield of potato (Table 3).These results supported the findings of Masud Mahmood (2002).

Economics

Execution of twice hand weeding fetched the maximum net returns (₹318346/ha) followed by one hand weeding with supplementation of straw mulch 5 t/ha (₹286549/ha) and straw mulch applied alone (₹254241/ha). A similar trend was observed in B:C ratio. Therefore, application of straw mulch was beneficial over polythene mulch. These results supported the findings of Dixit *et al.* (2016).

Conclusion

Based on two years experimentation it was concluded that twice hand weedings 20 and 40 DAP resulted an effective control of weeds achieving 78% weed control efficiency with maximum tuber yield (27.32 t/ha) followed by straw mulching with supplementation of one hand weeding which gave 76% weed control efficiency as well as tuber yield 25.39 t/ha. Non-chemical methods of weed management practices provide effective management

Table 3 Weed biomass g/m^2, weed control efficiency (%), yield and economics of potato as influenced by different weed management practices (pooled data of 2016-17 and 2017-18)

Treatment	30 DAP		60 DAP		At harvest		Tuber yield (t/ha)	Net returns (₹/ha)	B:C ratio
	Weed biomass	WCE%	Weed biomass	WCE%	Weed biomass	WCE%			
White plastic mulch	42.98	52.81	49.91	45.46	42.41	48.90	18.69	135957	0.90
Black plastic mulch	35.81	60.68	38.57	57.84	31.07	62.56	20.27	167612	1.19
Straw mulching	33.69	63.01	38.19	58.27	30.69	63.02	22.96	254241	2.75
HW + Straw mulching	24.17	73.46	21.33	76.69	13.83	83.34	25.39	286549	2.94
Two hand weeding	25.10	72.45	19.58	78.61	7.68	90.75	27.32	318346	3.40
One hand hoeing	38.41	57.83	34.05	62.79	26.55	68.01	16.53	163148	1.87
Hoeing + hand weeding	36.21	60.24	23.65	74.15	16.15	80.54	17.76	177603	1.92
Metribuzin 0.5 kg/ha	33.03	63.73	34.83	61.93	27.33	67.06	21.89	244043	2.84
Metribuzin 0.5 kg/ha + HW	28.12	69.12	23.41	74.41	25.41	69.38	22.39	248533	2.78
Weedy check	91.08		91.50		82.99		14.20	129600	1.49
SEm ±	2.076		1.792		1.693		1.02	24726.99	0.216
LSD(P=0.05)	6.078		5.247		4.957		2.99	72386.35	0.632

Economics was calculated on the basis of prevailing market price of inputs used and output obtained from each treatment.

of weeds as compared to chemical methods and the use of straw mulch material reduces the doses of herbicidal application.

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