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Weed Dynamics And Yield Of Potato As Influenced By Integrated Weed Management

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A B S T R A C T

The experiment was conducted in Department of Agronomy, College of Agriculture (RVSKVV), Gwalior (M.P.) during the *Rabi* season of 2017-2018. The trial was laid out in a randomized block design replicated three times with 10. All the integrated weed management practices gave more tuber yield than weedy check. Amongst different weed control treatments, two hand weeding (HW) at 20 and 40 DAP was the most effective treatment for reducing weed population and weed dry weight and improving the growth. On the basis of above findings, it may be concluded that the maximum potato yield and net return were obtained from two H. W. 20 and 40 DAP, followed by one H. W. at 20 DAP + straw mulching 5 t/ha at 25 DAP. In the scarcity of labourer, the farmer may chose the second option *i.e.*, one H. W. at 20 DAP + straw mulching 5 t/ha at 25 DAP or straw mulching 5 t/ha at 5 DAP. B:C ratio was obtained higher in two H. W. 20 and 40 DAP followed by one H. W. at 20 DAP + straw mulching 5 t/ha at 25 DAP.

Key words : Weeds,Hand weeding, Plastic mulch, Hand hoeing, Sraw mulching

INTRODUCTION

India stands second largest producer of potato in the world, contributing 10% of the world's total potato production. In 2015-16, potato was cultivated on 2.13 million hectares in India, with a production of 43.77 million tonnes and productivity of 23.07 tones/ha. While, in Madhya Pradesh potato is cultivated on 141.05 thousand ha area with a production of 3161 thousand tonnes and productivity of 22.410 t/ha in (FAO 2014). It covers 6.6% of total area and contributes 7.22% in national potato production. Potatoes crops are poor competitive with weeds, so relatively weed-free condition is required for successful production. Weeds reduced potato tuber yield by 53.4% (Hidayat *et al.* 2013) to 86% (Monteiro *et al.* 2011). Controlling weeds led to 18-82% increment in tuber potato yield (Jaiswal and Lal 1996). The standard methods of controlling weeds in potato crop have been limited to hoeing or herbicides (Eberlein *et al.* 1997, Harker and O'donovan 2013). However, the synthetic herbicides have residual effects in foods, soil, and water (Abouziena *et al.* 2008 and Serajchi *et al.* 2013). Moreover, the overuse of herbicides led to the rapid evolution of herbicide-resistant weeds (Powles and Yu 2010). Integrated weed management (IWM) can be a holistic approach to weed management that integrates different methods of weed control to provide crop an advantage over weeds. It is practiced globally at varying levels of adoption from farm to farm. IWM has the potential to restrict weed populations to manageable levels, reduce the adverse environmental impact of individual weed management practices, increase cropping system sustainability, and reduce selection pressure for weed resistance to herbicides (Harker and O'Donovan 2013). Plastic mulches have various beneficial effects on crop production in arid regions, including crop earliness, crop cleanliness, prevent soil erosion, conservation of soil moisture and weed control as well as fertility and improving yield and the control of weeds, pests and diseases (Kumar and Lal 2012, Hidayat *et al.* 2013). Immirzi *et al.* (2009) reported that the main advantages of the plastic mulches are the decreased use of chemicals in weed control, reduced water consumption, faster crop development, improved plant health and better yield quality. Different types and colours of plastic mulch have characteristic optical properties that change the levels of light radiation reaching the soil, causing increases or decreases in the soil temperature (Kasirajan 2012). Efficiency of plastic mulches varied according to the plastic colour i.e. white, black, blue, brown, green, red and yellow (Mahmood *et al.* 2002, Grundy and Bond, 2007, Dvořák *et al.* 2012).

MATERIAL AND METHODS

Experimental site

The experiment was conducted in field of the College of Agriculture (RVSKVV), Gwalior (M.P.). The topography of the field was uniform with proper drainage. The soil of the experimental field was sandy clay loam. Few soil samples of the surface soil up to 15 cm, depth was taken randomly before sowing and a composite sample made after mixing all these, was analyzed in the laboratory for mechanical and chemical composition. Data obtained are presented in **Table 1**.

Table 1. Analysis of soil

Soil component	Percentage	Methods used
Sand	59.50	By international pipette method (Piper, 1950)
Silt	17.20	
Clay	22.30	
Mechanical analysis of the soil		
Soil constituents	**Value Status**	**Methods**
Available Nitrogen	155.59 kg/ha	Alakaline permanganate method (Subbiah and Asiza, 1956)
Available Phosphorus	17.51 kg/ha	Olsen‟s methods (Olsen *et al.*, 1954)
Available Potassium	245.13 kg/ha	Flame Photometer (Muhur *et al.*, 1965)
Organic Carbon	0.44 (%)	Walkley and Black‟s Rapid Titration method (Piper, 1950).
Chemical analysis of the experimental soil		
Physico-Chemical Characteristics		
Cation Exchange	16.23	Ammonium Acetate method
Electrical Conductivity (mm hos/ cm) at 25°C	0.73	Solubridge method (Richard, 1954)
pH	7.59	Blackman‟s Glass Electrode pH meter (Muhur *et al.* 1965)

Experimental details

The experiment was conducted in randomized block design replicated three times with 10 treatments namely white plastic mulch (50 micron), black plastic mulch (50 micron), straw mulching 5 t/ha at 5 DAP, one HW at 20 DAP + straw mulching 5 t/ha at 25 DAP, two HW at 20 and 40 DAP, one hand hoeing at 20 DAP, hoeing at 20 DAP and one HW at 40 DAP, recommended herbicide (Metribuzine 0.5 kg /ha as PE), recommended herbicide (metribuzine 0.5 kg /ha as PE) + one HW at 40 DAP and weedy check).

Crop management

The layout of experimental plot was done as per specification mentioned in layout plan with the help of measuring tap, rope, bamboo pegs and manual labour. Field was divided into 30 plots having irrigation channels and path. The nutrients were applied through FYM (10 t/ha) and vermicompost (10 t/ha). Manure was applied immediately before sowing. FYM containing 0.5 % N, 0.2 % P and 0.5 % K and vermicompost 0.5-1.5 % N, 0.1-0.3% P and 0.15-0.56 % K, respectively.

Seed potato tubers were taken out from cold storage and kept in the potato shed for 15 days before planting to accelerate the sprouting. Thick curtains were fixed to each and every window to avoid the direct entry of sunlight and maintain proper aeration. Sprouting occurred after 7 days. Seeds were planted 30 quintal /ha by manually with a uniform distance of sixty centimetres between rows and twenty centimetres distance between plant to plant. The planting was done on 16 November, 2017.

The first irrigation was given immediately after planting to ensure proper establishment of sprout. Subsequent irrigation was given at about 15-20 days interval up to maturity by furrow method as when required to potato. Haulm cutting of potato crop was done at 90 DAP and tuber digging was done after 10 days after haulm cutting by using spade, manually. Border rows plant was harvested first and then tubers from net plot were dug. While digging, care was taken for digging injury to tubers. After harvesting the potato tubers were graded into three groups on the basis of tuber weight and number viz. >25 g, 50-75 g, and <75 g and weighed separately to record yield.

Sampling procedures

Sampling was done at 30 and 60 days after planting and at harvest for growth analysis. Five plants from net area of each plot were randomly selected from three successive stage by selecting row in the first stage, plant of one-meter running row from selected row in the second stage and ultimate sample unit from selected plants of one-meter running row in third stage of selection with the help of simple random sampling without replacement.

RESULTS AND DISCUSSION

The major broad leaf weed species in the experimental plots were found 5 weeds, *viz. Cyperus rotundus, Phalaris minor, Convovulus arvensis, Chenopodium album, Spergula arvensis,* and the other weed species in experimental plots were found 3 weeds viz., *Polypogon monspeliensis Avena fatua, Anagallis arvensis and Medicago hispida.* These nine species were most dominant, contributing about 100 per cent of the total weed flora. These results are in accordance with Sharma *et al.* (2004), Tomar *et al.* (2008), and *Arora et al*. (2009).

Weed population/m^2

The weed population of *Cyperus rotundus* was significantly influenced with the different weed management treatments at 30, 60 days after planting (DAP) and harvest stages. Two HW at 20 and 40 DAP treatment resulted in lowest weed population of *Cyperus rotundus*, and maximum population was recorded under the treatment weedy check) at all the stages.

Weed population of *Phalaris minor* was affected significantly at the stages of 30, 60 DAP and harvest. At 30 DAP, the treatments of 2 HW at 20 and 40 DAP completed weed control of *Phalaris minor* and maximum population was recorded under the treatment weedy check. At 60 DAP, the population of this weed was found comparatively less under 2 HW at 20 and 40 DAP and, it was at par with black plastic mulch (50 micron). However, maximum population was recorded under weedy check. At harvest, application of 2 HW at 20 and 40 DAP which was at par with black plastic mulch (50 micron) and hoeing at 20 DAP and one HW at 40 DAP. Maximum weed population was recorded under weedy check.

Different weed management treatments significantly influenced the *Chenopodium album* population at 30, 60 DAP and harvest. At 30 DAP, the minimum population was recorded in treatment 2 HW at 20 and 40 DAP which was at par with one HW at 20 DAP + straw mulching 5 t/ha at 25 DAP, recommended herbicide (metribuzine 0.5 kg/ha as PE) + 1 HW at 40 DAP, recommended herbicide (metribuzine 0.5 kg/ha as PE) and white plastic mulch (50 micron). Maximum weed population of *Chenopodium album* were noted under weedy check, which was at par with 1 hand hoeing at 20 DAP and hoeing at 20 DAP and 1 HW at 40 DAP. At 60 DAP, treatment 2 HW at 20 and 40 DAP gave significantly maximum control of *Chenopodium album*. Maximum weed population of *Chenopodium album* were noted under weedy check, which was at par with 1 hand hoeing at 20 DAP. At harvest, treatment 2 HW at 20 and 40 DAP gave significantly higher control of *Chenopodium album* and maximum weed population of *Chenopodium album* were recorded under weedy check) which was at par with 1 hand hoeing at DAP.

Weed populations of *Convolvulus arvensis* were affected significantly at the stages of 30, 60 DAP and harvest. At 30 DAP, treatments two HW at 20 and 40 DAP recorded significantly lower population of *Convolvulus arvensis* over rest of treatments except hoeing at 20 DAP and 1 HW at 40 DAP. Maximum weed population of *Convolvulus arvensis* was recorded under weedy check. At 60 DAP, treatment 2 HW at 20 and 40 DAP gave significantly control of *Convolvulus arvensis* over rest of treatments and it was at par with straw mulching 5 t/ha at 5 DAP. Maximum weed population of *Convolvulus arvensis* was recorded under weedy check. At harvest stage, treatment 2 HW at 20 and 40 DAP resulted in significantly lowest population of *Convolvulus arvensis*, over rest of the treatments and maximum weed population was recorded weedy check treatment.

Weed populations of *Spergula arvensis* were significantly reduced under the application of various treatments of weed control in the stages of 30, 60 DAP and harvest At 30 DAP, the population of this weed was found comparatively less under 2 HW at 20 and 40 DAP and, it was at par with straw mulching 5 t/ha at 5 DAP. However, maximum population was recorded under weedy check. At 60 DAP, application of 2 HW at 20 and 40 DAP significantly superior overall rest of the treatments. Minimum weed population was recorded under 2 HW at 20 and 40 DAP and maximum weed population was recorded under weedy check, which at par with one hand hoeing at 20 DAP. At harvest stage, minimum weed population of *Spergula arvensis* were recorded under two hands weeding at 20 and 40 DAP. Maximum weed population (4.50) were recorded under weedy check.

Population of other weeds, *viz. Polypogon monspeliensis, Avena fatua, Medicago hispida and Anagallis arvensis* differed significantly among various weed control treatments at 60 DAP of crop growth. Minimum population of all other weeds was registered in application 2 HW at 20 and 40 DAP which was significantly less than all rest of the other treatments. The maximum population of all other weeds was recorded under weedy check.

Both the narrow and broad leaves and total weed population was differed significantly at 30, 60 DAP and harvest stages. The lowest narrow leaf weed population was noted in treatment 2 HW at 20 and 40 DAP gave significantly control over rest of treatments. Maximum narrow leaf weed population was recorded under weedy check at all crop growth stages. These species were most dominant in Gwalior region. These results are in accordance with Sharma *et al*. (2004), Tomar *et al*. (2008), and Arora *et al*. (2009).

At stage of 30, 60 DAP and harvest, the minimum total dry weight was noted in treatment 2 H.W. at 20 and 40 DAP. Maximum total dry weight was recorded under weedy check.

These results are in accordance with Kosterna *et al.* (2014) who concluded that application of straw mulch at the beginning of growing period of vegetable reduced in number and mass of weed. The higher density of *Cyperus rotundus* may be due to the fact that it

belongs to C4 plant and has quick germination and survival capacity as well as the greater competitive ability than the other weeds. These results are in conformity of the results reported by Sandyan *et al*. (1989), Khurana *et al.* (1992) and Yadav *et al*. (2014) most effective control of broad leaf as well as narrow leaf weeds over other treatments at 40 DAP and harvest.

Weed control efficiency

Weed control efficiency ranged from 19.10 to 77.40 per cent. The highest weed control efficiency was estimated in 2 HW 20 and 40 DAP, The next effective weed control treatments was hoeing at 20 DAP and 1 HW at 40 DAP, followed by recommended herbicide (metribuzine 0.5 kg /ha as PE)+ 1 HW at 40 DAP. The lowest weed control efficiency was observed under white plastic mulch (50 micron).

ECONOMICS OF THE TREATMENTS

Tuber yield (t/ha) harvest index and weed index

Significant effect due to different weed control treatment was observed on tuber yield, and harvest index at harvest. Maximum tuber yield (22.38 t/ha) was recorded with treatment 2 HW at 20 and 40 DAP which was at par with 1 HW at 20 DAP + straw mulching 5 t/ha at 25 DAP, straw mulching 5 t/ha at 5 DAP and recommended herbicide (metribuzine 0.5 kg /ha as PE)+ 1 HW at 40 DAP. However, the significantly minimum tuber yield (11.81 t/ha) was recorded under weedy check treatment which was at par with one hand hoeing at 20 DAP.

Harvest index showed significant variation in all the treatment. Harvest Index was maximum 65.66% in 2 HW at 20 and 40 DAP followed by 1 HW at 20 DAP + straw mulching 5 t/ha at 25 DAP (63.45%). Minimum harvest index was 51.11 % in weedy check.

Different weed control treatments denoted the varying values of weed index ranging from 5.71 to 47.22 per cent. Treatment 2 HW at 20 and 40 DAP gave the completely weed control. One HW at 20 DAP + straw mulching 5 t/ha at 25 DAP recorded lowest weed index followed by straw mulching 5 t/ha at 5 DAP and recommended herbicide (metribuzine 0.5 kg /ha as PE) + 1 HW at 40 DAP. Similarly, weedy check resulted in maximum weed index followed by 1 hand hoeing at 20 DAP.

These finding are in accordance with Sandhu *et al*. (1976), Gill *et al.* (1983), Singh *et al.* (2007), and Abouziena *et al.* (2008).

ECONOMICS

The choice of any weed control method ultimately depends on economics and efficiency in controlling weeds. The cost of chemical weed control is actually less than that of manual weeding, hoeing and mulching. This has been a major incentive to many farmers for switching over to herbicides. Weed control by using herbicides is one of the easiest, time saving and economical alternative as compared to manual weeding (Rao and Narayana 1985).

From the different weed control treatment two hand weeding at 20 and 40 DAP gave highest net return of Rs. 245677/ha which was at par with Treatment 2 HW at 20 and 40 DAP. All other treatments were at par with 1 HW at 20 DAP + straw mulching 5 t/ha at 25 DAP (Rs. 222261/ha), straw mulching 5 t/ha at 5 DAP (Rs. 189841/ha), recommended herbicide (metribuzine 0.5 kg /ha as PE) + 1 HW at 40 DAP (Rs. 183158/ha) and T_8 (Rs. 179960/ha). Minimum net return (Rs. 91792 /ha) was received in white plastic mulch (50 micron). Similarly, two hand weeding at 20 and 40 DAP performed the highest benefit cost ratio of 2.51, closely followed by treatment 1 HW at 20 DAP + straw mulching 5 t/ha at 25 DAP (2.15). Whereas, minimum B:C ratio was obtained in white plastic mulch (50 micron), black plastic mulch (50 micron) and weedy check. All these above treatments, were most effective weed control treatments recorded higher yield and weed control efficiency, also recorded higher benefit cost ratio. Similar finding were also reported by Habib *et al*. (1991), Singh *et al.* (2007), Singh (2010) and Yadav *et al*. (2014).

CONCLUSIONS

All the integrated weed management practices gave more tuber yield than weedy check. Amongst different weed control treatments, Two hand weeding at 20 and 40 DAP was the most effective treatment for reducing weed population and weed dry weight and improving the growth. On the basis of above findings, it may be concluded that the maximum potato yield and net return were obtained from 2 H.W. 20 and 40 DAP, followed by one H.W. at 20 DAP + straw mulching 5 t/ha at 25 DAP. In the scarcity of labourer, the farmer may chose the second option *i.e.* 1 H.W. at 20 DAP + straw mulching 5 t/ha at 25 DAP or straw mulching 5 t/ha at 5 DAP. B:C ratio was obtained higher in 2 H.W. 20 and 40 DAP followed by 1 H.W. at 20 DAP + straw mulching 5 t/ha at 25 DAP.

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Table 1. Effect of different weed control measures on different weed populations at 30 DAP, 60 DAP and harvest stage of potato

Treatments	*Cyperus rotundus* /m²	*Phalaris minor* /m²	*Chenopodium album* /m²	*Convolvulus arvensis* /m²	*Spergula arvensis* /m²	*Cyperus rotundus* /m²	*Phalaris minor* /m²	*Chenopodium album* /m²	*Convolvulus arvensis* /m²	*Spergula arvensis* /m²	*Cyperus rotundus* /m²	*Phalaris minor* /m²	*Chenopodium album* /m²	*Convolvulus arvensis* /m²	*Spergula arvensis* /m²
White plastic mulch (50 micron)	1.89 (77.33)	1.42 (26.67)	0.80 (6.67)	1.77 (2.67)	3.18 (9.67)	1.75 (56.00)	1.30 (20.00)	1.73 (54.67)	3.32 (10.67)	4.05 (16.00)	1.71 (52.00)	1.22 (16.67)	1.44 (50)	4.02 (3)	3.67 (10)
Black plastic mulch (50 micron)	1.64 (44.00)	1.30 (20.00)	1.26 (18.67)	1.76 (2.67)	2.90 (8.00)	1.72 (52.00)	1.12 (13.33)	1.42 (26.67)	2.85 (7.67)	3.76 (13.67)	1.67 (46.67)	1.04 (11.00)	1.35 (22.33)	3.53 (2.33)	3.57 (3.67)
Straw mulching 5 t/ha at 5 DAP	1.97 (93.33)	1.20 (16.00)	1.20 (16.00)	2.34 (5.00)	1.76 (2.67)	1.64 (44.00)	1.35 (22.67)	1.16 (45.33)	1.34 (1.33)	3.12 (9.33)	1.58 (38.33)	1.26 (18,33)	1.14 (40.00)	2.26 (1)	2.71 (7.33)
One HW at 20 DAP + straw mulching 5 t/ha at 25 DAP	1.55 (36.00)	0.80 (6.33)	0.77 (6.00)	2.11 (4.00)	2.41 (5.33)	1.72 (52.00)	1.25 (18.67)	1.06 (28.00)	2.12 (4.00)	2.67 (6.67)	1.67 (46.33)	1.19 (15.67)	0.99 (25.00)	1.87 (3)	2.40 (5.33)
Two HW at 20 and 40 DAP	0.95 (9.00)	0.53 (3.67)	0.73 (5.33)	1.05 (0.67)	1.29 (1.33)	1.20 (18.00)	1.05 (11.33)	0.84 (12.67)	1.17 (1.00)	1.17 (1.00)	1.09 (12.33)	1.03 (10.67)	0.65 (11.00)	1.17 (1.33)	1.17 (1.33)
One hand hoeing at 20 DAP	1.76 (57.33)	1.08 (12.00)	1.72 (44.00)	1.77 (2.67)	1.77 (2.67)	1.82 (66.67)	1.60 (40.00)	1.82 (66.67)	4.25 (17.67)	4.52 (20.00)	1.78 (60.00)	1.39 (26.33)	1.78 (60.33)	4.48 (3)	3.93 (11)
Hoeing at 20 DAP and one HW at 40 DAP	2.19 (156.00)	1.27 (18.67)	1.63 (78.67)	1.34 (1.33)	3.53 (12.00)	1.25 (16.00)	1.26 (18.67)	1.12 (13.33)	3.74 (13.67)	4.29 (18.00)	1.15 (14.00)	1.16 (14.67)	1.48 (10)	4.29 (3.33)	3.84 (1)
Recommended herbicide (metribuzine 0.5 kg/ha as PE)	2.36 (229.33)	1.44 (28.00)	0.79 (0.00)	2.61 (6.33)	3.13 (9.33)	1.94 (86.67)	1.69 (49.33)	1.23 (8.00)	2.41 (5.33)	3.66 (13.00)	1.90 (80)	1.64 (44.00)	1.34 (6.00)	2.96 (4)	3.28 (1)
Recommended herbicide (metribuzine 0.5 kg/ha as PE) + 1 HW at 40 DAP	2.15 (144.00)	0.84 (7.00)	0.78 (0.00)	2.80 (7.33)	2.34 (5.00)	1.80 (62.67)	1.40 (25.33)	1.19 (6.67)	2.11 (4.00)	3.29 (10.33)	1.74 (55.00)	1.31 (20.67)	1.22 (4.67)	2.48 (3)	3.00 (1.67)
Weedy Check	2.45 (280.00)	1.63 (42.67)	1.75 (49.33)	3.83 (14.33)	4.71 (21.67)	2.28 (190.67)	1.89 (78.67)	1.86 (73.33)	4.50 (20.00)	4.84 (23.00)	2.26 (181.67)	1.85 (71.67)	1.83 (67.33)	5.05 (7.67)	4.50 (10.67)
LSD	**0.090**	**0.151**	**0.177**	**0.466**	**0.472**	**0.069**	**0.113**	**0.105**	**0.515**	**0.475**	**0.080**	**0.154**	**0.092**	**0.328**	**0.290**
Transformation	**Log x**	**Log x**	**Log x**	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$	**Log x**	**Log x**	**Log x**	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$	**Log x**	**Log x**	**Log x**	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$

Table 2. Effect of different weed control measures on other weed population at 60 days after planting of potato

Treatments	*Polypogon monspeliensis* / m^2	*Avena fatua* / m^2	*Medicago hispida* / m^2	*Anagallis arvensis* / m^2
White plastic mulch (50 micron)	3.81 (14.00)	3.93 (15.00)	3.53 (12.00)	3.18 (9.67)
Black plastic mulch (50 micron)	3.53 (12.00)	3.67 (13.00)	3.27 (10.33)	2.77 (7.33)
Straw mulching 5 t/ha at 5 DAP	2.40 (5.33)	2.32 (5.00)	2.11 (4.00)	2.34 (5.00)
One HW at 20 DAP + straw mulching 5 t/ha at 25 DAP	1.86 (3.00)	2.11 (4.00)	1.68 (2.33)	1.86 (3.00)
Two HW at 20 and 40 DAP	1.17 (1.00)	1.17 (1.00)	1.05 (0.67)	1.17 (1.00)
One hand hoeing at 20 DAP	4.14 (16.67)	4.48 (19.67)	4.22 (17.33)	3.98 (15.33)
Hoeing at 20 DAP and one HW at 40 DAP	4.02 (15.67)	4.18 (17.00)	3.89 (14.67)	3.53 (12.00)
Recommended herbicide (metribuzine 0.5 kg/ha as PE)	3.23 (10.00)	3.23 (10.00)	2.84 (7.67)	2.47 (5.67)
Recommended herbicide (metribuzine 0.5 kg/ha as PE) + 1 HW at 40 DAP	2.85 (7.67)	2.61 (6.33)	2.60 (6.33)	2.24 (4.67)
Weedy Check	5.15 (26.00)	4.88 (23.33)	4.78 (22.33)	4.88 (23.33)
LSD	**0.401**	**0.379**	**0.331**	**0.393**
Transformation	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$

Table 3. Effect of various weed control measures on population narrow leaves, broad leaves, sedges and total weeds at 30 DAP, 60 DAP and harvest stage

Treatments	Narrow leaved	Broad leaved	Sedges	Total weeds	Narrow leaved	Broad leaved	Sedges	Total weeds	Narrow leaved	Broad leaved	Sedges	Total weeds
White plastic mulch (50 micron)	1.55 (36.33)	0.95 (9.33)	1.89 (77.33)	2.09 (123.00)	1.71 (51.00)	2.00 (101.00)	1.75 (56.00)	2.32 (208.00)	1.47 (29.67)	1.64 (43.33)	1.71 (52.00)	2.10 (125.00)
Black plastic mulch (50 micron)	1.44 (28.00)	1.32 (21.33)	1.64 (44.00)	1.97 (93.33)	1.60 (40.00)	1.80 (64.00)	1.72 (52.00)	2.19 (156.00)	1.37 (23.33)	1.53 (34.33)	1.67 (46.67)	2.02 (104.33)
Straw mulching 5 t/ha at 5 DAP	1.27 (18.67)	1.32 (21.00)	1.97 (93.33)	2.12 (133.00)	1.57 (37.00)	1.48 (30.33)	1.64 (44.00)	2.05 (111.33)	1.40 (25.33)	1.27 (18.67)	1.58 (38.33)	1.91 (82.33)
One HW at 20 DAP + straw mulching 5 t/ha at 25 DAP	1.07 (11.67)	0.99 (10)	1.55 (36.00)	1.76 (57.67)	1.45 (28.33)	1.38 (24.00)	1.72 (52.00)	2.02 (104.33)	1.32 (21.00	1.11 (13.00)	1.67 (46.33)	1.90 (80.33)
Two HW at 20 and 40 DAP	0.68 (5.00)	0.77 (6.00)	0.95 (9.00)	1.30 (20.00)	1.12 (13.33)	1.01 (10.67)	1.20 (18.00)	1.60 (40.00)	1.06 (11.67)	0.72 (5.67)	1.09 (12.33)	1.47 (29.67)
One hand hoeing at 20 DAP	1.16 (14.67)	1.74 (55.00)	1.76 (57.33)	2.10 (127.00)	1.90 (79.67)	2.13 (133.67)	1.82 (66.67)	2.45 (280.00)	1.61 (41.33)	1.90 (80.00)	1.78 (60.00)	2.26 (181.33)
Hoeing at 20 DAP and one HW at 40 DAP	1.49 (30.67)	1.65 (44.00)	2.19 (156.00)	2.36 (231.00)	1.73 (53.67)	1.84 (69.33)	1.25 (16.00)	2.15 (141.00)	1.46 (29.00)	1.68 (48.33)	1.15 (14.00)	1.96 (91.33)
Recommended herbicide (metribuzine 0.5 kg/ha as PE)	1.57 (37.33)	1.10 (12.67)	2.36 (229.33)	2.45 (279.33)	1.86 (72.33)	1.65 (45.67)	1.94 (86.67)	2.31 (204.67)	1.73 (54.33)	1.48 (30.33)	1.90 (80.00)	2.22 (164.67)
Recommended herbicide (metribuzine 0.5 kg/ha as PE) + 1 HW at 40 DAP	1.08 (12.00)	1.13 (13.67)	2.15 (144.00)	2.23 (169.67)	1.62 (42.00)	1.58 (38.33)	1.80 (62.67)	2.15 (143.00)	1.47 (29.33)	1.35 (22.33)	1.74 (55.00)	2.03 (106.67)
Weedy Check	1.81 (64.33)	1.85 (70.33)	2.45 (280)	2.62 (414.67)	2.10 (125)	2.22 (165)	2.28 (190.67)	2.68 (480.67)	1.96 (91.67)	1.96 (92.33)	2.26 (181.67)	2.56 (365.67)
LSD	**0.118**	**0.142**	**0.090**	**0.066**	**0.065**	**0.100**	**0.069**	**0.035**	**0.105**	**0.111**	**0.080**	**0.036**
Transformation	**Log x**	**Log x**	**Log x**	**Log x**	**Log x**	**Log x**	**Log x**	**Log x**	**Log x**	**Log x**	**Log x**	**Log x**

Table 4. Effect of different treatments on total dry weight of narrow leaves, broad leaves, sedges and total weeds (g/m^2) at 30 DAP, 60 DAP and harvest stage

Treatments	Narrow leaved	Broad leaved	Sedges	Total weeds	Narrow leaved	Broad leaved	Sedges	Total weeds	Narrow leaved	Broad leaved	Sedges	Total weeds
White plastic mulch (50 micron)	17.73	1.03	5.67	24.43	66.75	9.65	2.60	79.00	61.39	7.18	2.11	70.68
Black plastic mulch (50 micron)	14.07	1.01	2.92	18.00	39.00	3.90	2.33	45.23	35.88	2.84	2.06	40.78
Straw mulching 5 t/ha at 5 DAP	11.07	0.92	2.16	14.15	28.80	9.80	1.92	40.52	24.92	8.18	1.20	34.30
One HW at 20 DAP + straw mulching 5 t/ha at 25 DAP	9.47	0.99	2.33	12.79	23.85	3.85	2.32	30.02	21.14	2.99	1.85	25.98
Two HW at 20 and 40 DAP	6.40	0.67	1.15	8.22	14.55	1.60	0.63	16.78	11.76	1.16	0.53	13.45
One hand hoeing at 20 DAP	12.93	1.76	8.36	23.05	40.20	12.40	3.00	55.60	33.66	10.16	2.54	46.36
Hoeing at 20 DAP and one HW at 40 DAP	8.67	1.17	13.69	23.53	17.10	2.05	0.68	19.83	13.73	1.50	0.48	15.71
Recommended herbicide (metribuzine 0.5 kg/ha as PE)	8.40	1.33	13.13	22.86	34.35	1.85	4.00	40.20	29.10	1.25	3.42	33.77
Recommended herbicide (metribuzine 0.5 kg/ha as PE) + 1 HW at 40 DAP	7.60	1.03	7.56	16.19	20.25	1.20	2.75	24.20	14.50	0.71	2.33	17.54
Weedy Check	22.93	2.41	19.29	44.64	43.80	15.80	9.08	68.68	39.80	13.47	8.09	61.36
LSD	**1.617**	**0.122**	**0.933**	**1.867**	**22.624**	**1.474**	**0.437**	**22.130**	**19.659**	**1.562**	**0.551**	**19.051**

Table 5. Effect of different treatments on weed control efficiency, harvest index, weed index and economics of potato as influenced by integrated weed management

Treatments	WCE (%)	Harvest index (%)	Weed index (%)	Tuber yield (t/ha)	Total cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C Ratio
White plastic mulch (50 micron)	61.39	53.38	29.62	15.75	156968	236250	91792	0.57
Black plastic mulch (50 micron)	35.88	55.57	25.11	16.76	146968	251405	116937	0.79
Straw mulching 5 t/ha at 5 DAP	24.92	62.92	16.57	18.67	102694	280035	189841	1.92
One HW at 20 DAP + straw mulching 5 t/ha at 25 DAP	21.14	63.45	5.71	21.10	106804	316565	222261	2.15
Two HW at 20 and 40 DAP	11.76	65.66	0.00	22.38	102448	335635	245677	2.51
One hand hoeing at 20 DAP	33.66	54.79	39.27	13.59	97242	203875	119133	1.27
Hoeing at 20 DAP and one HW at 40 DAP	13.73	56.64	33.69	14.84	101352	222640	133788	1.35
Recommended herbicide (metribuzine 0.5 kg/ha as PE)	29.10	58.92	21.26	17.62	96870	264330	179960	1.94
Recommended herbicide (metribuzine 0.5 kg/ha as PE) + 1 HW at 40 DAP	14.50	60.53	19.39	18.04	99872	270525	183158	1.91
Weedy Check	39.80	51.11	47.22	11.81	95872	177195	93823	0.99
LSD	-			**4.47**	**87957.76**	**67113**	**87957.76**	-