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Effect of chemical weed management practices on black gram under sandy clay loam soils of Madhya Pradesh, India

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Abstract
An investigation on " Effect of Weed Management Practices on Growth and Yield of Blackgram." under adoptic and climatic condition of northern part of Madhya Pradesh was carried out during *Kharif* season of 2015 atthe Research Farm of the Department of Agronomy, College of Agriculture, Gwalior (M. P.). The experiment was laid a out in randomized block design (R.B.D.) replicated three timed with 12 treatments. *Cyperusrotundus, Echinochloa crus-galli, Dectylecteniumagypticum* & *Acrachaneracemosa* as narrow-leaf and *Digeraarvensis, Commelinabenghalensis* & *Phylenthusniruri* as broad-leaf were the weed species dominant and contributing about 96.29 per cent of the total weed flora.Weed control efficiency, weed index yield and harvest index were the higher under two hand weeding treatment at 20 & 40 DAS followed by PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i./ha, PE application of Pendimethalin + Imazethapyr (pre-mix) @ 1000 g a.i./ha. However,The maximum net return and B: C ratio were under PE application of Pendimethalin+Imazethapyr (pre-mix) @ 1000 g a.i./ha (Rs. 34810/ha) over rest of the treatments followed by by PoE application of Imazethapyr+Imazamox (pre-mix) @ 80 g a.i./ha.

Keywords: Blackgram, economics, WUE, WI and yield

Introduction
Black gram cultivated in India from ancient times.It is one of the most highly priced pulse of India. India is the largest producer and consumer of Black gram [Vigna mungo (L.) Hepper] in the world. It is grown during Kharif as well as summerseason. It belongs to family Leguminoceae.

Black gram occupies 31 lakh hectares area in the country with a production of 14 lakh tonnes with productivity of 451.61 kg/ha. In Madhya Pradesh, black gram is grown in 5.71 lakh hectares area, production is 1.48 lakh tonnes and productivity is 269 kg/ha (ZPDK, 2011). In Gwalior district, black gram was sown in 5.07 thousand hectares area, production was 1.54 thousand tonnes and productivity was 303 kg/ha during the year 2011 - 12 (C.L.R.S. Website, 2015).

Identification of critical period of weed competition is the most important factor in crop production. Weeds are a major problem for successful cultivation of black gram in rainy season as crop initial growth is relatively slow. Therefore, weed management at early stages of crop growth is essential. Seed yield reduction up to 46.8% has been reported due to uncontrolled weeds in black gram. Emergence of weeds in pulses being simultaneously with the crop, leading to severe competition between the crop and weeds (Kandaswamy, 2000) [9]. When pulses are raised during monsoon season, weeds emerge in succession almost throughout the crop season because of favourable environmental conditions (Singh, 1993) [21]. Weeds not only reduce the yield but also act as silent robbers of scarce and essential nutrients and moisture. therefore, an experiment was conducted at research farm of COA, RVSKVV, Gwalior to judge the effect of chemical weed management practices on black gram under sandy clay loam soils of Madhya Pradesh, India.

The investigation was carried out at the Research Farm College of Agriculture Gwalior (M.P.) under AICRP on Weed Science during the *kharif* season of 2015. Gwalior is located at 26º13' North latitude and 78º14' East longitude and is 206 metres above sea mean level. The weather condition was normal during the crop season with an average maximum and minimum temperature during growing period as 35.2^0C and 24.5^0C; respectively. The total rainfall received during the rainy season from July to October 2015 was 515.00 mm. Randomized Completely Block Design (RBD) was used for experiment with 12 treatments replicated three times. The treatments were as:T_1:Imazethapyr @ 70 g *a.i.*/ ha PE, T_2: Imazethapyr @ 80 g *a.i.*/ ha PE, T_3: Imazethapyr @ 70 g *a.i.*/ ha PoE, T_4: Imazethapyr @ 80 g *a.i.*/ ha PoE, T_5: Imazethapyr + Imazamox (pre - mix) @ 70 g *a.i.*/ ha PE, T_6: Imazethapyr + Imazamox (pre - mix) @ 80 g *a.i.*/ ha PE, T_7: Imazethapyr + Imazamox (pre - mix) @ 70 g *a.i.*/ ha PoE, T_8: Imazethapyr + Imazamox (pre - mix) @ 80 g *a.i.*/ ha PoE, T_9: Pendimethalin @ 1000 g *a.i.*/ ha PE, T_{10}: Pendimethalin + Imazethapyr (pre - mix) @ 1000 g *a.i.*/ ha PE, T_{11}: Two hand weeding at 20 & 40 DAS and Weedy check.

The soil of the experimental field was sandy clay loam in texture. Itwas low in organic carbon (0.40%), available nitrogen (183.50 kg/ha) and medium in available phosphorus (14.4 kg/ha), potash contents (243.00 kg/ha) and was slightly alkaline in reaction (pH- 7.57). The size of net plot was 4.0 m x 3.0 m. Field was ploughed with disc plough followed by two tillage operations by cultivators. Later on the fields was leveled by planker to get a good tilth condition of the field.'T9' variety of black gram was used @ 18 kg/ha at 40 cm x 10 cm apart with 20: 50: 20 (N: P: K: kg/ha) fertilizer/ha. The seed was sown on July 20, 2015. Urea, single super phosphate and muriate of potash were used as the source of nitrogen, phosphorus and potassium; respectively. The full dose of NPK was applied in furrow (5 cm deep below seed) as a basal dose.

The five tagged plants, for recording the post-harvest observations, were harvested separately from the net plots. The net plot was harvested by sickles and the harvested material of each plot was tied in bundles. Bundles were kept as such for drying for 3 – 4 days, and then weighed to record biological yield per plot.

The produce of each plot was threshed separately with the help of manual labours by beating the bundles with wooden stick followed by winnowing with the help of indigenous winnower *Supa* (Local name). After cleaning the seed; yield per plot was recorded. Stover yield was calculated by subtracting seed yield from bundle weight (biological yield).

The quantity of herbicides as per treatment was sprayed by handsprayer in respective plots. The water was used @ 600 litre per hectare. As per treatments herbicide were applied as pre- and post - emergence. The harvest index is considered as the yield of economic part expressed as the percentage of the total biological yield in the term of dry matter.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (in case of seed yield)}}{\text{Biological yield (biomass in this case)}} \times 100$$

The counting of species-wise weeds was done randomly by quadrate of one square metre from each plot. Three quadrate was thrown in each plot and then averages were worked out. The observations were recorded at 30, 60 days after sowing (DAS) and at harvest. The weed uprooted randomly at one place by quadrate of one square metre with the help of *khurpi* in each plot. These were oven dried and their weight was recorded in gram. The weed index (WI) was calculated by using the formula given by Gill and Kumar, 1969. Weed control efficiency of various treatments were worked out with the help of following formula as prescribed by Mani *et al.*1973 [11].

For different treatments gross returns were calculated on the basis of prevailing market rate of produce and net profit by subtracted cost of cultivation per hectare from gross income. Benefit: Cost Ratio (BCR) was calculatedas gross return / Cost of cultivation. Logarithmic (Y = Log x) and square root ($Y = \sqrt{X+0.5}$) transformation scales were used for satisfying the condition of homogeneity of variance; where X is the original value of species wise weed population. Statistical analysis by performed as per standard procedure as prescribed by Gomez and Gomez (1984) [6].

Result and discussion

Effect on weeds

Weed flora

The major weed flora was found in the experimental field *viz. Cyperusrotundus*, *Echinochloa crus-galli*, *Dactyloctenium Aegyptium* & *Acrachne racemosa* as narrow-leaf and *Digera arvensis*, *Commelina benghalensis* & *Phylenthusniruri* as broad-leaf. These 7 species were most dominant and contributing about 96.29 per cent of the total weed flora; while less than 3.71 per cent was contribute by other weeds like; *Alternentherasessilis*, *Parthenium hesterophorus* and *Trianthemamonogyna*.

Table 1: Effectof different Weed Management Practices on dry weight of total weeds, weed control efficiency (WCE) and weed index (WI) of blackgram

Symbol	Dry weight of total weeds (g/m^2) at			WCE at 60 DAS (%)	WI (%)
	30 DAS	60 DAS	Harvest		
T_1	29.03	44.73	61.30	62.77	32.50
T_2	24.90	39.17	48.93	67.41	23.93
T_3	21.80	19.47	25.30	83.80	15.65
T_4	17.73	12.00	16.47	90.01	8.57
T_5	37.77	57.63	76.87	52.04	41.58
T_6	33.40	51.03	60.60	57.53	39.78
T_7	18.80	14.00	20.67	88.35	11.76
T_8	15.07	6.90	10.07	94.26	4.19
T_9	39.00	58.19	75.40	51.57	41.87
T_{10}	12.47	9.50	12.10	92.09	4.69
T_{11}	5.00	4.90	9.85	95.92	-
T_{12}	84.93	120.17	134.42	-	60.82
S.E. (m)±	2.23	1.79	2.08		
C.D. (at 5%)	6.56	5.26	6.13		

Table 2: Effectof different Weed Management Practices on *cyperus*, *echinochloa*, *daactyloctenium* and *archne*weed population of blackgram

Symbol	*Cyperusrotundus*population/m^2 at			*Echinochloa crus - galli* population/m^2 at			*Daactylocteniumaegyptium* population/m^2 at			*Arachne racemosa*population/m^2 at		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1	1.40 (25.33)	1.33 (21.33)	1.18 (15.33)	1.12 (13.33)	3.2 (10.00)	2.79 (7.33)	0.96 (9.33)	2.73 (7.00)	2.67 (6.67)	0.99 (10.00)	2.85 (7.67)	2.73 (7.00)
T_2	1.31 (20.67)	1.24 (17.67)	1.04 (11.33)	1.06 (12.00)	2.90 (8.00)	2.58 (6.33)	0.90 (8.00)	2.47 (5.67)	2.33 (5.00)	0.95 (9.00)	2.59 (6.33)	2.48 (5.67)

T_3	1.23 (17.33)	1.09 (12.33)	0.95 (9.00)	1.02 (10.67)	2.84 (7.67)	2.24 (4.67)	0.78 (6.33)	2.43 (5.67)	2.06 (4.00)	0.68 (5.67)	2.06 (4.00)	1.90 (3.33)
T_4	1.14 (14.33)	0.98 (9.67)	0.66 (5.00)	0.99 (10.00)	2.67 (6.67)	2.03 (3.67)	0.75 (5.67)	2.11 (4.00)	1.64 (2.33)	0.67 (5.00)	1.84 (3.00)	1.56 (2.00)
T_5	1.55 (36.00)	1.48 (30.33)	1.37 (23.33)	1.22 (17.33)	3.42 (11.33)	3.23 (10.00)	1.09 (13.00)	3.17 (9.67)	2.91 (8.00)	1.17 (15.00)	3.44 (11.33)	3.07 (9.00)
T_6	1.48 (30.33)	1.36 (23.33)	1.30 (20.33)	1.16 (14.67)	3.23 (10.00)	2.90 (8.00)	1.04 (11.00)	3.08 (9.00)	2.67 (6.67)	1.08 (12.00)	3.18 (9.67)	2.91 (8.00)
T_7	1.14 (13.67)	0.91 (8.33)	0.72 (5.33)	1.08 (12.00)	2.18 (4.33)	1.95 (3.33)	0.70 (5.33)	1.86 (3.00)	1.64 (2.33)	0.73 (5.67)	1.66 (2.33)	1.46 (1.67)
T_8	1.02 (10.67)	0.73 (5.67)	0.43 (3.00)	0.98 (9.67)	1.56 (2.00)	1.29 (1.33)	0.68 (5.00)	1.27 (1.33)	1.00 (0.67)	0.59 (4.00)	1.46 (1.67)	1.05 (0.67)
T_9	1.56 (37.00)	1.48 (30.67)	1.38 (24.00)	1.24 (18.33)	3.32 (10.67)	3.18 (9.67)	1.06 (11.67)	3.13 (9.33)	2.96 (8.33)	1.19 (15.67)	3.58 (12.33)	2.24 (10.00)
T_{10}	1.00 (10.00)	0.78 (6.33)	0.59 (4.00)	0.86 (7.33)	1.68 (2.33)	1.29 (1.33)	0.75 (5.67)	1.66 (2.33)	1.17 (1.00)	0.65 (4.67)	1.56 (2.00)	1.05 (0.67)
T_{11}	0.68 (5.00)	0.53 (3.67)	0.40 (2.67)	0.36 (2.33)	1.29 (1.33)	1.17 (1.33)	0.36 (2.33)	1.17 (1.00)	1.05 (0.67)	0.48 (3.00)	1.05 (0.67)	0.88 (0.33)
T_{12}	1.73 (53.67)	1.65 (45.00)	1.53 (34.33)	1.47 (30.00)	4.87 (23.33)	4.51 (20.00)	1.29 (20.00)	4.13 (16.67)	3.76 (13.67)	1.52 (33.00)	5.08 (25.33)	4.66 (21.33)
S.E. (m)±	0.05	0.06	0.07	0.06	0.21	0.22	0.07	0.22	0.23	0.08	0.20	0.18
C.D. (at 5%)	0.14	0.18	0.19	0.19	0.61	0.64	0.20	0.66	0.68	0.25	0.60	0.53
Transformation	Log x	Log x	Log x	Log x	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$	Log x	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$	Log x	$\sqrt{x+0.5}$	$\sqrt{x+0.5}$

Table 3: Effectof different weed management practices on *digera,commelina, phylanthus* and other weed populations of blackgram

Symbol	*Digeraarvensis* population/m² at			*Commelinabenghalensis*population/m² at			*Phylanthusniruri* population/m² at			Other weeds population/m² at		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1	2.57 (6.33)	2.20 (4.33)	1.93 (3.33)	2.38 (5.33)	2.24 (4.67)	2.00 (3.67)	2.24 (4.67)	2.10 (4.00)	2.04 (3.67)	2.24 (4.67)	2.22 (4.67)	2.06 (4.00)
T_2	2.22 (4.67)	1.95 (3.33)	1.76 (2.67)	2.16 (4.33)	1.90 (3.33)	1.77 (2.67)	2.20 (4.33)	1.95 (3.33)	1.68 (2.33)	2.02 (3.67)	1.90 (3.33)	1.82 (3.00)
T_3	2.02 (3.67)	1.34 (1.33)	1.22 (1.00)	1.74 (2.67)	1.56 (2.00)	1.34 (1.33)	1.68 (2.33)	1.34 (1.33)	1.22 (1.00)	1.86 (3.00)	1.44 (1.67)	1.22 (1.00)

Table 4: Effectof different Weed Management Practices on total narrow and broad leaf weeds population of blackgram

Symbol	Total narrow leaf weeds population/m² at			Total broad leaf weeds population/m² at			Total weeds population/m² at		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1	1.76 (58.00)	1.66 (37.00)	1.56 (36.33)	1.29 (21.00)	1.23 (17.67)	1.15 (14.67)	1.89 (79.00)	1.80 (63.67)	1.70 (51.00)
T_2	1.70 (49.67)	1.57 (37.67)	1.45 (28.33)	1.22 (17.00)	1.12 (13.33)	1.03 (10.67)	1.82 (66.67)	1.71 (51.00)	1.59 (39.00)
T_3	1.60 (40.00)	1.47 (29.67)	1.32 (21.00)	1.05 (11.67)	0.79 (6.33)	0.63 (4.33)	1.71 (51.67)	1.55 (36.00)	1.40 (25.33)
T_4	1.54 (35.00)	1.36 (23.33)	1.10 (13.00)	0.88 (7.67)	0.59 (4.00)	0.30 (2.33)	1.63 (42.67)	1.43 (27.33)	1.18 (15.33)
T_5	1.91 (81.33)	1.80 (62.67)	1.70 (50.33)	1.44 (28.33)	1.30 (20.33)	1.22 (16.67)	2.04 (109.67)	1.92 (83.00)	1.83 (67.00)
T_6	1.83 (68.00)	1.71 (52.00)	1.63 (43.00)	1.40 (25.67)	1.27 (19.00)	1.16 (14.67)	1.97 (93.67)	1.85 (71.00)	1.76 (57.67)
T_7	1.56 (36.67)	1.25 (18.00)	1.10 (12.67)	1.01 (11.00)	0.77 (6.00)	0.70 (5.00)	1.67 (47.67)	1.38 (24.00)	1.25 (17.67)
T_8	1.46 (29.33)	1.02 (10.67)	0.69 (5.67)	0.89 (8.33)	0.50 (3.33)	0.20 (1.67)	1.57 (37.67)	1.14 (14.00)	0.84 (7.33)
T_9	1.92 (82.67)	1.80 (63.00)	1.71 (52.00)	1.45 (25.33)	1.30 (20.00)	1.20 (16.00)	2.01 (111)	1.92 (83.00)	1.89 (68.00)
T_{10}	1.44 (27.67)	1.10 (13.00)	0.83 (7.00)	0.49 (4.00)	0.42 (2.67)	0.10 (1.33)	1.50 (31.67)	1.18 (15.67)	0.89 (8.33)
T_{11}	1.10 (12.67)	0.82 (6.67)	0.66 (4.67)	0.36 (2.67)	0.30 (2.33)	0.30 (2.00)	1.18 (15.33)	0.95 (9.00)	0.82 (6.67)
T_{12}	2.14 (136.67)	2.04 (110.33)	1.95 (89.33)	1.71 (52.00)	1.63 (43.33)	1.53 (34.00)	2.28 (188.67)	2.19 (153.67)	2.09 (123.33)
S.E. (m)±	0.03	0.04	0.07	0.12	0.08	0.08	0.03	0.04	0.06
C.D. (at 5%)	0.09	0.13	0.19	0.35	0.23	0.22	0.10	0.12	0.17
Transformation	Log x	Log x	Log x	Log x	Log x	Log x	Log x	Log x	Log x

Weed population/m²

The population/ m² of species - wise all narrow-leaf and broad-leaf weeds, other weeds, total narrow - leaf weeds, total broad - leaf weeds and total weeds were reduced drastically under different weed control methods at all the stages of crop growth as compared to weedy check. These results are accordance with Yadav *et al*. (2014a) [33] who concluded that weed control measures significantly reduced the population of weeds as compared to the weedy check in black gram. Significantly lowest population were recorded under two hand weeding at 20 & 40 DAS; while highest noted under weedy check. Similar result was also obtained by Kewat *et al.* (2014) [10] and Balyan *et al*. (2016) [2]. Among herbicidal treatments; PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i./ ha, PE application of Pendimethalin + Imazethapyr (pre - mix) @ 1000 g a.i./ ha and PoE application of Imazethapyr

@ 80 g a.i./ha were registered at par values and superior over rest of the treatments (Table 4.1 to 4.11).These results are in close agreement with Hossain *et al.* (2014) [8] who reported lowest narrow-leaf weeds density with application of Imazethapyr + Imazamox. Tilgam *et al*. (2015) [26] also reported that Pendimethalin + imazethapyr 1000 g/ha as pre - emergence or pre-mix application of Imazethapyr + Imazamox 80 g/ha as post-emergence are most effective weed management practices for controlling the narrow-leaf weeds in blackgram. Similar results were also obtained by Veeraputhiran and Chinnusamy (2008) [30], Patel *et al.* (2014) [15], Tomar *et al*. (2014) [29] and Yadav *et al.* (2014) [32].

Weed dry weight (g/m^2)

Dry weight of weeds were significantly reduced due to weed control treatments at 30 & 60 DAS and at harvest stages. All weed control treatments observed lower weed dry weight compared with untreated check. The significantly minimum dry weight of total weeds was noted with two hand weeding at 20 & 40 DAS treated plot due to obtained least population of narrow-leaf and broad - leaf weeds; while highest dry weight was recorded under weedy check (Table 4.12).

Similar results were also reported by Aggarwal *et al*. (2014) [1], Kewat *et al.* (2014) [10], Yadav *et al.* (2015) [31], Balyan *et al*. (2016) [2] and Nirala *et al*. (2016) [13]. Among herbicidal treatments; lower dry weight was recorded under PoE application of Imazethapyr + Imazamox (pre - mix) @ 80 g a.i./ha; which was statistically at par with PE application of Pendimethalin + Imazethapyr (pre - mix) @ 1000 g a.i./ha and both were observed significantly superior compared to other treatments. Similar results were also obtained by Patel *et al.* (2014) [15], Tomar *et al.* (2014) [29] in case of pre-mix application of Pendimethalin + Imazethapyr; Patil *et al.* (2013) [16] in case of Imazethapyr + Imazamox in Clusterbean crop and Veeraputhiran and Chinnusamy (2008) [30] in respect to alone application of Imazethapyr.

Weed control efficiency (%) and weed index (%)

The higher weed control efficiency was recorded under two hand weeding at 20 & 40 DAS (95. 92%). The next effective treatments was PoE application of Imazethapyr + Imazamox (pre - mix) @ 80 g *a.i.*/ha (94.26%) followed by PE application of Pendimethalin + Imazethapyr (pre-mix) @ 1000 g a.i./ha (92.09%). The maximum weed control efficiency under these treatments was reflected through to lower dry weight of weeds. These results are in tune with the findings of Srivastava and Srivastava (2002) [24], Mansoori (2013) [12], Patil *et al.* (2013) [16], Kewat *et al*. (2014) [10], Tiwari *et al.* (2014) [27], Tilgam *et al*. (2015) [26], Yadav *et al*. (2015) [31], Nirala *et al*. (2016) [13]. Weed index is indirectly related to the reduction in yield due to weed population and weed dry weight. The significantly superior weed index was registered under two hand weeding at 20 & 40 DAS over rest of the treatments; while weedy check noticed uneconomic value of weed index (60.82%).Among herbicidal treatments; PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i./ha (4.19%) followed by PE application of Pendimethalin + Imazethapyr (pre - mix) @ 1000 g a.i./ha (4.69%) were recorded effective value. Drastic reductions in seed yield of blackgram due to higher weed competition in weedy check have been reported by Shaikh *et al.* (2002) [19], Rathi *et al*. (2004) [18], Rao *et al*. (2010) [17], Singh *et al*. (2011) [22], Kewat *et al.* (2014) [10], Bhowmic *et al*. (2015) [3] and Tilgam *et al*. (2015) [26].

Yield (kg/ha) and Harvest index (%)

All the weed control treatments significantly increased the seed yield, stover yield and biological yield/ha over weedy check (393 kg, 1544 kg and 1938 kg; respectively). The maximum values were obtained with two hand weeding at 20 & 40 DAS (1003 kg, 2719 kg and 3721 kg; respectively) followed by PoE application of Imazethapyr+Imazamox (pre-mix) @ 80 g a.i./ha (961 kg, 2669 kg and 3630 kg; respectively), PE application of Pendimethalin+Imazethapyr (pre-mix) @ 1000 g a.i./ha (956 kg, 2656 kg and 3612 kg; respectively) and PoE application of imazethapyr @ 80 g a.i./ha (917 kg, 2555 kg and 3471 kg; respectively) were observed statistically on par and significantly superior over rest of the treatments.

Table 5: Effectof different weed management practices on seed yield, stover yield, biological yield and harvest index (hi) of blackgram

Treatments	Symbol	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	HI (%)
Imazethapyr @ 70 g a.i./ha (PE)	T_1	677	2013	2690	25.17
Imazethapyr @ 80 g a.i./ha (PE)	T_2	763	2203	2966	25.75
Imazethapyr @ 70 g a.i./ha (PoE)	T_3	846	2383	3229	26.19
Imazethapyr @ 80 g a.i./ha (PoE)	T_4	917	2555	3471	26.38
Imazethapyr+Imazamox (pre-mix) @ 70 g a.i./ha (PE)	T_5	586	1784	2370	24.74
Imazethapyr+Imazamox (pre-mix) @ 80 g a.i./ha (PE)	T_6	604	1833	2438	24.81
Imazethapyr+Imazamox (pre-mix) @ 70 g a.i./ha (PoE)	T_7	885	2466	3352	26.43
Imazethapyr+Imazamox (pre-mix) @ 80 g a.i./ha (PoE)	T_8	961	2669	3630	26.49
Pendimethalin @ 1000 g a.i./ha (PE)	T_9	583	1773	2357	24.72
Pendimethalin+Imazethapyr (pre-mix) @ 1000 g a.i./ha (PE)	T_{10}	956	2656	3612	26.47
Two hand weeding at 20 & 40 DAS	T_{11}	1003	2719	3721	26.95
Weedy check	T_{12}	393	1544	1938	20.28
S.E. (m)±		30	61	71	0.25
C.D. (at 5%)		89	181	211	0.74

The superiority of these treatments over weedy check in increasing yield has also been reported by Mansoori (2013) [12], Aggarwal *et al.* (2014) [1], Hossain *et al.* (2014) [8], Patel *et al.* (2014) [15], Hossain and Malik (2015) [7, 24], Pal *et al.* (2015) [14], Singh *et al.* (2015) [23], Teja *et al.* (2015) [25], Tilgam*et al.* (2015) [26]. The all weed control treatments significantly increased harvest index over weedy check (20.28%); which recorded lowest value over rest of the treatments. The significantly higher value of harvest index was recorded with two hand weeding at 20 & 40 DAS (26.95%) being statistically at par with PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i./ha (26.49%), PE application of Pendimethalin + Imazethapyr (pre-mix) @ 1000 g a.i./ha (26.47%), PoE application of Imazethapyr + Imazamox (pre - mix) @ 70 g a.i./ha (26.43%) and PoE application of Imazethapyr @ 80 g a.i./ha (26.38%) and

significantly economical over rest of the treatments.It may be possible due to lesser weed population under these plots hence increased growth factors availability resulting increase harvest index. These results in agreement with Pal *et al.* (2015) [14], Tilgam *et al.* (2015) [26] and Nirala *et al.* (2016) [13].

Economics

The choice of any weed control method ultimately depends on economics and weed controlling efficiency. The cost of chemical weed control is actually less than that of manual weeding. This has been a major incentive to many farmers for switching over to herbicides.

All the weed control treatments gave more net returns over weedy check (Rs. 7032/ha). The maximum net return was found with PE application of Pendimethalin+Imazethapyr (pre-mix) @ 1000 g a.i./ha (Rs. 34810/ha) over rest of the treatments. The next order best treatments were; PoE application of Imazethapyr+Imazamox (pre-mix) @ 80 g a.i./ha (Rs. 33619), PoE application of Imazethapyr @ 80 g a.i./ha (Rs. 32096) and two hand weeding at 20 & 40 DASregistered (Rs. 30354) net income per hectare; over rest of the treatments.Similar results were also obtained by Aggarwal *et al.* (2014) [1] Hossain *et al.* (2014) [7], Sharma *et al.* (2014) and Hossain and Malik (2015) [7, 24].

The highly economical benefit: cost ratio was recorded under PE application of Pendimethalin+Imazethapyr (pre-mix) @ 1000 g a.i./ha (3.34) followed by PoE application of Imazethapyr+Imazamox (pre-mix) @ 80 g a.i./ha (3.06) and PoE application of imazethapyr @ 80 g a.i./ha (3.06); while lowest was noticed under weedy check (1.51).Similar findings were also reported by Tilgam *et al.* (2015) [26] and Yadav *et al.* (2015) [31].

Table No. 6: Cost of cultivation (Rs./ha) excluding treatment cost of different treatments of blacgram

S. No.	Particular of expenditure	Cost of cultivation (Rs/ha)
1	One ploughing	1500
2	Harrowing by tractor 2 times @ Rs. 750/ha harrowing	1500
3	Seed rate (18 kg/ha Rs. 100/kg	1800
4	Seed treatment	50
5	Fertilizer	2849
6	Sowing charges	750
8	Harvesting 10 labour @ Rs. 250/labour	2500
9	Threshing charge @ Rs. 500/hour + 5 labour @ 250/labour	2250
10	Miscellaneous	500
	Total cost Rs.	13699

Table No. 7: Effectof different Weed Management Practices on Cost of cultivation, gross return, net income and B:C ratio of blackgram

Treatments	Symbol	Seed yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs./ha)	Treatment cost (Rs./ha)	Total cost of cultivation (Rs./ha)	Gross return (Rs/ha)	Net income (Rs/ha)	B:C Ratio
Imazethapyr @ 70 g a.i./ha (PE)	T_1	677	2013	13699	1676	15375	35259	19884	2.29
Imazethapyr @ 80 g a.i./ha (PE)	T_2	763	2203	13699	1844	15543	39692	24149	2.55
Imazethapyr @ 70 g a.i./ha (PoE)	T_3	846	2383	13699	1676	15375	43968	28593	2.86
Imazethapyr @ 80 g a.i./ha (PoE)	T_4	917	2555	13699	1844	15543	47639	32096	3.06
Imazethapyr+Imazamox (pre-mix) @ 70 g a.i./ha (PE)	T_5	586	1784	13699	2338	16037	30549	14512	1.90
Imazethapyr+Imazamox (pre-mix) @ 80 g a.i./ha (PE)	T_6	604	1833	13699	2600	16299	31483	15184	1.93
Imazethapyr+Imazamox (pre-mix) @ 70 g a.i./ha (PoE)	T_7	885	2466	13699	2338	16037	45976	29940	2.87
Imazethapyr+Imazamox (pre-mix) @ 80 g a.i./ha (PoE)	T_8	961	2669	13699	2600	16299	49918	33619	3.06
Pendimethalin 1000 g/ ha PE	T_9	583	1773	13699	1933	15632	30391	14759	1.94
Pendimethalin + Imazethapyr (pre - mix) 1000 g/ ha PE	T_{10}	956	2656	13699	1150	14849	49659	34810	3.34
Two hand weeding at 20 & 40 DAS	T_{11}	1003	2719	13699	8000	21699	52053	30354	2.40
Weedy check	T_{12}	393	1544	13699	0	13699	20731	7032	1.51

Conclusion

On the basis of above experimentation it can be concluded that the PE application of Pendimethalin + Imazethapyr (pre - mix) @ 1000 g a.i./ ha followed by PoE application of Imazethapyr + Imazamox (pre - mix) @ 80 g a.i./ ha are better economical and impressive effective weed control practices as compare to other chemical weed management practices for sandy clay loam soils of of Madhya Pradesh, India.

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