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Efficacy of herbicides on performance of chickpea (*Cicer arietinum*) in western Rajasthan

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ABSTRACT

An experiment was conducted from winter (*rabi)* season 2017–18 to winter (*rabi)* season 2020–21 at the research farm of College of Agriculture, Sumerpur, Pali, Rajasthan to find out the efficacy of herbicides in chickpea (*Cicer arietinum* L.) on sandy loam soils of western Rajasthan. The experiment comprised of 8 treatments with 4 replications in randomized block design (RBD) using cultivar RSG 974. The application of pendimethalin 30 EC @750 g/ha as pre-emergence (PE) recorded mean maximum seed yield of 15.02 q/ha followed by PE application of metalachlor 50 EC @1000 g/ha (12.52 q/ha) and were significantly superior over rest of herbicidal treatments. A similar trend was also found in weed parameters, growth and yield attributes under study. The mean maximum net returns (49112 ₹/ha) and a benefit to cost ratio (2.19) was recorded with pendimethalin 30 EC @750 g/ha as pre-emergence followed by treatment metalachlor 50 EC @1000 g/ha as pre-emergence (1.95) as against minimum in weedy check (0.89) during study period. Although, hoeing twice at 25 and 40 DAS gave higher seed yield (17.69 q/ha) and significantly superior over rest of treatments except in net return and B:C ratio.

Keywords: Chickpea, Economics, Herbicides, Weed parameters, Yield attributes

Chickpea (*Cicer arietinum* L.) is an important vegetable protein (20–25%) and a good source of dietary fibre, starch, minerals and vitamins. It is typically low in fat, contains no cholesterol and is high in iron, potassium and magnesium. It is the second most crop, after soybean in India providing high-quality proteins for human and animal nutrition. In Rajasthan, it is cultivated on 2.11 million ha with a production of 2.26 million tonnes and contributes 14% of total country's chickpea production (Anonymous 2021). In India and Rajasthan, its cultivation is mainly restricted to less fertile/marginal soil under rainfed conditions, higher weed infestation, effect of weather aberrations, lack of integration of nutrient supply sources, not utilizing the proper biofertilizer etc. which are major constraints for higher productivity. Weeds are the most underestimated form of biotic stress in agriculture and cause significant reduction up to 75% in chickpea yield (Bankoti *et al.* 2021). Thus, management of weeds is nowadays observed as most remunerative practice in chickpea production to get guaranteed maximum yield and high quality of grain and straw in contact to continuously increasing labour cost and scarcity of labour for manual weeding. Continuous changes occurs both in weed population, dry matter accumulation and its intensification in the chickpea field on temporal scale mainly due to anthropogenic changes brought in crop management practices. Keeping these facts in view, performance of various herbicides were studied because they are most efficient and cost-effective besides easy to apply for weed management in chickpea and chickpea based cropping systems. Herbicides are the best substitute against the traditional practice of weeding (manual weeding) and help to economize cost of production (Yadav *et al.* 2019).

MATERIALS AND METHODS

The present study was carried out at the research farm of College of Agriculture, Sumerpur, Pali (Rajasthan) from *rabi* 2017–18 to *rabi* 2020–21 to find out the efficacy of various herbicides on chickpea. The experimental soil was sandy loam and slightly alkaline in reaction (*p*H 7.80), low in organic carbon (0.26%), low in available nitrogen (197.3 kg/ha), medium in available phosphorus (27.80 kg/ha) and high in available potassium (283.0 kg/ha). Eight treatments involving different herbicides and their combinations, viz. W_1, Weedy check; W_2, Pendimethalin 30 EC @750 g/ha; W_3, Metalachlor 50 EC @1000 g/ha; W_4, Imizethapyr 35% + Imazamox 35% WDG @60 g/ha; W_5, Pendimethalin 30 EC @750 g/ha+ W_4; W_6, Metalachlor 50 EC @1000 g/ha+ W_4; W_7, One hoeing at 25 DAS and W_8, Two hoeing at 25 DAS and 40 DAS were tested in Randomized block design

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(RBD) with 4 replications. The chickpea crop variety RSG 974 was sown by hand, keeping the row distance of 30 cm and seed rate of 80 kg/ha on first fortnight of November and harvested in second week of March in respective years. The cultivation of crop was followed as per recommended zonal package of practices using fertilizer dose (20 kg N and 40 kg P_2O_5 /ha). The herbicides were applied using flat fan nozzle as per treatment. A light irrigation was applied just after sowing to ensure uniform germination of the crop followed by application of pre-emergence (PE) herbicides while post emergence herbicides were applied at 25 Days after sowing (DAS). The manual hoeing was practiced twice, viz. 25 and 40 DAS to provide weed free crop environment to chickpea crop in respective treatments. The gross plot size was 6.0 m × 4.8 m while net plot size was 5.0 m × 3.6 m. Observation was taken as per standard procedure at harvest of the crop and as follows:

Weed dry matter: Weeds were collected from 2 casually selected spots through a quadrate of 0.25 m^2 (0.5m × 0.5 m) were being sun dried for a day followed by oven dried at 65°C till a constant weight was achieved. The final dry weight of both broad leaves weed and grasses and sedges were recorded and expressed in g/m^2.

Weed control efficiency (WCE): Weed control efficiency (%) was calculated as (Mani *et al.* 1973):

$$\text{WCE (\%)} = \frac{\text{Weed biomass in unweeded plot} - \text{Weed biomass in treated plot}}{\text{Weed biomass in unweeded plot (Weekly check)}} \times 100$$

Weed index (WI): Weed index was calculated as (Gill and Kumar 1969):

$$\text{WI (\%)} = \frac{\text{Yield from weed free plot} - \text{Yield from treated plot}}{\text{Yield from weed free plot}} \times 100$$

Plant height (cm): Five healthy uniform plants were selected randomly, tagged and their height was measured at harvest using metre scale and their average was worked out.

100-seed weight (g): A representative sample of chickpea grains were taken from each plot at the time of threshing; thereafter 100 grains were counted, weighed.

Seed yield (kg/ha): After threshing, winnowing and cleaning, seed yield from individual plot was weighed separately. Similarly fodder yield was calculated.

Harvest index (%): The harvest index was calculated by the standard formula suggested by Donald and Hamblin (1976) i.e. the percent ratio of the economic yield (grain yield) and biological yield.

Net return (₹/ha): The total monetary return was calculated using minimum support prices declared by Government of India for respective years. To realize the most gainful treatment, economics of treatments under study were calculated in terms of net monetary return (₹/ha) by subtracting the cost of cultivation from gross return. Cost of cultivation was calculated based on prevailing prices of inputs.

Benefit cost ratio: This was calculated treatment wise to ascertain economic viability of the treatments as:

B:C ratio=Net return (₹/ha)/Total cost of cultivation (₹/ha)

RESULTS AND DISCUSSION

Weed Parameters: The weed density in chickpea is influenced by growth behaviour, agro-ecological conditions and cultural practices. Two sites from each plot were identified for studying weed parameters using 0.25 m^2 quadrate. The experimental site was infested with broadleaf weed species, viz. Bathua (*Chenopodium album* L.), Shahatra (*Fumaria parviflora* Lam.), vetch (*Lathyrus* spp.), white sweet clover (*Melilotus albus* Medik.), common vetch (*Vicia sativa* L.), Jangali palak (*Rumex dentatus* L.), red chickweed (*Anagallis arvensis* L.) and narrow leaf weeds, viz. wild oat [*Avena sterilis* subsp. *ludoviciana* (Durieu) Gillet & Magne], Poa [*Poa infirma* (Kunth)] and annual beard-grass [*Polypogon monspeliensis* (L.) Desf.].

Weed biomass production, weed control efficiency (WCE) and weed index (WI) (Table 1) showed that all the treatments were significantly affected. The mean minimum weed dry matter production (4.94 g/m^2), mean maximum weed control efficiency (85.51%) and mean minimum reduction in yield i.e. weed index (14.76%) was recorded with the PE application of pendimethalin 30% EC @1.0 kg/ha as against the weedy check (33.96 g/m^2, 0 and 60.58%, respectively) during individual as well as in mean study. The treatment 2 hoeings at 25 and 40 DAS was recorded minimum weed dry matter while maximum was recorded in weedy check. However, post emergence (PoE) application of ready mix of imizethapyr + imazamox @20 g/ha at 25 DAS caused mild phytotoxicity on crop as well as on weeds resulted in higher weed control efficiency (85.51%).

This might be because Pendimethalin, which kills weeds by deterring cell division and elongation, has a broad spectrum of activity (Das 2015). The significant variations in weed parameters at harvest may be due to timely herbicidal applications that successfully reduced total weed dry matter, maintained a weed free environment and reduced crop weed competition (Niranjan *et al*. 2020). The weed free environment up to 40 DAS caused maximum reduction of weed dry matter because of prolonged effect of manual hoeing on controlling the weeds and further aggravated by shading effect of crop. These findings were also reported by Chaudhari *et al.* (2016) and Manasa *et al.* (2022).

Growth Attributes: The data (Table 2) shows that plant height of chickpea at harvest was found to be affected significantly under different treatments. It was highest under the PE application of pendimethalin 30 EC @750 g/ha (W_2) and metalachlor 50 EC @1000 g/ha (W_3). Further, both PE herbicides were found significantly superior over rest of herbicidal treatments. However, the application of imizathapyr and imizamox check the crop growth and caused a significant reduction in plant height (Rathod *et al.* 2017). The increase in height was attributed to the weed free environment at initial stage of crop growth and

Table 1 Effect of herbicides on weed parameters in chickpea

Treatment	Weed dry matter (g/m^2)					Weed control efficiency (%)					Weed index (%)				
	2017–18	2018–19	2019–20	2020–21	Mean	2017–18	2018–19	2019–20	2020–21	Mean	2017–18	2018–19	2019–20	2020–21	Mean
W_1	36.34	34.19	33.40	31.90	33.96	0.00	0.00	0.00	0.00	0.00	77.51	58.89	57.35	48.55	60.58
W_2	5.96	5.77	3.74	4.29	4.94	83.58	83.18	88.79	86.49	85.51	19.86	18.10	16.87	4.20	14.76
W_3	10.83	12.26	12.01	9.51	11.15	70.14	64.07	64.06	70.14	67.10	46.14	29.44	28.94	10.93	28.86
W_4	14.10	13.87	13.87	12.87	13.68	60.96	59.39	58.42	59.56	59.58	73.51	47.62	45.54	36.33	50.75
W_5	6.43	6.04	3.68	3.75	4.98	82.21	82.29	88.98	88.22	85.42	54.71	39.09	37.68	33.16	41.16
W_6	6.05	5.82	4.65	5.35	5.47	83.33	82.93	86.07	83.20	83.88	62.98	42.31	39.90	33.76	44.74
W_7	13.12	12.79	12.11	9.36	11.85	63.69	62.57	63.73	70.54	65.13	12.47	20.03	16.32	9.67	21.03
W_8	4.12	3.70	3.88	3.53	3.81	88.66	89.17	88.37	88.91	88.78	0.00	0.00	0.00	0.00	8.38
S.Em±	0.70	0.50	0.48	0.42	0.32	1.48	1.32	1.29	0.92	0.80	2.70	2.39	3.00	1.89	1.43
CD (P=0.05)	2.05	1.48	1.41	1.23	0.94	4.37	3.90	3.80	2.71	2.34	7.95	7.02	8.81	5.55	4.21

Treatment details are given in Materials and Methods.

availability of nutrients to crop with the pre-emergence application of various herbicides (Singh *et al*. 2014 and Bankoti *et al.* 2021).

Yield and yield attributes: Four years mean data (Table 2 and 3) revealed that the various yield attributes, viz. number of pods/plant, number of seeds/pod and seed index were significantly influenced by application of herbicides as against the rest of treatments and weedy check. The mean maximum number of pods/plant (39.91), number of seeds/pod (1.50) and seed index (17.43 g) were recorded in treatment PE application of pendimethalin 30 EC @750 g/ha as against minimum in weedy check (26.46, 1.25 and 16.50 g, respectively) during study period. However, in individual years the seed index was found nonsignificant. The impact of the weed free environment maintained due to pre-emergence application of herbicides and manual hoeing meet the resources demand particularly nutrient, water and light to the crop at the critical stage on-site. The better initial growth promoted flowering and higher pod production because of timely supply of resources might have reduced shedding of flowers and pods (Yadav *et al.* 2019). Significantly higher number of yield attributes, viz. No. of pods/plant, seed index and No. of seeds/pod in these treatments was mainly due to lower weed dry weight and minimum crop-weed competition during the crop growth period due to pre- and post-emergence application of herbicide. The minimum weed biomass and maximum weed control efficiency enabled the crop to utilize essential nutrients, proper moisture, better light and maximum space. The results are in agreement with Singh *et al.* (2014), Chandrakar *et al.* (2015) and Singh and Jain (2017).

Data on seed and fodder yield of chickpea was significantly influenced by different weed control treatments. The pre-emergence application of pendimethalin 30 EC @750 g/ha recorded significantly mean maximum chickpea grain yield of 15.02 q/ha as against minimum of 6.92 q/ha in weedy check. The similar trend was observed in fodder yield and it was ranged from 13.88 to 29.54 q/ha. The extent of rise in grain yield was 155% with the weed management practices. The PE application of pendimethalin 30 EC @750 g/ha recorded mean maximum harvest index (37.83%) followed by per-emergence metalachlor 50 EC @1000 g/ha (35.20%). It was attributed due to higher chickpea grain yield and lower fodder yield. Yield enhancement over weedy check was because of shift of weed crop competition in favour of crop causes cumulative effect on yield attributes and seed index. Further, these treatments were associated with better weed control and decreased weed dynamics as well as improved yield contributing characters. The maximum crop grain yield was recorded under 2 hand weeding treatment. It might be due to reduction in weed infestation, which enhances proper translocation of photosynthetes from source to sink resulted in increase in harvest index (seed production ratio in total produce). The results found in the present study were also supported the findings of Dubey *et al.* (2018).

Economics: The cost of cultivation of chickpea included the expenditure incurred from field preparation to threshing

Table 2 Effect of herbicidal weed control on growth and yield attributes in chickpea

Treatment	Mean value of four years (*Rabi* 2017–18 to 2020–21)					
	Plant height (cm)	No. of pods/ plant (No.)	No. of seeds/pod (No.)	100 seed weight (gm)	Grain yield (q/ha)	Fodder yield (q/ha)
W_1	34.51	26.46	1.25	16.50	6.92	13.88
W_2	41.78	39.91	1.50	17.43	15.02	24.78
W_3	40.34	37.78	1.39	17.10	12.52	22.97
W_4	32.47	29.95	1.31	16.63	8.74	17.82
W_5	34.27	32.48	1.34	16.77	10.40	19.84
W_6	34.11	31.28	1.30	16.57	9.77	18.87
W_7	40.27	38.87	1.41	17.30	15.00	26.01
W_8	42.57	43.30	1.51	17.69	17.69	29.54
S.Em±	1.40	0.94	0.03	0.31	0.32	0.59
CD (P=0.05)	4.13	2.78	0.08	0.92	0.93	1.73

Treatment details are given in Materials and Methods.

Table 3 Effect of herbicidal weed control on harvest index and economics of chickpea

Treatment	Harvest Index (%)					Economics			
	2017–18	2018–19	2019–20	2020–21	Mean	Gross return	Cost of cultivation	Net returns	B:C ratio
						(₹/ha)			
W_1	25.89	35.61	35.64	32.87	32.50	33268	17300	15968	0.89
W_2	38.38	39.00	36.61	37.30	37.83	71532	22420	49112	2.19
W_3	33.33	36.55	35.16	35.77	35.20	59949	20120	39829	1.95
W_4	27.66	34.86	32.91	33.89	32.33	42020	22025	19995	0.86
W_5	34.62	34.89	34.54	33.72	34.44	49690	21915	27775	1.24
W_6	34.98	35.15	34.48	32.55	34.29	46830	22620	24210	1.04
W_7	37.93	35.09	36.86	36.89	36.69	66878	24513	42365	1.74
W_8	39.70	36.66	39.62	34.20	37.54	76255	28263	47993	1.72
S.Em±	1.04	1.48	1.48	1.19	0.75	1357.5		1357.5	0.07
CD (P=0.05)	3.06	4.34	4.35	3.50	2.22	3991.9		3991.9	0.19

Treatment details are given in Materials and Methods.

of the produce (Table 3).

Gross returns: A perusal of data revealed that the highest gross returns (₹76255/ha) was recorded with manual weeding twice at 25 and 40 DAS, hand weeding once at 25 DAS (₹66878/ha) and lowest gross returns (₹33268/ha) was recorded with weedy check. Among herbicidal treatments, the highest gross returns (₹71532/ha) was recorded with PE application of pendimethalin 30 EC @750 g/ha followed by metalachlor 50 EC @1000 g/ha (₹66878/ha) and was significantly superior over rest of the herbicidal treatments.

Net returns: Net return influenced under various weed control treatments revealed that significantly highest mean net return (₹49112/ha) and mean benefit: cost ratio (2.19) were accrued with PE application of pendimethalin 30 EC @750 g/ha which was mainly due to lower cost of cultivation (₹22420/ha) and higher economic yield of chickpea. This was at par with manual weeding twice at 25 and 40 DAS (₹47993/ha and 1.72, respectively) as against minimum in weedy check (₹15968/ha and 0.89, respectively) due to higher economic yield but higher cost of cultivation for manual weeding (₹28263/ha). The rising the input cost year after year increased the production cost and changed the benefits on account of variability in cost of inputs and outputs. Results suggested economic viability and agronomic feasibility of the weed management technology in chickpea cultivation and confirmed the findings reported by Indrajeet *et al.* (2020).

From the results, it may be summarized that application of pendimethalin 30 EC @750 g/ha and metalachlor 50 EC @1000 g/ha as pre-emergence recorded significantly weed parameters, yield attributes and also recorded significantly highest grain yield, net returns and B:C ratio in chickpea. Thus, these treatments may be recommended but location specificity verification required before recommendation. This practice timely control weeds and favour weed crop competition in favour of crop. Manual weeding is labour intensive, cumbersome, time consuming and cause injury to crop roots.

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