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Research Paper

Efficiency of post-emergence herbicides on growth and yield of chickpea (*Cicer arietinum*)

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ABSTRACT

A field experiment was conducted at Bikaner, Rajasthan, during the winter(*rabi*) seasons of 2013–14 and 2014–15, to test the efficiency of post-emergence herbicides on the growth and yield of chickpea (*Cicer arietinum* L.). The experiment comprising 10 weed-control treatments, i.e. weedy check, 2 hand-weeding at 20 and 40 days after sowing (DAS), imazethapyr 20 g (at 3–4-leaf stage), imazethapyr 30 g (at 3–4-leaf stage), imazethapyr 40 g (at 3–4-leaf stage), imazethapyr 50 g (at 3–4-leaf stage), imazethapyr 60 g (at 3–4-leaf stage), oxyfluorfen 50 g (at 3–4-leaf stage), oxyfluorfen 75 g (at 3–4-leaf stage), and pendimethalin 0.75 kg (pre-emergence, PE), in randomized block design with 3 replications. The minimum weed count, as well as weed dry weight were recorded with imazethapyr 60 g/ha but it has much detrimental effect on chickpea. The maximum grain yield (1.60 t/ha) was recorded with 2 hand-weedings–20 and 40 days after sowing (DAS) followed by pendimethalin 0.75 kg/ha (1.41 t/ha). Imazethapyr at all levels and oxyfluorfen at 50 g/ha and above had toxic effect on chickpea. The crop treated with imazethapyr 20 g/ha got recovered at later stage but at higher levels could not get full recovery. The maximum net returns of ₹ 58,582/ha and benefit: cost (B : C) ratio (3.51) was recorded under 2 hand-weeding treatment. Among the different herbicides, application of pendimethalin 0.75 kg/ha (PPE) resulted in significantly higher net returns of ₹ 49,592/ha and B : C ratio (3.14).

Key words: Chickpea, Herbicides, Imazethapyr, Oxyfluorfen, Pendimethalin, Weed

Chickpea is an important pulse crop grown in tropical and sub-tropical regions on light-textured soil in limited water-supply conditions in arid and semi-arid regions. Besides other production constraints, weed infestations are considered one of the most important constraints to limit its yield. Chickpea, however, is a poor competitor to weeds due to the slow growth rate and limited leaf-area development at the early stages of crop growth (30–45 days after sowing, DAS). In addition to slow initial crop growth, wider crop spacing also facilitates crop-weed competition which poses a serious limitation in chickpea production and thus, estimated seed yield loss may likely to go to the extent of 88% (Bhalla *et al*. 1998). Current chickpea weed-control strategies include crop rotations, mechanical practices, hand-weeding and mostly the application of pre-emergence herbicides usually farmers go for manual weeding under such situations. However, the availability of labour and cost involved make them seek for other low-cost alternatives for weed control. The use of post-emergence herbicides for season-long weed control is thus, preferred over early use of herbicides as pre-plant incorporation (fluchloralin and trifluralin) and pre-emergence (pendimethalin) as the later control weeds only during initial crop growth (up to 30 DAS). Hence an integration of both pre-emergence herbicides along with 1 manual weeding is needed under a season-long weed-management strategy. There is also a possibility that use of single post-emergence herbicide may replace the manual weeding and raise the income of farmers. The imidazolinone class of herbicides provides a broad-spectrum of weed-control activity (Kantar *et al*. 1999), flexibility in timing of application, low usage rates and low mammalian toxicity (Tan *et al*., 2005).

MATERIALS AND METHODS

A field study was conducted during the winter (*rabi*) season of 2013–14 and 2014–15 at Research farm of Agriculture Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner (28.00^{o} to 28.16^{o} N',

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72.55° to 73.42° E' and 234.7 m above mean sea-level). Ten weed-control treatments comprising weedy check, 2 hand weeding one at 20 and other at 40 DAS, imazethapyr 20 g/ha (at 3–4-leaf stage), imazethapyr 30 g/ha (at 3–4-leaf stage), imazethapyr 40 g/ha (at 3–4-leaf stage), imazethapyr 50 g/ha (at 3–4-leaf stage), imazethapyr 60 g/ha (at 3–4-leaf stage), oxyfluorfen 50 g/ha (at 3–4-leaf stage), oxyfluorfen 75 g/ha (at 3–4-leaf stage), and pendimethalin 0.75 kg/ha (PE), were evaluated in randomized block design with 3 replications. The soil of experimental site was loamy sand, having 0.08% organic carbon, 8.22 *p*H, 78, 22 and 210 kg/ha available N, P and K respectively. Chickpea 'RSG 888' was sown on 5 November 2013 and 8 November 2014 at 30 cm row-to-row spacing using a seed rate of 80 kg/ha and was harvested on 21 March 2014 and 28 March 2015 respectively. The recommended dose of fertilizers (20 kg N + 40 kg P + 40 kg K/ha) was applied basal dose through urea, single superphosphate (SSP) and murate of potash (MOP) respectively. Pre-emergence application of pendimethalin was done on the next day of sowing, whereas post-emergence application of imazethapyr was done at 25 days after sowing (DAS) as per the treatment with knapsack sprayer fitted with flat-fan nozzles. Two hand-weedings were done at 20 and 40 DAS. Weed density was recorded by using a quadrate of 0.25/m^2 at 60 DAS in all the treatments and then converted into the number of weeds/m^2. The weeds were dried in oven till a constant weight was observed and then transformed into g/m^2. Growth, yield parameters and yield of chickpea were recorded for 2 consecutive years. Nodules/plant were counted at 50 DAS from carefully uprooted 5 plants from each plot. The data on total weed count and weed dry matter were subjected to square-root transformation ($\sqrt{n+0.5}$) to normalize their distribution (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Weeds

The experiment field was infested mainly with lamb's quarters *Chenopodium album* L.), austration spinach (*Chenopodiastrum muriate* (L.) Fuentz Uotila & Borsch; sy. *Chenopodium murale* (L.)*, wild onion (Asphodelus tenuifolius Cav.), Melilotus* spp., nut grass (*Cyprus rotundus* L.), Indian fumitory (*Fumaria purviflora* Lam.) and *Eragrostis* sp., etc.

The density and dry weight of both monocot and dicot weeds were significantly reduced by all the weed-control treatments compared to weedy check (Table 1). Two hand-weeding treatment resulted in the lowest weed density and dry weight. However, among the different treatments, application of imazethapyr 60 g/ha was found effective in reducing the density and dry weight of dicot and total weeds followed by application of its respective lower doses, while pendimethalin 0.75 kg/ha was effective against monocot weeds. The lower density of weeds by imazethapyr in reducing weed dry matter might be primarily appeared due to broad-spectrum activity, particularly on establishment of plants of dicot weeds and its greater efficiency to retard cell-division of meristems as a result of which weeds dry rapidly. Our results confirm the findings of Kantar *et al.* (1999), where about 84.6% of weed biomass was controlled with an application of imazethapyr. Papierniks *et al.* (2003) also recommended use of imazethapyr in legumes, which inhibits acetohydroxy acid synthase and the synthesis of branched-chain amino acids. Application of pendimethalin was effective for the plots where only grassy weeds were dominated as against imazethapyr which was effective against annual broad-leaf

Table 1. Effect of weed-control measures on weed density, weed dry weight, plant height and nodules per plant of chickpea (pooled data over 2 years)

Treatment	Monocot weeds/m^2	Dicot weeds/m^2	Total weeds/m^2	Total weeds dry weight (g/m^2)	Plant height (cm)	Nodules/ plant
Weedy check	2.84 (7.58)	4.50 (19.96)	5.28 (27.54)	207.50	49.47	15.24
2 hand-weedings	0.97 (0.54)	0.99 (0.54)	1.23 (1.08)	9.79	45.19	16.23
Imazethapyr 20 g/ha	2.28 (4.75)	1.78 (2.71)	2.81 (7.46)	16.21	45.37	18.97
Imazethapyr 30 g/ha	2.23 (4.58)	1.49 (1.79)	2.60 (6.38)	10.88	44.05	17.54
Imazethapyr 40 g/ha	1.67 (2.42)	1.76 (2.71)	2.32 (5.13)	9.71	45.66	18.05
Imazethapyr 50 g/ha	2.07 (4.17)	1.21 (1.13)	2.38 (5.29)	9.69	46.15	16.62
Imazethapyr 60 g/ha	1.61 (2.25)	1.33 (1.29)	1.99 (3.54)	6.78	45.08	15.88
Oxifluorfen 50 g/ha	1.81 (2.88)	1.78 (2.83)	2.46 (5.71)	23.66	45.06	16.15
Oxyfluorfen 75 g/ha	1.88 (3.08)	1.79 (2.71)	2.50 (5.79)	16.90	45.80	17.43
Pendimethalin 0.75 kg/ha	1.40 (1.63)	3.41 (11.25)	3.64 (12.88)	122.70	49.81	18.39
SEm±	0.12	0.11	0.13	3.48	0.50	0.76
CD (P=0.05)	0.34	0.32	0.38	10.23	1.47	2.25

weeds, grassy weeds and perennial sedges.

Chickpea

Different weed-management practices had significant positive impacts on the growth, yield attributes and yield of chickpea (Tables 1, 2). Significantly the lowest values of nodules/plant, pods/plant, seeds/pod and seed index were recorded under weedy check and the highest values for these parameters were recorded under imazethapyr 20 g/ha. However, the taller plants were recorded by pendimethalin 0.75 kg/ha followed by weedy check. Application of a higher dose of imazethapyr reduced the plant height, nodules/plant, pods/plant and seeds/pod compared with lower doses of herbicides, on the contrary, seed index increased over application of reduced doses. The higher level of these parameters could be attributed due to low crop-weed competition under treatments.

All weed-management practices significantly enhanced seed and straw yields over weedy check (Table 2). However, there was no significant difference between seed and straw yield with imazethapyr doses. The hand-weeding twice resulted in significantly higher seed yield (1.6 t/ha) over the remaining treatments except for pendimethalin 0.75 kg/ha. Among the herbicides, imazethapyr 20 g/ha recorded higher seed yield closely followed by oxyfluorfen 50 g/ha, further seed yield declined consistently with an increase in herbicide doses. This might be due to the decreased number of seeds/pod and seed index. The increase in seed yield in hand-weeded and pendimethalin-applied plots could be attributed due to the fact that these treatments resulted in a beneficial effect on final yield. Patra and Naik (2001) also reported increased pods/plant owing to weed-control treatments. The differential contribution of yield components towards seed yield was obtained with different treatments. Effective control of weeds by herbicides might have resulted in better availability of soil moisture and nutrients, as evident by the beneficial effect on crop growth. The higher seed yield in treatments imazethapyr or its lower levels over weedy check might be due to suppression of weed seed germination and seedling development at early stages due to pre-emergent herbicides. Two hand-weeding treatment provides better microclimate for the development of plants with minimizing 2 fluxes of weed at the critical growth stage. Weedy check gave reduced yields due to the presence of weeds and resulted in increased weed competition for growth resources, especially for moisture, nutrients and light Hiremath *et al*. (1997) and Kori (2000) reported similar yield reduction due to the presence of weeds.

Economics

All the weed-control treatments resulted in higher net returns and B : C ratio over weedy check (Table 2). While the highest net returns and B : C ratio was obtained with 2 hand-weeding treatment. However, Among the herbicide treatments, higher net returns (49,592) and B : C (3.14) ratio was recorded in pendimethalin 0.75 kg/ha closely followed by imazethapyr 20 g/ha due to higher seed yield and subsequently lower cost of cultivation (Mene *et al.,* 2003). Whereas, the higher dose of imazethapyr up to 60 g/ha recorded lower net returns and B : C ratio followed by weedy check, it is quite important to note that keeping the land free of weeds throughout the crop-growth period is practically impossible by the farmers, since involves huge cost on labour. Tewari e*t al.* (1989) reported that, the additional amount of income obtained under 2 hand-weedings treatment appeared to be immaterial when compared to cost of weeding incurred to maintain weed-free conditions beyond 8 weeks after sowing. The availability of working forces in villages has been reduced considerably at a par-

Table 2. Effect of weed control measures on pods/plant, seeds/pod, seed index, seed and straw yield and economics of chickpea (pooled data over 2 years)

Treatment	Pods/ plant	Seed/ pod	Seed index (g)	Seed yield (kg/ha)	Straw yield (kg/ha)	Net returns (₹/ha)	Benefit : cost ratio
Weedy check	18.03	1.35	14.22	734	1,667	18,072	1.87
2 hand-weedings	41.54	1.48	15.46	1,596	3,107	58,582	3.51
Imazethapyr 20 g/ha	48.83	1.58	15.48	1,227	2,573	41,398	2.85
Imazethapyr 30 g/ha	43.97	1.51	15.50	1,020	2,078	30,017	2.33
Imazethapyr 40 g/ha	47.84	1.56	15.38	923	2,067	25,827	2.13
Imazethapyr 50 g/ha	43.24	1.52	15.35	703	1,542	13,843	1.60
Imazethapyr 60 g/ha	41.03	1.46	15.30	606	1,245	8,138	1.35
Oxifluorfen 50 g/ha	44.44	1.53	15.39	1,207	2,392	39,763	2.78
Oxyfluorfen 75 g/ha	46.26	1.54	15.33	1,159	2,323	37,348	2.66
Pendimethalin 0.75 kg/ha	47.73	1.56	15.30	1,410	2,838	49,592	3.14
SEm±	0.94	0.03	0.08	49	104	–	–
CD (P=0.05)	2.78	0.08	0.23	143	307	–	–

ticular stage of crop growth is also difficult.

It was concluded from 2 year study that, application of imazethapyr 60 g/ha was found effective in reducing the density and dry weight of dicot and total weeds but also have phytotoxicity on chickpea crop, while pendimethalin 0.75 kg/ha was effective against monocot weeds. Pendimethalin 0.75 kg/ha increased the seed yield and economically feasible in chickpea in arid regions.

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