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RESEARCH NOTE

Weed management with pre- and post-emergence herbicide under varying tillage systems in chickpea grown after sorghum

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ABSTRACT

An experiment was conducted during 2019–20 at Rani Lakshmi Bai Central Agricultural University (RLBCAU), Jhansi to evaluate the effect of tillage and weed management treatments on weeds and productivity of chickpea grown after sorghum. Major broad-leaved weeds were: *Anagallis arvensis* (48%), *Spergula arvensis* (12.3%), *Medicago denticulata* (8.6%), *Melilotus alba* (8.0%); and narrow-leaved, *Cyperus rotundus* (17.0%) and *Dactyloctenium aegyptium* (2.7%). Adoption of zero tillage (ZT) and ZT+ residue retention increased mean grain yield of chickpea by 10.6 and 21.1%, respectively over the conventional tillage (CT). Pre-emergence application (PE) of pendimethalin 1.0 kg/ha followed by (*fb*) post-emergence application (PoE) of clodinafop-propargyl + Na-acifluorfen 122.5 g/ha at 30 DAS controlled weeds effectively and resulted in 8.6, 19.3 and 43.5% more grain yield than pendimethalin *fb* hand weeding, pendimethalin alone and unweeded check, respectively. It was concluded that clodinafop-propargyl + Na-acifluorfen proved to be a good substitute for hand weeding at 30 DAS but its dose and timing of application need to be further standardized at different locations.

Keywords: Chickpea, Clodinafop-propargyl + Na-acifluorfen, Pendimethalin, Sorghum residue, Weed management, Zero tillage

Chickpea (*Cicer arietinum* L.) also called Bengal gram, is the largest produced food legume in South Asia and in India. The chickpea has a lion's share of 49.3% in the total pulses production of 25.6 million tonnes in India (Gaur 2021). However, the productivity of chickpea is quite low (1.14 t/ha) considering its potential (up to 3 t/ha) with better soil and crop management. Among the factors responsible for low yield are poor crop stand and weed infestation (Sanketh *et al*. 2021). Adopting conventional practices like repeated ploughings to prepare a fine seedbed for germination and establishment exposes the weed seeds from lower soil layers (Chauhan *et al.* 2012). A bold-seeded crop like chickpea does not require fine tilth (Parihar *et al*. 2019). Poor competitive ability of chickpea makes weeds to cause yield losses up to 90% under severe infestation (Mukherjee 2007). Application of pre-emergence herbicide like pendimethalin provides good early season weed control (Singh and Jain, 2017), but the farmers often have to resort to manual weeding in the later stages which is quite costly. Lack of any suitable post-emergence herbicide for controlling weeds, especially the broad-leaved species is a major limitation in chickpea. A mixture of clodinafop-propargyl + Na-acifluorfen is recommended in soybean, and showed promise in chickpea despite some phytotoxicity (Nath *et al*. 2018). The present experiment was planned to evaluate the efficacy of sequential application of pre- and post-emergence herbicide under varying tillage systems on weed control and performance of chickpea grown after sorghum.

The experiment was carried out on sandy clay-loam soil at the research farm of Rani Lakshmi Bai Central Agricultural University (RLBCAU), Jhansi, Uttar Pradesh during 2019-20. Twelve treatment combinations comprised of three tillage practices in main-plots, *viz*. zero tillage (ZT), ZT with residue (ZT+R), conventional tillage (CT), and four weed management treatments in sub-plots, *viz*. pre-emergence application (PE) of pendimethalin 1.0 kg/ha, pendimethalin 1.0 kg/ha PE followed by (*fb*) post-emergence application (PoE) of clodinafop-propargyl + Na-acifluorfen 122.5 g/ha at 30 days after sowing (DAS), pendimethalin 1.0 kg/ha PE *fb* hand weeding at 30 DAS, and unweeded check. A split-plot design with three replications was used. Sowing of chickpea variety "*RVG-202*" was done with happy-seeder on 9 November, 2019 along with basal application of 100 kg DAP/ha. One irrigation was given in mid-January, and the crop was harvested on 5 April, 2020. Crop residue 5 t/ha of the previous sorghum crop was retained on the soil surface in the respective treatments. Glyphosate was applied at 1.2 kg/ha before sowing in ZT plots. Observations on species-wise weed density and biomass were recorded from

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0.25 m^2 area at 30 days interval. Similarly, crop biomass was taken from 0.25 m^2 area, and grain yield at maturity was taken from the net plot area (10 m^2).

Effect on weeds

Predominant weed species at 30 DAS observed in the CT-unweeded control were: *Anagallis arvensis* (48.0%), *Spergula arvensis* (12.3%), *Medicago denticulata* (8.6%), *Melilotus alba* (8.0%) and *Parthenium hysterophorus* (1.8%) among broad-leaved; and *Cyperus rotundus* (17.0%) and *Dactyloctenium aegyptium* (2.7%) among narrow-leaved weeds. Thus, the crop field was dominated by the broad-leaved species (>80%), and *Anagallis arvensis* constituted about half of total weed population. The relative proportion of broad-leaved species at 60 DAS was comparatively lower under ZT+R (76.4%) as compared to ZT alone (81.1%) and CT (84.4%) **(Table 1)**. Tillage checked the infestation of *Cyperus rotundus*, but it regenerated under ZT despite glyphosate application.

Significant variations in total weed density and biomass due to tillage and weed management practices were observed at 30 and 60 DAS (**Table 2**). There was no significant difference in weed density under ZT and ZT+R at 30 DAS, but it was significantly higher under CT at both the stages. Retention of sorghum residue caused decrease in weed density under ZT+R. Repeated ploughings under CT brought the weed seeds to the surface, which were exposed to the light, leading to greater emergence of diverse weed flora as compared to ZT (Chauhan *et al.* 2012).

Application of pendimethalin resulted in weed suppression from the early stages. At 30 DAS, the weed density in the pendimethalin treatments was significantly lower than unweeded check. Application of clodinafop-propargyl *fb* Na-acifluorfen at 30 DAS resulted in efficient control of both broad-leaved and narrow-leaved weeds, resulting in significantly lower weed density and biomass than other treatments. Pendimethalin is primarily a grassy weed killer with limited effect on broad-leaved species (Kaur and Kumar 2016). Accordingly, the broad-leaved weeds which were left uncontrolled with pendimethalin, were very efficiently controlled by clodinafop-propargyl + Na-acifluorfen or hand weeding at 30 DAS. Post-emergence application of clodinafop-propargyl + Na-acifluorfen resulted in significantly lower weed density and biomass at 60 DAS as compared to pendimethalin alone or along with hand weeding. Initial suppression of the few grassy weeds with pendimethalin and later control of broad-leaved weeds with clodinafop-propargyl + Na-acifluorfen resulted in lower crop-weed competition.

Effect on chickpea growth

There was no significant effect of tillage on biomass accumulation of chickpea at 30 DAS, but the biomass at 60 DAS was significantly higher under ZT+R than CT **(Table 2)**. Presence of sorghum residue with ZT had a beneficial effect on dry matter accumulation due to reduced weed pressure and modified hydro-thermal regime (Acharya *et al*. 2018). Similarly, the weed management practices did not have any effect on crop biomass at 30 DAS, but pre-emergence application of pendimethalin *fb* clodinafop propargyl + Na-acifluorfen PoE showed significantly lower biomass at 60 DAS as compared to other pendimethalin-applied treatments. The post-emergence application of clodinafop-propargyl + Na-acifluorfen at 30 DAS resulted in a limited and temporary scorching effect on chickpea foliage, which suppressed the crop growth for about 20 days, and resulted in relatively lower dry matter accumulation at 60 DAS. However, the plants recovered from the phytotoxic effect of clodinafop-propargyl + Na-acifluorfen, and accumulated more plant biomass at 90 DAS, which was at par with pendimethalin PE *fb* hand weeding.

Relationship between the crop and weed biomass showed a significant negative correlation ($Y = -0.30X + 361.6$; $R^2 = 0.95$). There was a decrease of 0.30 g/m^2 crop biomass with unit increase in weed biomass at 60 DAS. This suggests that increased weed biomass production caused a greater suppressing effect on crop dry matter accumulation.

Effect on grain yield

Grain yield of chickpea was significantly more under ZT+R (1.71 t/ha) as compared to CT (1.35 t/ha) and ZT (1.51 t/ha) **(Table 2)**. Retention of sorghum residue had a positive effect on crop growth and yield

Table 1. Relative proportion (%) of different weed species under varying tillage of unweeded check at 60 DAS

Weed species	ZT	ZT + R	CT
Broad-leaved			
Anagallis arvensis	43.5	36.7	49.8
Spergula arvensis	15.7	15.7	13.0
Medicago denticulata	11.7	12.8	8.8
Melilotus alba	4.3	5.1	8.0
Parthenium hysterophorus	2.0	1.6	1.7
Coronopus didymus	2.0	2.6	1.9
Others	1.8	1.8	1.2
Total	81.1	76.4	84.4
Narrow-leaved			
Cyperus rotundus	16.0	20.2	12.6
Dactyloctenium aegyptium	2.9	3.4	2.9
Total	18.9	23.6	15.6

Table 2. Effect of tillage and weed control practices on weeds crop growth, yield and economics of chickpea

Treatment	Weed density (no./m^2)		Weed biomass (g/m^2)		Crop biomass (g/m^2)		Grain yield (t/ha)	Total cost of cultivation (x10^3 ₹/ha)	Net returns (x10^3 ₹/ha)	Net B:C ratio
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS				
Tillage										
ZT	49.0	65.1	11.1	29.4	24.9	179.8	1.51	26.9	48.7	1.79
ZT+R	45.1	54.5	9.6	21.0	24.3	181.9	1.71	29.4	56.3	1.90
CT	99.9	133.3	26.6	76.0	26.3	172.1	1.35	31.9	35.7	1.10
LSD (p=0.05)	7.1	8.9	1.5	4.5	NS	5.1	0.14	-	-	-
Weed management										
Pendimethalin 1.0 kg/ha PE	46.8	61.1	11.0	27.8	25.1	191.3	1.50	28.8	46.1	1.62
Pendimethalin 1.0 kg/ha PE *fb* clodinafop-propargyl + Na-acifluorfen 122.5 g/ha PoE	46.6	21.3	11.3	10.2	25.4	167.2	1.86	30.2	62.6	2.09
Pendimethalin 1.0 kg/ha PE *fb* HW	46.7	36.4	11.1	14.6	25.1	195.9	1.70	32.1	52.9	1.67
Unweeded control	118.7	218.2	29.6	115.9	26.0	157.3	1.05	26.3	26.0	1.01
LSD (p=0.05)	3.8	6.3	1.0	3.0	NS	3.3	0.04	-	-	-

*PE= Pre-emergence; PoE = Post-emergence; *fb* = followed by

attributes, which led to significantly higher grain yield when compared with other practices. Application of pendimethalin *fb* clodinafop-propargyl + Na-acifluorfen was the best weed management practice with respect to grain yield, followed by pendimethalin *fb* hand weeding. Nath *et al*. (2018) also reported that clodinafop-propargyl + Na-acifluorfen controlled weeds effectively and increased the yield of chickpea despite some phytotoxicity symptoms on crop foliage. Chickpea requires nipping to check vertical growth of plants, and this effect may have also been achieved through application of clodinafop-propargyl + Na-acifluorfen. Interaction revealed that the highest grain yield of chickpea (2.02 t/ha) was obtained under ZT+R with application of clodinafop-propargyl + Na-acifluorfen.

Effect on economics

Among the tillage practices, the cost incurred on CT (31.9 x10^3 ₹/ha) was higher compared to ZT and ZT+R. On the other hand, the total cost of cultivation was lower under ZT and ZT+R, besides the cost of residue included under ZT+R **(Table 2)**. Employing manual hand weeding after pendimethalin resulted in increased cost of cultivation compared to the use of pendimethalin PE *fb* clodinafop-propargyl + Na-acifluorfen PoE. Despite the increased cost of cultivation under CT, the net returns, and net B:C ratio (1.10) were lower compared to the better performing treatments ZT+R (1.90) and ZT (1.79). Among the weed management practices, pendimethalin PE *fb* clodinafop-propargyl + Na-acifluorfen PoE recorded more net returns (62.6 x10^3 ₹/ha) and net B:C ratio (2.09).

It was concluded that zero-till chickpea can be grown successfully with retention of sorghum residue. Weeds can be effectively controlled with glyphosate application before sowing, pendimethalin 1.0 kg/ha PE *fb* clodinafop-propargyl + Na-acifluorfen 122.5 g/ha PoE.

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