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Integrated weed management in chickpea (*Cicer arietinum* L.) under rainfed conditions of Karnataka, India

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ABSTRACT

A field investigation was carried out during winter seasons of 2012-13, 2013-14 and 2014-15 at Agricultural Research Station, Gulbarga (Karnataka) to evaluate the effect of pre and post emergence herbicides on weeds and productivity of chickpea cv. JG-11. Ten treatments were tested in randomized block design with three replications. Among the herbicidal treatments, pendimethalin 38% CS 0.75 kg a.i ha^{-1}PE + hand weeding (HW) at 30-35 days after sowing (DAS) and pendimethalin 30% EC 0.75 kg a.i ha^{-1}+ imazethapyr 2% 1.0 kg a.i ha^{-1} PE + one hoeing at 30-35 DAS recorded significantly higher seed yield (1198 kg ha^{-1}), net returns (Rs. 25107 ha^{-1}) and B:C ratio (2.10) and lower weed dry weight (11.3 g m^{-2}) and higher weed control efficiency (83%) than all other herbicidal treatments except two hand weedings at 20 and 40 DAS. It may be inferred from the present investigation that these herbicidal treatments could be used effectively as an alternative for controlling weeds and obtaining optimum seed yield of chickpea under rainfed conditions of Karnataka.

Key words: Chickpea, Herbicides, Pre-emergence, Weeds, Weed dry weight.

INTRODUCTION

Chickpea is one of the most important pulse crops of India, grown both under conserved soil moisture and irrigated situations. The productivity of chickpea has fallen due to various constraints such as biotic and abiotic factors. Among the biotic constraints wilt, dry root rot and blight are the major constraints in Karnataka. In addition to that, the weeds also result in major loss in yield by competing for space, nutrients, water and light. Poor weed management is one of the most important yield limiting factors in chickpea. Weeds can remove plant nutrients from soil more efficiently than crops. Under rainfed ecosystem, efficient water use by weeds may increase severity of drought and results in a low crop yield. Most weed species can grow faster and taller than chickpea and inhibit its growth, absorbs sunlight, and affect photosynthesis and plant productivity adversely (Rao 2000). Generally, for the control of weeds farmers do manual weeding. But with the increase in labour cost and scarcity of labour, manual weed control has become a difficult task in chickpea. Being slow in its early growth and short statured plant, chickpea is highly susceptible to weed competition and weeds causes up to 75% yield loss (Chaudhary *et al*., 2005). Solh and Pala (1990) reported 40-87 % yield loss in chickpea due to weeds. Weed management in chickpea is an important component of plant protection thus improving production potential of the crop. Therefore, the work was undertaken to observe the effect of different weed management practices on productivity of chickpea under rainfed conditions.

MATERIALS AND METHODS

A field experiment was conducted during post rainy season of 2012-13, 2013-14 and 2014-15 at Agricultural Research Station, Gulbarga, Karnataka. The soil of the experimental field was clay loam having organic carbon 0.50 %, available nitrogen 180 kg ha^{-1}, phosphorous 25 kg ha^{-1} and potash 350 kg ha^{-1} and EC 0.41 dS/m with pH 8.80. The experiment consisting of 10 treatments *viz*., pendimethalin 30% EC (0.75 kg a.i ha^{-1}) as pre-emergence (PE) + one hand weeding (HW) at 25-30 days after sowing (DAS), pendimethalin 38% CS (0.75 kg a.i ha^{-1}) PE, pendimethalin 38% CS (0.75 kg a.i ha^{-1}) PE + one HW at 30-35 DAS, oxyflourofen 23.5%EC (0.25 kg a.i ha^{-1}) at 20 DAS + one hoeing at 30-35 DAS, fenoxyprop ethyl 7.5% EC (60 g a.i g ha^{-1}) at 25-30 DAS, pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1} PE, pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1} PE + one hoeing at 30-35 DAS, one hand weeding at 30-35 DAS, two hand weedings at 20 and 40 DAS and weedy checks. The experiment was laid out in randomized block design with three replications. After thorough preparation of land the chickpea seed treated with *Rhizobium* (1250 g ha^{-1}), *phosphate solubilizing bacteria*

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(1250 g ha^{-1}) and *Trichoderma* (4 g kg^{-1}) was sown on first fortnight of October during different seasons by adopting the spacing of 30 x 10 cm. Before sowing, entire dose of nitrogen (25 kg ha^{-1}) and phosphorus (50 kg ha^{-1}) was applied as basal as per the recommendations. The pre and post emergence herbicide treatments were imposed as per schedule during October and November months, respectively. The rainfall received during crop season was 26.8 mm, 49.6 mm and 53.6 mm during 2012-13, 2013-14 and 2014-15, respectively. There were no major pests and diseases during all the three years of experimentation. Weed dry weight was recorded at harvest only. The data on dry weight were subjected to arcsine transformation before statistical analysis to normalize their distribution. Data for individual years were pooled and statistically analyzed as per the procedure given by Gomez and Gomez (1984) for randomized block design.

Weed control efficiency (WCE) was calculated by the following formula.

$$WCE\ (\%) = \frac{WCC - WCT}{WCC} X\ 100$$

Where,

WCC = Dry weight of weeds in unweeded control plot

WCT = Dry weight of weeds in treated plot

Recording observations of data

Regarding agronomic characters, ten competitive plants were randomly selected from each plot and observations were recorded for growth and yield attributes. Whereas, seed yield obtained from the net plot area was recorded at physiological maturity and expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

Influence of weedicides on weeds: The dominant weed flora of the experimental plots included *Echinochloa spp*, *Panicum spp*, and *Cynodon dactylon* among grasses, *Cyperus rotundus* among sedges and *Amarantes viridis*, *Physalis minima*, *Chrozophora rottleri*, *Phyllanthus niruri*, *Aristolochia bracteata*, *Trianthema portulacastrum*, *Portulaca oleracea* and *Digera arvensis* among broadleaf weeds.

All the weed control treatments significantly reduced the total weed dry weight over weedy check at all stages of observation (Table 1). All the integrated treatments were significantly superior to alone application of herbicides in reducing weed dry weight. Among the treatments, pendimethalin 38% CS 0.75 kg a.i ha^{-1} PE + HW at 30-35 DAS recorded the highest WCE (83.06%) and lowest weed dry weight (11.3 g m^{-2}) and was on par with pendimethalin 30% EC 0.75 kg a.i ha^{-1} PE + imazethapyr 2% 1.0 kg ha^{-1} PE + one hoeing at 30-35 DAS. The results are corroborating with those reported by Ratnam and Reddy (2011).

Effect on crop: No crop injury was observed with the pre emergence herbicides applied under study. However, post-emergence application of oxyflourofen 23.5% EC 0.25 kg a.i ha^{-1} at 20 DAS caused injury (20%) to chickpea but it recovered subsequently.

Influence on growth and yield parameters of chickpea: Plant height differed significantly due to different weed control treatments. Higher plant height was recorded in two hand weedings at 20 and 40 DAS since no weeds were allowed to grow throughout the crop growth period which enabled zero crop-weed competition for resources throughout the crop growth period. Whereas, weedy check recorded the minimum plant height. The main reason was due to the presence of more number of monocots and dicot weeds associated with the crop which exhibited severe competition throughout the crop growth. Weed competition has the effect of progressively decreasing the plant height in chickpea (Ratnam and Reddy, 2011). All the herbicidal treatments and two hand weedings at 20 and 40 DAS recorded significantly more plant height than weedy check (Table 2). Maximum plant height (35.3 cm) was observed in two hand weedings at 20 and 40 DAS which was at par with that recorded under pendimethalin 38% CS 0.75 kg a.i ha^{-1} PE + HW at 30-35 DAS and pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1} PE + one hoeing at 30-35 DAS.

The treatments comprising of two hand weedings at 20 and 40 DAS and herbicidal application recorded significantly more number of branches than weedy check (Table 2). Maximum number of branches was recorded in two hand weedings at 20 and 40 days after sowing (6.7 $plant^{-1}$) followed by pendimethalin 38% CS 0.75 kg a.i ha^{-1} PE + HW at 30-35 DAS and pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1} PE + one hoeing at 30-35 DAS.

The perusal of data in Table 2 indicated that all weed control treatments were significantly superior to weedy check in influencing number of pods per plant. Maximum number of pods (33.7 $plant^{-1}$) were recorded under two hand weedings at 20 and 40 DAS followed by pendimethalin 38% CS 0.75 kg a.i ha^{-1} PE + HW at 30-35 DAS (33.1 $plant^{-1}$) and pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1} PE + one hoeing at 30-35 DAS (32.6 $plant^{-1}$), respectively. Lowest number of pods (21.8 plant-1) were recorded under weedy check.

Influence on crop productivity: Seed yield differed significantly owing to different weed control treatments (Table. 3). Significantly higher seed yield was recorded in two hand weedings at 20 and 40 days after sowing (1244 kg ha^{-1}) mainly due to the complete elimination of weeds throughout the crop growth which enabled minimum

Table 1: Weed dry weight and weed control efficiency (WCE) under different pre and post emergence herbicides

Treatments	Wed dry weight (g m^{-2})				WCE (%)			
	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled
T_1: Pendimethalin 30% EC 0.75 kg a.i ha^{-1}, PE + one HW at 25-30 DAS	38.6 (38.4)	13.2 (21.3)	10.8 (19.2)	20.9 (26.3)	55.78	76.92	72.09	68.26
T_2: Pendimethalin 38% CS 0.75 kg a.i ha^{-1}, PE	63.1 (52.6)	21.5 (27.6)	19.1 (25.9)	34.6 (35.4)	27.72	62.41	50.65	46.93
T_3: Pendimethalin 38% CS 0.75 kg a.i ha^{-1}, PE + HW at 30-35 DAS	21.5 (27.6)	7.3 (15.7)	5.2 (13.2)	11.3 (18.8)	75.37	87.24	86.56	83.06
T_4: Oxyflourofen 23.5% EC 0.25 kg a.i ha^{-1} at 20 DAS + one hoeing at 30-35 DAS	71.9 (58.0)	24.6 (29.7)	22.4 (28.2)	39.6 (38.7)	17.64	56.99	42.12	38.92
T_5: Fenoxyprop ethyl 7.5% EC 60 g ha^{-1} POE at 25-30 DAS	69.7 (56.6)	23.8 (29.2)	21.2 (27.4)	38.2 (37.7)	20.16	58.39	45.22	41.26
T_6: Pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1}, PE	52.3 (46.3)	17.9 (25.0)	15.3 (23.0)	28.5 (31.5)	40.09	68.71	60.47	56.42
T_7: Pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1}, PE + one hoeing at 30-35 DAS	23.7 (29.1)	8.1 (16.5)	7.6 (16.0)	13.1 (20.6)	72.85	85.84	80.36	79.68
T_8: One hand weeding at 30-35 DAS	41.7 (40.2)	14.2 (22.1)	12.7 (20.9)	22.9 (27.7)	52.23	75.17	67.18	64.86
T_9: Two hand weeding at 20 and 40 DAS	6.7 (15.0)	1.8 (7.7)	1.2 (6.3)	3.2 (9.7)	92.33	96.85	96.90	95.36
T_{10}: Weedy check	87.3 (69.1)	57.2 (49.1)	38.7 (38.5)	61.1 (52.2)	0.00	0.00	0.00	0.00
S.Em±	2.72	1.05	0.6	1.23	2.15	2.98	2.72	2.31
CD at 5%	8.08	3.13	1.7	3.65	6.38	8.85	8.08	6.88

*Figures in the parenthesis are arcsine transformed values

DAS: Days after sowing, HW: Hand weeding, PE: Pre emergence, POE: Post emergence

Table.2: Growth and yield parameters of chickpea as influenced by different pre and post emergence herbicides

Treatments	Plant height (cm)				No. of branches plant^{-1}				No. of pods plant^{-1}				100 seed weight (g)			
	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled
T_1: Pendimethalin 30% EC 0.75 kg a.i ha^{-1}, PE + one HW at 25-30 DAS	28.4	35.7	35.1	33.1	4.8	6.4	5.8	5.7	26.2	34.6	34.8	31.9	20.2	21.6	20.6	20.8
T_2: Pendimethalin 38% CS 0.75 kg a.i ha^{-1}, PE	27.4	34.4	31.8	31.2	3.5	4.6	4.6	4.2	22.2	29.3	29.0	26.8	19.7	21.1	19.2	20.0
T_3: Pendimethalin 38% CS 0.75 kg a.i ha^{-1}, PE + HW at 30-35 DAS	29.5	37.1	36.2	34.3	4.9	6.5	6.6	6.0	26.8	35.4	37.1	33.1	20.9	22.4	21.0	21.4
T_4: Oxyflourofen 23.5% EC 0.25 kg a.i ha^{-1} at 20 DAS + one hoeing at 30-35 DAS	27.7	34.8	30.8	31.1	3.9	5.2	4.4	4.5	22.5	29.7	27.0	26.4	19.7	21.2	18.8	19.9
T_5: Fenoxyprop ethyl 7.5% EC 60 g ha^{-1} POE at 25-30 DAS	27.9	35.1	30.2	31.1	4.7	6.2	4.6	5.2	23.2	30.7	28.2	27.4	20.0	21.5	19.0	20.2
T_6: Pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1}, PE	28.0	35.2	32.0	31.7	4.7	6.2	4.8	5.2	24.1	31.8	30.4	28.8	20.1	21.5	19.5	20.4
T_7: Pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1}, PE + one hoeing at 30-35 DAS	29.1	36.6	35.7	33.8	4.8	6.4	6.4	5.9	26.3	34.8	36.6	32.6	20.3	21.8	20.8	21.0
T_8: One hand weeding at 30-35 DAS	28.2	35.4	33.2	32.3	4.7	6.2	5.4	5.4	25.6	33.8	32.2	30.5	20.1	21.6	19.6	20.4
T_9: Two hand weeding at 20 and 40 DAS	29.9	37.6	38.4	35.3	5.5	7.3	7.2	6.7	26.9	35.5	38.8	33.7	21.1	22.6	21.4	21.7
T_{10}: Weedy check	19.8	23.1	22.7	21.9	3.4	4.5	4.4	4.1	19.5	23.8	22.2	21.8	17.3	18.0	17.1	17.5
S.Em±	1.1	1.3	1.1	1.0	0.2	0.3	0.2	0.2	1.1	1.3	1.1	1.2	0.5	0.6	0.6	0.6
CD at 5%	3.4	3.8	3.2	3.1	0.6	0.8	0.7	0.5	3.2	3.9	3.2	3.4	1.5	1.9	1.8	1.7

DAS: Days after sowing, HW: Hand weeding, PE: Pre emergence, POE: Post emergence

Table.3: Yield and economics of chickpea as influenced by different pre and post emergence herbicides (pooled over 3 years)

Treatments	Seed yield (kg ha^{-1})				Gross returns (Rs.ha^{-1})	Net returns (Rs.ha^{-1})	B:C ratio
	2012-13	2013-14	2014-15	Pooled			
T_1: Pendimethalin 30% EC 0.75 kg a.i ha^{-1}, PE + one HW at 25-30 DAS	963	1250	1130	1114	44573	21308	1.92
T_2: Pendimethalin 38% CS 0.75 kg a.i ha^{-1}, PE	808	1159	1028	998	39933	18933	1.90
T_3: Pendimethalin 38% CS 0.75 kg a.i ha^{-1}, PE + HW at 30-35 DAS	1036	1355	1202	1198	47907	25107	2.10
T_4: Oxyflourofen 23.5% EC 0.25 kg a.i ha^{-1} at 20 DAS + one hoeing at 30-35 DAS	774	1074	963	937	37480	17245	1.85
T_5: Fenoxyprop ethyl 7.5% EC 60 g ha^{-1} POE at 25-30 DAS	792	1108	1002	967	38693	18093	1.88
T_6: Pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1}, PE	863	1187	1097	1049	41960	19995	1.91
T_7: Pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1}, PE + one hoeing at 30-35 DAS	1034	1286	1183	1168	46707	24742	2.13
T_8: One hand weeding at 30-35 DAS	909	1239	1114	1087	43493	22093	2.03
T_9: Two hand weeding at 20 and 40 DAS	1122	1387	1224	1244	49773	26573	2.15
T_{10}: Weedy check	738	752	801	764	30547	10947	1.56
S.Em±	33	43	42	38	2019	902	0.07
CD at 5%	99	128	121	115	5997	2681	0.22

DAS: Days after sowing, HW: Hand weeding, PE: Pre emergence, POE: Post emergence

competition and causing better plant growth along with higher number of branches and number of pods per plant. Among the herbicidal treatments, application of pendimethalin 38% CS 0.75 kg a.i ha^{-1} PE + HW at 30-35 DAS (1198 kg ha^{-1}) and pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1} PE + one hoeing at 30-35 DAS (1168 kg ha^{-1}) recorded significantly higher seed yield as compared to other treatments. These three treatments significantly out yielded all the other weed control treatments. The high seed yield in these treatments could be attributed to more number of branches and number of pods per plants due to lesser competition offered by weeds for light, water and nutrients etc., which resulted in more uptake of nutrients, water and produced more photosynthates. Similar results have also been reported by Ratnam and Reddy (2011) and Pedde *et al* (2013). Integrated weed management i.e, herbicides and hand weeding has been reported to be superior over application of herbicide alone by earlier workers as well (Sharma, 2009; Singh and Singh 2000).

Economics : Higher gross returns were recorded in two hand weedings at 20 and 40 days after sowing (Rs. 49773 ha^{-1}). Among the herbicidal treatments, application of pendimethalin 38% CS 0.75 kg a.i ha^{-1} PE + HW at 30-35 DAS (Rs. 47907 ha^{-1}) and pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1} PE + one hoeing at 30-35 DAS (Rs. 46707 ha^{-1}) recorded significantly higher gross returns. The higher gross returns were mainly attributed by higher seed yield, obtained due to higher weed control efficiency. The lower gross returns (Rs. 30547 ha^{-1}) was recorded with weedy check, which was mainly owing to less seed yield obtained due to uncontrolled weeds throughout the crop growth. Significantly higher net returns were recorded in two hand weedings at 20 and 40 days after sowing (Rs. 26573 ha^{-1}) followed by treatments of pendimethalin 38% CS 0.75 kg a.i ha^{-1} PE + HW (Rs. 25107 ha^{-1}) and pendimethalin 30% EC + imazethapyr 2% + one hoeing (Rs. 24742 ha^{-1}). Higher benefit - cost ratio (2.15) was recorded in two hand weedings at 20 and 40 (DAS) followed by pendimethalin 38% CS + HW (2.10) and pendimethalin 30% EC + imazethapyr 2% + one hoeing (2.13). This was mainly due to higher gross returns along with lesser cost of cultivation, particularly less weed management cost.

CONCLUSION

It can be inferred from the present investigation that, application of pendimethalin 38% CS 0.75 kg a.i ha^{-1} PE + HW at 30-35 DAS or pendimethalin 30% EC + imazethapyr 2% 1.0 kg ha^{-1} PE + one hoeing at 30-35 DAS were the most effective alternative for controlling weeds and in obtaining optimum seed yield in chickpea under rainfed conditions of Karnataka state.

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