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Bio-efficacy of pre-emergence herbicides on weed management in chickpea (*Cicer arietinum* L.)

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Abstract
A field experiment was carried out during *Rabi*, 2023 at Agriculture college farm, University of Agricultural Sciences, Raichur, Karnataka, India. The experiment was laid out in Randomized Complete Block Design with three replications and seven pre emergence herbicidal treatments and two checks (weedy and weed free check) different treatments. The results of the experiment revealed that among the pre emergence herbicide treatments, application of S- Metolachlor @ 3840 g *a.i.* ha^{-1} had resulted in lower density of all categories of weeds, higher weed control efficiency, lower weed index and higher yield parameters which was statistically on par with same herbicide at its moderate doses of 2400 g *a.i.* ha^{-1} and 1920 g *a.i.* ha^{-1}. Hence, S-Metolachlor @1920 g *a.i.* ha^{-1} could be used as an effective weed management practice in chickpea.

Keywords: Pre emergence herbicides, chickpea, weed density, weed dry matter and weed control efficiency

Introduction
Pulses play an important role in human nutrition, soil fertility build up and in the economy of small and medium farmers due to less investment, restoration of soil fertility and low water requirement. Besides being rich in protein, they sustain the productivity of cropping systems. Their ability to use atmospheric nitrogen through biological nitrogen fixation (BNF) is economically more sound and environmentally acceptable. Among the pulses, chickpea (*Cicer arietinum* L.) is one of the oldest known cultivated legume. It grows on a very light sandy loam to heavy textured clay soils, and it can fix up to 140 kg N ha^{-1} in a growing period.

The major chickpea growing states in India are Maharashtra, Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Rajasthan, Uttar Pradesh and Gujarat. In India, Karnataka ranks fourth in the cultivation of chickpea with an area of 0.713 m ha, with annual production of 0.4 m t and productivity was 733 kg ha^{-1} (Anon., 2022) [1]. In north eastern dry zone of Karnataka, chickpea is one of the important rainfed crop grown during *rabi* season. But productivity of chickpea is low in spite of high-yielding varieties and new agronomic practices. Poor weed management is one of the most important yield limiting factor in chickpea, as it is poor competitor to weeds.

Chickpea appears to be a poor weed competitor among rabi pulses because of slow growth rate and limited leaf development at early stage of crop growth and establishment (Ratnam *et al.*, 2011) [9], with yield losses ranging from 40% to 87% due to its initial lag in growth rate and number of leaf (Poonia and Pithia, 2013) [8]. Chaudhary *et al.* (2005) [4] also found losses up to 75% due to temporal mismatch. It was found that crop weed competition was not at very early stage (Barker, 2017) [2] but weeds establish themselves which compete later. Singh *et al.* (2000) [10] stated that in chickpea, first 60 days are found to be crucial for competition between crop and weed. Weeds need to be properly managed not only for enhancing yield but also for improving fertilizer use efficiency, moisture use efficiency (Verma *et al.*, 2009). Hence, this experiment was conducted with an objective to assess the effect of pre-emergence herbicides on weed dynamics and yield of chickpea.

Materials and methods

A field experiment was laid out in Randomized Complete Block Design with nine treatments comprising of seven pre emergent herbicides along with weedy and weed free check which were replicated thrice during *rabi*, 2023 at Agricultural College Farm, UAS, Raichur, which is situated at a latitude of 16^0 15' N of 77^0 20'E at an elevation 389 m above the mean sea level. The soil of the experimental site was vertisol with low organic carbon (0.52) and available nitrogen (209 kg ha^{-1}), medium available phosphorus (45 kg ha^{-1}) and high available potassium (450 kg ha^{-1}). The chickpea (JG-11) seeds were sown with a spacing of 30 cm × 10 cm on 1^{st} October, 2023 when there was sufficient moisture in *vertisols* of the experimental site. The crop was fertilized with recommended dose of fertilizers (25:50:0 kg NPK ha^{-1}, respectively). Weed density was recorded by placing a quadrant of 0.25 m^2 at random places in each plot and converted to m^2. The weed density and dry weight data at 56 DAS was subjected to transformation $\sqrt{(x+0.50)}$.

Weed control efficiency was calculated by the formula given by Lal (1990) [6].

$$\text{WCE (\%)} = \frac{W_c - W_t}{W_c} \times 100$$

Where, W_c = Dry weight of weeds in weedy check (g m^{-2})

W_t = Dry weight of weeds in respective treatment plot (g m^{-2})

Weed index was computed by the formula given by Gill and Kumar (1992).

$$\text{WI (\%)} = \frac{X - Y}{X} \times 100$$

Where

X = Total yield (kg ha^{-1}) from the weed free plot or best treatment plot

Y = Total yield (kg ha^{-1}) from the treatment for which weed index has to be calculated.

Results and discussion

Weed flora of the experimental field consisted of *Chenopodium album* L., *Abutilon theophrasti* L. *Celosia argentea* L., *Phyllanthus niruri* L., *Euphorbia geniculata* L., *Centella asiatica* L., *Cyperus rotundus* L., *Dinebra retroflexa* L., However predominant weeds were *Abutilon theophrasti* L., *Cyperus rotundus* L., *Centella asiatica* L.

Weed density (No. m^{-2})

At 56 DAS weedy check had resulted in significantly higher broad-leaved, grassy, sedge and total weed density (7.54 and 11.74 m^{-2} respectively) followed by treatments containing S-Metolachlor @ 1440 g *a.i.*ha^{-1}, @ 960g *a.i.*ha^{-1}, Oxyflurofen @ 100 g *a.i.*ha^{-1} and pendimethalin @1000 g *a.i.*ha^{-1} (5.67 and 8.75 m^{-2}, 6.74 and 9.84 m^{-2}, 4.63 and 7.47 m^{-2}, and 5.17 and 7.87 m^{-2} respectively). Significantly lower density of broad-leaved, grassy, sedge and total weed density was recorded in weed free check (0.71 m^{-2}). Among the herbicide treatments, lower broad-leaved, grassy, sedge and total weed density was reported from the application of S-Metolachlor @ 3840 g *a.i.*ha^{-1}(3.37, 0.71, 2.17 and 3.83m^{-2} respectively), S-Metolachlor @2400 g *a.i.*ha^{-1} (3.36, 0.71, 2.29 and 4.01 m^{-2} respectively) and S-Metolachlor @1920 g *a.i.*ha^{-1} (3.89, 0.71, 2.61 and 4.47 m^{-2} respectively), which were found statistically on par with each other.

Table 1: Density of weeds (No. m^{-2}) at 56 DAS as influenced by different weed management practices in chickpea

Treatments	Density of weeds (No. m^{-2})			
	Broad-leaved weeds	Grassy weeds	Sedges	Total weed density
T_1: S-Metolachor 96% EC @ 960 g *a.i.* ha^{-1} at 0-3 DAS	6.74 (45.03)	3.25 (10.05)*	4.35 (18.40)	8.60 (73.49)
T_2: S-Metolachlor 96% EC @ 1440 g *a.i.* ha^{-1} at 0-3 DAS	5.67 (32.16)	0.71 (0.00)	3.77 (13.93)	6.78 (46.05)
T_3: S-Metolachlor 96% EC @ 1920 g *a.i.* ha^{-1} at 0-3 DAS	3.89 (14.66)	0.71 (0.00)	2.61 (6.41)	4.47 (19.45)
T_4: S-Metolachlor 96% EC @ 2400 g *a.i.* ha^{-1} at 0-3 DAS	3.36 (10.82)	0.71 (0.00)	2.29 (4.89)	4.01 (15.67)
T_5: S-Metolachlor 96% EC @ 3840 g *a.i.* ha^{-1} at 0-3 DAS	3.37 (10.83)	0.71 (0.00)	2.17 (4.19)	3.83 (14.21)
T_6: Pendimethalin 30% EC @ 1000 g *a.i.* ha^{-1} at 0-3 DAS	5.17 (26.33)	3.07 (8.96)	3.16 (9.51)	7.13 (50.29)
T_7: Oxyfluorfen 23.5% EC @ 100 g *a.i.* ha^{-1} at 0-3 DAS	4.63 (21.06)	0.71 (0.00)	0.71 (0.00)	5.94 (34.75)
T_8: Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_9: Weedy check	7.54 (56.58)	3.93 (14.96)	6.01 (35.62)	10.37 (107.29)
S.Em.±	0.23	0.05	0.17	0.22
C.D. (P=0.05)	0.68	0.14	0.50	0.65

Significantly higher broad-leaved, grassy, sedge and total density of weeds was observed at all the stages in weedy check which might be due to availability of ample space, nutrients, moisture and light that helped in better weed growth in the treatment combined with the exclusion of weed management methods in order to maintain it as control treatment for recording weed parameters. Whereas lower total weed density was observed in weed free check at all the stages because of complete removal of weeds by hand weeding whenever the weeds were emerged thereby destroying all kinds of weeds from the treatment and providing better environment with rich sources for the best crop growth and yield. Similar reports were reported by Gatari *et al.* (2015) who reported that the higher weed density per square meter was recorded at 20 DAS in weedy check while the lowest weeds per square meter was recorded under hand hoeing. Application of S-Metolachlor 96% EC herbicide at higher and moderate doses (3840, 2400, and 1920 g *a.i.*ha^{-1}) decreased the total weed density by obstructing the weed growth by their mode of action during the critical period of crop-weed competition from initial seedling stage to even upto harvesting. These findings were in line with the results of Bulti and Alemu (2019) [3] who reported that application of S-Metolachlor with 1.0 kg ha^{-1} along with one hand weeding 5 WAE (weeks after emergence) were reduced the total weed density by 96.5% over weedy check. Whereas pendimethalin 30% EC @1000 g *a.i.* ha^{-1} and Oxyfluorfen 23.5% EC @ 100 g *a.i.* ha^{-1} were also suppressed the number of weeds but not comparable with S-Metalochlor at higher and moderate doses (at 3840, 2400 and 1920 g *a.i.* ha^{-1}).

Table 2: Effect of different weed management practices on weed parameters and grain yield of in chickpea

Treatment	Total dry weight (g m^{-2}) of weeds at 56 DAS	Weed control efficiency (%) at 56 DAS	Seed yield (kg ha^{-1})
T_1: S-Metolachor 96% EC @ 960 g *a.i.* ha^{-1} at 0-3 DAS	*10.52 (110.22)	16.86	600
T_2: S-Metolachlor 96% EC @ 1440 g *a.i.* ha^{-1} at 0-3 DAS	8.21 (66.93)	30.68	762
T_3: S-Metolachlor 96% EC @ 1920 g *a.i.* ha^{-1} at 0-3 DAS	4.98 (24.40)	68.77	1510
T_4: S-Metolachlor 96% EC @ 2400 g *a.i.* ha^{-1} at 0-3 DAS	4.75 (22.21)	69.41	1552
T_5: S-Metolachlor 96% EC @ 3840 g *a.i.* ha^{-1} at 0-3 DAS	4.45 (19.37)	70.22	1654
T_6: Pendimethalin 30% EC @ 1000 g *a.i.* ha^{-1} at 0-3 DAS	7.90 (62.17)	42.01	998
T_7: Oxyfluorfen 23.5% EC @ 100 g *a.i.* ha^{-1} at 0-3 DAS	5.68 (31.74)	56.19	1263
T_8: Weed free check	0.71 (0.00)	100.00	1717
T_9: Weedy check	12.04 (144.52)	0.00	443
S.Em.±	0.18	2.15	69
C.D. (P=0.05)	0.55	6.43	208

DAS = Days After Sowing *a.i.*= Active ingredient EC = Emulsifiable concentrates
*Figures in parentheses indicate original values Total weed count (x) data were transformed to $(x+1)^{1/2}$

At 56 DAS, among the herbicide treatments significantly higher weed control efficiency was observed in the treatment receiving S-Metolachlor 96% EC @ 3840 g *a.i.* ha^{-1} (70.22%), S-Metolachlor 96% EC @ 2400 g *a.i.* ha^{-1}(69.41%) and S-Metolachlor 96% EC @ 1920 g *a.i.* ha^{-1} (68.77%) and they were on par with each other. Whereas, significantly lower weed control efficiency was seen in weedy check with zero percentage. Among the herbicide treatments significantly lower efficiency was seen in the treatment receiving S-Metolachor 96% EC @ 960 g *a.i.* ha^{-1} (16.86%), followed by pendimethalin 30% EC @ 1000 g *a.i.* ha^{-1} (42.01%). Whereas oxyfluorfen 23.5% EC @ 100 g *a.i.* ha^{-1} (56.19%) performed in between among all the treatments.The significantly higher weed control efficiency in weed free check at all stages was due to complete removal of weeds through frequent hand weeding operations in the treatment. The lower weed control efficiency was reported from weedy check due to exemption of all kinds of weed management measures which in turn led to significantly higher dry weight of weeds in the treatment.

Among herbicides treatments significantly higher weed control efficiency was observed due to application of S-Metolachlor herbicide at higher doses @ 3840 g *a.i.*ha^{-1} and it was statistically comparable with same herbicide with dosage of 2400 and 1920 g *a.i.*ha^{-1}which might be attributed to the efficacy of herbicide at these concentration by inhibiting the synthesis of long chain fatty acids in major weed flora, which in turn led to destruction of chlorophyll pigment of the weeds thereby causing them to reduce their density and dry weight through decreased utilization of sunlight, space, nutrients and soil moisture. This kind of result in weed control efficiency was also reported by Muhammed *et al.* (2012), who reported that amongst pre emergence herbicides, weed control efficiency (WCE) of S-Metolachlor 960 EC @ 2.0 L ha^{-1} and atrazine 50% WP @ 0.25 kg ha^{-1} were 88.44 and 78.89% respectively in maize. Whereas same herbicide at lower dose @ 960 and 1440 g *a.i.*ha^{-1} was found ineffective with lower weed control efficiency indicating their non suitability for effective weed management. Whereas oxyflurofen was better than S-Metolachlor at lower doses of 960 and 1440 g *a.i.* ha^{-1} because of their effectiveness in controlling major weeds.

Significantly higher seed yield (1717 kg ha^{-1}) was observed in weed free check and it was on par with herbicide treatment S-Metolachlor 96% EC @ 3840, 2400 and 1920 g *a.i.* ha^{-1} (1654, 1552 and 1510 kg ha^{-1} respectively), and were on par with each other whereeas medium yield was observed in the treatment receiving Oxyflurofen 23.5% EC @100 g *a.i.* ha^{-1} with the value of 1263 kg $ha.^{-1}$ While significantly least seed yield was seen in the treatment S-Metolachor 96% EC @ 960 g *a.i.* ha^{-1} (600 kg ha^{-1}), among herbicide treatments and it was on par with same herbicide @ 1400 g *a.i.* $ha.^{-1}$ (762 kg ha^{-1})Whereas among all the treatments least seed yield was noticed in weedy check (443 kg ha^{-1})

Chickpea yield varies depending on the weed management strategies used, mostly because of resource competition, soil and crop health. Crop plants face competition with weeds for vital resources including light, water, and nutrients. Weeds can outcompete the crop and drastically lower chickpea output if they are not controlled. Through their potential to change the soil microenvironment by taking minerals that chickpea plants would otherwise be able to access, weeds can affect the availability of nutrients in the soil. Hence chickpea yield may be impacted by different weed management practices. This can be seen by better performance of weed free check and also treatments with S-Metolachlor at higher and moderate doses (3840, 2400 and 1920 g *a.i.* ha^{-1}) due to the less crop-weed competition environment because of lower weed density, weed dry matter, good crop health status as indicated by SPAD values in these treatments, and also the better nodulations, good number of pods and better dry matter accumulation in seeds (test weight). All these growth and yield parameters could able to help in improved yield in weed free check and also S-Metolachlor at higher and moderate doses.

These findings are in line with Waktole *et al.* (2019) [13], he reported that application of S-Metolachlor resulted in the highest grain yield on haricot bean. Similarly, Singh *et al.* (2013) [12] reported that the herbicides provided high weed control efficiency and produced the highest grain yield. Similarly, Dawit *et al.* (2011) [5] reported that effectiveness of S-metolachlor (1 kg ha^{-1}) increased the yield of common bean.

Conclusion

It can be concluded from the experiment that new molecule of pre-emergence herbicide S-Metolachlor 96% EC was effective in suppressing the weeds growth from moderate to higher doses (*viz.*, 1920, 2400 and 3840g *a.i.* ha^{-1}) at critical period of crop weed competition period upto 56 DAS besides maintaining good yield of chicpea which was comparable to weed free check at its moderate to higher doses (*viz.*, 1920, 2400 and 3840g *a.i.* ha^{-1}). Hence, the newer herbicide molecule S-Metolachlor 96% EC can be used effective pre emergent herbicide in chickpea at 1920 g *a.i.* ha^{-1}.

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