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Weed management in chickpea under soybean-chickpea cropping system

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Abstract
A field experiment was conducted at Agriculture Research Station, Janawada, Bidar to study the efficacy of sequential application of herbicides on growth and yield of chickpea (*Cicer arietinum* L.) in north eastern transitional zone of Karnataka. Among the different herbicide treatments in chickpea the application of pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr 10 SL @ 75 g a.i. ha^{-1} in chickpea crop recorded significantly higher seed yield (2198 kg ha^{-1}) due to higher growth parameters *viz*., plant height (42.32 cm), number of branches (6.89), leaf area (6.99 dm^2 plant^{-1}), leaf area index (2.33), leaf area duration (47.38 day) and yield parameters viz., number of pods (40.01), pod weight per plant (19.23 g plant^{-1}), seed yield per plant (7.69 g plant^{-1}) and test weight (18.32 g plant^{-1}). This was mainly due to lower weed density 0.5 m^{-2} (3.12) and weed index (9.77%) compared to other herbicide treatments respectively. However, weed free check recorded significantly higher growth and yield parameters due to weed free environment maitained throught out the growth period of the crop compared to rest of the treatments.

Keywords: Efficacy, pendimethalin, imazethapyr, chickpea

Introduction
Chickpea (*Cicer arietinum* L.) is one of the important grain legume of the world which is grown in 45 countries across five continents. India is the largest producer of chickpea accounting to 75 per cent of the world production. The major chickpea growing states in India are Maharashtra, Andra Pradesh, Bihar, Karnataka, Madhya Pradesh, Rajasthan, Uttar Pradesh and Gujarath. Chickpea can fix up to 140 kg ha^{-1} in a growing period. Chickpea is an important pulse crop globally; it is cultivated on about 10.4 m ha area adding 8.57 m t of grain to the global food basket with an average productivity of 826 kg ha^{-1}. India grows chickpea on about 10.22 m ha with 9.88 m t production and average productivity of 967 kg ha^{-1}. In Karnataka area under gram is 0.92 m ha with production of 0.57 m t and productivity of 622 kg ha^{-1} (Anon., 2015) [2]. Chickpea is one of the most important pulses (*rabi*) crop grown in rainfed farming system throughout India. It is used for human consumption as well as animal feeding. Both husks and bits of the *dal* are valuable cattle feed. Fresh green leaves are used as vegetable. It is a rich source of protein (21.1%). Besides, it contain 61.5 per cent carbohydrates and 4.5 per cent fat and is also rich in Ca, Fe and Niacin. Its leaves secrete malic acid (90-95%) and oxalic acid (5-10%), which have medicinal properties important against stomachache, intestinal disorder and blood purification (Singh *et al*., 2003).

Weed competition is one of the most important causes of yield reduction in chickpea which is estimated to be 20-40 per cent depending on the weed species, their density and period of weed crop competition. The effective control of weeds can help in improving the productivity of chickpea. The weed free maintenance up to 45 days after sowing resulted in 96 per cent increase in seed yield of chickpea compared to uncontrolled weedy situations (Bhutada and Bhale, 2015) [5]. The effective and economical weed control in chickpea on large scale is not possible through hand weeding or use of mechanical tools because of time and labour intensiveness and difficulty due to intermittent rains. The herbicides like alachlor, fluchloralin and pendimethalin which are recommended for weed control in chickpea are being used by the farmers (Raskar and Bhoi, 2002) [13]. These herbicides have been quite effective on grasses and their continuous use has resulted in weed shift in some areas in favour of non-grassy weeds like *Cleome viscosa*, *Celosia argentea*, *Trianthema monogyna* and *Commelina benghalensis*, *Argemon mexicana*, which are highly competitive with chickpea crop. Further, these herbicides proved ineffective against *Cyperus rotundus* and *Commelina benghalensis.* This could be due to immobility of herbicides from leaves to the tubers of *Cyperus rotundus*. Therefore, there is a need to have alternate herbicides which may provide wide spectrum of weed control to avoid weed shift and also possible development of herbicide resistance. The new herbicides namely; quizalofop-ethyl, Imazethapyr, chlorimuron-ethyl and fenoxyprop ethyl have been developed to control wide range of weeds in broad-leaved crops including chickpea. Therefore the experiment was carried out to study the weed management in chickpea under soybean-chickpea cropping system.

Materials and methods

The experiment was conduct at Agricultural Research Station, Janawada, Bidar as part of Ph.D. research work to study the efficacy of weed management on chickpea (*Cicer arietinum* L.) in north eastern transitional zone of Karnataka during *rabi* 2014 and 2015. The land was ploughed once with mould-board plough and brought to fine tilth with two harrowing. The stubbles and weeds were collected and disposed off from the experimental area. At the time of sowing, the recommended dose of fertilizer for chickpea was applied in the form of urea, diamonium phosphate (DAP) and muriate of potash as basal dose. The healthy seeds of chickpea variety GBM-2 was treated with biofertilizer, mainly *Rhizobium* @ and PSB. The recommended seed rate was used for sowing. The pre-emergence herbicides *viz.*, Pendimethalin 30 EC, Pendimethalin 38.7 CS, and Oxyfluorfen 23.5 EC were sprayed uniformly one day after sowing of the crop. The pre-emergence application was made on the soil surface uniformly with minimum trampling. The post emergence herbicides *viz.*, Imazethapyr 10 SL, Quizalofop-p-ethyl 5 EC and Fenoxyprop-p-ethyl 5 EC were applied uniformly at 21 DAS as per the treatment. The soil was medium deep black, neutral in reaction. The experiment was laid out in randomized block design with the twelve treatment and three replications. In the treatment (T_{10}) one hand weeding (between 30-45 DAS) and two inter cultivations (30 and 45 DAS) were taken. The results have been discussed at the probability level of five per cent. The level of significance used in ‘F’ and ‘t’ test were p=0.05. Critical difference values were calculated whenever the ‘F’ test was significant. The data was analyzed statistically for test of significance following the procedure described by Gomez and Gomez (1984) [6].

Results and discussion

Effect of weed management on weed density and weed index

The total weed population differed significantly due to different weed control treatments at all the growth stages (Table 1 and Fig.1, 2). The study indicated that the highest weed density was recorded in weedy check (6.41, 7.14, 7.24 and 7.40/0.5m^2 at 20, 40, 60 DAS and at harvest, respectively) and lowest with weed free check (0.71, 0.71, 0.71 and 0.71/ 0.5 m^2 at 20, 40, 60 DAS and at harvest). The effect of pre emergent herbicides was very effective at early stage and among the different weed control practices at 20 DAS, application of pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr @ 75 g a.i. ha^{-1}at 20 DAS + IC (35 DAS) was very effective in controlling all types of weeds (3.12/ 0.5 m^2) over weedy check. This was mainly due to effective control of weeds by pendimethalin as pre emergence besides use of imazethapyr as post emergence herbicide and one Intercultivation carried out during critical period of crop growth These results are in conformity with findings of Baskaran and Kavimani *et al.* (2014) [3]. However, from 40 DAS onwards the total weed count recorded with the application of pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr @ 75 g a.i. ha^{-1}at 20 DAS + IC (35 DAS) (2.72, 2.96 and 3.16 at 40, 60 DAS and at harvest, respectively) was lower and it was followed by application of pendimethalin 30 EC @ 1 kg a.i. ha^{-1} + IC (30 and 45 DAS) + one HW (between 30-45 DAS) (2.79, 3.03 and 3.23 at 40, 60 DAS and at harvest, respectively), pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* quizalofop p ethyl @ 75 g a.i. ha^{-1}at 20 DAS + IC (35 DAS) (2.86, 3.04 and 3.31 at 40, 60 DAS and at harvest, respectively) and pendimethalin 38.7 CS@ 700 g a.i. ha^{-1} *fb* fenoxyprop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (2.88, 3.12 and 3.35 at 40, 60 DAS and at harvest, respectively) over weedy check (7.14, 7.24 and 7.40 at 40, 60 DAS and at harvest, respectively) indicating weed controlling efficiency of herbicides when applied in sequence. Similar results were also reported by Poonia and Pithia (2013) [10]. Among the various herbicides used, T_{10}, T_1, T_3 and T_5 registered significantly lower weed count at 20 DAS. The superiority of these treatments could be attributed to effective control of weeds by use of pre emergence herbicides and also post emergence herbicides. As a result of this number of grassy weeds, sedges and broad leaved weeds as well as total weeds were significantly lower in these treatments. The treatments comprising application of pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (9.77%), pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* fenoxyprop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (12.21%), pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* quizalofop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (12.23%) and pendimethalin 30 EC @ 1 kg a.i. ha^{-1} + IC (30 & 45 DAS) + HW (30-45 DAS) (12.46%) recorded significantly lower weed index values and were found to be on par with each other. The lowest weed index was recorded with weed free check (0.00). Significantly higher weed index values were recorded with the application of imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS + IC (30 & 45 DAS) (36.04%), quizalofop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (30 & 45 DAS) (36.74%) and fenoxyprop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (30 & 45 DAS) (37.47%). More number of weeds offered maximum competition for basic resources like nutrient, moisture, space and light which was evident throughout the crop growth period as indicated through yield. This inturn was responsible for maximum reduction in the seed yield (1299 kg ha^{-1}). These results are in conformity with Poonia and Pithia (2013) [10] and Patil *et al*. (2017).

Weed management practices on growth parameters

The predominant attribute of growth would be the plant height which was responsible for producing more number of leaves and in turn leaf area for higher contribution to photosynthesis of the plant. At harvest, weed free check recorded 86.84 per cent increased plant height over weedy check. Lower plant height at harvest was recorded with weedy check (25.08 cm). While the treatments like application of pendimethalin 30 EC @ 1 kg a.i. ha^{-1} + IC (30 & 45 DAS) + HW (30-45 DAS) (41.06 cm) recorded on par plant height along with pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (42.32 cm), pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* quizalofop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (41.20 cm) and pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* fenoxyprop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (41.14 cm) have recorded higher but on par plant height, but significantly higher compared to weedy check (25.08 cm). Total number of branches was significantly higher with weed free check (7.72) when compared to weedy check (4.08) (Table 2). The unfavorable condition created by the weeds in case of weedy check might be the reason for lower number of branches whereas the uninterrupted availability of all the growth resources in weed free check resulted in more number of branches in weed free check. The possible reason for the more number of branches may be attributed to reduced crop weed competition and providing favourable environment for growth of chickpea at early growth stages. These results are in line with Adhikari and Ghosh (2014) [1], Purena *et al*. (2015) [11] and Patil *et al*. (2017).

Leaf area increased from 30 to 60 DAS. At 60 DAS, the pooled data revealed that application of pendimethalin 30 EC @ 1 kg a.i. ha^{-1} + IC (30 & 45 DAS) + HW (30-45 DAS) (6.79 dm^2 plant^{-1}) recorded on par leaf area along with pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (6.99 dm^2 plant^{-1}), pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* quizalofop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (6.81 dm^2 plant^{-1}) and pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* fenoxyprop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (6.80 dm^2 plant^{-1}). It is well known that the persistence of the assimilatory surface area is a prerequisite for prolonged photosynthetic activity and ultimately crop productivity. The leaf area indicates the photosynthetic area available for synthesis of food. Higher leaf area assimilates leads to higher dry matter thus increasing the growth attribute like plant height and inturn higher source to sink relationship. Simila trend was observed with LAI and LAD. Similar findings were reported by Ranjeeth *et al*. (2013) [12] and Shekhar *et al.* (2014) [15].

Weed management practices on yield parameters

Significant differences were observed with respect to seed yield of chickpea due to different weed control treatments. In the present study, pooled data indicated that weed free check recorded significantly higher seed yield (2438 kg ha^{-1}) over weedy check (1299 kg ha^{-1}). The increase in yield was to the tune of 87.68 per cent (Table 3 and Fig.3). Among the different weed control treatments, significantly higher seed yield was recorded with the application of pendimethalin 30 EC 1kg a.i. ha^{-1} + IC (30 & 45 DAS) + HW (30-45 DAS) (2133 kg ha^{-1}) and sequential application of pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (2198 kg ha^{-1}), pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* quizalofop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (2140 kg ha^{-1}) and pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* fenoxyprop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (2137 kg ha^{-1}) recorded 69.21, 64.74 and 64.51 per cent increased yield over weedy check which were on par with each other and the same was attributed to better control of weeds and higher weed control efficiency when herbicides were applied in sequence. This gives the clear indication that, under scarcity of labour, use of sequential application of herbicide could be followed as an alternative method of weed control. Seed yield was closely associated with straw yield which followed similar trend. The above results are in accordance with the findings of Ranjeet *et al*. (2013) [12], Sangwan *et al*. (2016) [14] and Bheiru Singh *et al*. (2017) [4].

This gives the clear indication that, under scarcity of labour, use of sequential application of herbicide could be followed as an alternative method of weed control. Seed yield was closely associated with straw yield which followed similar trend. The above results are in accordance with the findings of Shekhar *et al.* (2014) [15]. The higher seed yield may be attributed to improved yield components *viz.*, number of pods plant^{-1}, pod weight plant^{-1} and seed weight plant^{-1}. Application of pendimethalin 30 EC @ 1 kg a.i. ha^{-1} + IC (30 & 45 DAS) + HW (30-45 DAS) (38.82,18.88 and 7.47 g, respectively) and sequential application pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (40.01, 19.23 and 7.69 g, respectively) and pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* quizalofop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (38.95, 18.73 and 7.49 g, respectively) and pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* fenoxyprop p ethyl @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) (38.90, 18.70 and 7.48 g, respectively) have recorded on par data of the above said yield contributing parameters which were attributed to on par seed yield among them (Table 3). Weedy check recorded lower number of pods (23.71) over weed free check (44.37), thus noticed substantially reduced seed yield. Increase in pod weight in these treatments accommodated higher seed weight. Weedy check showed lower seed weight (4.56 g) over weed free check (8.53 g). The results corroborate findings of Navell Chander *et al*. (2014) [8], Goud *et al*. (2013) [7], Shekhar *et al*. (2014) [15] and Bheiru Singh *et al*. (2017) [4].

The sequential application of pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} *fb* imazethapyr @ 75 g a.i. ha^{-1} at 20 DAS + IC (35 DAS) was the effective weed management practice in reducing the weed biomass and increasing the yield of chickpea under scarcity of labour.

Table 1: Effect of herbicides on weed biomass at different growth stages and weed index in chickpea (2 year pooled data)

Treatments	Total weed count (No. 0.5 m^{-2})				Weed index (%)
	20DAS	40DAS	60DAS	At harvest	
T_1	3.12 (3.92)	2.72 (12.76)	2.96 (3.44)	3.16 (4.08)	9.77
T_2	3.73 (5.97)	3.33 (14.58)	3.51 (5.19)	3.65 (5.68)	20.16
T_3	3.19 (4.10)	2.86 (3.17)	3.04 (3.67)	3.31 (4.51)	12.23
T_4	3.75 (6.05)	3.45 (13.98)	3.59 (5.44)	3.73 (5.96)	24.98
T_5	3.24 (4.28)	2.88 (3.19)	3.12 (3.93)	3.35 (4.64)	12.21
T_6	3.82 (6.31)	3.57 (5.40)	3.70 (5.86)	3.81 (6.27)	28.04
T_7	4.77 (10.45)	4.44 (8.88)	4.67 (9.94)	4.82 (10.65)	36.04
T_8	4.81 (10.57)	4.51 (9.19)	4.73 (10.19)	4.84 (10.73)	36.74
T_9	4.84 (10.75)	4.52 (9.27)	4.76 (10.36)	4.85 (10.82)	37.47
T_{10}	3.24 (4.26)	2.79 (2.93)	3.03 (3.63)	3.23 (4.27)	12.46
T_{11}	6.41 (19.81)	7.14 (24.68)	7.24 (25.38)	7.40 (26.56)	46.91
T_{12}	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.00
S.Em.±	0.07	0.06	0.07	0.05	2.53
C.D. at 5%	0.21	0.19	0.22	0.15	7.43

Figures in the parentheses indicate the original value, data subjected for transformation using $\sqrt{x+0.5}$, where x is weed count
T_1: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_7: Imazethapyr @ 75 a.i. ha^{-1} (POE- 20 DAS) + IC (35 DAS),
T_2: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_8: Quizalofop-p-ethyl @ 75 a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T_3: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_9: Fenoxyprop-p-ethyl @ 75a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T_4: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{10}: Pendimethalin @ 1 kg a.i. ha^{-1} (PRE)+ IC (30 & 45 DAS)+ one HW (between 30 to 45 DAS),
T_5: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* by Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{11}: Weedy check
T_6: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{12}: Weed free check

Table 2: Growth of chickpea at different growth stages as influenced by weed management practices (2 year pooled data)

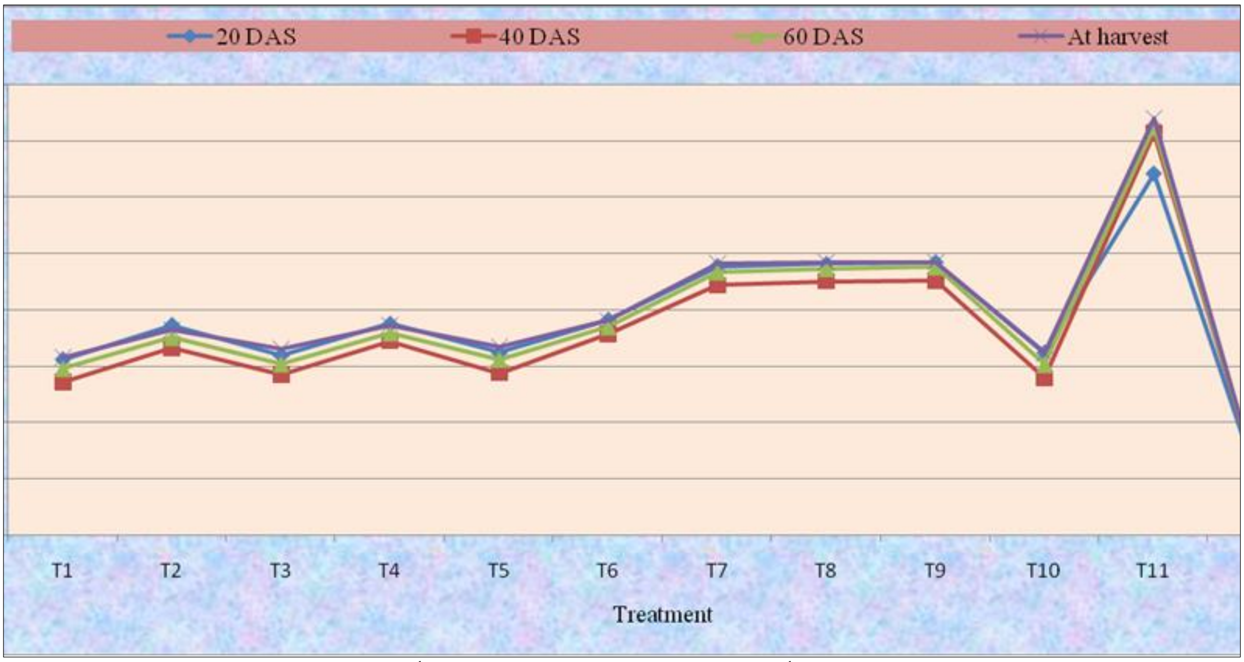
Treatment	Plant height (cm) at harvest	No. of branches at harvest	Leaf area (dm^2 $plant^{-1}$)	LAI	LAD (30-60DAS)	Dry matter production (g $plant^{-1}$)
T_1	42.32	6.89	6.99	2.33	47.38	19.27
T_2	37.46	6.10	6.19	2.06	41.94	17.09
T_3	41.20	6.71	6.81	2.27	46.13	18.76
T_4	35.16	5.73	5.81	1.94	39.37	16.00
T_5	41.14	6.70	6.80	2.27	46.07	18.73
T_6	33.77	5.50	5.58	1.86	37.81	15.40
T_7	30.07	4.90	4.97	1.66	33.66	13.77
T_8	29.72	4.84	4.91	1.64	33.28	13.62
T_9	29.40	4.79	4.86	1.62	32.92	13.39
T_{10}	41.06	6.69	6.79	2.26	45.98	18.77
T_{11}	25.08	4.08	4.15	1.38	28.08	11.42
T_{12}	46.86	7.72	7.76	2.59	52.54	21.54
S.Em.±	1.08	0.19	0.19	0.06	1.29	0.55
C.D. at 5%	3.18	0.58	0.55	0.18	3.78	1.62

T_1: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_7: Imazethapyr @ 75 a.i. ha^{-1} (POE- 20 DAS) + IC (35 DAS),
T_2: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_8: Quizalofop-p-ethyl @ 75 a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T_3: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_9: Fenoxyprop-p-ethyl @ 75a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T_4: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{10}: Pendimethalin @ 1 kg a.i. ha^{-1} (PRE)+ IC (30 & 45 DAS)+ one HW (between 30 to 45 DAS),
T_5: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* by Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{11}: Weedy check
T_6: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{12}: Weed free check

Table 3: Number of pods, pod weight, seed yield and hundred seed weight of chickpea as influenced by weed management practices in soybean-chickpea cropping system

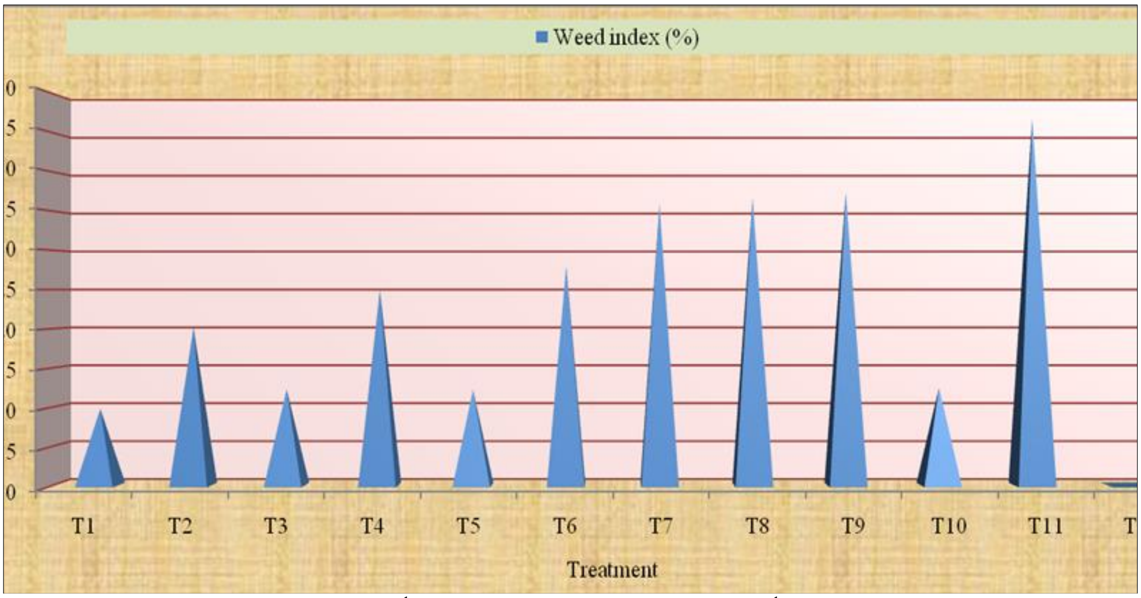
Treatment	Number of pods (plant^{-1}) at harvest	Pod weight (g plant^{-1})	Seed yield (g plant^{-1})	Hundred seed weight (g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	40.01	19.23	7.69	18.32	2198	4500
T_2	35.42	17.03	6.81	16.22	1946	4177
T_3	38.95	18.73	7.49	17.83	2140	4401
T_4	33.25	15.98	6.39	15.22	1827	3939
T_5	38.90	18.70	7.48	17.81	2137	4417
T_6	31.93	15.35	6.14	14.62	1754	3800
T_7	28.43	13.67	5.47	13.02	1562	3523
T_8	28.10	13.51	5.40	12.87	1544	3498
T_9	27.80	13.36	5.35	12.73	1527	3475
T_{10}	38.82	18.88	7.47	17.78	2133	4555
T_{11}	23.71	11.40	4.56	10.86	1299	3138
T_{12}	44.37	21.33	8.53	20.31	2438	4669
S.Em.±	1.08	0.52	0.20	0.49	59	130
C.D. at 5%	3.19	1.53	0.61	1.46	175	381

NS – Non significant
T_1: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_7: Imazethapyr @ 75 a.i. ha^{-1} (POE- 20 DAS) + IC (35 DAS),
T_2: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_8: Quizalofop-p-ethyl @ 75 a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T_3: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_9: Fenoxyprop-p-ethyl @ 75a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T_4: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{10}: Pendimethalin @ 1 kg a.i. ha^{-1} (PRE)+ IC (30 & 45 DAS)+ one HW (between 30 to 45 DAS),
T_5: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* by Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{11}: Weedy check
T_6: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{12}: Weed free check



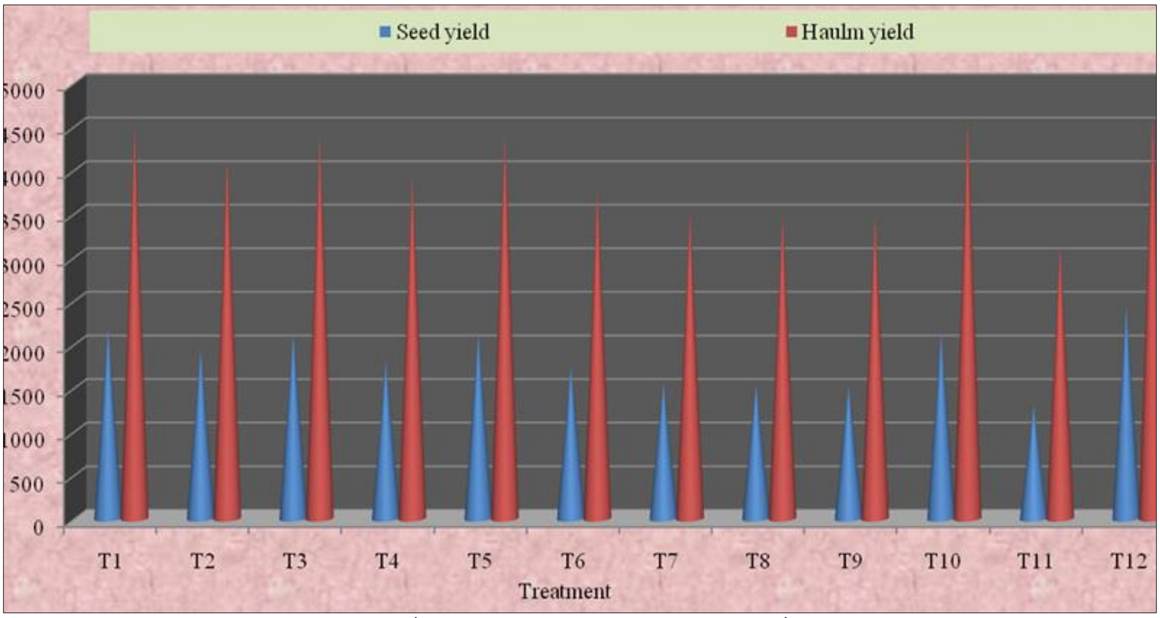
T_1: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_7: Imazethapyr @ 75 a.i. ha^{-1} (POE- 20 DAS) + IC (35 DAS),
T_2: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_8: Quizalofop-p-ethyl @ 75 a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T_3: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_9: Fenoxyprop-p-ethyl @ 75a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T_4: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{10}: Pendimethalin @ 1 kg a.i. ha^{-1} (PRE)+ IC (30 & 45 DAS)+ one HW (between 30 to 45 DAS),
T_5: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* by Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS
T_{11}: Weedy check
T_6: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T_{12}: Weed free check

Fig 1: Total weed count in chickpea at different growth stages as influenced by weed management in soybean-chickpea cropping system



T1: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T7: Imazethapyr @ 75 a.i. ha^{-1} (POE- 20 DAS) + IC (35 DAS),
T2: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T8: Quizalofop-p-ethyl @ 75 a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T3: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T9: Fenoxyprop-p-ethyl @ 75a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T4: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T10: Pendimethalin @ 1 kg a.i. ha^{-1} (PRE)+ IC (30 & 45 DAS)+ one HW (between 30 to 45 DAS),
T5: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* by Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS
T11: Weedy check
T6: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T12: Weed free check

Fig 2: Weed index of weeds in chickpea as influenced by weed management in soybean-chickpea cropping system



T1: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T7: Imazethapyr @ 75 a.i. ha^{-1} (POE- 20 DAS) + IC (35 DAS),
T2: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Imazethapyr @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T8: Quizalofop-p-ethyl @ 75 a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T3: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T9: Fenoxyprop-p-ethyl @ 75a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS),
T4: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Quizalofop-p-ethyl @ 75g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T10: Pendimethalin @ 1 kg a.i. ha^{-1} (PRE)+ IC (30 & 45 DAS)+ one HW (between 30 to 45 DAS),
T5: Pendimethalin 38.7 CS @ 700 g a.i. ha^{-1} (PRE) *fb* by Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS
T11: Weedy check
T6: Oxyfluorfen @ 0.1 kg a.i. ha^{-1} (PRE) *fb* Fenoxyprop-p-ethyl @ 75 g a.i. ha^{-1} (POE-20 DAS) + IC (35 DAS)
T12: Weed free check

Fig 3: Seed and haulm yield of chickpea as influenced by weed management in soybean-chickpea cropping system

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