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# Bio-efficacy and phyto-toxicity of new herbicides against weeds in soybean

**Pundas, GK Shrivastava and Rakesh Ratre**

**Abstract**
The proposed experiment was carried out during *kharif* season of 2016 at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). The experiment was comprised of weed management practices *viz.* $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE,$T_4$- Clodinafop 12.5 % w/w M @ 1000 g a.i. $ha^{-1}$ as PoE, $T_5$- Fomesafen 17.5%w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_6$- Fomesafen 11.1% w/w + fluzifop- p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE, $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE, $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE, $T_9$- Hand weeding twice at 20 and 40 DAS and $T_{10}$- weedy check. Experiment was laid out in Randomized Block Design with three replications. Result indicated that the $T_9$- hand weeding twice at 20 and 40 DAS however, it was found effective in enhancing plant height, growth of branches and dry matter production of soybean showed *at par* with $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE. $T_9$ -hand weeding twice at 20 and 40 DAS was found effective in enhancing number of nodules $plant^{-1}$, dry weight of nodules and crop growth rate followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_4$- Clodinafop 12.5% w/w M @ 1000 g a.i. $ha^{-1}$ as PoE and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

**Keywords:** bio-efficacy**,** Herbicide, phytotoxicity, soybean

## Introduction
Soybean [*Glycine max* (L.) *Merrill*] is one of the most important oilseed crop in the world and it is also wonder crop of the 20th century. It is a cheapest source of vegetable oil and protein. It contains about 40 percent protein, well balanced in essential amino acids, 18-20 per cent oil rich with poly unsaturated fatty acids specially Omega 6 and Omega 3 fatty acids, 6-7 percent total mineral, 5-6 percent crude fiber and 17-19 percent carbohydrates. Soybean due to its various uses is rightly called "Golden Gift" of nature to mankind.

Wide spectrum new herbicides are required to control the majority the weed flora in soybean crop. Mostly the farmers are using pre-plant incorporated and pre-emergence herbicides for weed control in soybean, but their efficacy are reduced by various climatic and edaphic factors. Hand weeding is a traditional and effective method of weed control, but untimely and continuous rains as well as unavailability of labour at peak time are main limitations of manual weeding. The only alternative that needs to be explored is the use of post-emergence herbicides. The screening of such herbicides in soybean reveals their efficiency against either monocotyledonous or dicotyledonous weeds. Hence, their mixtures may broaden the window of weed management by broad-spectrum weed control (Bineet *et al.*, 2001) [2].

Now a day a few herbicides like imazethapyr, quizalofop and fenoxaprop are available, which can be used safely in soybean (Sharma *et al.*, 2009) [14]. Recent investigations have revealed that Imidazolinones group of herbicide is very effective in controlling the weeds in soybean (e.g. Imazethapyr). These herbicides are active against broad leaf and grassy weed, but their effects are variable at different places depending on the soil type intensity and type of weed flora, rainfall etc (Yadav *et al.*, 2009) [18].

## Material and Method
The experiment was carried out during *kharif* season (03 July to 03 November) The soil of the experimental field was medium texture with low, medium and high in N, P and K,

respectively. The climate of the region is sub-humid to semi-arid. Experiment was laid out in Randomized Block Design with three replications. Soybean variety JS 97-52 was sown on 3rd July, 2016 at a spacing of 30 cm ×5 cm with a seed rate of 75 kg $ha^{-1}$. The crop was harvested on 3rd November, 2016. Weed management practices were adopted as per the treatments. Hand weeding was performed as per the treatments. Hand weeding once at 25 DAS was done in treatments $T_9$. While two hand weeding was done in treatment $T_9$ *i.e.* farmer's practice at 20 DAS and 40 DAS. All chemical were applied as post-emergence at 20 DAS. The required quantity of herbicide Imazethapyr (Pursuit 10 EC), Quizalophop ethyl (Targa Super 5 EC) Fomesafen (Reflex), Clodinofop (Kover), Chlorimuron ethyl (Amix), Fluazifop-p-butyl (Fusilade) were applied. The quantity of water used as carrier was 1.2 litre $plot^{-1}$. The calculated above mentioned quantity of herbicide, as per treatment, was mixed in 1.2 litre of water and sprayed over the gross plot by knapsack sprayer using flat fan nozzle as blind application.The doses of different herbicides were determined as per treatment according to their active ingredient present in the commercial products.Weed flora was observed before and after treatment. The important weed species associated with the soybean crop in the experimental field were grouped according to nature of cotyledons as monocotyledonous and dicotyledonous weeds as well as sedges.

**Biometric Observations**

The data on weed population were recorded at different growth stages of crop before herbicide application and at 25, 50, 75 DAS and at harvest with the help of quadrate (0.5 x 0.5 m) at two randomly selected places in each plot and then converted into per square meter. Effect of herbicide phyto-toxicity like yellowing, epinasty, hyponasty, necrosis, scorching, etc. on soybean observed at 1, 3, 6 and 9 days after herbicide application on 0 to 10 point scale, as summarized.

The weed density of different weed species were studied at 25, 50, and 75 DAS and at harvest. The weed study in each plot was made at random from two selected spots and for this purpose quadrate (0.25 $m^{-2}$) was used. Only green weeds sample were taken. Counting of weeds was done according to species and total population of weeds was also worked out. The data were recorded $m^{-2}$ for statistical analysis. Production of dry matter by weeds was recorded at 25, 50, and 75 DAS and at harvest in soybean. Weeds present in quadrate were uprooted carefully along with roots. The roots of the samples were cut and only aerial parts were cleaned, sun-dried and finally oven-dried at 60°C for 48 hours. After complete oven drying, the dry matter was recorded species-wise and as well as total dry matter of weeds for different treatments. The Weed index (WI) and weed control efficiency (WCE %) data are presented in Table 9 & 10. were calculated using following formulae

$$\text{WCE}(\%) = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

Where,

WCE = Weed control efficiency (%)

DWC = Dry weight of weeds in weedy check plot (g)

DWT = Dry weight of weeds in treated plot (g)

$$\text{WI}\ (\%) = \frac{\text{Maximum seed yield} - \text{Seed yield from treated plot}}{\text{Maximum seed yield}} \times 100$$

Weed data were subjected to square root transformation to normalize their distribution before

statistical analysis. The experimental data were analysed statistically by following Fischer's method of analysis of variance wherever 'F' test was significant at p=0.05 the results have been compared among treatments based on critical difference at same level of significance.

**Results and Discussion**

**Weed flora**

The experimental site was infested with various weed species consisting of different species of monocot and dicot weeds. The major weed flora observed in the experimental field were *Parthenium hysterophorus*, *Euphorbia geniculata*, *Celosia argentea*, *Echinocloa colonum*, *Cynodon dactylon*, *Cyperus rotandus*, *Convolvulus arvensis*, and *Alternanthera spp*.

**1. Total and species wise weed density production by weeds**

Total and species wise weed density were recorded at 25, 50, 75 DAS and at harvest and data are presented in Table 1, 2, 3 & 4. Significantly maximum *parthenium* density was recorded under $T_{10}$- weedy check irrespective of date observation followed by $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE and $T_6$- Fomesafen 11.1% w/w + fluzifop-p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE. Minimum *Parthenium* density was recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE.

It was recorded that density of *Euphorbia geniculata* was significantly maximum under $T_{10}$- weedy check followed by $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE. minimum density of *Euphorbia geniculata* was recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE.

Significantly maximum density of *Celosia argentea* was recorded under $T_{10}$- weedy check followed by $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE. Minimum density of *Celosia argentea* was recorded under T9- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE.

Significantly maximum density of *Echinocloa colonum*, *Convolvulus arvensis*, and *Alternanthera spp*. was recorded under $T_{10}$- weedy check followed by $T_7$- Imazethapyr @ 300 g a.i. $ha^{-1}$ as PoE, and $T_6$- Fomesafen 11.1% w/w + fluazifop-p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE.

Minimum *Echinocloa colonum*, *Convolvulus arvensis*, and *Alternanthera spp*. Density was recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i.

$ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE.

Significantly maximum density of *Cynodon dactylon and Cyperus rotandus*. was recorded under $T_{10}$- weedy check followed by $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE. Minimum *Cynodon dactylon and Cyperus rotandus* was recorded under $T_9$- hand weeding twice at 20 abd 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME@ 750 g a.i. $ha^{-1}$ as PoE.

Throughout the period of investigation, others weeds spp. had non-significant variation was recorded in weed density of soybean due to different application of new herbicides.

Significantly maximum density of total weed was recorded under $T_{10}$- weedy check followed by $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE.

It was depicted from the data, (Table 4.17 to Table 4.20) that the total weed species and species wise weed density in the $T_{10}$- weedy check was significantly higher compared to other weed management practices throughout the period of investigation. This was due to no any weed management practices applied to control weeds which freely proliferated and compete with the crop for available nutrient, moisture and sunlight resulting in reduction of crop yield. Similar results were observed by Prabhakar *et al.* (1992) [12], Chavan *et al.* (1999) [3], Idapuganti *et al.* (2005) [6] Pandya *et al.* (2006) [11] and Vyas and Kushwaha (2008) [17].

**2. Total and species wise dry matter production by weeds**

Production of dry matter by weeds was recorded species wise at 25, 50, 75 DAS and at harvest and data are presented in Table 5, 6, 7 & 8.

Significantly maximum production of dry matter by weed species namely *Parthenium hysterophorus,* was recorded under $T_{10}$- weedy check irrespective of date of observation followed by $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE and $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400 + 16 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by weed *Parthenium hysterophorus* was recorded under $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE followed by $T_9$- hand weeding twice at 20 and 40 DAS and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Significantly maximum production of dry matter by weed species namely *Euphorbia geniculata*, was recorded under $T_{10}$- weedy check followed by $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE and $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by weed *Euphorbia geniculata,* was recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Significantly maximum production of dry matter by weed species namely *Celosia argentea,* was recorded under $T_{10}$- weedy check followed by $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by weed *Celosia argentea* was recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE and $T_6$- Fomesafen 11.1% w/w + fluzifop-p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE.

Significantly maximum production of dry matter by weed species namely *Echinocloa colonum*, was recorded under $T_{10}$- weedy check followed by $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE and $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by weed *Echinocloa colonum*, was recorded under $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE followed by $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_9$- hand weeding twice at 20 and 40 DAS.

Significantly maximum production of dry matter by weed species namely *Cynodon dactylon*, was recorded under $T_{10}$- weedy check followed by $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE, $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by weed *Cynodon dactylon* was recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_8$- Quizalofop ethyl + Chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Significantly maximum production of dry matter by weed species namely *Cyperus rotandus*, was recorded under $T_{10}$- weedy check followed by $T_6$- Fomesafen 11.1% w/w + fluzifop-p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE and $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by weed *Cyperus rotandus* was recorded $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Significantly maximum production of dry matter by weed species namely *Convolvulus arvensis*, was recorded under $T_{10}$- weedy check followed by $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by weed *Convolvulus arvensis* was recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Significantly maximum production of dry matter by weed species namely *Alternthra spp* was recorded under $T_{10}$- weedy check followed by $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by weed *Alternanthera spp* was recorded under $T_9$ - hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Significantly maximum production of dry matter by others weed was recorded under $T_{10}$- weedy check followed by $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE and $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE. Minimum production of dry matter by others weeds was recorded under $T_9$- hand weeding twice at 20 and 40

DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Significantly maximum production of dry matter by total weed was recorded under $T_{10}$- weedy check followed by $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE Minimum production of dry matter by Total weed recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Production of dry matter by all species and other weed species were observed significantly maximum under $T_{10}$- weedy check and significantly minimum production of dry matter under treatment $T_9$- hand weeding twice at 20 and 40 DAS, throughout the period of investigation. Vyas and Jain (2003) [16], Halvankar *et al.* (2005) [5], Idapuganti *et al.* (2005) [6], Deore *et al.* (2008) [4] and Karande *et al.* (2008) [8] also reported similar results from their study.The data on weed growth rate of soybean was observed during 0-25, 25-50, 50-75 DAS and 75 DAS at harvest. Treatment $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE showed maximum weed growth rate followed by $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE. Weed growth rate initially showed increasing trend at 0-25 DAS which then declined at 25-50 DAS which again increased during 50-75 DAS and finally decreased during 75 DAS -at harvest in treatment $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_5$- Fomesafen 17.5% w/w ME and $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE.

Weed growth rate showed continuously decreasing trend up to at harvest stage in treatment $T_6$- Fomesafen 11.1% w/w + fluzifop-p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE and $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE. Weed growth rate was initially increased at 25-50 DAS but decreased there after till at harvest. At all the stages significantly maximum weed growth rate was recorded under $T_{10}$- weedy check. Treatment $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE recorded minimum weed growth rate at all the stages up to at harvest.

High weed growth rate in these treatments may be due to the favourable condition for weed growth and development, as weeds are more competitive in nature than the crop. Weed free at early stage of crop and so on reduces the weed growth rate because these treatments does not provide much more space, nutrient and all favorable condition for weed and shows smothering effects to the weeds, as weeds are newly germinated and less competitive at this stage. Therefore weeds could not flourish and showed lower growth rate.

Weed control efficiency was observed at 25, 50, 75 DAS and at harvest and data are presented in Table 9. At 25 DAS, numerically highest weed control efficiency was recorded under $T_9$- Hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE, $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE, $T_6$- Fomesafen 11.1% w/w + fluzifop-p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE, $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE, $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE. At 50, 75 DAS and at harvest, highest weed control efficiency was recorded under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE, $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE, $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE, $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE, $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_6$- Fomesafen 11.1% w/w + fluzifop-p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE.

Herbicidal application killed the weed seeds and weeds effectively and reduced the weed dry mass as compared to the control this resulted in increased weed control efficiency. Similar results were also reported by Venkatesha *et al*. (2008) [15], Khedkar *et al*. (2009) [9], Amaregonda *et al.* (2013) [1], Sangeetha *et al*. (2013) [13] and Jha *et al.* (2014) [7].

The data on weed index are presented in Table 10. Weed index had remarkably influenced by different new herbicides application. Maximum weed index was recorded under $T_{10}$- weedy check. Where, minimum weed index was recorded under $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE and $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. $ha^{-1}$ as PoE - followed by $T_8$- Quizalofop ethyl + chlorimuron ethyl @ 400+16 g a.i. $ha^{-1}$ as PoE, $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 750 g a.i. $ha^{-1}$ as PoE and $T_4$- Clodinafop 12.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE, $T_7$- Imazythapyr @ 300 g a.i. $ha^{-1}$ as PoE, $T_6$- Fomesafen 11.1% w/w + fluzifop-p-butyl 11.1% w/w SL @ 1000 g a.i. $ha^{-1}$ as PoE and $T_5$- Fomesafen 17.5% w/w ME @ 1000 g a.i. $ha^{-1}$ as PoE.

Weed index indicate the reduction in yield due to weed competition as compared to the maximum attained seed yield. The maximum weed index recorded under where no weed management practices are applied ultimately causes reduction in seed yield also reported maximum weed index under untreated control. Similar results were also reported by Kushwah and Vyas (2005) [10] and Jha *et al.* (2014) [7].

**Table 1:** Total and species wise weed density at 25 DAS as influenced by different new herbicides

| Treatment | Dose (a.i $ha^{-1}$) ml /g | *Parthenium hysterophorus* | *Euphorbia geniculata* | *Celosia argentea* | *Eichinochloa colonum* | *Cynodon dactylon* | *Cyperus rotundus* | *Convolvulus arvensis* | *Alternanthera spp* | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 3.80 (14.0) | 2.20 (4.3) | 2.41 (5.33) | 2.60 (6.33) | 2.04 (3.67) | 2.73 (7.0) | 2.73 (7.0) | 2.04 (3.67) | 2.18 (4.33) | 7.49 (55.7) |
| $T_2$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 3.08 (9.0) | 1.68 (2.3) | 1.95 (3.33) | 2.20 (4.33) | 1.86 (3.00) | 2.27 (4.7) | 2.27 (4.7) | 1.46 (1.67) | 1.79 (3.33) | 6.07 (36.3) |
| $T_3$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 2.60 (6.3) | 1.05 (0.7) | 1.34 (1.33) | 1.68 (2.33) | 1.34 (1.33) | 1.68 (2.3) | 1.56 (2.0) | 0.71 (0.00) | 2.12 (5.00) | 4.65 (21.3) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_4$ - Clodinafop 12.5% w/w ME | 1000 | 4.03 (16.7) | 3.67 (13.0) | 2.85 (7.67) | 2.96 (8.33) | 2.48 (5.67) | 3.67 (13.0) | 2.91 (8.0) | 2.67 (6.67) | 2.22 (4.67) | 9.16 (83.7) |
| $T_5$ - Fomesafen 17.5%w/w ME | 1000 | 4.88 (23.3) | 3.13 (9.3) | 2.79 (7.33) | 2.79 (7.33) | 2.54 (6.00) | 3.76 (13.7) | 3.13 (9.3) | 2.35 (5.00) | 2.34 (5.00) | 9.32 (86.3) |
| $T_6$ - Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 4.98 (24.3) | 2.73 (7.0) | 2.60 (6.33) | 3.02 (8.67) | 2.40 (5.33) | 2.97 (8.3) | 3.18 (9.7) | 2.68 (6.67) | 2.00 (4.33) | 9.00 (80.7) |
| $T_7$ - Imazethapyr | 300 | 4.91 (23.7) | 2.68 (6.7) | 2.60 (6.33) | 3.02 (8.67) | 2.32 (5.00) | 2.91 (8.0) | 3.19 (9.7) | 2.73 (7.00) | 2.24 (4.67) | 8.95 (79.7) |
| $T_8$ - Quizalofop ethyl + chlorimuron ethyl | 400+16 | 5.02 (24.7) | 3.13 (9.3) | 2.85 (7.67) | 2.91 (8.00) | 2.32 (5.00) | 3.48 (11.7) | 3.13 (9.3) | 2.54 (6.00) | 1.72 (3.00) | 9.23 (84.7) |
| $T_9$ - Hand weeding | 20-40 DAS | 1.05 (0.7) | 0.71 (0.0) | 0.71 (0.00) | 0.88 (0.33) | 0.71 (0.00) | 1.05 (0.7) | 0.88 (0.3) | 0.71 (0.00) | 0.88 (0.33) | 1.57 (2.3) |
| $T_{10}$ - Weedy check | | 8.23 (67.3) | 6.74 (45.0) | 3.13 (9.33) | 3.85 (14.33) | 2.91 (8.00) | 6.74 (45.0) | 3.97 (15.3) | 3.13 (9.33) | 3.29 (10.33) | 14.58 (224.0) |
| SEm ± | | 0.20 | 0.12 | 0.12 | 0.15 | 0.14 | 0.13 | 0.12 | 0.09 | 0.434 | 0.24 |
| CD (P=0.05) | | 0.60 | 0.36 | 0.36 | 0.43 | 0.41 | 0.39 | 0.35 | 0.28 | NS | 0.71 |

Figures in the parentheses are original values; data were transformed through√x+0.5 which are given in bold

**Table 2:** Total and species wise weed density at 50 DAS as influenced by different new herbicides

| Treatment | Dose (a.i $ha^{-1}$) ml /g | *Parthenium hysterophorus* | *Euphorbia geniculata* | *Celosia argentea* | *Eichinochloa colonum* | *Cynodon dactylon* | *Cyperus rotundus* | *Convolvulus arvensis* | *Alternanthera spp* | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 3.08 (9.0) | 2.18 (4.33) | 1.34 (1.33) | 2.73 (7.00) | 2.11 (4.00) | 2.91 (8.00) | 1.64 (2.33) | 1.58 (2.00) | 2.04 (3.67) | 6.49 (41.7) |
| $T_2$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 2.73 (7.0) | 1.68 (2.33) | 1.22 (1.00) | 2.34 (5.00) | 1.34 (1.33) | 2.41 (5.33) | 1.05 (0.67) | 1.17 (1.00) | 1.86 (3.00) | 5.21 (26.7) |
| $T_3$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 1.68 (2.3) | 1.05 (0.67) | 0.71 (0.00) | 1.46 (1.67) | 0.88 (0.33) | 1.86 (3.00) | 0.71 (0.00) | 0.71 (0.00) | 2.46 (4.67) | 3.63 (12.7) |
| $T_4$ - Clodinafop 12.5% w/w ME | 1000 | 4.10 (16.3) | 3.29 (10.33) | 1.95 (3.33) | 3.76 (13.67) | 3.53 (12.00) | 3.44 (11.33) | 1.95 (3.33) | 3.03 (8.67) | 2.02 (3.67) | 9.12 (82.7) |
| $T_5$ - Fomesafen 17.5%w/w ME | 1000 | 3.72 (13.3) | 3.13 (9.33) | 1.46 (1.67) | 3.08 (9.00) | 3.08 (9.00) | 4.06 (16.00) | 2.11 (4.00) | 2.54 (6.00) | 2.03 (3.67) | 8.51 (72.0) |
| $T_6$ - Fomesafen 11.1% w/w + fluazifop-p-butyl 11.1% w/w SL | 1000 | 3.34 (10.7) | 3.62 (12.67) | 1.39 (1.67) | 3.58 (12.33) | 2.97 (8.33) | 3.33 (10.67) | 2.85 (7.67) | 2.91 (8.00) | 1.72 (3.00) | 8.69 (75.0) |
| $T_7$ - Imazethapyr | 300 | 3.34 (10.7) | 2.91 (8.00) | 1.87 (3.00) | 2.73 (7.00) | 3.66 (13.00) | 3.08 (9.00) | 2.73 (7.00) | 3.03 (8.67) | 1.94 (3.33) | 8.38 (69.7) |
| $T_8$ - Quizalofop ethyl + chlorimuron ethyl | 400+16 | 3.29 (10.3) | 3.62 (12.67) | 1.39 (1.67) | 3.03 (8.67) | 3.18 (9.67) | 3.83 (14.33) | 2.11 (4.00) | 2.73 (7.00) | 1.43 (2.00) | 8.41 (70.3) |
| $T_9$ - Hand weeding | 20-40 DAS | 0.71 0.0 | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.88 (0.33) | 0.88 (0.33) |
| $T_{10}$ - Weedy check | - | 6.74 (45.0) | 6.23 (38.33) | 2.34 (5.00) | 6.94 (47.67) | 6.69 (44.33) | 6.10 (36.67) | 3.93 (15.00) | 3.53 (12.00) | 3.29 (10.33) | 15.96 (254.3) |
| SEm ± | | 0.12 | 0.12 | 0.15 | 0.10 | 0.12 | 0.15 | 0.13 | 0.10 | 0.28 | 0.16 |
| CD (P=0.05) | | 0.36 | 0.36 | 0.46 | 0.31 | 0.35 | 0.43 | 0.40 | 0.30 | 0.83 | 0.47 |

Figures in the parentheses are original values; data were transformed through√x+0.5 which are given in bold

**Table 3:** Total and species wise weed density at 75 DAS as influenced by different new herbicides

| Treatment | Dose (a.i.$ha^{-1}$) ml /g | *Parthenium hysterophorus* | *Euphorbia geniculata* | *Celosia argentea* | *Eichinochloa colonum* | *Cynodon dactylon* | *Cyperus rotundus* | *Convolvulus arvensis* | *Alternanthera spp* | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 2.73 (7.00) | 1.86 (3.00) | 1.22 (1.00) | 1.77 (2.67) | 2.85 (7.67) | 2.34 (5.00) | 1.46 (1.67) | 1.46 (1.67) | 1.76 (2.67) | 5.73 (32.33) |
| $T_2$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 2.34 (5.00) | 1.34 (1.33) | 1.05 (0.67) | 1.05 (0.67) | 2.11 (4.00) | 1.77 (2.67) | 0.88 (0.33) | 1.05 (0.67) | 1.17 (1.00) | 4.08 (16.33) |
| $T_3$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 1.68 (2.33) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 1.68 (2.33) | 1.05 (0.67) | 0.71 (0.00) | 0.71 (0.00) | 0.88 (0.33) | 2.48 (5.67) |
| $T_4$ - Clodinafop 12.5% w/w ME | 1000 | 3.13 (9.33) | 3.48 (11.67) | 1.86 (3.00) | 2.91 (8.00) | 3.39 (11.00) | 3.66 (13.00) | 1.86 (3.00) | 3.03 (8.67) | 2.66 (6.67) | 8.65 (74.33) |
| $T_5$ - Fomesafen 17.5%w/w ME | 1000 | 3.34 (10.67) | 3.58 (12.33) | 1.46 (1.67) | 3.03 (8.67) | 3.13 (9.33) | 3.13 (9.33) | 2.11 (4.00) | 2.34 (5.00) | 2.11 (4.00) | 8.09 (65.00) |
| $T_6$ - Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 3.03 (8.67) | 2.91 (8.00) | 1.39 (1.67) | 2.91 (8.00) | 3.89 (14.67) | 3.72 (13.33) | 2.85 (7.67) | 2.91 (8.00) | 2.68 (6.67) | 8.78 (76.67) |
| $T_7$ - Imazethapyr | 300 | 3.03 (8.67) | 2.97 (8.33) | 1.77 (2.67) | 3.81 (14.00) | 3.08 (9.00) | 3.08 (9.00) | 2.73 (7.00) | 2.60 (6.33) | 2.39 (5.33) | 8.41 (70.33) |
| $T_8$ - Quizalofop ethyl + chlorimuron ethyl | 400+16 | 3.13 (9.33) | 3.39 (11.00) | 1.39 (1.67) | 3.48 (11.67) | 3.89 (14.67) | 3.39 (11.00) | 2.11 (4.00) | 2.73 (7.00) | 2.48 (5.67) | 8.74 (76.00) |
| $T_9$ - Hand weeding | 20-40 DAS | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| $T_{10}$ - Weedy check | - | 3.76 (13.67) | 5.24 (27.00) | 2.54 (6.00) | 5.30 (27.67) | 5.90 (34.33) | 4.77 (22.33) | 3.53 (12.00) | 3.24 (10.00) | 3.42 (11.33) | 12.83 (164.33 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | ) |
| SEm ± | | 0.08 | 0.11 | 0.19 | 0.11 | 0.13 | 0.14 | 0.13 | 0.10 | 0.18 | 0.17 |
| CD (P=0.05) | | 0.24 | 0.31 | 0.56 | 0.32 | 0.39 | 0.42 | 0.38 | 0.29 | 0.54 | 0.52 |

Figures in the parentheses are original values; data were transformed through√x+0.5 which are given in bold

**Table 4:** Total and species wise weed density at harvest as influenced by different new herbicides

| Treatment | Dose (a.i. ha$^{-1}$) ml/g | *Parthenium hysterophorus* | *Euphorbia geniculata* | *Celosia argentia* | *Eichinochloa colonum* | *Cynodon dactylon* | *Cyperus rotundus* | *Convolvulus arvensis* | *Alternanthera spp* | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 2.11 (4.00) | 1.46 (1.67) | 1.22 (1.00) | 1.56 (2.00) | 1.68 (2.33) | 2.18 (4.33) | 1.46 (1.67) | 1.46 (1.67) | 2.04 (3.67) | 4.77 (22.33) |
| $T_2$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 1.46 (1.67) | 1.05 (0.67) | 1.05 (0.67) | 1.05 (0.67) | 1.34 (1.33) | 1.34 (1.33) | 0.88 (0.33) | 1.05 (0.67) | 1.86 (3.00) | 3.25 (10.33) |
| $T_3$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 1.05 (0.67) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.88 (0.33) | 0.71 (0.00) | 0.71 (0.00) | 2.26 (4.67) | 2.47 (5.67) |
| $T_4$ - Clodinafop 12.5% w/w ME | 1000 | 3.02 (8.67) | 2.79 (7.33) | 1.86 (3.00) | 3.08 (9.00) | 2.85 (7.67) | 2.91 (8.00) | 1.93 (3.33) | 2.60 (6.33) | 2.02 (3.67) | 7.58 (57.00) |
| $T_5$- Fomesafen 17.5%w/w ME | 1000 | 2.85 (7.67) | 2.18 (4.33) | 1.46 (1.67) | 2.80 (7.33) | 2.47 (5.67) | 3.03 (8.67) | 2.11 (4.00) | 2.34 (5.00) | 2.03 (3.67) | 6.96 (48.00) |
| $T_6$ - Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 2.79 (7.33) | 2.40 (5.33) | 1.39 (1.67) | 2.79 (7.33) | 3.08 (9.00) | 2.96 (8.33) | 2.40 (5.33) | 2.72 (7.00) | 1.72 (3.00) | 7.40 (54.33) |
| $T_7$ – Imazethapyr | 300 | 3.13 (9.33) | 2.79 (7.33) | 1.77 (2.67) | 3.08 (9.00) | 3.44 (11.33) | 2.85 (7.67) | 2.73 (7.00) | 2.60 (6.33) | 1.94 (3.33) | 8.03 (64.00) |
| $T_8$ - Quizalofop ethyl + chlorimuron ethyl | 400+16 | 3.08 (9.00) | 2.91 (8.00) | 1.68 (2.33) | 3.02 (8.67) | 3.44 (11.33) | 2.79 (7.33) | 2.11 (4.00) | 2.54 (6.00) | 1.43 (2.00) | 7.69 (58.67) |
| $T_9$ - Hand weeding | 20-40 DAS | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.88 (0.33) | 0.88 (0.33) |
| $T_{10}$ - Weedy check | - | 3.39 (11.00) | 3.62 (12.67) | 2.54 (6.00) | 4.74 (22.00) | 4.26 (17.67) | 3.39 (11.00) | 3.24 (10.00) | 3.08 (9.00) | 3.29 (10.33) | 10.49 (109.67 ) |
| SEm ± | | 0.13 | 0.14 | 0.15 | 0.12 | 0.12 | 0.12 | 0.13 | 0.14 | 0.28 | 0.22 |
| CD (P=0.05) | | 0.38 | 0.42 | 0.45 | 0.35 | 0.37 | 0.35 | 0.40 | 0.40 | 0.83 | 0.65 |

Figures in the parentheses are original values; data were transformed through√x+0.5 which are given in bold

**Table 5:** Total and species wise dry matter production of weeds 25 DAS as influenced by different new herbicides

| Treatment | Dose (a.i. ha$^{-1}$) ml /g | *Parthenium hysterophorus* | *Euphorbia geniculata* | *Celosia argentea* | *Echnochloa colonum* | *Cynodon dactylon* | *Cyperus rotundus* | *Convolvulus arvensis* | *Alternanthera spp* | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 1.79 (3.19) | 1.62 (2.62) | 1.65 (2.71) | 0.98 (0.96) | 1.68 (2.84) | 1.64 (2.67) | 1.66 (2.75) | 1.39 (1.93) | 1.69 (2.38) | 4.75 (22.05) |
| T2 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 1.61 (2.61) | 1.21 (1.45) | 1.64 (2.67) | 0.77 (0.59) | 1.26 (1.60) | 1.22 (1.49) | 1.53 (2.34) | 1.19 (1.42) | 1.54 (1.89) | 4.07 (16.05) |
| T3 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 0.98 (0.96) | 1.03 (1.07) | 1.14 (1.31) | 0.35 (0.12) | 0.92 (0.85) | 1.04 (1.07) | 1.13 (1.27) | 0.84 (0.71) | 1.47 (1.72) | 3.10 (9.09) |
| T4 - Clodinafop 12.5% w/w ME | 1000 | 2.12 (4.51) | 2.10 (4.41) | 1.84 (3.40) | 1.46 (2.13) | 1.60 (2.57) | 1.77 (3.15) | 1.53 (2.33) | 1.61 (2.58) | 1.60 (2.07) | 5.26 (27.15) |
| $T_5$ - Fomesafen 17.5%w/w ME | 1000 | 2.13 (4.53) | 1.86 (3.45) | 1.73 (2.99) | 1.60 (2.55) | 1.65 (2.71) | 1.87 (3.51) | 1.75 (3.06) | 1.43 (2.06) | 1.56 (1.93) | 5.22 (26.78) |
| $T_6$ - Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 2.12 (4.49) | 1.80 (3.22) | 1.50 (2.26) | 1.58 (2.51) | 1.48 (2.19) | 1.94 (3.76) | 1.67 (2.77) | 1.48 (2.18) | 1.57 (1.99) | 5.09 (25.39) |
| $T_7$ - Imazethapyr | 300 | 2.18 (4.74) | 1.89 (3.55) | 1.52 (2.30) | 1.65 (2.73) | 1.34 (1.79) | 1.79 (3.20) | 1.72 (2.95) | 1.56 (2.43) | 1.72 (2.48) | 5.16 (26.18) |
| $T_8$ - Quizalofop ethyl + chlorimuron ethyl | 400+16 | 2.17 (4.69) | 1.88 (3.52) | 1.52 (2.32) | 1.61 (2.59) | 1.06 (1.13) | 1.79 (3.22) | 1.58 (2.49) | 1.43 (2.04) | 1.59 (2.03) | 4.95 (24.02) |
| $T_9$ - Hand weeding | 20-40 DAS | 1.02 (1.04) | 0.84 (0.71) | 0.84 (0.71) | 0.95 (0.91) | 0.84 (0.71) | 1.02 (1.04) | 0.94 (0.89) | 0.84 (0.71) | 0.71 (0.00) | 0.71 (0.00) |
| $T_{10}$ - Weedy check | - | 3.07 (9.42) | 3.10 (9.61) | 1.93 (3.74) | 1.93 (3.73) | 1.88 (3.55) | 2.95 (8.73) | 1.94 (3.77) | 1.80 (3.25) | 2.03 (3.64) | 7.07 (49.43) |
| SEm ± | | 0.04 | 0.03 | 0.06 | 0.04 | 0.13 | 0.06 | 0.03 | 0.04 | 0.11 | 0.08 |
| CD (P=0.05) | | 0.14 | 0.10 | 0.17 | 0.13 | 0.40 | 0.18 | 0.09 | 0.10 | 0.32 | 0.24 |

Figures in the parentheses are original values; data were transformed through√x+0.5 which are given in bold

**Table 6:** Total and species wise dry matter production of weeds 50 DAS as influenced by different new herbicides

| Treatment | Dose (a.i.ha$^{-1}$) ml /g | *Parthenium hysterophorus* | *Euphorbia geniculata* | *Celosia argentea* | *Echnochloa colonum* | *Cynodon dactylon* | *Cyperus rotundus* | *Convolvulus arvensis* | *Alternanthera spp* | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 2.25 (5.07) | 1.83 (3.37) | 1.51 (2.28) | 2.17 (4.75) | 2.09 (4.39) | 2.48 (6.16) | 1.52 (2.34) | 1.86 (3.48) | 2.35 (5.11) | 4.66 (21.19) |
| T2 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 2.08 (4.35) | 1.69 (2.88) | 1.57 (2.48) | 1.87 (3.50) | 1.62 (2.64) | 2.00 (4.02) | 1.45 (2.12) | 1.51 (2.29) | 2.13 (4.06) | 4.10 (16.32) |
| T3 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 1.81 (3.29) | 1.45 (2.12) | 1.18 (1.41) | 1.65 (2.74) | 1.18 (1.41) | 1.90 (3.63) | 1.18 (1.41) | 1.18 (1.41) | 2.44 (5.48) | 3.84 (14.26) |
| T4 - Clodinafop 12.5% w/w ME | 1000 | 2.68 (7.22) | 2.63 (6.94) | 1.88 (3.56) | 2.67 (7.17) | 2.63 (6.94) | 2.75 (7.59) | 1.77 (3.15) | 2.45 (6.05) | 2.21 (4.44) | 5.43 (29.00) |
| $T_5$ - Fomesafen 17.5%w/w ME | 1000 | 2.73 (7.48) | 2.64 (7.00) | 1.68 (2.82) | 2.59 (6.73) | 2.56 (6.59) | 3.04 (9.27) | 1.94 (3.78) | 2.45 (6.04) | 2.57 (6.22) | 5.64 (31.34) |
| $T_6$ - Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 2.51 (6.32) | 2.68 (7.22) | 1.98 (3.95) | 2.55 (6.51) | 2.59 (6.71) | 2.67 (7.16) | 2.48 (6.18) | 2.46 (6.05) | 2.35 (5.20) | 5.56 (30.51) |
| $T_7$ - Imazethapyr | 300 | 2.49 (6.22) | 2.57 (6.65) | 1.68 (2.85) | 2.50 (6.26) | 2.70 (7.29) | 2.52 (6.38) | 2.13 (4.56) | 2.45 (6.03) | 2.80 (7.43) | 5.59 (30.79) |
| $T_8$ - Quizalofop ethyl + chlorimuron ethyl | 400+16 | 2.51 (6.31) | 2.68 (7.23) | 1.62 (2.65) | 2.58 (6.67) | 2.58 (6.67) | 3.03 (9.20) | 1.99 (4.00) | 2.44 (5.99) | 2.42 (5.37) | 5.52 (29.97) |
| $T_9$ - Hand weeding | 20-40 DAS | 1.18 (1.41) | 1.18 (1.41) | 1.18 (1.41) | 1.18 (1.41) | 1.18 (1.41) | 1.18 (1.41) | 1.18 (1.41) | 1.18 (1.41) | 0.71 (0.00) | 2.49 (5.68) |
| $T_{10}$ - Weedy check | - | 4.52 (20.4) | 4.08 (16.66) | 2.70 (7.34) | 4.51 (20.42) | 4.39 (19.31) | 3.98 (15.89) | 3.33 (11.10) | 3.14 (9.89) | 5.96 (35.26) | 8.74 (75.89) |
| SEm ± | | 0.05 | 0.05 | 0.08 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | 0.20 | 0.12 |
| CD (P=0.05) | | 0.15 | 0.16 | 0.24 | 0.15 | 0.09 | 0.08 | 0.09 | 0.10 | 0.59 | 0.34 |

Figures in the parentheses are original values; data were transformed through √x+0.5 which are given in bold

**Table 7:** Total and species wise dry matter production of weeds 75 DAS as influenced by different new herbicides

| Treatment | Dose (a.i ha$^{-1}$) ml/g | *Parthenium hysterophorus* | *Euphorbia geniculata* | *Celosia argentea* | *Eichinochloa colonum* | *Cynodon dactylon* | *Cyperus rotundus* | *Convolvulus arvensis* | *Alternanthera spp* | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 2.71 (7.35) | 2.20 (4.88) | 1.81 (3.31) | 2.62 (6.89) | 2.52 (6.36) | 2.98 (8.94) | 1.84 (3.39) | 2.24 (5.05) | 1.38 (1.40) | 4.12 (16.47) |
| $T_2$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 2.51 (6.31) | 2.04 (4.18) | 1.89 (3.59) | 2.25 (5.07) | 1.95 (3.83) | 2.41 (5.83) | 1.75 (3.07) | 1.82 (3.32) | 1.27 (1.31) | 3.52 (12.01) |
| $T_3$ - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 2.18 (4.77) | 1.75 (3.07) | 1.42 (2.04) | 1.99 (3.97) | 1.42 (2.04) | 2.29 (5.26) | 1.42 (2.04) | 1.42 (2.04) | 1.62 (3.77) | 3.38 (11.48) |
| $T_4$ - Clodinafop 12.5% w/w ME | 1000 | 3.23 (10.47) | 3.17 (10.06) | 2.27 (5.16) | 3.22 (10.40) | 3.17 (10.07) | 3.31 (11.01) | 2.13 (4.56) | 2.96 (8.77) | 1.97 (3.38) | 5.14 (25.97) |
| $T_5$- Fomesafen 17.5%w/w ME | 1000 | 3.29 (10.85) | 3.18 (10.15) | 2.02 (4.10) | 3.12 (9.76) | 3.09 (9.55) | 3.66 (13.45) | 2.34 (5.48) | 2.95 (8.76) | 1.75 (2.56) | 5.05 (25.05) |
| $T_6$ - Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 3.02 (9.17) | 3.23 (10.47) | 2.39 (5.73) | 3.07 (9.45) | 3.11 (9.73) | 3.22 (10.38) | 2.99 (8.96) | 2.96 (8.78) | 1.91 (3.18) | 5.14 (25.92) |
| $T_7$ – Imazethapyr | 300 | 3.00 (9.02) | 3.10 (9.65) | 2.03 (4.13) | 3.01 (9.08) | 3.25 (10.57) | 3.04 (9.24) | 2.57 (6.61) | 2.95 (8.75) | 1.76 (2.61) | 5.05 (25.21) |
| $T_8$ - Quizalofop ethyl + chlorimuron ethyl | 400+16 | 3.02 (9.15) | 3.23 (10.49) | 1.95 (3.84) | 3.10 (9.67) | 3.10 (9.67) | 3.65 (13.34) | 2.40 (5.80) | 2.94 (8.69) | 1.72 (2.51) | 4.94 (23.95) |
| $T_9$- Hand weeding | 20-40 DAS | 1.42 (2.04) | 1.42 (2.04) | 1.42 (2.04) | 1.42 (2.04) | 1.42 (2.04) | 1.42 (2.04) | 1.42 (2.04) | 1.42 (2.04) | 1.10 (0.71) | 2.62 (6.39) |
| $T_{10}$ - Weedy check | - | 5.98 (35.79) | 5.39 (29.15) | 3.58 (12.85) | 5.97 (35.74) | 5.81 (33.79) | 5.27 (27.81) | 4.40 (19.42) | 4.16 (17.31) | 2.21 (4.46) | 6.11 (36.89) |
| SEm ± | | 0.01 | 0.02 | 0.07 | 0.05 | 0.02 | 0.02 | 0.05 | 0.04 | 0.33 | 0.19 |
| CD (P=0.05) | | 0.03 | 0.06 | 0.20 | 0.15 | 0.06 | 0.07 | 0.15 | 0.11 | NS | 0.55 |

Figures in the parentheses are original values; data were transformed through √x+0.5 which are given in bold

**Table 8:** Total and species wise dry matter production of weeds at harvest as influenced by different new herbicides

| Treatment | Dose (a.i.ha$^{-1}$) ml or g | *Parthenium hysterophorus* | *Euphorbia geniculata* | *Celosia argentea* | *Echnochloa colonum* | *Cynodon dactylon* | *Cyperus rotundus* | *Convolvulus arvensis* | *Alternanthera spp* | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 2.87 (8.26) | 2.34 (5.49) | 1.92 (3.72) | 2.78 (7.74) | 2.67 (7.15) | 3.16 (10.05) | 1.95 (3.81) | 2.38 (5.68) | 2.35 (5.11) | 4.37 (18.60) |
| T2 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 2.66 (7.09) | 2.16 (4.70) | 2.00 (4.03) | 2.38 (5.70) | 2.07 (4.30) | 2.55 (6.55) | 1.85 (3.45) | 1.93 (3.73) | 2.13 (4.06) | 3.71 (13.26) |
| T3 - Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 2.31 (5.36) | 1.85 (3.45) | 1.51 (2.29) | 2.11 (4.46) | 1.51 (2.29) | 2.43 (5.92) | 1.51 (2.29) | 1.51 (2.29) | 2.44 (5.48) | 3.49 (11.70) |
| T4- Clodinafop 12.5% | 1000 | 3.43 | 3.36 | 2.40 | 3.41 | 3.36 | 3.51 | 2.26 | 3.13 | 2.21 | 5.04 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| w/w ME | | (11.77) | (11.31) | (5.80) | (11.69) | (11.32) | (12.37) | (5.13) | (9.85) | (4.44) | (24.90) |
| $T_5$- Fomesafen 17.5%w/w ME | 1000 | 3.49 (12.20) | 3.37 11.41) | 2.14 (4.60) | 3.31 (10.97) | 3.27 (10.74) | 3.88 (15.11) | 2.48 (6.16) | 3.13 (9.84) | 2.57 (6.22) | 5.31 (27.77) |
| $T_6$- Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 3.21 (10.30) | 3.43 (11.77 | 2.53 (6.44) | 3.25 (10.62) | 3.30 (10.94) | 3.41 (11.67) | 3.17 (10.07) | 3.14 (9.86) | 2.35 (5.20) | 5.24 (27.05) |
| $T_7$ – Imazethapyr | 300 | 3.18 (10.14) | 3.29 (10.84) | 2.15 (4.65) | 3.19 (10.21) | 3.44 (11.89) | 3.22 (10.39) | 2.72 (7.43) | 3.13 (9.83) | 2.80 (7.43) | 5.47 (29.47) |
| $T_8$-Quizalofop ethyl + chlorimuron ethyl | 400+16 | 3.20 (10.28) | 3.43 (11.79) | 2.07 (4.31) | 3.29 (10.86) | 3.29 (10.86) | 3.87 (14.99) | 2.55 (6.52) | 3.12 (9.77) | 2.42 (5.37) | 5.23 (26.90) |
| $T_9$ - Hand weeding | 20-40 DAS | 1.51 (2.29) | 1.51 (2.29) | 1.51 (2.29) | 1.51 (2.29) | 1.51 (2.29) | 1.51 (2.29) | 1.51 (2.29) | 1.51 (2.29) | 0.71 (0.00) | 2.49 (5.68) |
| $T_{10}$ - Weedy check | - | 7.38 (54.55) | 6.66 (44.43) | 4.42 (19.58) | 7.38 (54.47) | 7.17 (51.50) | 6.51 (42.39) | 5.43 (29.59) | 5.13 (26.39) | 5.96 (35.26) | 8.03 (64.02) |
| SEm ± | | 0.03 | 0.04 | 0.05 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.20 | 0.12 |
| CD (P=0.05) | | 0.08 | 0.11 | 0.14 | 0.11 | 0.12 | 0.09 | 0.12 | 0.13 | 0.59 | 0.36 |

Figures in the parentheses are original values; data were transformed through√x+0.5 which are given in bold

**Table 9:** Effect of new herbicides on weed control efficiency (%) in soybean

| Treatment | Dose (a.i. ha$^{-1}$) ml / g | Weed control efficiency (%) | | | |
|---|---|---|---|---|---|
| | | 25 DAS | 50 DAS | 75 DAS | At harvest |
| $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 57.02 | 73.69 | 78.20 | 80.60 |
| $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 69.06 | 79.94 | 83.38 | 85.21 |
| $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 83.91 | 85.62 | 88.09 | 89.40 |
| $T_4$- Clodinafop 12.5% w/w ME | 1000 | 45.22 | 59.84 | 66.72 | 70.38 |
| $T_5$- Fomesafen 17.5%w/w ME | 1000 | 45.73 | 58.92 | 65.97 | 69.70 |
| $T_6$- Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 48.91 | 58.60 | 65.70 | 69.47 |
| $T_7$- Imazethapyr | 300 | 48.25 | 61.79 | 68.34 | 71.82 |
| $T_8$- Quizalofop ethyl + chlorimuron ethyl | 400+16 | 51.98 | 59.76 | 66.66 | 70.32 |
| $T_9$- Hand weeding | 20-40 DAS | 85.31 | 90.71 | 92.30 | 93.14 |
| $T_{10}$-Weedy check | - | - | - | - | - |

**Table 10:** Effect of new herbicides on weed index (%) in soybean

| Treatment | Dose (a.i. ha$^{-1}$) ml / g | Weed Index (%) |
|---|---|---|
| $T_1$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 750 | 10.67 |
| $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1000 | 5.38 |
| $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME | 1250 | 5.38 |
| $T_4$- Clodinafop 12.5% w/w ME | 1000 | 10.67 |
| $T_5$- Fomesafen 17.5%w/w ME | 1000 | 32.01 |
| $T_6$- Fomesafen 11.1% w/w + fluazifop- p-butyl 11.1% w/w SL | 1000 | 26.68 |
| $T_7$- Imazethapyr | 300 | 21.34 |
| $T_8$- Quizalofop ethyl + chlorimuron ethyl | 400+16 | 10.40 |
| $T_9$- Hand weeding | 20-40 DAS | - |
| $T_{10}$-Weedy check | - | 54.67 |

## Conclusion

Maximum total and species wise weed density and dry matter accumulation of *Parthenium hysterophorus, Euphorbia geniculata, Celosia argentia, Ecinocloa colonum, Cynodon dactylon, Cyperus rotundus, Convolvulus arvensis, and Alternanthera spp* etc were observed under $T_{10}$- weedy check and minimum was observed under $T_9$- hand weeding twice at 20 and 40 DAS followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. ha$^{-1}$. Weed growth rate showed decreasing trend at all the growth stages from 25 DAS up to at harvest. Highest weed control efficiency was found under $T_9$- hand weeding twice at 20 and 40 DAS which was closely followed by $T_3$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1250 g a.i. ha$^{-1}$ and $T_2$- Fomesafen 17.5% w/w ME + Clodinafop 12.5% w/w ME @ 1000 g a.i. ha$^{-1}$ as PoE.

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