The Pharma Innovation Journal 2023; 12(1): 2389-2391

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(1): 2389-2391

www.thepharmajournal.com
Received: 02-11-2022
Accepted: 07-12-2022

Borje SA
M.Sc. Department of Agronomy, Post Graduate Institute, MPKV, Rahuri, Maharashtra, India

Sinare BT
Department of Agronomy, Post Graduate Institute, MPKV, Rahuri, Maharashtra, India

Shete BT
Department of Agronomy, Post Graduate Institute, MPKV, Rahuri, Maharashtra, India

Patil MR
Department of Statistics, Post Graduate Institute, MPKV, Rahuri, Maharashtra, India

Corresponding Author:
Borje SA
M.Sc. Department of Agronomy, Post Graduate Institute, MPKV, Rahuri, Maharashtra, India

Efficacy of different herbicides for weed control in soybean (*Glycine max* L.)

Borje SA, Sinare BT, Shete BT and Patil MR

Abstract
A field experiment was conducted at the Seed Cell Unit (F Block), Mahatma Phule Krishi Vidyapeeth, Rahuri, during *Kharif* season of 2021-2022. The experiment was laid out in randomized block design (RBD) with three replications and nine treatments. The results revealed that, lowest weed population, weed dry weight, weed index, weed persistence index with highest weed control efficiency (100%) was obtained in weed free treatment, which was at par with application of diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS and pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS. The maximum herbicide efficiency index was reported by application of diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS (6.82) which is followed by and at par treatment pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS (4.48).

Keywords: Soybean, herbicides, weed count, weed dry matter, weed control efficiency, weed index, weed persistence index, herbicide efficiency index

Introduction
Soybean (*Glycine max* L.) is a "Golden bean" which occupies an important position in agricultural economy of India and claims premier position among the major oil producing countries in the world. Besides being an important oil seed crop, it also plays a major role in atmospheric nitrogen fixation. The conventional method of weed control with hand weeding is time consuming, expensive and laborious, under such circumstances it is more favorable to use chemicals due to scarcity of human labour during peak season and to obtain higher weed control efficiency and economic returns from cultivation of soybean. Application of herbicides as pre-emergence for effective weed control in soybean are required to be used within very short period i.e., 2-3 days after sowing. It is important to compare the effectiveness of various promising herbicides in terms of soybean productivity and weed competition with weed-free environment. Suitable herbicide for effective control of mixed weed flora is required for better adoption in this crop by the farmers. Therefore, present investigation was conducted to find out the suitable herbicide for effective weed control in soybean.

Materials and Methods
The experiment was conducted at Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar during *Kharif* 2021-2022. The experiment was laid out in randomized block design consisted of nine weed control treatments, *viz*. T_1 : Pendimethalin 30% EC @ 1000 g ha^{-1} (PE), T_2 : Pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS, T_3 : Imazethapyr 10% SL @ 100 g ha^{-1} at 20 DAS, T_4 : Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 50 + 75 g ha^{-1} at 20 DAS, T_5 : Diclosulam 84% WDG @ 25 g ha^{-1} (PE), T_6 : Diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS, T_7 : Imazethapyr 35% + Imazamox 35% WG 70 g ha^{-1} + MSO Adjuvant @ 2 ml/l of water at 20 DAS, T_8 : Weed free and T_9 : Weedy Check. The gross and net plot sizes were 3.60 m x 4.00 m and 2.70 m x 3.80 m., respectively. The variety used was 'Phule Sangam'. Soil was medium in available nitrogen (186.12 kg ha^{-1}), medium in available phosphorus (18.03 kg ha^{-1}) and high in potassium (453.02 kg ha^{-1}). The soil was slightly alkaline in reaction (pH 7.67) with normal in electrical conductivity of 0.32 dSm^{-1}. The recommended fertilizer dose of 50 kg N, 75 kg P_2O_5 and 45 kg K_2O ha^{-1} was applied. Along with growth and yield parameters, the weed flora, weed density and dry matter were recorded and weed control efficiency and weed index were estimated as measures of weed control.

Results and Discussion

Weed flora

In the experimental plot different weed speies observed, were sedges likes *Cyperus rotundus*, monocot weeds *viz*., *Cynodon dactylon, Commelina benghalensis, Eragrostis minor* and dicot weeds *viz*., *Digera arvensis, Acalypha india, Euphorbia heterophylla, Portulaca oleraceae, Phyllanthus niruri, Tridex procumbens, Parthenium hysterophorus, Alteranthera triandra, Achyranthes aspera, Convolvulus arvensis,* etc.

Weed density

The weed density m^{-2} at all growth stages was significantly the lowest in weed free treatment. The minimum value of total count of weeds was documented under treatment diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS (30.39 m^{-2}) at harvest. The results were in conformity with those obtained by Nagre *et al*. (2017) [3] and Patidar *et al*. (2019) [5].

Weed dry matter

In the weed free treatment, there was no weed dry matter due to absence of weeds. Among the herbicidal treatment, diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS (57.04 g m^{-2}) recorded the lowest weed biomass ha^{-1}. Maximum weed dry matter was documented in treatment weedy check (533.78 g m^{-2}) and it was significantly higher over rest of the treatments. The cumulative weed dry matter accumulated by weeds was significantly minimum in weed free treatment. Similar results were reported by Nainwal *et al.* (2010) [4] and Patil and Raundal (2017) [7].

Weed index

Among the herbicidal treatments, Diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS recorded the lower weed index (2.27%). It was at par with application of pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS, diclosulam 84% WDG @ 25 g ha^{-1} (PE), imazethapyr 35% + imazamox 35% WG 70 g ha^{-1} + MSO Adjuvant @ 2 ml/l of water at 20 DAS (3.23, 12.42 and 13.12% respectively). Weed free treatment recorded the lowest weed index (0%). The highest weed index (41.40%) was recorded in weedy check (control) as a result of uncontrolled weed growth which lead to higher competition with the crop. The similar results were obtained by Meena *et al.* (2011) [2] and Nagre *et al*. (2017) [3].

It was computed by the formula given below.

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

Where,
X- Yield from weed free check
Y- Yield from the treatment for which weed index to be calculated.

Weed Persistence Index

Among the herbicidal treatment minimum weed persistence index found in diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS (0.80) followed by pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS (0.95). These findings were parallel to conclusion of Patil *et al*. (2018) [6].

Weed persistence index was computed by the formula, (Walia, 2010) [10].

$$WPI = \frac{\text{Dry matter of weeds in treated plot (g)}}{\text{Dry matter of weeds in weedy check plot (g)}} \times \frac{\text{Weed count in weedy check plot (g)}}{\text{Weed count in treated plot (g)}}$$

Herbicides Efficiency Index

The maximum value of herbicide efficiency index was found in treatment diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS (6.82) which is followed by the treatment pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS (4.48). While treatment imazethapyr 10% SL 100 g ha^{-1} at 20 DAS reported minimum value (0.62) of herbicide efficiency index. Application of diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS particularly showed better efficacy in limiting weeds and thereby, herbicide efficiency index value is higher. These results were found in accordance with the results of Nagre *et al*. (2017) [3].

It can be computed by using following formula,

$$HEI = \frac{\frac{(YT-YC)}{YC} \times 100}{\frac{DMT}{DMC} \times 100}$$

Where,
YT- Yield from treatment
DMT- Dry matter of weeds in a particular treatment
YC- Yield from weedy check
DMC- Dry matter of weeds in weedy check

Weed Control Efficiency

Among the herbicidal treatments, application of diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS recorded significantly higher weed control efficiency (86.36). The higher WCE in these treatments might be due to the significant reduction in weed biomass because of the effective weed control practices through application of pre-emergence herbicides and one hoeing at 20 DAS. The results were well collaborating with the findings of Patil *et al.* (2018) [6] and Emmiganur and Hosmath (2020) [1].

Weed control efficiency at harvest was calculated based on weed count m^{-2} by using following formula.

$$WCE\ (\%) = \frac{WPC-WPT}{WPC} \times 100$$

Where,
WPC- Weed population m^{-2} in weedy check plot
WPT- Weed population m^{-2} in treated plot

Grain yield

The significantly higher grain yield (2926 kg ha^{-1}) was obtained in weed free treatment which was at par with the herbicidal treatment application of diclosulam 84% WDG @ 25 g ha-1 (PE) + 1 hoeing at 20 DAS (2860 kg ha^{-1}) and application of pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS (2833 kg ha^{-1}). These results are in comparision with the conclusion of Singh *et al*. (2016) [9] and Nagre *et al*. (2017) [3].

Straw yield

The significantly higher grain yield (3898 kg ha^{-1}) was obtained in weed free treatment which was at par with the

herbicidal treatment application of diclosulam 84% WDG @ 25 g ha-1 (PE) + 1 hoeing at 20 DAS (3820 kg ha^{-1}) and application of pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS (3786 kg ha^{-1}). These results are in the agreement with those of Meena *et al*. (2011) [2] and Nagre *et al*. (2017) [3].

Table 1: Weed density, weed dry matter, weed index, weed persistence index, herbicide efficiency index, weed control efficiency, grain yield and straw yield as influenced by different treatment

Treatment	Weed Density (m^{-2})	Weed dry matter (g m^{-2})	Weed index (%)	Weed persistence index	Herbicide efficiency index	Weed control efficiency (%)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1: Pendimethalin 30% EC @ 1000 g ha^{-1} (PE)	72.95 (8.57)	235.18 (15.35)	17.60	1.36	0.91	67.33	2412	3381
T_2: Pendimethalin 30% EC @ 1000 g ha^{-1} (PE) + 1 hoeing at 20 DAS	35.31 (5.98)	80.67 (8.99)	3.23	0.95	4.48	84.19	2833	3786
T_3: Imazethapyr 10% SL @ 100 g ha^{-1} at 20 DAS	90.82 (9.56)	316.55 (17.81)	21.05	1.47	0.62	59.26	2307	3256
T_4: Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 50 + 75 g ha^{-1} at 20 DAS	83.95 (9.19)	287.34 (16.96)	17.90	1.44	0.78	62.34	2398	3373
T_5: Diclosulam 84% WDG @ 25 g ha^{-1} (PE)	58.05 (7.65)	165.82 (12.89)	12.42	1.20	1.65	73.96	2560	3422
T_6: Diclosulam 84% WDG @ 25 g ha^{-1} (PE) + 1 hoeing at 20 DAS	30.39 (5.56)	57.04 (7.56)	2.27	0.80	6.82	86.36	2860	3820
T_7: Imazethapyr 35% + Imazamox 35% WG 70 g ha^{-1} + MSO Adjuvant @ 2 ml/l of water at 20 DAS	71.37 (8.48)	221.55 (14.90)	13.12	1.32	1.27	67.92	2540	3407
T_8: Weed free	0.00 (0.71)	0.00 (0.71)	-	-	-	100.00	2926	3898
T_9: Weedy Check	223.59 (14.96)	533.78 (23.09)	41.40	1.00	-	0.00	1713	2482
S. Em ±	0.11	0.42	4.10	0.07	0.72	0.74	122	158
C. D. at 5%	0.33	1.27	12.28	0.22	2.16	2.23	365	473

Conclusion

In soybean weed could be effectively managed by pre-emergence application of diclosulam 84% WDG @ 25 g ha^{-1} with one hoeing at 20 DAS with higher yields.

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