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Effect of Pre- and Post-Emergence Herbicides on Weed Biomass, Nutrient Depletion, and Growth of Soybean in Humid South-Eastern Plains of Rajasthan

Bharat Lal Meena, D.S. Meena[1], R.K. Meena[1] and Harkesh Meena[2]

Rajasthan University of Veterinary and Animal Sciences, Bikaner-334 001, India
[1]Agriculture University, Kota-324 001, India
[2]Uttar Banga Krishi Vishwavidyalaya, Cooch Behar-736 165, West Bengal
E-mail: bharatmeena447@gmail.com

Abstract: Field experiment was conducted during the *kharif* season of 2019 at the Agricultural Research Station, Ummedganj, Kota (Rajasthan), to evaluate the effect of various herbicide treatments on nutrient depletion and growth of soybean (*Glycine max* L. Merrill). The experiment comprised eight treatments, including pre- and post-emergence herbicides and hand weeding, laid out in a randomized block design with three replications. The herbicide application significantly reduced weed density and dry weight, thereby reducing nutrient depletion by weeds and improving crop growth and yield attributes. Maximum nutrient depletion by weeds with losses of 50.2 kg nitrogen, 3.58 kg phosphorus, and 41.4 kg ha^{-1} potassium was under the weedy check, indicating the severity of nutrient loss in untreated plots. In contrast, minimum nutrient removal by weeds under two hand weeding at 20 and 40 days after sowing, followed by the application of sodium acifluorfen + clodinafop-propargyl @ 165 + 80 g *a.i.* ha^{-1} at 20 days after sowing, also resulted in improved crop growth.

Keywords: Soybean, Herbicides, Nutrient depletion, Growth, Sodium acifluorfen + clodinafop-propargyl

Soybean (*Glycine max* L. Merrill) is a major oilseed and legume crop. India ranks fourth globally in soybean area and fifth in production, with 12.14 million hectares of area and 12.99 million tonnes of production in 2022 (SOPA 2023). Weed infestation is a significant challenge in soybean production, causing yield losses of 58–85%, depending on weed species and infestation (Kewat et al., 2000). Weeds also deplete essential soil nutrients up to 21.4 kg N and 3.4 kg P ha^{-1} (Pandya et al., 2005) and reduce yields by up to 55% under unchecked conditions (Malik et al., 2006). Major weed species in soybean fields include *Echinochloa colona*, *Cynodon dactylon*, *Amaranthus viridis*, and *Cyperus rotundus* (Singh and Rajkumar 2008, Sangeetha et al., 2012). Although manual weeding is effective but it is labor-intensive, costly, and often impractical due to labor shortages and unpredictable monsoon rains. In this context, the application of selective pre- and post-emergence herbicides provides a viable and cost-effective alternative for weed management in soybean cultivation.

The study addresses the major constraint of weed infestation in soybean cultivation in the Humid South-Eastern Plains of Rajasthan. Manual weeding is often impractical due to labour scarcity, costly, time consuming and intermittent rainfall during *Kharif* season; therefore, herbicidal weed control is remains the only alternative. The objective was to evaluate the effect of pre- and post-emergence herbicides on weed biomass, nutrient depletion, and soybean growth, and to identify an effective and economically viable herbicidal method of weed control.

MATERIAL AND METHODS

The experimental site is situated at 25°13′N latitude and 75°28′E longitude, with an altitude of 271 meters above mean sea level. The soil of the experimental field was clay loam in texture, with a medium fertility level, and the pH of the soil is 7.6. The experiment was laid out in a randomized block design with three replications. The experiment comprised eight treatments, *viz*., T_1 – pendimethalin 30% EC @ 1.0 kg *a.i.* ha^{-1} as pre-emergence, T_2 – pendimethalin + imazethapyr (premix) @ 960 g *a.i.* ha^{-1} as pre-emergence, T_3 – sodium acifluorfen + clodinafop-propargyl @ 165 + 80 g *a.i.* ha^{-1} at 20 days after sowing, T_4 – quizalofop-ethyl @ 50 g *a.i.* ha^{-1} at 20 days after sowing, T_5 – imazethapyr @ 100 g *a.i.* ha^{-1} days after sowing, T_6 – imazethapyr + propaquizafop premix @ 50 + 75 g *a.i.* ha^{-1} days after sowing, T_7 – hand weeding at 20 and 40 days after sowing, and T_8 – weedy check. The soybean variety RKS-113 was used for experimental material. Each treatment was applied to plots with adequate spacing between rows and replications to avoid spray drift and edge effects. Herbicides were applied by a knapsack sprayer fitted with a flat fan nozzle. Growth parameters*, viz.,* plant height, branches per plant, and dry matter accumulation, were recorded at different growth stages by five randomly selected plants from each plot.

To determine nutrient depletion, weed samples were collected from an area of 1 m² selected randomly at three spots in each of the plots within each plot at 30 and 60 DAS. The collected weed samples were initially shade-dried and

Table 1. Effect of pre and post emergence herbicides on dry matter accumulation, branches plant^{-1}, plant height, weed dry weight and nutrient depletion by weeds

Treatments	Dry matter accumulation (g mrl^{-1})	Branches plant^{-1} (no.)	Plant height (cm)	Nutrient depletion (kg ha^{-1})			Dry weight of weeds (g m^{-2})
				N	P	K	
T1	105.34	3.53	67.7	28.1	1.98	23.0	7.09 (49.34)
T2	123.70	3.93	70.3	21.7	1.50	17.7	5.80 (32.63)
T3	138.43	4.13	71.2	19.0	1.31	15.5	5.53 (29.62)
T4	113.54	3.80	68.2	23.8	1.67	19.5	6.35 (39.32)
T5	120.40	3.87	68.9	22.9	1.59	18.6	6.22 (37.75)
T6	131.37	4.07	69.4	20.5	1.46	16.7	5.71 (31.61)
T7	154.13	4.60	75.2	14.5	1.00	11.9	4.55 (19.74)
T8	63.43	3.13	59.8	50.2	3.58	41.4	9.48 (88.83)
CD (p=0.05)	15.00	0.45	7.34	1.93	0.12	1.45	0.29

Data in parenthesis are original values of weed dry weight. **Square root transformed value (√x+1) of weed dry weight used for statistical analysis

then dried in an electric oven at 65 ± 5°C till their weight became constant and ground for chemical analysis. Nitrogen content in weed samples was estimated using the Kjeldahl method as outlined by Piper (1966). Phosphorus was determined by the vanadomolybdate yellow color method following the procedure described by Jackson (1973), while potassium was estimated using a flame photometer from the triple acid extract, also as per the method outlined by Jackson (1973). Nutrient depletion by weeds (kg ha^{-1}) was determined by multiplying the nutrient content in weed biomass with the total weed dry matter (kg ha^{-1}) and dividing by 100.

Nutrient depletion by weeds (kg ha^{-1}) = Nutrient content in weeds × Weed dry matter (kg ha^{-1})/100

RESULTS AND DISCUSSION

Effect on growth of crop: Soybean growth parameters responded positively to effective weed management. Plant height and branches in plant showed an increasing trend (almost linear) with advancement in plant age up to 75 DAS and thereafter remained constant till harvest. Plant height (75.2 cm), number of branches per plant (4.60), and dry matter accumulation (154.13 g) were highest under hand weeding twice at 20 and 40 DAS, closely followed by post-emergence application of sodium acifluorfen + clodinafop (premix) 165 + 80 g *a.i.* ha^{-1} at 20 DAS and imazethapyr + propaquizafop (premix) 50 + 75 g *a.i.* ha^{-1} PoE at 20 DAS (Table 1). Minimum were observed in weedy check. Similar results were also reported in earlier studies (Meena et al., 2009, Gupta and Chandrakar, 2014 , Harithavardhini et al., 2016).

Nutrient content in weeds, weed dry matter, and nutrient depletion by weeds: The nutrient content in weed biomass was statistically non-significant across treatments. However, the total nutrient depletion by weeds was directly governed by the amount of weed dry matter accumulated under each treatment. The different herbicides significantly influenced the weed dry matter accumulation, which affected the growth of soybean and nutrient depletion by weeds from the soil (Table 1). The highest weed dry matter in the weedy check, which consequently resulted in the maximum nutrient removal, 50.2 kg ha^{-1} of nitrogen, 3.58 kg ha^{-1} of phosphorus, and 41.4 kg ha^{-1} of potassium. Among the herbicides, sodium acifluorfen + clodinafop-propargyl (premix) 165 + 80 g *a.i.* ha^{-1} PoE at 20 DAS was the most effective in reducing weed dry matter, thereby restricting nutrient depletion to 19.0 kg N, 1.31 kg P, and 15.5 kg K ha^{-1}. This was closely followed by imazethapyr + propaquizafop (premix) 50 + 75 g *a.i.* ha^{-1} PoE at 20 DAS and pendimethalin + imazethapyr (premix) 960 g *a.i*. ha^{-1} as pre-emergence. The lowest dry matter accumulation was observed under two hand weedings at 20 and 40 DAS, which led to minimum nutrient depletion. Similar results were also reported in earlier studies (Meena et al., 2009, Gore et al., 2014, Panda et al., 2015, Elankavi et al., 2019).

CONCLUSION

The effective weed management significantly reduces weed dry matter accumulation and nutrient depletion, thereby improving the growth and productivity of soybeans. Two-hand weeding at 20 and 40 DAS proved to be the most

effective in minimizing weed biomass and nutrient loss while simultaneously maximizing crop growth. Sodium acifluorfen + clodinafop-propargyl and imazethapyr + propaquizafop were highly effective post-emergence herbicides that not only suppressed weed growth but also restricted nutrient depletion and enhanced crop growth.

AUTHOR'S CONTRIBUTION

Bharat Lal Meena carried out the field experiment and collected the data, performed statistical analysis, interpreted and drafted the manuscript. Harkesh Meena assisted in statistical analysis, interpretation and drafting of the manuscript. D.S. Meena and R. K. Meena)supervised the work, reviewed it critically and edited the final version. All authors read and approved the final version.

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