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RESEARCH NOTE

Herbicidal effects on *Cyperus rotundus* in soybean under custard apple based agri-horti system

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ABSTRACT

A Field experiment was conducted during *Kharif* season of 2021 under custard apple based agri-horti system, at agricultural farm of Rajiv Gandhi South Campus, BHU, Barkachha, Mirzapur to study the effect of herbicide on *Cyperus rotundus*. The experiment was carried out in randomized block design (RBD) having seven treatments replicated thrice. Application of different doses of pyroxasulfone as company sample (GSP sample) were compared with pyroxasulfone 85%WG (Market sample) 150 ml/ha, imazethapyr 1000 ml/ha, hand weeding at 20 and 40 DAS and weedy check. Application of pyroxasulfone 85%WG (GSP sample) 187.5 ml/ha, significantly reduced the density and dry weight of *C. rotundus* with least weed effectiveness (WE) and highest weed control efficiency (WCE) and crop resistance index (CRI). Compared to the other treatments, application of pyroxasulfone 85%WG (GSP sample) 187.5 ml/ha produced maximum net returns and hence proved to be more effective.

Keywords: Agroforestry, Biological yield, Crop resistance index, Herbicides, Weed control efficiency

Being an important and cheapest source of concentrated protein of good quality as well as vegetable oil, Soybean [*Glycine max* (L.) Merrill.] holds an important position among Indian agricultural crops accounting for 37% of total oilseeds area and 54 % of area under *Kharif* season oilseed crops. Among all the states, Madhya Pradesh (M.P.) dominates soybean cultivation, contributing approximately 83% of the nation's total production, earning it the title of 'soy-state' (Jadav *et al.* 2022). Soybeans contain high proportion of unsaturated fatty acids, 18% oil, and about 45% protein (Malukani 2016). Hence, many agricultural scientists and food specialists view it as a potential tool against world hunger and a source of protein for the future (Kumar *et al.* 2022).

With the rising population, the demand for food security intensifies, paving the way for sustainable agricultural practices such as Agroforestry. It is an integrated approach of cultivating forest trees, agricultural crops as well as livestock on same unit of land. It provides a diverse source of income to the farmers by providing more than one output at a time from limited land resources. However, presence of tree components on the field supplies moisture, nutrients with leaf litter and regulates temperature. With this perspective, soybean has been cultivated within diverse agroforestry systems worldwide, with the goal of improving productivity and overall profitability (Sharma *et al.* 2023). Nevertheless, among the major challenge faced by soybean-producing countries, weeds pose critical threat, potentially reducing the yield by up to 40% (Soliman *et al.* 2015). These invasive plants have a more substantial economic impact than other crop pests (Gharde *et al.* 2018). In the initial growth phases of soybean, severe weed infestations, particularly *C. rotundus* (family Cyperaceae) diminishes the productivity of the crop. This perennial sedge propagates through under-ground vegetative structures demonstrating tolerance to or evasion from herbicides. They are widely distributed across the tropical and sub-tropical regions globally and proliferates rapidly through an extensive network of under-ground tubers exhibiting strong apical dominance. Hence, effective weed management practices are essential for enhanced crop growth and improved productivity using herbicides, which are effective and economical (Khaffagy *et al.* 2022).

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The field experiment was conducted at Rajiv Gandhi South Campus, BHU, Barkachha, Mirzapur (U.P) (25º 302 N Latitudes and 82º 352 E Longitudes and at an altitude of 168 m above mean sea level) during *Kharif* season of 2021-22. The region falls under semi-arid eastern plain zone (Zone-III A) which is mostly rainfed with extreme summer and extreme winter season. The experimental field has sandy clay loam soil. The soybean cv. (*NRC 86*) *Ahilya-6* was sown manually at a spacing of 40 x 40 cm and at a depth of 2-3cm utilizing 70-75 kg seed/ha. Foot sprayer equipped with a flat fan nozzle was used for the herbicidal application as per the treatment using 500 litres of water/ha. Recommended fertilizers dose (N:P:K-25:60:40) was supplied through Urea, SSP and MOP to fulfil the nutritional requirement of soybean. The experiment employed randomised block design with 7 treatments each replicated thrice. The treatments were: pyroxasulfone 85%WG (GSP sample) 120 ml/ha, pyroxasulfone 85%WG (GSP sample) 150 ml/ha, pyroxasulfone 85%WG (GSP sample) 187.5 ml/ha, pyroxasulfone 85%WG (market sample) 150 ml/ha, imazethapyr 1000 ml/ha, hand weeding at 20 and 40 DAS and control. The Pyroxasulfone treatments were applied as pre-emergence herbicides, while Imazethapyr was used as a post-emergence herbicide. A non- treated controlled plot was included for comparative analysis. In the Agri-horti system, trees were planted at a distance of 4x4 m, reaching heights of 3-7 m, characterized by broad, open crowns and irregularly spaced branches.

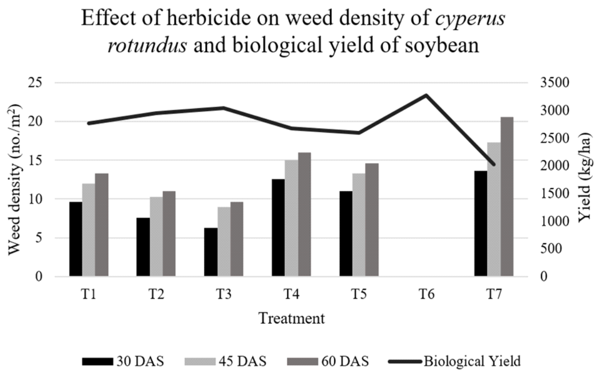
A quadrate of 0.25 m^2 was randomly placed at three places within each plot. Total weed density, weed dry biomass, Weed Control Efficiency (WCE) (Prachand *et al.* 2015) of *C. rotundus* (number/m^2) was monitored periodically at 30, 45 and 60 DAS. Additionally, absolute weed density, Crop Resistance Index (CRI) (Mishra and Misra 1997) and Weed Effectiveness (U.S.D.A./I.C.A.R. A.I.C.R.P.W.C. 1988) were also calculated. Upon reaching full maturity the crop was harvested. After thorough sun drying, the yield from each net plot was weighed for biological yield (kg/ha) as well as grain yield (kg/ha). Data were analysed by using standard statistical techniques. Least significant differences (LSD) at 5% level of probability were worked out for comparing the treatments means.

Effect on *C. rotundus*

The herbicidal treatments, during critical period of crop weed competition effectively suppressed both the density and biomass of weeds (**Table 1**), leading to a significant reduction in population and dry weight of *C. rotundus* compared to weedy check. Kumar *et al*. (2021) reported similar findings, highlighted that density and dry weight of grassy weeds were significantly lower with application of pyroxasulfone. The pre-emergence application of herbicides delayed the critical weed period, allowing crop to establish themselves more effectively at an early stage as indicated by Knezevic *et al.* (2019). Furthermore, increased doses of pyroxasulfone 85%WG, corresponded to lower population and weight of *C. rotundus*. Among herbicidal treatments, pre-emergence application of 187.5 ml/ha of pyroxasulfone 85%WG (GSP sample) significantly reduced the population and dry biomass of *C. rotundus* compared to other herbicidal treatments and it was statistically at par with the application of 150 ml/ha of pyroxasulfone 85%WG (GSP sample) across all stages of observations (**Table 1**). These results align with findings of Kumar *et al*. (2021) which indicated that different concentrations of Pyroxasulfone have significantly lowered the weed density. However, the application of 1000 ml/ha of Imezathapyr 85% SL recorded highest density and dry biomass of *C. rotundus* respectively as these provided less restricted growing environment to *C. rotundus* when compared to other herbicidal treatments. Moreover, the pyroxasulfone 85%WG (GSP sample) 150 ml/ha and pyroxasulfone 85%WG

Table 1. Effect of herbicides on density and dry weight of *C. rotundus* at 30, 45 and 60 days after sowing (DAS)

Treatment	Weed density (no./m^2)			Absolute density (no./m^2)			Dry weight (g/m^2)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Pyroxasulfone 85%WG (GSP sample) 120 ml/ha	9.60	12.00	13.30	3.20	4.00	4.43	2.3	2.52	2.79
Pyroxasulfone 85%WG (GSP sample)150 ml/ha	7.60	10.30	11.00	2.53	3.43	3.67	1.82	2.47	2.64
Pyroxasulfone 85%WG (GSP sample) 187.5 ml/ha	6.30	9.00	9.60	2.10	3.00	3.20	1.51	2.16	2.30
Pyroxasulfone 85%WG (Market sample) 150 ml/ha	12.60	15.00	16.00	4.20	5.00	5.33	3.02	3.15	3.36
Imazethapyr 1000 ml/ha	11.00	13.30	14.60	3.67	4.43	4.87	2.64	3.19	3.50
Hand weeding at 20 and 40 DAS	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Control	13.60	17.30	20.60	4.53	5.77	6.87	3.26	3.63	4.33
LSD (p=0.05)	3.10	2.80	3.42	1.03	0.93	1.14	0.32	0.32	0.35



T_1-Pyroxasulfone 85%WG (GSP sample) 120 ml/ha, T_2-Pyroxasulfone 85%WG (GSP sample) 150 ml/ha, T_3-Pyroxasulfone 85%WG (GSP sample) 187.5 ml/ha, T_4-Pyroxasulfone 85%WG (Market sample) 150 ml/ha, T_5-Imazethapyr 1000 ml/ha, T_6-hand weeding at 20 and 40 DAS and T_7-Control.

Figure 1. Effect of herbicide on weed density of *Cyperus rotundus* and biological yield of soybean

(GSP sample) 187.5 ml/ha concentration of herbicides used in the experiments were suggested as the best treatments for suppressing the weed growth in different crops *i.e.* 125-250ml/ha when compared to other pre-emergence herbicides (Yamaji *et al.* 2014).

Relative efficiency of weed control treatments is judged by calculating the WCE compared to untreated check (**Table 2**). The application of pyroxasulfone 85%WG (GSP sample) at 187.5 ml/ha observed the highest WCE of *C. rotundus*, indicating that relative killing of potential weeds under particular treatment has a significant impact on WCE. In contrast, plots that were hand weeded twice exhibited minimum density and dry biomass of *C. rotundus* due to reduced crop-weed competitions and even exhibited maximum WCE similar to findings of Meena *et al.* (2022). Nevertheless, the plots underwent two hand weeding outperformed all the herbicidal treatments suggesting this method may be a better alternative for controlling *C. rotundus*.

Weed effectiveness index is the per cent reduction in crop yield under a particular treatment due to the presence of weeds in comparison to weed free plot. The highest weed effectiveness index for *C. rotundus* was observed with the application of 150 ml/ha of Pyroxasulfone 85%WG (market sample), demonstrating that higher herbicide concentrations led to a reduction in weed populations.

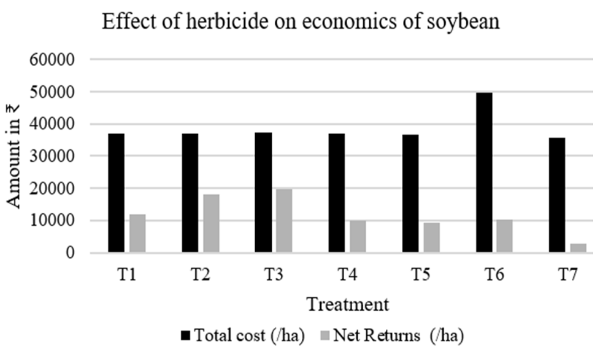
The healthiness of the crop plant is indicated by crop resistance index parameter due to effective weed management. The maximum crop resistance index was recorded with application of 187.5 ml/ha of pyroxasulfone 85% WG (GSP sample) outperforming other herbicidal treatments. This dosage of pyroxasulfone 85%WG (GSP sample) consistently enhanced the CRI at all stages of crop growth, indicating reduced harmful effect of herbicidal treatment on soyabean crop as compared to others. In contrast, the control plot exhibited a lower CRI value of 1.00, highlighting the severe effects of weed competition on the soybean crop, as noted by Gupta *et al.* (2019). The variation in growth of sedges with higher doses of pre-emergence application of Pyroxasulfone is attributed to higher absorption of herbicidal solution by infant weeds, aligning with the studies of Kumar *et al.* (2021).

Effect on yield of soybean

Significant influence of herbicidal application on soybean yield was recorded (**Table 2**). The use of 187.5 ml/ha of pyroxasulfone 85%WG (GSP sample) resulted in significant enhancement of both the grain yield (1264 kg/ha) and biological yield (3048 kg/ha) compared to other herbicidal treatments, and it was statistically at par with 150 ml/ha of pyroxasulfone 85%WG (GSP sample). This was attributed to maximum crop growth associated with higher dose of herbicide applied in T_3, which provides a relative weed free environment, thereby minimizing competition and promoting enhanced crop growth and yield. The results were corroborated with the findings of Kumar *et al.* (2021) who recorded significant difference in growth and yield attributes at different doses of Pyroxasulfone treatment in Maize crop. Conversely, the lowest yield was recorded under weedy check over herbicides application due to

Table 2. Effect of herbicides on *C. rotundus* indices and yield of soybean

Treatment	WCE (%)			CRI			WE (%)			Grain Yield (kg/ha)	Biological Yield (kg/ha)
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS		
Pyroxasulfone 85%WG (GSP sample) 120 ml/ha	29.4	30.6	35.4	2.63	2.17	2.36	70.6	69.4	64.6	1061	2768
Pyroxasulfone 85%WG (GSP sample)150 ml/ha	44.1	32.0	39.0	3.67	2.39	2.55	55.9	59.5	53.4	1223	2946
Pyroxasulfone 85%WG (GSP sample) 187.5 ml/ha	53.7	40.5	46.7	4.83	2.92	3.07	46.3	52.0	46.6	1264	3048
Pyroxasulfone 85%WG (Market sample) 150 ml/ha	7.4	13.3	22.3	1.44	1.36	1.72	92.6	86.7	77.7	1020	2672
Imazethapyr 1000 ml/ha	19.1	12.1	19.0	1.82	1.46	1.72	80.9	76.9	70.9	1003	2601
Hand weeding at 20 and 40 DAS	100.0	100.0	100.0	0.00	0.00	0.00	0.0	0.0	0.0	1316	3278
Control	0.0	0.0	0.0	1.00	1.00	1.00	100	100	100	852	2026



T_1-Pyroxasulfone 85%WG (GSP sample) 120 ml/ha, T_2-Pyroxasulfone 85%WG (GSP sample) 150 ml/ha, T_3-Pyroxasulfone 85%WG (GSP sample) 187.5 ml/ha, T_4-Pyroxasulfone 85%WG (Market sample) 150 ml/ha, T_5-Imazethapyr 1000 ml/ha, T_6-hand weeding at 20 and 40 DAS and T_7-Control.

Figure 2. Effect of herbicide on economics of soybean

heavy weed infestation and poor performance of yield attributes. Moreover, twice hand weeded plot recorded maximum biological yield (3278 kg/ha) than all other herbicidal treatments.

Although, maximum WE, grain and biological yield was achieved with twice hand weeded plots but it showed a lower net returns (10232 ¹ /ha) than 187.5 ml/ha of pyroxasulfone 85%WG (GSP sample) (19828 ¹ /ha) (**Figure 2**) due to high labour charges which ultimately increased the cultivation cost.

Based on the above results it is concluded that application of 187.5 ml/ha of pyroxasulfone 85%WG (GSP sample) had significantly reduced the density of *C. rotundus* with highest WCE and CRI as well as highest net returns. Hence, use of 187.5 ml/ha of Pyroxasulfone 85% WG (GSP sample) will prove to be an excellent weed control in soybean crop. Further, pyroxasulfone is also successful in supressing weeds for various other crops like corn, sunflower, peanuts, potatoes etc (Yamaji *et al.* 2014). Its low dosage, high activity, broad control and long-lasting effect can meet all the objectives of weed management. Moreover, involvement of agri-horti system in the present experiment will also prove beneficial to the farmers by increasing crop productivity and enhancing their net income compared to sole cropping.

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