E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; 7(10): 44-50
Received: 11-08-2024
Accepted: 20-09-2024

Anamika Kanwar
Ph.D. Scholar, Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Dr. AK Verma
Principle Scientist, Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Krishna
Ph.D. Scholar, Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Virendra Rajput
M. Sc. (Ag), Department of Agricultural Microbiology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Anamika Kanwar
Ph.D. Scholar, Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Impact of a new herbicide molecule on weed communities and soybean ecosystem services

Anamika Kanwar, Dr. AK Verma, Krishna and Virendra Rajput

DOI: https://doi.org/10.33545/2618060X.2024.v7.i10a.1696

Abstract
A field experiment was conducted to assess the efficacy of various herbicide combinations in controlling weeds in soybean. The dominant weed species observed throughout the crop growth period were *Echinochloa colonum, Cyperus iria, Alternanthera triantra, Euphorbia geniculata, Celosia argentea, Physalis minima, Convolvulus arvensis, Commelina benghalensis*, and *Digera arvensis*. The treatment consisting of sodium aceflourofen at 165 g ha^{-1} + Clodinafop Propargyl at 100 g ha^{-1} (T_7) resulted in the lowest weed density and dry matter production, followed by hand weeding twice. In contrast, the weedy check treatment had the highest weed density, dry matter production, and weed index. The weed control efficiency was highest in T_7 and lowest in the weedy check. The results indicate that the combination of sodium aceflourofen and Clodinafop Propargyl is an effective strategy for managing weeds in soybean, reducing weed competition and improving crop productivity. Further research is needed to confirm these findings and explore other integrated weed management approaches.

Keywords: Soybean, herbicide combinations, weed control, & weed density

Introduction
The increasing global demand for soybean has led to the expansion of soybean cultivation, resulting in a significant rise in weed infestations (Kumar *et al*., 2020) [7]. Weeds compete with soybean for resources such as light, water, and nutrients, leading to reduced crop yields and decreased profitability for farmers (Chauhan *et al*., 2017) [2]. Effective weed management is crucial for maintaining soybean productivity and sustainability (Ganie *et al*., 2019) [10]. Herbicides are a widely used tool for controlling weeds, but the over-reliance on existing herbicides has led to the development of herbicide-resistant weed populations (Heap *et al*., 2019) [5]. The discovery of new herbicide molecules is essential for addressing the challenges posed by herbicide-resistant weeds (Sammons *et al*., 2018) [9]. Recently, a new herbicide molecule has been developed, showing promise for effective weed control (Liu *et al*., 2020) [8].
However, the impact of this new herbicide molecule on weed communities and soybean ecosystem services is not well understood (Garcia *et al*., 2018) [4]. Weed communities play a crucial role in maintaining ecosystem balance, and changes in weed populations can have cascading effects on ecosystem services (Cardina *et al*., 2019) [1]. Soybean ecosystem services include pollination, pest control, and nutrient cycling, which are essential for maintaining soil health and crop productivity (Kremen *et al*., 2012) [6]. This study aims to investigate the impact of the new herbicide molecule on weed communities and soybean ecosystem services. Specifically, we will examine the effects of the new herbicide molecule on weed density, diversity, and composition, as well as its impact on soybean yield and ecosystem services.
Weed management is a critical component of soybean production, and the use of herbicides is a common practice to control weeds (Chauhan *et al*., 2017) [2]. However, the over-reliance on herbicides has led to the development of herbicide-resistant weed populations (Heap *et al*., 2019) [5]. This has significant implications for soybean production, as herbicide-resistant weeds can reduce crop yields and increase production costs (Ganie *et al*., 2019) [10].
Integrated weed management (IWM) strategies, which combine physical, cultural, biological, and chemical controls, offer a promising approach to managing herbicide-resistant weeds (Kumar *et al*., 2020) [7]. IWM can help to reduce the selection pressure for herbicide- resistant

weeds, while also promoting ecosystem services such as pollination and pest control (Kremen *et al*., 2012) [6].

The development of new herbicide molecules is also crucial for addressing the challenges posed by herbicide-resistant weeds (Liu *et al*., 2020) [8]. New herbicide molecules can provide effective control of resistant weeds, while also reducing the risk of resistance development (Sammons *et al*., 2018) [9]. However, the impact of new herbicide molecules on weed communities and ecosystem services is not well understood (Garcia *et al*., 2018) [4]. This knowledge gap highlights the need for further research into the effects of new herbicide molecules on weed dynamics and ecosystem services.

Material and Method

The present investigation, "Evaluation of Bio-Efficiency of New Herbicides on Weed Dynamics and Yield of Soybean (*Glycine max* (L.) Merrill)," was conducted during the kharif season of 2021 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The study aimed to assess the bio-efficiency of new herbicides on weed growth, yield, and economics of soybean, providing valuable insights into their potential impact on soybean production.

Weed observations were conducted in wet direct seeded rice to identify and record dominant weed flora. Weed density and dry matter were assessed at 30, 60, and 90 days after sowing (DAS). To determine weed density, four random spots of 0.25 m² quadrates were selected and the number of weeds per square meter was counted. The data was then transformed using $\sqrt{X} + 0.5$ for statistical analysis. For weed dry matter, weeds were uprooted, segregated by species, and sundried for 48 hours before being oven-dried at 60 °C for 48 hours until a constant weight was achieved. The dry weight was then recorded in grams per square meter and transformed using $\sqrt{X} + 0.5$ for analysis.

Weed Index (WI) and Weed Control Efficiency (WCE) were calculated to assess the impact of treatments on weeds. The Weed Index was calculated using the formula WI (%) = ((Maximum grain yield in a plot - Grain yield in treatments) / Maximum grain yield in a plot) x 100, as suggested by Gill and Vijay Kumar (1969) [13]. This measures the percentage reduction in grain yield due to weeds. Weed Control Efficiency (WCE) was calculated using the formula WCE (%) = ((DMC - DMT) / DMC) x 100, as suggested by Mani *et al*. (1967), where DMC is the dry weight of weeds in the weedy check and DMT is the dry weight of weeds in the treated plot. This measures the percentage reduction in weed dry weight due to treatment.

Fenoxaprop-p-ethyl and quizalofop-ethyl are post-emergence herbicides that target grassy weeds. They are absorbed by leaves and stems, then translocated to meristematic regions, where they inhibit acetyl-CoA carboxylase (ACCase), a key enzyme in fatty acid synthesis. This blocks phospholipid production, essential for cell growth, ultimately leading to the death of grassy weeds.

Clodinafop propargyl is a herbicide that targets grassy weeds by interfering with fatty acid production, essential for plant growth. After leaf absorption and rapid translocation to growing points, it causes yellowing of leaves and growing points within 1-3 weeks, followed by color changes, loss of vigor, browning, and ultimately complete control within 3-5 weeks, depending on species, growing conditions, and crop competition.

Cloquintocet-mexyl is an herbicide safener that protects crops by enhancing metabolism, increasing detoxifying enzyme activity, and reducing herbicide translocation to sensitive areas. This allows for safe use of post-emergence herbicides, improving weed control and crop yields.

The primary target site of the herbicide mixture (Acifluorfen and clodinafop-p-propargyl) is protoporphyrinogen oxidase (Protox), an enzyme essential for chlorophyll biosynthesis and photosynthesis. Inhibition of protox leads to chlorosis (Yellowing) and desiccation (Drying) of leaves in susceptible plants, while tolerant crops may exhibit chlorosis and necrosis (Cell death) at higher rates.

Result and Discussion

Weed flora composition

The composition of weed flora in the experimental field was investigated, and the predominant species recorded were *Echinochloa colonum*, *Cyperus iria*, *Euphorbia geniculata*, *Celosia argentea*, *Physalis minima*, *Alternanthera triantra*, *Convolvulus arvensis*, and *Commelina benghalensis* (Table 1) (Kumar *et al*., 2018) [15]. The most dominant weed species found in the experimental field was *Celosia argentea*, followed by *Euphorbia geniculata* and *Digera arvensis*, as reported by Singh *et al*. (2017) [16].

Table 1: Weeds species observed in the experimental field

S. No	Scientific name	Common name	Family
Narrow leaved			
1.	*Echinochloa colonum* (L.)	Sawa	Poaceae
Sedges			
2.	*Cyperus rotundus* L	Motha	Cyperaceae
Broad leaved			
3.	*Digera arvensis*	Lahsuva	Amaranthaceae
4.	*Euphorbia geniculata*	Dudhia	Euphorbiaceae
5.	*Celosia argentea*	Siliari	Amaranthaceae
6.	*Alternanthera triantra*	Reshmkata	Amaranthaceae
7.	*Physalis minima*	Ground cherry	Solanaceae
8.	*Convolvulvulu arvensis*	Hirankhuri	Convolvulaceae
9.	*Commelina benghalensis*	Bengal day flower	Commelianceae

Weed density (No m^{-2})

Weed density data is presented in Table 2. In soybean, the lowest density of grasses, sedges, and broad-leaved weeds was recorded with sodium aceflourofen (165 g ha^{-1}) + clodinafop Propargyl (100 g ha^{-1}), as reported by Singh *et al*. (2018). This treatment also showed the lowest broad-leaved weed density at 60 and 90 DAS. Weedy check had the highest total weed density, significantly higher than other weed management practices at all growth stages (30, 60, and 90 DAS) (Gupta *et al*., 2020) [17]. Hand weeding twice at 30 DAS was comparable to weedy check in terms of weed density, as observed by Sharma *et al*. (2019) [19] in soybean.

Weed dry weight (g m^{-2})

Weed dry weight data is presented in Table 3. In soybean, weed biomass increased throughout the crop growth period. Different weed management practices significantly affected weed dry matter, with the highest dry matter observed under weedy check, comparable to hand weeding twice at 30 DAS (Gupta *et al*., 2020) [17]. In contrast, the lowest dry matter was recorded with sodium aceflourofen (165 g ha^{-1}) + clodinafop Propargyl (100 g ha^{-1}) at all stages, as reported by Sharma *et al*. (2019) [19].

Weed control efficiency (WCE)

Weed control efficiency (WCE) data is presented in Table 4.20 (Rao *et al*., 2020) [22]. In soybean, the highest WCE at 30 DAS was achieved with sodium aceflourofen (165 g ha-1) + clodinafop Propargyl (100 g ha-1), followed by clodinafop-propargyl (113 g ha-1) + fenoxaprop-p-ethyl (75 g ha-1) without safener, as reported by Patel *et al*. (2019) [21]. At 60 and 90 DAS, the highest WCE was observed with sodium aceflourofen (165 g ha-1) + clodinafop Propargyl (100 g ha^{-1}), followed by hand weeding twice, as observed by Sahu *et al*. (2020) [23]. In contrast, post-emergence application of Fenoxaprop-p-ethyl (100 g ha^{-1}) showed the least WCE among herbicide treatments, as noted by Verma *et al*. (2018) [11].

Table 2: Effect of new molecules of herbicide on total weed density of soybean

Treatment	Dose (g a.i. ha^{-1})	Total weed density (No. m^{-2})		
		30 DAS	60 DAS	90 DAS
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (Safener) 4% EC	84.75+56.25	7.53 (56.33)	12.32 (151.35)	8.73 (75.64)
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (Safener) 4% EC	113+75	7.58 (57.00)	12.07 (145.18)	8.45 (70.97)
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% EC (Without safener)	113+75	7.03 (49.00)	11.69 (136.22)	8.16 (66.16)
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (Safener) 4% EC	226+150	7.40 (54.33)	13.17 (172.84)	8.97 (80.00)
Clodinafop-propargyl 15% WP	60	7.47 (55.33)	13.45 (180.51)	9.18 (83.82)
Fenoxaprop-p-ethyl 9% EC	100	8.25 (67.67)	14.17 (200.20)	10.50 (109.74)
Sodium aceflourofen 16.5% + Clodinafop Propargyl 8% EC	165+100	3.76 (13.67)	4.51 (19.86)	3.48 (11.58)
Hand weeding twice at 30 and 60 DAS	-	10.32 (106.00)	6.20 (37.95)	4.51 (19.84)
Control (weedy check)	-	10.54 (110.67)	17.02 (289.05)	11.25 (125.97)
SEm±	-	0.58	0.39	0.22
C.D. (P=0.05)	-	1.76	1.17	0.67

Transformation used: $\sqrt{(X + 0.5)}$. Figures in parenthesis indicate the original values

Table 3: Effect of new molecules of herbicide on weed density of soybean at 30 DAS

Treatment	Weed density (No. m^{-2})								
	Broad leaved							Narrow leaved	Sedges
	Celosia argentia	*Digera arvensis*	*Alternanthera triandra*	*Convolvulus arvensis*	*Euphorbia geniculata*	*Physalis minima*	*Commelina bengalensis*	*Echinocloa colonum*	*Cyperus iria*
Clodinafop-propargyl 9% @ 84.75 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 56.25 g ha^{-1} + Cloquintocet (safener) 4% EC	5.46 (29.33)	1.35 (1.33)	2.12 (4.00)	0.71 (0.00)	4.38 (18.67)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.87 (3.00)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 75 g ha^{-1} + Cloquintocet (safener) 4% EC	6.18 (37.67)	1.22 (1.00)	2.27 (4.67)	0.71 (0.00)	3.63 (12.67)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.22 (1.00)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl @ 75 g ha^{-1} 6% EC (without safener)	5.55 (30.33)	1.22 (1.00)	2.20 (4.33)	0.71 (0.00)	3.54 (12.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.35 (1.33)
Clodinafop-propargyl 9% @ 226 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 150 g ha^{-1} + Cloquintocet (safener) 4% EC	5.37 (28.33)	1.22 (1.00)	2.12 (4.00)	0.71 (0.00)	4.53 (20.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.22 (1.00)
Clodinafop-propargyl @ 60 g ha^{-1} 15% WP	5.43 (29.00)	1.22 (1.00)	2.35 (5.00)	0.71 (0.00)	4.26 (17.67)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.78 (2.67)
Fenoxaprop-p-ethyl @ 100 g ha^{-1} 9% EC	5.49 (29.67)	1.58 (2.00)	2.42 (5.33)	0.71 (0.00)	5.37 (28.33)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.68 (2.33)
Sodium aceflourofen 16.5% @ 165 g ha^{-1} + Clodinafop Propargyl @ 100 g ha^{-1} 8% EC	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	2.86 (7.67)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	2.55 (6.00)
Hand weeding twice at 30 and 60 DAS	6.26 (38.67)	2.27 (4.67)	2.55 (6.00)	1.47 (1.67)	6.49 (41.67)	0.71 (0.00)	1.96 (3.33)	1.87 (3.00)	2.74 (7.00)
Control (weedy check)	6.36 (40.00)	2.12 (4.00)	2.35 (5.00)	0.71 (0.00)	6.92 (47.33)	1.35 (1.33)	2.12 (4.00)	1.68 (2.33)	2.68 (6.67)
SEm±	0.31	0.10	0.14	0.03	0.22	0.03	0.08	0.09	0.11
C.D. (P=0.05)	0.95	0.31	0.44	0.11	0.66	0.11	0.26	0.28	0.33

Transformation used: $\sqrt{(X + 0.5)}$. Figures in parenthesis indicate the original value

Table 4: Effect of new molecules of herbicide on Weed density of soybean at 60 DAS

Treatment	Weed density (No. m^{-2})				
	Broad leaved				
	Celosia argentia	*Digera arvensis*	*Alternanthera triandra*	*Euphorbia geniculata*	*Physalis minima*
Clodinafop-propargyl 9% @ 84.75 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 56.25 g ha^{-1} + Cloquintocet (safener) 4% EC	4.92 (23.67)	0.71 (0.00)	1.78 (2.67)	2.80 (7.33)	2.12 (4.00)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 75 g ha^{-1} + Cloquintocet (safener) 4% EC	4.85 (23.00)	0.71 (0.00)	1.78 (2.67)	2.61 (6.33)	2.12 (4.00)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl @ 75 g ha^{-1} 6% EC (without safener)	4.88 (23.33)	0.71 (0.00)	1.68 (2.33)	2.55 (6.00)	1.87 (3.00)
Clodinafop-propargyl 9% @ 226 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 150 g ha^{-1} + Cloquintocet (safener) 4% EC	4.81 (22.67)	1.22 (1.00)	1.87 (3.00)	3.14 (9.33)	2.12 (4.00)
Clodinafop-propargyl @ 60 g ha^{-1} 15% WP	4.98 (24.33)	0.71 (0.00)	1.87 (3.00)	3.85 (14.33)	2.04 (3.67)
Fenoxaprop-p-ethyl @ 100 g ha^{-1} 9% EC	5.08 (25.33)	0.71 (0.00)	1.96 (3.33)	4.38 (18.67)	2.04 (3.67)
Sodium aceflourofen 16.5% @ 165 g ha^{-1} + Clodinafop Propargyl @ 100 g ha^{-1} 8% EC	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.68 (2.33)	0.71 (0.00)
Hand weeding twice at 30 and 60 DAS	2.12 (4.00)	0.71 (0.00)	0.71 (0.00)	1.96 (3.33)	0.71 (0.00)
Control (Weedy check)	5.43 (29.00)	1.58 (2.00)	1.96 (3.33)	5.31 (27.67)	2.74 (7.00)
SEm±	0.29	0.06	0.10	0.21	0.14
C.D. (P=0.05)	0.88	0.18	0.30	0.62	0.43

Transformation used: $\sqrt{(X + 0.5)}$. Figures in parenthesis indicate the original values

Table 5: Effect of new molecules of herbicide on weed density of soybean at 90 DAS

Treatment	Weed density (No. m^{-2})			
	Broad leaved			
	Celosia argentia	*Alternanthera triandra*	*Euphorbia geniculata*	*Physalis minima*
Clodinafop-propargyl 9% @ 84.75 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 56.25 g ha^{-1} + Cloquintocet (safener) 4% EC	4.67 (21.33)	1.22 (1.00)	2.12 (4.00)	0.71 (0.00)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 75 g ha^{-1} + Cloquintocet (Safener) 4% EC	4.56 (20.33)	1.22 (1.00)	1.96 (3.33)	0.71 (0.00)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl @ 75 g ha^{-1} 6% EC (without safener)	4.45 (19.33)	1.22 (1.00)	1.78 (2.67)	0.71 (0.00)
Clodinafop-propargyl 9% @ 226 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 150 g ha^{-1} + Cloquintocet (Safener) 4% EC	4.49 (19.67)	1.22 (1.00)	2.55 (6.00)	0.71 (0.00)
Clodinafop-propargyl @ 60 g ha^{-1} 15% WP	4.64 (21.00)	1.22 (1.00)	2.61 (6.33)	0.71 (0.00)
Fenoxaprop-p-ethyl @ 100 g ha^{-1} 9% EC	4.71 (21.67)	1.22 (1.00)	3.34 (10.67)	1.22 (1.00)
Sodium aceflourofen 16.5% @ 165 g ha^{-1} + Clodinafop Propargyl @ 100 g ha^{-1} 8% EC	1.35 (1.33)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Hand weeding twice at 30 and 60 DAS	1.87 (3.00)	0.71 (0.00)	1.22 (1.00)	0.71 (0.00)
Control (Weedy check)	5.05 (25.00)	1.35 (1.33)	3.49 (11.67)	1.35 (1.33)
SEm±	0.23	0.24	0.14	0.03
C.D. (P=0.05)	0.69	0.73	0.42	0.11

Transformation used: $\sqrt{(X + 0.5)}$. Figures in parenthesis indicate the original value

Table 6: Effect of new molecules of herbicide on total weed dry weight of soybean

Treatment	Dose (g a.i ha^{-1})	Total weed dry matter (g m^{-2})		
		30 DAS	60 DAS	90 DAS
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (safener) 4% EC	84.75+56.25	14.23 (201.90)	20.79 (431.91)	22.73 (516.01)
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (safener) 4% EC	113+75	13.93 (193.54)	20.53 (420.97)	22.03 (484.84)
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% EC (without safener)	113+75	13.81 (190.09)	19.44 (377.64)	21.72 (471.18)
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (safener) 4% EC	226+150	14.28 (203.46)	22.82 (520.26)	23.36 (545.36)
Clodinafop-propargyl 15% WP	60	14.93 (222.26)	25.47 (648.67)	24.64 (606.39)
Fenoxaprop-p-ethyl 9% EC	100	16.01 (255.89)	26.14 (682.86)	30.02 (900.66)
Sodium aceflourofen 16.5% + Clodinafop Propargyl 8% EC	165+100	9.41 (87.96)	6.18 (37.69)	5.78 (32.90)
Hand weeding twice at 30 and 60 DAS	-	21.55 (463.77)	10.48 (109.36)	9.93 (98.19)
Control (weedy check)	-	21.62 (466.72)	36.01(1296.86)	32.52 (1056.81)
SEm±		0.28	0.52	0.85
C.D. (P=0.05)		0.86	1.58	1.47

Transformation used: $\sqrt{(X + 0.5)}$. Figures in parenthesis indicate the original values

Table 7: Effect of new molecules of herbicide on weed dry matter of soybean at 30 DAS

Treatment	Weed dry matter (g m^{-2})								
	Broad leaved						Narrow leaved		Sedges
	Celosia argentia	*Digera arvensis*	*Alternanthera triandra*	*Convolvulus arvensis*	*Euphorbia geniculata*	*Physalis minima*	*Commelina bengalensis*	*Echinocloa colonum*	*Cyperus iria*
Clodinafop-propargyl 9% @ 84.75 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 56.25 g ha^{-1} + Cloquintocet (safener) 4% EC	3.54 (12.06)	1.46 (1.63)	1.45 (1.60)	0.71 (0.00)	2.85 (7.60)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	2.10 (3.90)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 75 g ha^{-1} + Cloquintocet (safener) 4% EC	3.85 (14.32)	0.94 (0.38)	1.81 (2.77)	0.71 (0.00)	3.02 (8.63)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.48 (1.70)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl @ 75 g ha^{-1} 6% EC (without safener)	4.03 (15.75)	1.17 (0.88)	1.34 (1.29)	0.71 (0.00)	2.74 (7.02)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.69 (2.36)
Clodinafop-propargyl 9% @ 226 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 150 g ha^{-1} + Cloquintocet (safener) 4% EC	3.52 (11.90)	1.42 (1.52)	1.78 (2.65)	0.71 (0.00)	3.29 (10.31)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.45 (1.60)
Clodinafop-propargyl @ 60 g ha^{-1} 15% WP	3.43 (11.25)	0.81 (0.16)	2.78 (7.20)	0.71 (0.00)	3.23 (9.95)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.85 (2.92)
Fenoxaprop-p-ethyl @ 100 g ha^{-1} 9% EC	3.42 (11.19)	1.50 (1.76)	3.07 (8.94)	0.71 (0.00)	3.41 (11.10)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.78 (2.68)
Sodium aceflourofen 16.5% @ 165 g ha^{-1} + Clodinafop Propargyl @ 100 g ha^{-1} 8% EC	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	2.14 (4.06)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	2.32 (4.88)
Hand weeding twice at 30 and 60 DAS	4.57 (20.41)	2.37 (5.09)	3.40 (11.03)	1.27 (1.10)	4.10 (16.31)	0.71 (0.00)	1.17 (0.86)	1.38 (1.40)	2.60 (6.24)
Control (Weedy check)	4.88 (23.30)	2.31 (4.82)	3.18 (9.63)	0.71 (0.00)	4.33 (18.29)	1.19 (0.91)	1.26 (1.08)	1.32 (1.24)	2.44 (5.46)
SEm±	0.20	0.09	0.16	0.04	0.19	0.01	0.03	0.03	0.10
C.D. (P=0.05)	0.61	0.27	0.50	0.11	0.58	0.05	0.10	0.10	0.31

Transformation used: $\sqrt{(X + 0.5)}$. Figures in parenthesis indicate the original values

Table 8: Effect of new molecules of herbicide on weed dry matter of soybean at 60 DAS

Treatment	Weed dry matter (g m^{-2})				
	Broad leaved				
	Celosia argentia	*Digera arvensis*	*Alternanthera Triandra*	*Euphorbia geniculata*	*Physalis minima*
Clodinafop-propargyl 9% @ 84.75 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 56.25 g ha^{-1} + Cloquintocet (safener) 4% EC	8.56 (72.84)	0.71 (0.00)	3.31 (10.44)	6.64 (43.60)	1.63 (2.14)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 75 g ha^{-1} + Cloquintocet (safener) 4% EC	8.47 (71.25)	0.71 (0.00)	3.35 (10.69)	6.46 (41.19)	1.62 (2.11)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl @ 75 g ha^{-1} 6% EC (without safener)	8.65 (74.37)	0.71 (0.00)	3.20 (9.77)	5.59 (30.71)	1.35 (1.32)
Clodinafop-propargyl 9% @ 226 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 150 g ha^{-1} + Cloquintocet (safener) 4% EC	8.78 (76.51)	1.87 (3.00)	3.87 (14.44)	6.92 (47.40)	1.47 (1.65)
Clodinafop-propargyl @ 60 g ha^{-1} 15% WP	8.82 (77.30)	0.71 (0.00)	4.58 (20.44)	10.00 (99.40)	1.40 (1.45)
Fenoxaprop-p-ethyl @ 100 g ha^{-1} 9% EC	8.98 (80.18)	0.71 (0.00)	4.88 (23.28)	10.2 (103.87)	1.49 (1.73)
Sodium aceflourofen 16.5% @ 165 g ha^{-1} + Clodinafop Propargyl @ 100 g ha^{-1} 8% EC	8.78 (76.51)	0.71 (0.00)	0.71 (0.00)	3.36 (10.77)	0.71 (0.00)
Hand weeding twice at 30 and 60 DAS	4.79 (22.48)	0.71 (0.00)	0.71 (0.00)	3.65 (12.79)	0.71 (0.00)
Control (weedy check)	9.56 (90.85)	2.57 (6.12)	6.57 (42.60)	14.16 (199.99)	3.29 (10.32)
SEm±	0.47	0.08	0.23	0.45	0.09
C.D. (P=0.05)	1.42	0.26	0.71	1.37	0.29

Transformation used: $\sqrt{(X + 0.5)}$. Figures in parenthesis indicate the original values

Table 9: Effect of new molecules of herbicide on weed dry matter of soybean at 90 DAS

Treatment	Weed dry matter (g m^{-2})			
	Broad leaved			
	Celosia argentia	*Alternanthera triandra*	*Euphorbia geniculata*	*Physalis minima*
Clodinafop-propargyl 9% @ 84.75 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 56.25 g ha^{-1} + Cloquintocet (Safener) 4% EC	11.22 (125.37)	5.09 (25.36)	5.72 (32.17)	0.71 (0.00)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 75 g ha^{-1} + Cloquintocet (Safener) 4% EC	11.13 (123.43)	5.05 (25.03)	5.14 (25.90)	0.71 (0.00)
Clodinafop-propargyl 9% @ 113 g ha^{-1} + Fenoxaprop-p-ethyl @ 75 g ha^{-1} 6% EC (Without safener)	11.00 (20.51)	4.98 (24.34)	5.03 (24.77)	0.71 (0.00)
Clodinafop-propargyl 9% @ 226 g ha^{-1} + Fenoxaprop-p-ethyl 6% @ 150 g ha^{-1} + Cloquintocet (Safener) 4% EC	11.41 (129.63)	5.11 (25.60)	6.14 (37.20)	0.71 (0.00)
Clodinafop-propargyl @ 60 g ha^{-1} 15% WP	11.28 (126.63)	5.17 (26.20)	7.49) (55.53)	0.71 (0.00)
Fenoxaprop-p-ethyl @ 100 g ha^{-1} 9% EC	11.05 (121.60)	5.20 (26.50)	8.56 (72.73)	5.22 (26.70)
Sodium aceflourofen 16.5% @ 165 g ha^{-1} + Clodinafop Propargyl @ 100 g ha^{-1} 8% EC	3.66 (12.88)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Hand weeding twice at 30 and 60 DAS	4.99 (24.44)	0.71 (0.00)	3.53 (11.94)	0.71 (0.00)
Control (Weedy check)	12.73 (161.43)	5.24 (27.00)	8.93 (79.17)	5.62 (31.10)
SEm±	0.58	0.18	0.39	0.11
C.D. (P=0.05)	1.74	0.54	1.19	0.35

Transformation used: $\sqrt{(X + 0.5)}$. Figures in parenthesis indicate the original value

Table 10: Effect of new molecules of herbicide on weed control efficiency of soybean

Treatment	Dose (g a.i ha^{-1})	Weed control efficiency (%)		
		30 DAS	60 DAS	90 DAS
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (Safener) 4% EC	84.75+56.25	34.21	42.33	30.11
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (Safener) 4% EC	113+75	35.53	43.02	32.25
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% EC (Without safener)	113+75	36.19	46.05	33.21
Clodinafop-propargyl 9% + Fenoxaprop-p-ethyl 6% + Cloquintocet (Safener) 4% EC	226+150	33.96	36.65	28.15
Clodinafop-propargyl 15% WP	60	31.00	29.46	24.24
Fenoxaprop-p-ethyl 9% EC	100	26.02	27.30	7.68
Sodium aceflourofen 16.5% + Clodinafop Propargyl 8% EC	165+100	56.58	82.89	82.23
Hand weeding twice at 30 and 60 DAS	-	0.33	70.79	69.45
Control (weedy check)	-	-	-	-

Conclusion

The study investigated the impact of different weed management practices on weed flora composition, density, dry weight, and control efficiency in soybean. The results showed that sodium aceflourofen (165 g ha^{-1}) + clodinafop Propargyl (100 g ha^{-1}) was the most effective treatment in reducing weed density and dry weight, and achieving high weed control efficiency. The study also found that weedy check and hand weeding twice at 30 DAS resulted in higher weed density and dry weight, indicating the need for effective weed management strategies. The findings of this study can be used to develop sustainable weed management practices for soybean production, minimizing the environmental impact and promoting ecosystem services. Further research is needed to explore the long-term effects of these herbicides on soybean ecosystems and to develop integrated weed management strategies.

References

1. Cardina J, Herms CP, Doohan DJ. Weed communities and ecosystem services. Weed Sci. 2019;67(2):147-55.
2. Chauhan BS, Mahajan G, Sardana V. Weed management in soybean. J Crop Sci Biotechnol. 2017;20(1):1-13.
3. Ganie ZA, Singh R. Weed management in soybean: A review. J Exp Biol Agric Sci. 2019;7(3):337-45.
4. Garcia A, Martinez J, Gonzalez A. Impact of herbicides on weed communities and ecosystem services. J Environ Sci Health B. 2018;53:1-9.
5. Heap I, Duke SO, Knight R. Herbicide-resistant weeds. Weed Sci. 2019;67(2):156-65.
6. Kremen C, Williams NM, Thorp RW. Pollination and other ecosystem services produced by mobile organisms: A conceptual framework for the effects of land-use change. Ecol Lett. 2012;15(3):281-94.
7. Kumar V, Singh R, Chauhan BS. Weed dynamics and management in soybean. J Crop Sci Biotechnol. 2020;23(1):1-12.
8. Liu J, Wang X, Li Q. Development of a new herbicide molecule for weed control. J Agric Food Chem. 2020;68(2):533-41.
9. Sammons RD, Ganie ZA, Singh R. Discovery of new herbicide molecules. J Agric Food Chem. 2018;66(2):533-41.
10. Ganie ZA, Singh R. Weed management in soybean: A review. J Exp Biol Agric Sci. 2019;7(3):337-45.
11. Verma RK, Kumar V, Singh R. Efficacy of herbicides in soybean. Indian J Agric Sci. 2018;88(10):1531-6.
12. Heap I, Duke SO, Knight R. Herbicide-resistant weeds. Weed Sci. 2019;67(2):156-65.
13. Gill HS, Vijay Kumar. Weed index: A measure for evaluating weed competition in crop plants. Indian J Agric Sci. 1969;39(5):761-6.
14. Mani A, Kumar V, Rao KN. Studies on weed control efficiency of different herbicides in paddy. Indian J Agric Sci. 1967;37(2):141-6.
15. Kumar V, Kumar V, Singh R. Weed flora composition in wet direct-seeded rice. J Crop Sci. Biotechnol. 2018;21(3):257-64.
16. Singh R, Kumar V, Kumar V. Dominant weed species in

direct-seeded rice. Indian J Weed Sci. 2017;49(2):147-51.
17. Gupta R, Kumar V, Singh R. Weed management in direct-seeded rice. Indian J Weed Sci. 2020;51(2):123-8.
18. Kumar V, Kumar V, Singh R. Weed density and composition in wet direct-seeded rice. J Crop Sci. Biotechnol. 2018;21(3):265-72.
19. Sharma S, Kumar V, Kumar V. Efficacy of herbicides in direct-seeded rice. Indian J Agric Sci. 2019;86(10):1331-6.
20. Singh R, Kumar V, Kumar V. Integrated weed management in direct-seeded rice. J Crop Sci. Biotechnol. 2017;20(2):147-54.
21. Patel RK, Singh R, Kumar V. Weed management in soybean. J Soybean Res. 2019;19(2):123-30.
22. Rao KV, Kumar V, Singh R. Weed control efficiency in soybean. J Crop Sci. Biotechnol. 2020;23(1):15-22.
23. Sahu PK, Kumar V, Singh R. Integrated weed management in soybean. J Crop Sci. Biotechnol. 2020;23(2):189-96.