JSAES
Journal of Sustainable Agricultural and Environmental Sciences

Print ISSN : 2735-4377
Online ISSN : 2785-9878
Homepage: https://jsaes.journals.ekb.eg/

Research Article

Evaluation of Weed Control Treatments on Growth, Quality and Productivity of Soybean and Associated Weeds

El-Seidy, E.H.[1], Soliman, I.E.[2] and Dawoud, F. E.[1,*]

[1] Department of Agronomy, Faculty of Agriculture, Tanta University, Egypt.
[2] Weed Research Central Laboratory, Agriculture Res. Center, Giza, Egypt.
* Correspondence: Dawoud, F. E.

Article info: -
- **Received:** 1 July 2025
- **Revised:** 27 July 2025
- **Accepted:** 31 July 2025
- **Published:** 1 August 2025

Keywords:
Soybean (*Glycine max, L.*); weeds; weed control treatments; Herbicides (Stomp Extra + Fusilade forti + Basagran + Select super); residues.

Abstract:

This study was carried out during the 2022 and 2023 seasons at Sakha Agriculture Research Station, Agriculture Research Center, Egypt. The experiment was conducted to study the effect of integrated control of weeds in soybean fields, growth characters, yield components of soybean (*Glycine max*, L.) and determination of herbicide residues in soybean seeds. The field experiment was laid out in a randomized complete blocks design (RCBD) with four replicates. The results indicated that is possible to use one of the weed control treatments in heavy infested soil with weeds. (Stomp Extra 45.5 % at the rate of 1.5 L/fed.+ Fusilade forti 15% at the rate of 1.4 L/fed.) or (Basagran 48% at the rate of 0.5 L/fed + Select super 12.5% at the rate of 0.25 L/fed.) or (Stomp Extra 45.5 % CS at the rate of 1.5 L/fed. + hand hoeing) or (Basagran 48% at the rate of 0.5 L/fed + hand hoeing)), which, recorded the best weed control and highest increase of soybean seed yield (ton/fed), and- enhanced oil and protein percentages as compared to the untreated control, without any residues in seeds of soybean after harvest.

1. Introduction

Soybean (*Glycine max*, L.) is one of the most important legume crops worldwide, with a harvested area of 129.5 million ha and total production of 371.7 million ton with an average yield of 2.87 ton/ ha (1.21 ton/fed). Globally, soybean has become the main source of vegetable oil and protein. Its needs contain about 40% of protein and 20% of oil, representing 61% of the world's oil seed production (ASA, 2022). In Egypt, soybean is significant in preserving food security because of its high-quality vegetable oil and protein. The cultivated area in 2022 was 31 thousand feds, which produced 36 thousand tons, by an average of 1.16 ton/fed. (The yearly book of economic and statistics of the Ministry of Agriculture in Egypt 2022). Weeds strongly compete with soybean plants for moisture, light, nutrients and space that limit the crop yield, increase production costs paid for irrigation, harvesting and weed controlling, thus reduce crop yield from 37 to 52% in soybean even with advanced technology applied as in USA (Soltani *et al*., 2017), but in India, weeds cause 31% yield loss in soybean (Gharde *et al.,* 2018). Stomp Extra combined with hand hoeing or Basagran with hand hoeing, greatly enhanced plant growth and yield components. It is generally known that weed competition lowers soybean seeds' protein and oil content. The data obtained in this study agree with the results due to limited nutrient availability and reduced photosynthesis. Therefore, better weed control improves seed quality by increasing protein and oil levels, (Rupareliya *et al*., 2020).

Hand hoeing treatments, whether applied alone or in combination with herbicides, consistently enhanced soybean seed quality by improving chlorophyll content, nutrient accumulation, and oil and protein percentages. These results highlight the crucial role of manual weeding in supporting effective weed management and optimizing crop performance. Integrated use of herbicides with different modes of action efficiently controlled weeds and gave better seed yield than their application (Peer *et al*., 2013 and Vazquez-Garcia *et al*., 2020). Using pendimethaline or bentazone + clethodium on soybean weed control gave the highest yield and weed control as compared to hand hoeing twice or the un-weeded check (Soliman *et al*., 2015).

Several recent studies have highlighted the effectiveness of herbicides and manual hoeing in controlling weeds and improving soybean yield. (Soliman and Hamza, 2016) demonstrated that using Stomp Extra and Basagran with hand hoeing significantly reduced both fresh and dry weight of grassy and broad-leaved weeds, improving crop growth. (Fakkar and El-Dakkak, (2015)) confirmed that combining herbicides such as Basagran and Select Super with manual hoeing under high plant density resulted in optimal weed suppression and better yield performance. Savaliya *et al*., (2017) showed that two sessions of hand hoeing and applying Pendimethalin and Quizalofop-ethyl provided effective weed control in soybean fields. Dykun *et al*., (2020) assessed using post-emergence herbicides such as Bentazon and Imazamox, effectively decreasing the density and biomass of broad-leaved weeds in legumes. Nagar, (2017) also confirmed that manual hoeing combined with Pendimethalin application successfully minimized weed infestation and promoted crop development. Additionally, studies by Raj *et al.*, (2020) and Meseldžija *et al.*, (2020) demonstrated that Pendimethalin and Imazethapyr effectively lowered weed population and biomass, increasing soybean productivity.

Therefore, study's main objective was to evaluate the effect of integrated control of weeds in soybean fields, growth characters, yield components of soybean (*Glycine max,* L.) and determination of herbicide residues in soybean seeds.

2. Materials and Methods

This study was carried out during both the 2022 and 2023 summer seasons at Sakha Agriculture Research Station, Agriculture Research Center, Egypt, to study the effect of different treatments on weeds, quality and productivity of soybean crop and determination of herbicide residues in soybean seeds. The field experiment was laid out in a randomized complete blocks design (RCBD) with four replicates. The plot area was 18 m^2 (5 ridges with 6 m long and 60 cm apart).

Treatments were as follows:

1. Stomp Extra 45.5% CS (Pendimethalin) at the rate of 1.5 L/fed. Applied surface spray before irrigation and before sowing + hand hoeing after 30 days after sowing.
2. Stomp Extra 45.5% CS (Pendimethalin) at the rate of 1.5 L/fed. Applied surface spray before irrigation and before sowing + Fusilade forti 15% EC (fluazifop- p-butyl) at the rate of 1.4 L/fed. Applied after 30 days from sowing.
3. Basagran 48% AS (bentazon) at the rate of 0.5 L/fed Applied at 21 days after sowing + hand hoeing after 30 days after sowing.
4. Basagran 48% AS (bentazon) at the rate of 0.5 L/fed Applied 21 days after sowing + Select super 12.5% EC (clethodim) at 0.25 L/fed. Applied 30 days after sowing.
5. Hand hoeing twice at 21 and 35 days after sowing.
6. Control (untreated).

The soil texture in both experiments was clay loam. Chemical and physical analyses of the soil were carried out according to Jackson (1973), and data are shown in Table 1.

Table 1. Mechanical and chemical analysis of soil.

Season	Organic matter %	Soil pH	Sand %	Silt %	Clay %	Textural class	N (ppm)	P (ppm)	K (ppm)
2022	1.81	7.9	20.00	33.81	51.43	Clay	27.15	16.90	280.0
2023	1.73	7.88	19.27	29.91	49.40	Clay	22.37	18.45	277.10

2.1. Herbicides

Four herbicides were tested in the experiment as individually, trade name, common name, Rate/fed, IUPAC names, Chemical group, Mode of action and PHI (It's the period that must pass between the application of a pesticide (or other chemical) and when a crop can be safely harvested) of the used herbicides are given in Table (2). The herbicides in both experiments were sprayed by a Knapsack sprayer (CP3 with water volume 200 liters / fed) in both seasons. Seeds of soybean (*Glycine max* L.) were sown in hills.

The cultivated variety was Giza 111. The previous crop in the two seasons was wheat. The sowing dates were achieved on 1st and 15th June in the 2022 and 2023 seasons, respectively. The crop was sown at a seed rate of 30 kg per fed. Sowing was carried out manually after thorough land preparation, including plowing and leveling to create a suitable seedbed. The land was then laid out and divided into basins. A pre-irrigation was applied before sowing. Fertilization was carried out by applying 150 kg/fed of single super phosphate (15% PO) at sowing, along with 15–20 kg/fed of nitrogen in the form of ammonium nitrate (33.5%) to promote early growth. Additionally, 50 kg/fed of potassium sulfate (48% KO) was applied before the first irrigation. Irrigation was carried out every 12–15 days.

Table 2. Trade name, Common name, Chemical name and PHI for tested herbicides.

	Trade name	Common name	Chemical name	PHI
1	Stomp Extra 45.5 % CS	Pendimethalin	N-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine	60 days
2	Basagran 48% As	Bentazone	3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide	50 days
3	Select super 12.5 % EC	Clethodim	(±)-2-[(E)-1-[(E) -3-chloroallyloxyimino] propyl]-5-[2-(ethylthio) propyl]-3-hydroxycyclohex-2-enone	35 days
4	Fusilade Forti 15% EC	fluazifop- p- butyl	Butyl(R)-2-[4-Y[5-(trifluoromethyl)-2- pyridinyl] oxy] phenoxy] propionate	56 days

Table 3. Scientific, English and family names for weed accompanied soybean crop in the experimental site during the2022 and 2023 seasons.

Weed types	Scientific name	English name	Family name
Broad- leaved weeds	*Portulaca oleracea*	Common Purslane	Portulacaceae
	Xanthium strumarium	Cocklebur	Compositae
	Amaranthus ascendens	Celosia argentea	Amaranthaceae
	Corchorus olitorius	Jews mallow	Tiliaceae
Grassy weeds	*Echinochloa crusgallli.*	Chinochloacrrus-galli	Gramineae
	Digitarias anguinalis	Crab grass	Gramineae

2.2. Data recorded

The dominant weed species counted in the experimental plots in both seasons are shown in Table (3).

2.2.1. On weeds

Weeds were hand-pulled randomly from one square meter in each plot at 55 and 75 days after sowing. The weeds were identified into species and classified into broad- leaved, grassy and total weeds. The dry weight of the weeds was determined after drying them in an oven at 70 °C for 72 hours. The weight of each species was determined (g/m^2):

- Fresh weight of broad- leaved weeds (g/m^2)
- Dry weight of broad- leaved weeds (g/m^2)
- Fresh weight of grassy weeds (g/m^2)
- Dry weight of grassy weeds (g/m^2)
- Fresh weight of total annual weeds (g/m^2)
- Dry weight of total annual weeds (g/m^2)

The effect of study treatments on weeds will be estimated as % reduction, which will be calculated as follows:

Formula: Reduction% (R%) = (untreated – treated)/ untreated) x100

2.2.2. Yield and its components of soybean:

The samples of ten soybean plants were taken randomly from each plot at harvest. Plants of three inner rows for each plots were harvested to determine the following parameters:

1. Soybean plant height (cm).
2. Number of branches/plant
3. Number of pods/plant.
4. Pods weight /plant (g).
5. Seeds weight /plant (g)
6. Weight of 100 seeds (g).
7. Seeds yield weight (ton/fed)
8. Soybean seeds yield (ton/ fed). It will be recorded from the seeds of harvest plants / plot and converted to t/fed.

The effect of the study treatments on soybean plants will be estimated as % improvement, which will be calculated as follows:

Improvement% (I%) = (treated - untreated/ treated) x100

2.3. Crude protein content

Total nitrogen was determined according to the improved Kjeldahl methods of the Association of Official Agricultural Chemicals (A.O.A.C., 1990). Crude protein was calculated by multiplying total nitrogen by 6.25. Crude protein was determined in the Soil, Water and Environment Research Institute, Department of Soil Fertility and Plant Nutrition, Sakha Agriculture Research Station, Kafr El-Sheikh, Egypt.

2.4. Oil content (%)

Oil content of soybean seeds was determined the Soxhlet apparatus on a dry weight basis as described by De Castro and Priego-Capote (2010). Oil content was determined in the Field Crops Res. Institute, Crops Legume Res. Section, Sakha Agricultural Station, Kafr El-Sheikh, Egypt.

2.5. Determination of herbicide residues

In the second season, the herbicide residues for Stomp Extra (pendimethalin), Basagran (bentazone), select super (clethodim) and Fusilade Forti (fluazifop-p-butyl), in soybean seeds were analyzed by using a Chromatographic HPLC system according to Nguyen *et al*.; (2008), in the Central Laboratory of Pesticides, Agriculture Research Center, Dokki, Giza, Egypt, by HPLC.

2.6. Statistical analysis

The collected data were subjected to proper statistical analysis of each plot according to the procedure outlined by Snedecor and Cochran (1980). Means were compared at 5% significance level by the least significant difference (L.SD) test. All statistical analysis was performed using the analysis of variance technique using the COSTAT computer software package.

The field experiments were conducted during the summer seasons of 2023 and 2024 at the experimental farm of Sakha Agriculture Research Station, Kafr El-Sheikh Government. This study collaboration with the weed Research Central Laboratory, Agricultural Research Center and Agronomy department, faculty of Agriculture Tanta University, Egypt, to study the effect of integrated control of weeds in soybean fields, growth characters, yield components of soybean (*Glycine max*), and determination of herbicide residues in soybean seeds.

3. Results and Discussion

3.1. Effect of weed control treatments on weeds:

3.1.1. Fresh weight of weeds (g/m^2) at 55 days from sowing

The data in Table 4 and Figure 1 indicate that there were significant differences among weed control treatments in reducing weed biomass at 55 days after sowing. The untreated control consistently exhibited the highest fresh weight of weeds, with total biomass reaching 1062.53 g/m² and 1995.12 g/m² in the first and second season, respectively. In contrast, all tested weed management practices resulted in substantial reductions in grassy and broad-leaved weed populations. Among these, the treatment combining Basagran with hand hoeing showed superior performance, with total weed biomass reduced to 115.02 g/m² and 390.67 g/m², and corresponding weed control efficiencies (R%) of 89.17% and 80.42%, suggesting its high effectiveness in integrated weed suppression.

Comparable efficacy was observed for Stomp Extra combined with hand hoeing and Stomp Extra with Fusilade forti, both of which significantly lowered total weed biomass to approximately 118.53 g/m² in the first season and slightly above 388–401 g/m² in the second. The R% values for these treatments ranged between 88.84% and 80.51%, confirming their reliable performance under field conditions. Basagran + Select super also provided effective control, although slightly less efficient in the second season, particularly against broad-leaved weeds, resulting in a marginally higher total weed biomass and a lower R% of 79.43%.

Hand hoeing alone, still reducing weed biomass significantly compared to the control, was the least effective among the treated options, with total weed biomass values of 168.45 g/m² and 466.09 g/m², and R% values of 84.15% and 76.64%. These results emphasize combining chemical and mechanical methods for optimal weed management. These results are the same trend as Fakkar and El-Dakkak (2015) who revealed that weed control treatments significantly decreased the fresh weight of grassy weed (g/m^2) in both seasons. Applying hand hoeing at 45 DAS and Basagran at 500 cm3/fed + select super at 500 cm3/fed resulted in the highest reduction of the fresh weight of grassy (g/m^2) in both growing seasons.

Table 4. Effect of weed control treatments on fresh weight (g/m²) at 55 days after sowing during the 2022 and 2023 seasons.

Weed control treatments	Fresh weight of weeds							
	Grassy weed (g/ m^2)		Broad-Leaved weeds (g/ m^2)		Total weeds (g/m^2)		Reduction %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Stomp Extra +Hand hoeing	32.93	106.57	85.49	282.34	118.42	388.75	88.85	80.51
Stomp Extra + Fusilade forti	24.35	100.89	94.18	300.39	118.53	401.28	88.84	79.89
Basagran + Hand hoeing	26.75	104.72	88.27	285.94	115.02	390.67	89.17	80.42
Basagran + Select super	22.67	99.86	101.22	298.18	123.89	410.46	88.34	79.43
Hand hoeing	50.83	123.35	117.62	286.78	168.45	466.09	84.15	76.64
Control (Untreated)	528.09	912.92	534.45	1250.04	1062.53	1995.12	0.00	0.00
L. S. D. at 5% level	0.11	0.7	0.38	0.45	0.43	0.96		

1st= First season, 2nd = second season

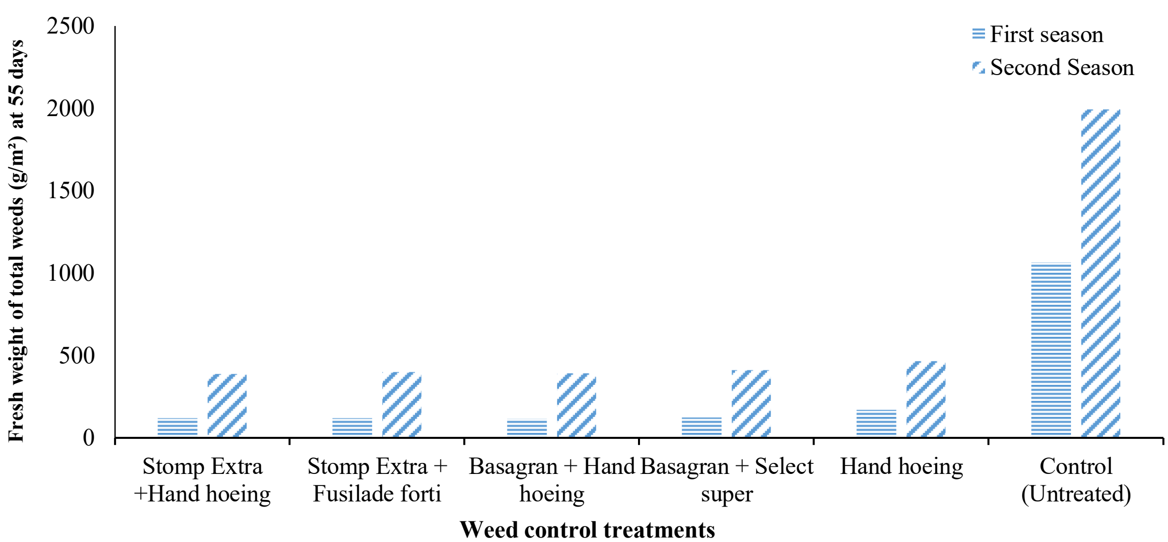

Figure 1. Effect of weed control treatments on fresh weight of total weeds (g/m²) at 55 days from sowing during the2022 and 2023 seasons.

3.1.2. Fresh weight of weeds (g/m²) at 75 days from sowing

Table 5 and Fig. 2 showed that at 75 days after sowing, the data reflect clear and statistically significant differences in weed control efficacy among the various treatments, as demonstrated by the reductions in fresh weed biomass compared to the untreated control. The control plots recorded the highest fresh weight of grassy and broad-leaved weeds, reaching 1306.81 g/m² and 1508.74 g/m² in 2022, and 2306.63 g/m² and 3725.96 g/m² in 2023. These values culminated in total weed biomasses of 3112.47 g/m² and 4677.27 g/m², highlighting the severity of weed infestation in the absence of management. In contrast, all applied treatments substantially suppressed weed growth.

Among the treatments, hand hoeing alone resulted in the greatest overall weed suppression, reducing total weed biomass to 231.70 g/m² and 956.08 g/m², with corresponding control efficiencies (R%) of 92.56% and 79.56%. This underscores the effectiveness of mechanical weed management even when used without herbicides. However, the integration of chemical and mechanical methods also produced strong outcomes. For example, combining Stomp Extra with hand hoeing led to total weed biomasses of 274.64 g/m² and 1095.7 g/m², achieving R% values of 91.18% and 76.57%. Similarly, Basagran combined with hand hoeing also showed high efficiency, with total weed weights of 325.71 g/m² and 1009.46 g/m², and R% of 89.54% and 78.42%.

Stomp Extra combined with Fusilade forti and Basagran with Select super were also slightly less effective. These treatments reduced weed biomass to 302.82–382.26 g/m² and 1142.05–1055.85 g/m² across both replicates, with weed control efficiencies between 87.72% and 90.27%. While all integrated treatments demonstrated significant reductions in weed populations, slight variations in performance may be attributed to differences in herbicide modes of action, weed species composition, or environmental interactions influencing efficacy. These results are confirmed by (Meseledzija *et al.*, 2020) and (Raj *et al.*, 2020) who found that application of pendimethalin and imazethapyr recorded the reduced weed number population/m² by 67.2%, fresh weed of weeds/m² by 45.8% at 60 days from sowing.

Table 5. Effect of weed control treatments on fresh weight (g/m²) at 75 days after sowing during the 2022 and 2023 seasons.

weed control treatments	Fresh weight of weeds							
	Grassy weed(g/m2)		Broad-Leaved weeds(g/m2)		Total weeds(g/m2)		R%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season
Stomp Extra +Hand hoeing	108.54	326.94	166.10	768.77	274.64	1095.70	91.18	76.57
Stomp Extra + Fusilade forti	115.00	344.27	187.82	797.77	302.82	1142.05	90.27	75.58
Basagran + Hand hoeing	95.37	306.58	230.34	702.88	325.71	1009.46	89.54	78.42
Basagran + Select super	111.67	338.49	259.51	717.37	382.26	1055.85	87.72	77.43
Hand hoeing	71.11	258.38	316.71	697.70	231.70	956.08	92.56	79.56
Control (Untreated)	1306.81	2306.63	1508.74	3725.96	3112.47	4677.26	0.00	0.00
L. S. D. at 5% level	0.16	0.55	0.88	0.24	0.74	0.35		

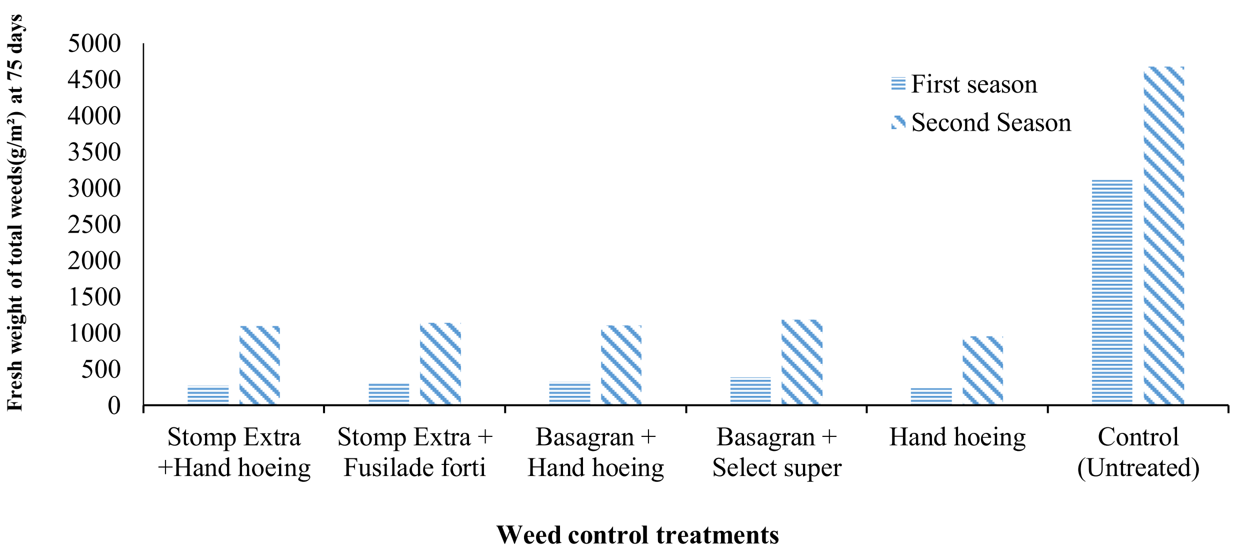

Figure 2. Effect of weed control treatments on fresh weight of total weeds (g/m²) at 75 days from sowing during the 2022 and 2023 seasons.

3.1.3. Dry weights of weeds (g/m²) at 55 days from sowing:

The data in Table 6 indicate that the dry weight measurements of both grassy and broad-leaved weeds indicate significant differences among the weed control treatments, with all treatments showing a considerable reduction compared to the untreated control. The untreated plots exhibited the highest dry weed biomass, recording 97.25 g/m² and 345.62 g/m² for grassy weeds, and 116.55 g/m² and 549.41 g/m² for broad-leaved weeds, in the first and second replicates, respectively. This resulted in total weed dry weights of 213.79 g/m² and 1000.72 g/m², underscoring the intensity of weed infestation in the absence of any control measures.

In contrast, integrated treatments combining herbicides with hand hoeing demonstrated superior weed suppression. The combination of Basagran + Hand hoeing achieved the lowest total dry weed weight (30.38 g/m² and 225.74 g/m²), and the highest reduction percentages of 85.79% and 77.44%. Similarly, the Stomp Extra + Hand hoeing treatment showed strong efficacy with total dry weights of 32.77 g/m² and 226.17 g/m², and corresponding reduction percentages of 84.67% and 77.40%. These results highlight the effectiveness of combining mechanical and chemical methods in managing grassy and broad-leaved weeds.

Treatments involving only chemical herbicides, such as Basagran + Select super and Stomp Extra + Fusilade forti, were also effective, although slightly less so. Their total dry weed weights ranged between 32.92–34.46 g/m² and 236.23–246.45 g/m², with reduction percentages from 83.88% to 84.60% in the first replicate, and 75.37% to 76.39% in the second. Hand hoeing alone, while effective, was relatively less efficient, resulting in total weed dry weights of 39.35 g/m² and 264.46 g/m², and reduction percentages of 81.59% and 73.57%. These results agree with (Fakkar and El-Dakkak, 2015) and (Soliman and Hamza, 2016), who indicated that the highest weed control efficiency was recorded under post and pre-emergence application.

Table 6. Effect of weed control treatments on dry weight (g/m²) at 55 days from sowing during the 2022 and 2023 seasons.

Weed control treatments	Dry weight of weeds(g/m²) at 55 days after sowing							
	Grassy weed (g/m²)		Broad-Leaved weeds (g/m²)		Total weeds (g/m²)		R%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season
Stomp Extra +Hand hoeing	12.29	64.27	20.48	161.91	32.77	226.17	84.67	77.40
Stomp Extra + Fusilade forti	10.65	69.63	22.28	166.60	32.92	236.23	84.60	76.39
Basagran + Hand hoeing	9.37	64.90	21.01	160.84	30.38	225.74	85.79	77.44
Basagran + Select super	11.62	76.12	22.84	170.33	34.46	246.45	83.88	75.37
Hand hoeing	13.89	80.03	25.46	184.43	39.35	264.46	81.59	73.57
Control (Untreated)	97.25	345.62	116.55	549.41	213.79	1000.72	0.00	0.00
L. S. D. at 5% level	0.10	0.35	0.62	0.19	0.62	0.21		

3.1.4. Dry weights of weeds (g/m²) at 75 days from sowing

The results in Table 7 and Fig. 3 showed significant differences in the dry weight of grassy and broad-leaved weeds among the weed control treatments. The untreated control plots exhibited the highest weed biomass, reaching 301.67 and 859.22 g/m² for grassy weeds, and 343.38 and 1065.27 g/m² for broad-leaved weeds in the first and second replicates, respectively. This resulted in total weed dry weights of 880.44 and 2205.28 g/m², confirming the need for effective weed management strategies to reduce weed pressure and its potential negative impact on crop performance.

All weed control treatments, significantly reduced the dry weight of weeds compared to the control. Among the integrated treatments, "Basagran + hand hoeing" achieved the most significant reduction in total weed biomass, recording 83.59 and 407.22 g/m² in the first and second replicates, respectively, with the highest reduction percentages of 90.51% and 81.53%. Combining chemical and mechanical methods can be particularly effective in long-term weed suppression. Similarly, the treatment of "Stomp Extra + hand hoeing" also showed a strong effect, reducing total weed dry weights to 88.23 and 417.84 g/m², corresponding to 89.98% and 81.05% reduction percentages.

Other chemical-based treatments such as "Basagran + Select Super" and "Stomp Extra + Fusilade Forti" were also effective, achieving total weed reductions ranging from 88.89 to 94.07 g/m² in the first replicate and 432.66 to 436.11 g/m² in the second. These treatments maintained high reduction percentages (above 89% in the first replicate and around 80% in the second), confirming their continued efficacy. Hand hoeing alone showed slightly lower performance, with total weed dry weights of 90.85 and 437.15 g/m², and corresponding reductions of 89.68% and 80.18%, suggesting that while effective, manual methods may be more efficient when integrated with chemical options.

The statistical significance of differences between treatments, supported by the LSD values at the 5% level, underlines the consistent advantage of integrated weed management. These findings highlight the importance of combining mechanical and chemical control measures to sustain weed suppression and minimize crop competition during critical growth stages. Such integrated approaches can improve crop yield potential and sustainably and environmentally responsibly maintain field cleanliness.

Table 7. Effect of weed control treatments on dry weight (g/m²) at 75 days from sowing during the 2022 and 2023 seasons.

Weed control treatments	Dry weight of weeds							
	Grassy weed (g/m2)		Broad-Leaved weeds (g/m2)		Total weeds(g/m2)		R%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season
Stomp Extra +Hand hoeing	41.11	144.89	47.11	272.95	88.23	417.84	89.98	81.05
Stomp Extra + Fusilade forti	39.44	153.37	49.44	279.29	88.89	432.66	89.90	80.38
Basagran + Hand hoeing	35.69	136.14	47.90	271.08	83.59	407.22	90.51	81.53
Basagran + Select super	43.33	157.24	50.74	278.86	94.07	436.11	89.32	80.22
Hand hoeing	39.06	152.91	51.80	292.48	90.85	437.15	89.68	80.18
Control (Untreated)	301.67	859.22	343.38	1065.27	880.44	2205.28	0.00	0.00
L. S. D. at 5% level	0.19	0.54	0.75	0.14	0.13	0.35		

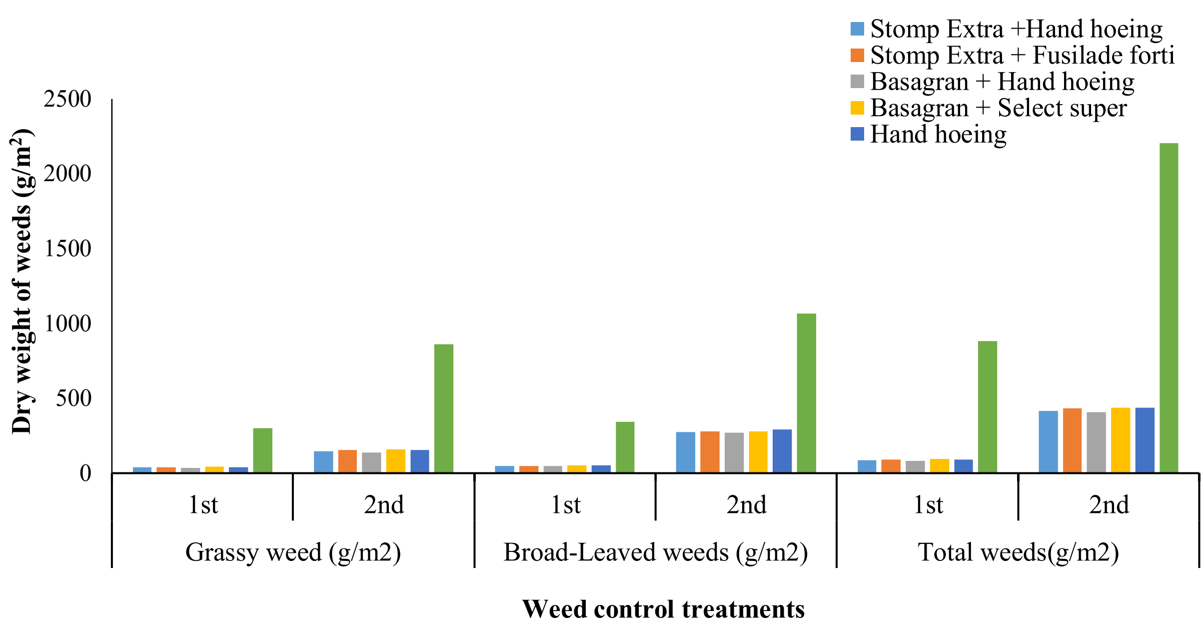

Figure 3. Effect of weed control treatments on dry weight (g/m²) at 75 days from sowing during the 2022 and 2023 seasons.

3.2. Yield and its components

3.2.1. Yield components

Table 8 showed the influence of weed control treatments on various crop morphological and yield-related traits over the 2022 and 2023 seasons. All treated plots demonstrated superior performance in plant height, number of branches per plant, pod and seed development metrics compared to the untreated control. The untreated plots recorded the lowest plant height (69.04 and 66.86 cm), the fewest branches (1.79 and 1.94), and substantially reduced productivity components, such as the number of pods per plant (30.71 and 28.82), seed weight (40.06 and 29.82 g), and pod weight (54.07 and 51.63 g) across the two seasons. These reductions can be attributed to high weed competition, which likely interfered with nutrient uptake, light interception, and general plant development.

Hand hoeing alone resulted in the highest plant height values (105.58 and 108.89 cm) among all treatments Also, it led to branch number and pod development parameters, indicating the effectiveness of timely manual weed removal in optimizing plant growth. However, combinations involving herbicides and hand hoeing also performed well, reflecting the advantage of integrated weed management approaches. These results are in harmony with those obtained by Nainwal and Saxena (2023), who showed that applying the pre-emergence, followed by one hand hoeing increased the number of branches, pods per plant and seed weight per plant.

Table 8. Effect of weed control treatments on yield components at harvest during the 2022 and 2023 seasons.

Weed control treatments	Rate (L/fed)	Plant height		Number of branches/ plant		Number of pods / plant		seed weight / plant (g)		pod weight / plant (g)	
		2022 Season	2023 Season	2022 Season	2023 Season	2022 Season	2023 Season	2022 Season	2023 Season	2022 Season	2023 Season
Stomp Extra + Hand hoeing	1.5	103.12	108.75	2.37	2.91	47.63	43.62	49.46	43.68	60.78	64.39
Stomp Extra + Fusiladeforti	1.5 + 1.4	102.74	105.19	2.48	2.95	47.43	44.03	48.89	43.29	60.81	64.57
Basagran + Hand hoeing	0.5	103.74	107.49	2.53	2.97	48.28	45.13	47.63	42.62	61.65	65.54
Basagran + Select super	0.5 + 0.25	102.27	105.99	2.45	2.91	47.96	44.42	46.61	40.53	60.96	64.66
Hand hoeing	Twice	105.58	108.89	2.52	3.02	47.90	44.25	48.31	42.18	61.28	65.12
Control (Untreated)	——	69.04	66.86	1.79	1.94	30.71	28.82	40.06	29.82	54.07	51.63
Mean**		**97.75**	**100.52**	**2.35**	**2.78**	**44.98**	**41.71**	**46.82**	**40.35**	**59.92**	**62.65**
L. S. D. at 5%		**0.19**	**0.17**	**0.61**	**0.27**	**0.25**	**0.15**	**0.26**	**0.16**	**0.27**	**0.19**

3.2.2. Soybean yield

The data in Table 9 and Fig. 4 indicate that all weed control treatments significantly enhanced crop performance compared to the untreated control. Notably, Basagran + Select Super combination resulted in the highest seed yield in the first season (1.67 ton/fed). It maintained a competitive yield in the second season (1.48 ton/fed), alongside consistently high straw yield and seed weight. Treatments combining herbicides with hand hoeing, such as Stomp Extra + Hand Hoeing and Basagran + Hand Hoeing, substantially increased yield and improvement percentage, with values exceeding 84% in both seasons. In contrast, the untreated control exhibited the lowest values across all measured parameters, underscoring the critical role of effective weed management. The LSD values confirm that the observed differences in yield parameters among treatments are statistically significant, highlighting the efficacy of integrated weed control strategies in improving crop productivity.

Table 9. Effect of weed control treatments on yield at harvest during the 2022 the and 2023 seasons.

Weed control treatments	Effect of treatments on crop yield							
	Straw yield (ton/fed)		Weight of 100 seeds (g)		Seed yield (ton/fed)		I%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Stomp Extra +Hand hoeing	3.28	3.07	17.51	17.27	1.44	1.40	84.72	74.29
Stomp Extra + Fusilade forti	3.19	2.90	17.73	17.46	1.43	1.64	84.62	78.05
Basagran + Hand hoeing	3.26	2.94	18.03	17.90	1.45	1.42	84.83	74.65
Basagran + Select super	3.13	3.06	17.95	17.75	1.67	1.48	86.83	75.68
Hand hoeing	3.17	3.08	16.61	16.26	1.10	1.10	80.00	67.27
Control (Untreated)	2.10	1.78	10.57	10.64	0.22	0.36	0.00	0.00
L. S. D. at 5% level	0.87	0.36	0.26	0.16	0.62	0.39		

1st = First season, 2nd = second season

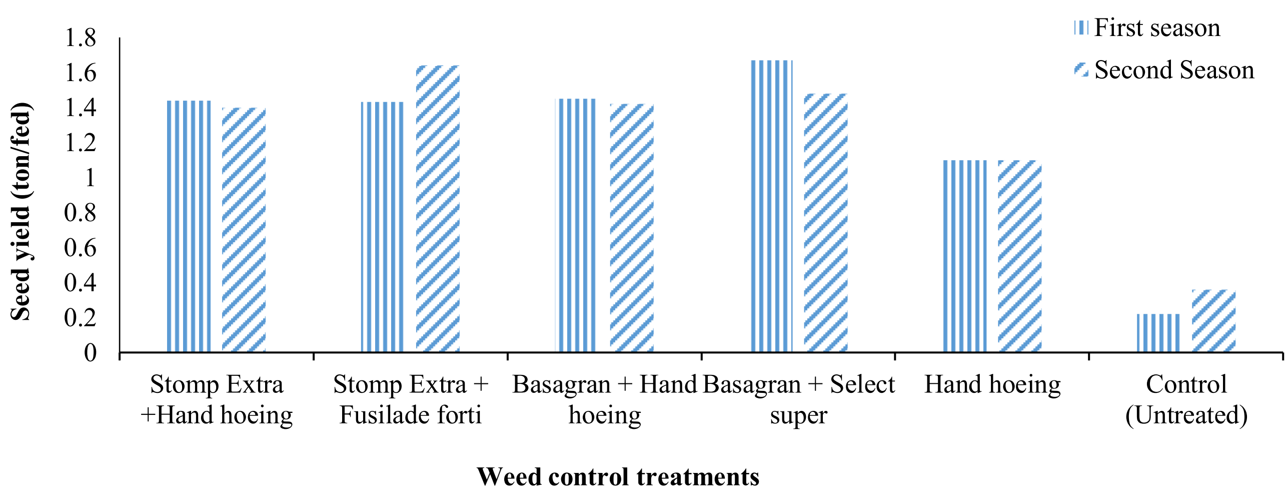

Figure 4. Effect of weed control treatments on seed yield (ton/fed) at harvest during the 2022 and 2023 seasons.

3.3. Crude protein and oil content

The data in Table 10 indicate that all weed control treatments significantly enhanced the crude protein and oil content in soybean compared to the untreated control. The combination of Stomp Extra with hand hoeing showed the most pronounced effect, achieving the highest values for crude protein in both seasons (35.18% and 34.07%) and corresponding improvements in protein content (48.33% and 51.83%). This treatment also maintained superior oil percentages and oil content. Other treatments, such as Stomp Extra with Fusilade forte and Basagran with hand hoeing, also improved soybean quality, albeit somewhat. The lowest values were consistently recorded in the untreated control, highlighting the detrimental impact of unchecked weed presence. The observed differences were statistically significant at the 5% LSD level, confirming the critical role of integrated weed management in optimizing soybean nutritional quality.

Table 10. Effect of weed control treatments on protein and oil content at harvest during the 2022 and 2023 seasons.

Weed control treatments	Effect of treatments on protein and oil content in soybean							
	Crude protein		I%		Oil percentage		I%	
	1^{st}	2^{nd}	1^{st}	2^{nd}	1^{st}	2^{nd}	1^{st}	2^{nd}
Stomp Extra +Hand hoeing	35.18	34.07	48.33	51.83	24.58	19.48	20.30	29.31
Stomp Extra + Fusilade forti	33.39	32.03	45.56	48.76	22.94	17.35	14.60	20.63
Basagran + Hand hoeing	32.47	30.93	44.01	46.94	22.82	17.30	14.15	20.40
Basagran + Select super	31.37	29.76	42.05	44.86	24.34	19.01	19.52	27.56
Hand hoeing	30.17	28.13	39.74	41.67	24.10	18.67	18.71	26.25
Control (Untreated)	18.18	16.41	0	0	19.59	13.77	0.00	0.00
L. S. D. at 5% level	0.34	0.34			0.31	0.31		

1^{st} = First season, 2^{nd} = second season

3.4. Determination of tested herbicides residues

The data in Table 11 indicate that "Stomp" (pendimethalin) and "Basagran" (bentazone) showed no detectable residues (ND) in the soybean seeds, as identified by HPLC at harvest. These results demonstrate that the application rates of 1.5 L/fed for pendimethalin and 0.5 L/fed for bentazone effectively minimize residue levels, ensuring compliance with the EU MRLs of 0.05 ppm and 0.1 ppm, respectively.

"Select Super" (clethodium) at an application rate of 0.25 L/fed exhibited a residue concentration of 0.00118 ppm, significantly lower than the EU's permissible MRL of 0.5 ppm. This indicates that clethodium residues remain within the safety threshold, reflecting its appropriate usage and effective degradation.

"Fusilade Forti" (flazifop-p-butyl), applied at 1.4 L/fed, recorded a residue level of 0.00101 ppm, far below the EU MRL of 0.2 ppm. This highlights the herbicide's safe application rate and compatibility with regulatory standards. These results are similar to those of Dawood *et al*., (2022), who indicated that in heavily infested soil with weeds, uses the weed control treatments (Amex + Fuselied Forte) or (Stomp + Fuselied Forte) which recorded best the annual weeds control and increase of pea seeds yield (ton/fed) without any residues.

Table 11. Residues of tested herbicides in soybean seeds as detected by HPLC (ppm) at harvest

Herbicides	Rate (L/fed)	Retention time (min)	Herbicides residues Mg /g (ppm)	Maximum residue level (MRL) Mg/ g (ppm) by (EU)
Stomp (pendimethalin)	1.5	3.447	ND	0.05
Basagran (bentazone)	0.5	8.579	ND	0.1
Select super (clethodium)	0.25	3.992	0.00118	0.5
Fusiladeforti (flazifop-p-butyl)	1.4	6.585	0.00101	0.2

ND = Not Detected

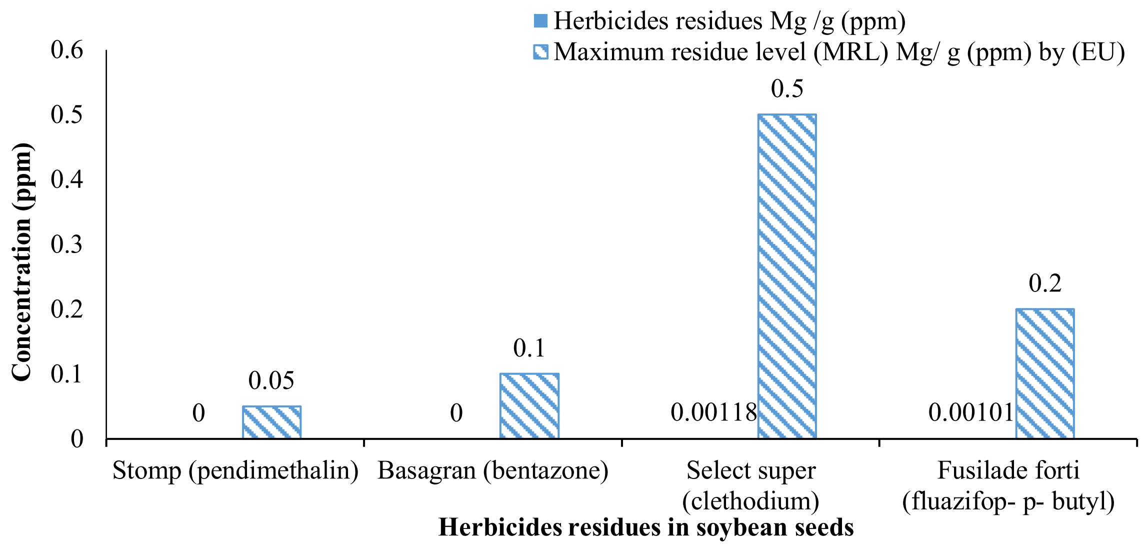

Figure 5. Residues of tested herbicides in soybean seeds as detected by HPLC (ppm) after harvest.

4. References

A.O.A.C. (1990). Official methods of analysis of the association official analytical chemists 14Th Ed. Washington, D. C., USA.

ASA, (2022). American soybean Association, A reference guide to important soybean facts and figures. SOYSTATS, STLOUIS, USA.

Dawood, E.M.; Soliman, I.E.; Hamed, S.A.; Keratum, A.Y.; and Kishk, A. (2022). Evaluations of Weed Control Treatments on Broomrape, Annual Weeds, and Productivity of Pea Crop. Journal of Plant Protection and Pathology, 13 (12), 329-335.

De Castro, M.L. and Priego-Capote, F. (2010). Soxhlet extraction: Past and present panacea. Journal of chromatography A, 1217 (16), 2383-2389.

Dykun, A.; Zherebko, V.; and Dykun, M. (2020). The effectiveness of herbicides in soybean cultivation. Žemės ūkio mokslai, 27 (3), 115-124.

Fakkar, A.A.O. and El-Dakkak A.A.A. (2015). Effect of crop sequence and weed control treatments on weeds and pea crop productivity. Annals of Agriculture Sciences, 60 (1): 157–168.

Gharde, Y., Singh, P.K., Dubey, R.P. and Gupta, P.K. (2018). Assessment of yield and economic losses in Agriculture due to weeds in India. Crop protection, 107, 12-18.

Jackson, M. L. (1973). Soil chemical analysis. Prentice HallInc., Englewood Cliffs., New Jersey U.S.A.

Meseldžija, M., Rajković, M., Dudić, M., Vranešević, M., Bezdan, A., Jurišić, A. and Ljevnaić-Mašić, B. (2020). Economic feasibility of chemical weed control in soybean production in Serbia. Agronomy, 10(2), 291.

Nagar, R.K. (2017). Effect of weed and nutrient management on density of various weeds and yield of coriander (*Coriandrum sativum*). International Journal of Research in Applied, 5 (11), 1– 6.

Nainwal, R. and Saxena, S.C. (2023). Effect of herbicides on plant growth and seed yield and quality of soybean (*Glycine max* L. Merr.). Environment Conservation Journal, 24(2), 77-82.

Nguyen, T.D.; Han, E.M.; Seo, M.S.; Kim, S.R., Yun, M.Y.; Lee, D.M.; and Lee, G.H. (2008). Amulti-residue method for the determination of 203 pesticides in rice paddies using gas chromatography/mass spectrometry, Analytica chemical, Acta., 619, 67-74

Peer, F.A.; Hassan, B., Lone, B.A.; Qayoom, S.; Ahmad, L.; Khanday, B.A.; and Singh, G. (2013). Effect of weed control methods on yield and yield attributes of soybean. African Journal of Agricultural Research, 8(48), 6135 - 6141.

Raj, R.K.; Sinha, K.K.; Kumari, S.; Choubey, A.K.; Pandit, A.; and Yadav, D.K. (2020). Effect of Weed Management Practices on Weed Control, Yield and Economics of Soybean [*Glycine max* (L.) Merrill]. Current Journal of Applied Science and Technology, 39 (9), 114-120.

Rupareliya, V.V.; Mathukia, R.K.; Gohil, B.S.; and Javiya, P.P. (2020). Effect of post emergence herbicides and their mixture on growth, yield and quality of soybean (*Glycine max* L.). Journal of Pharmacognosy and Phytochemistry, 9 (6): 1161-1164.

Savaliya, D.V.; Patel, T.U.; Patel, D.D.; Arvadiya, L. K.; Patel, P.S.; and Patel, D.K. (2017). Weed management in coriander. Agres- An International e-Journal, 6(1), 142 – 146.

Snedecor, G. W. and Cochran, W. G. (1980). Statistical Methods 6th Ed., lowa state univ. Press, Amess, USA, 325-330.

Soliman, I.E. and Hamza, A. (2016). Effect of biofertilizers and control treatments on roots nodulation, yield and associated weeds of soybean crop. Journal of Plant Protection and Pathology, 7(9), 593-604.

Soliman, I.E.; Morsi, A.R.; and Khaffagy, A.E. (2015). Effect of competitive abilities of some soybean genotypes, plant densities and weed control treatments on soybean (*Glycine max* L.*) and it*'s associated weeds Journal of Plant production, 6(8), 1413-1429.

Soltani, N.; Dille, J.A.; Burkee, I. C.; Everman, W. J.; Van Gessel, M.J.; Davis, V. H.; and Sikkema, P.H. (2017). Perspectives on potential soybean yield losses from weeds in North America. Weed Technology, 31 (1), 148-154.

Vazquez-Garcia, J.C.; Col Mohammad Zadeh, S.; Pal-ma. Bautista, G.; Rojano-Delgade, A. M., Dominguez-Valenzuela, J.A.; Cruz-Hipolito, H.E.; and Deprada,R.,(2020). New case of false-star-grass(chlerisdistichophylla) population evolving glyphosate resistance. Agronomy, 10(3), 377.