



Assessment of herbicide efficacy on growth and yield of three maize hybrids and associated weeds

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Abstract

A field experiment was conducted in during spring Farm and Karbala Governorate, Al-Hindiyah District, Al-Khairat Sub-district. The experiment was implemented with two factors and using the Randomized Complete Block Design (R.C.B.D.) arrangement of the split plots design with three replicates, the first factor represented three hybrids of maize and occupied the main plots (Torro, Top and Tawer), the second factor applied six treatments to weed control, four herbicides according to the approved recommendations (2,4-D, Reef Sulfuran, Trinity and Proponit.) and the two comparison treatments (weedy) and weed free. The results showed significant differences between the hybrids under study, as the Tawer hybrid was superior in the trait of weed density, percentage of weed control after 60 days, dry weight of weeds and percentage of weed inhibition. Torro hybrid was superior in the trait of leaf area, plant height, number of grains per ear and number of grains per row in weed free treatments, followed by the 2,4-D herbicide treatments. As for the percentage of weed control, it was superior in the traits of leaf area index, chlorophyll index, number of grains per row and number of grains per ear in the weed free treatments. Followed by 2,4-D herbicide treatments, and there was a significant interaction between the study factors, as weed free treatment outperformed the Torro can be used as the high yielding hybrid under stresses of herbicide applications since it had significantly greater growth Traits and largest grain number than Top and Tower. However, Tower can be considered as the most suppressive hybrid due to the significant reduction of weed dry Wight with a greater weed suppression. 2,4-D can be used in maize cropping systems due to its efficacy in comparison with the other herbicides.

Keywords: maize hybrids, weed control, herbicides .

Introduction

Maize is the third most important food crop grown worldwide. In recent times, the demand for its production has increased significantly due to its multiple uses, including food and feed, and it is used in various industrial applications. Maize is a highly adaptable crop, the development of hybrids with high yields and climate change adaptation helps bridge the gap between demand and supply for this crop [1]. A very important



role in human and animal nutrition in general and meets the protein and calorie requirements of millions of people around the world, especially in developing countries. It is a source of high fiber, antioxidants, minerals and other vitamins. However, in India and many countries of world, a large portion of the maize crop goes to poultry and animal feed [2] . Weeds compete with maize for sunlight, moisture and nutrients, leading to low productivity and delayed crop maturity , Herbicides only without integration with other non-chemical methods are not sustainable weed management. [3] .

The most important of these weeds spread in agricultural lands are the weed (*Malva praviiflora* L.) and the weed (*Echinochloa colonum* L.). The development of the Traits possessed by weeds makes them able to resist environmental conditions and external influences in order to survive for long periods and compete with the strategic crops that grow with them in agricultural lands , Among these specifications is that it has a single long taproot, which allows it to absorb nutrients and moisture and survive for a long time and enables it to grow The nature of the hard seeds also enables them to remain safe from external influences and can be transported over long distances by animals [4].

There are many methods that have contributed significantly to the development of agricultural production and increased food production worldwide. Use of herbicides has provided a revolutionary tool for managing the difficult tasks of combating the herbivores, which has contributed significantly to providing the requirements of global food security for human survival. Recently, many successes have been achieved in the process of combating The weeds through the use of chemicals, which represents a turning point in the development of methods of combating The weeds [5] . Herbicides that are applied directly to the soil before planting is one of the essential components of the many methods in the management programs of combating the weeds associated with the maize crop. the residual activity of pre-emergence herbicides allows farmers to control weeds that appear with the maize crop shortly after the crop has grown. All pre- and post-emergence herbicides did not cause any toxicity to the maize crop [6] . Pre-emergence herbicides that act on the soil improve the effectiveness of other weed control management by reducing the number and size of weeds that appear in the early stage of crop growth [7] . 2,4-D was the first commercial herbicide introduced to the market to control broadleaf weeds in the late 1940s. 2,4-D remains one of the most widely used herbicides in the world due to its low cost, selectivity, effectiveness, and wide range of weed control functions. another reason is that commercial formulations of 2,4-D dissolve easily in water and other solvents, resulting in rapid penetration through the leaves and also the roots, making it a more effective herbicide. 2,4-D herbicide plays a role in regulating plant growth as it acts as a mimic of the natural hormone auxin, which helps in enhancing cell division and elongation, leading to an increase in the life span of plants at low concentrations [8,9] .proponit is one of the most important selective herbicides and can be used to control broadleaf and narrow-leaved weeds in their cobly growth stages or before planting in maize fields and others [10]. Therefore, the aim of this study was to show the response of three maize hybrids, namely Torro,

Top and Tawer, to weed control operations, where the efficiency of some weed killers used in controlling the weed of pain-Grass and also the weed of Use botanical name instead is evaluated, with a statement of their effect on the growth and components of the yield of the maize crop.

Materials and Methods

Separate those headings into multiple sections, otherwise this subheading is unnecessary.

A field experiment was conducted in during spring Farm and Karbala Governorate, Al-Hindiyah District, Al-Khairat Sub-district , plowed with a rotary plough, then leveled and the experimental units were divided according to the randomized complete block design in split-plot arrangement with three replicates. Maize seeds were planted on 8/1/2024, as the experimental unit had an area of 9 m² and included four rows with a distance of 75 cm between them and a distance between plants of 25 cm with a plant density of 53333 plants ha⁻¹ [11] . The main plots were occupied with three hybrids of maize(Torro , Top and Tawer). The secondary plots included four chemical herbicides: 2.4-D, Reef Sulfuran, Trinity, Proponit. In addition to the weedy treatment and the weed-free treatment, as the herbicide were used by spraying the weeds according to the recommendations of the producing company (Table 1). Also, when applying the control process, weeds were removed from the experimental units that were free of weeds.

Table (1): Usage Rate of herbicides used in the study

The symbol	Treatment	The focus
H0	Weedy	-----
H1	Weed free	-----
H2	Trinity	507 -1000 ml/ha
H3	Proponit	450-500 ml/ha
H4	Reef Sulfuran	50-60 g/ha
H5	2,4-D	333 ml/ha

Traits weeds Under study

- **Weed density (plant m⁻²):** The number of weeds was calculated from an area of 50*50 cm after 60 days of control.
- **Weed control percentage %:** It was taken as a percentage of the number of weeds after 60 days of control according to the equation:

$$i_{\text{control percentage}} = \frac{\text{number of Weed in the comparison treatment} - \text{number of weeds in the control treatment}}{\text{number of Weed in the comparison treatment}} \times 100 \quad [12].$$

- **Dry weight of Weedy (g):** Weeds were cut from the soil surface level for an area of one square meter for each experimental unit at harvest, dried until the weight was constant, and then weighed.
- **Inhibition percentage:** It was calculated using the following equation:

inhibition percentage

$$= \frac{\text{Dry weight of Weed in comparison treatment} - \text{Dry weight of weeds in control treatment}}{\text{Dry weight of Weed in comparison treatment}} \times 100$$

Leaf area index : Calculated by dividing the leaf area by the area occupied by a single plant [13].

Chlorophyll index (SPAD): It was estimated by SPAD device where the average reading of five plants was taken from the leaf under the cob leaf randomly.

Number of grains in row (grain row⁻¹): The number of grains in the row was calculated manually for five e cob randomly selected from each experimental unit and the average was extracted.

Number of grains in cob (grain. cob⁻¹): The number of rows in the cob was calculated manually then multiplied by the number of grains in the row and then the average of the number of grains in the cob was extracted.

Results and Discussion.

Table (1): Types of weeds plants found in the field experiment.

	Scientific name	English name	Life cycle
1	<i>Echinochloa colonum</i> L.	Purple pain-Grass	annual
2	<i>Imperata cylindrical</i> L.	cogongrass	perennial
3	<i>Cyperus rotundus</i> L.	Nutgrass	perennial
4	<i>EchinochLoa crus-galli</i> L.	Portulaca oleracea	annual
5	<i>Cynodon dactylon</i> L.	Bermudagrass	perennial
6	<i>Alhagi maurorum</i> L.	Prickly alhagi	perennial
7	<i>Phragmites australis</i> L.	Phragmites australis	perennial
8	<i>LoLium temuLentum</i> L.	Cleavers	annual
9	<i>Malva praviflora</i> L.	Dwarf mallow	annual
10	<i>Chenopodium album</i> L.	White goosefoot	annual
11	<i>Carthamus oxyacanthu</i> L.	Wild safflower	annual
12	<i>Convolvulus arvensis</i> L.	Field bind weed	perennial

The types of weeds spread in the field experiment were identified, which numbered 12 weeds, The weeds were diverse, with broad leaves and also narrow leaves.

Weed density after 60 days of control (plant/m²).

Results of Table (2) showed no significant differences between the hybrids in weed density trait after 60 days of spraying. The herbicide spraying treatments caused a significant decrease in weed density, as the 2,4-D treatment outperformed in recording the lowest average weed density of 26.0 plants/m² compared to the weedy treatment, which gave 122.0 plants/m². Now, in the 2,4-D treatment, the narrow-leaved weeds were removed from the treatment because the herbicide only affects broad-leaved weeds, which caused a decrease in the number of weeds in this treatment. It is worth noting that there were no significant differences between the herbicide Reef Sulfuran, Trinity, and Proponit, as their averages reached 99.1 plants/m², 94.1 plants/m², and 98.3 plants/m², respectively. The interaction between hybrids and control treatments was significant. The interaction treatment of 2,4-D with the Tower hybrid gave the lowest average weed density of 23.0 plants/m² compared to the weed treatment with the same hybrid of 128.6 plants/m².

Table (2): Effect of chemical herbicide on weed density (plant/m²) after 60 days of spraying.

Control treatments	Hybrids			Average
	Torro	Top	Tower	
Weedy	123.3	114.0	128.6	122.0
Trinity	97.3	94.3	90.6	94.1
Proponit	93.6	89.3	112.0	98.3
Reef Sulfuran	99.0	96.0	102.3	99.1
2,4-D	27.0	28.0	23.0	26.0
Weed free	00.0	00.0	00.0	00.0
Average	73.39	70.28	76.11	
L.S.D 0.05	hybrids	Control treatments	interaction	
	N.S	6.059	10.447	

Percentage of weed control after 60 days (%).

The results of Table (3) showed no significant differences between the hybrids in the percentage of weed control trait after 60 days of spraying. The herbicide spraying treatments caused a significant increase in the percentage of weed control, as the 2,4-D treatment outperformed in recording the highest average percentage of weed control, reaching 78.46% compared to the weed treatment, which gave 00.00%. The reason for the superiority of the control percentage in this treatment is due to its superiority in reducing the density of weeds in (Table 2), which led to its superiority in the percentage of weed control. It is worth noting that there were no significant differences between the herbicide Reef Sulfuran, Trinity, and Proponit, as their averages reached 18.47%, 22.38%, and 19.01%, respectively. The interaction between hybrids and control treatments was significant. The interaction treatment of 2,4-D with the Tower hybrid gave



the highest average weed control percentage, reaching 82.14%, compared to the treatment of the weed with the same hybrid, reaching 00.00%.

Table (3): Effect of chemical herbicide on the percentage of weed control after 60 days of spraying.

Control treatments	Hybrids			Average
	Torro	Top	Tower	
Weedy	00.00	00.00	00.00	00.00
Trinity	20.81	16.71	29.64	22.38
Proponit	23.53	20.83	12.65	19.01
Reef Sulfuran	19.61	15.45	20.34	18.47
2,4-D	78.01	75.22	82.14	78.46
Weed free	100	100	100	100
Average	40.33	38.04	40.80	
L.S.D 0.05	hybrids	Control treatments	interaction	
	N.S	4.958	8.826	

Dry weight of Weedy (g m²).

The results of Table (4) showed no significant differences between the hybrids in the dry weight of weedy. The herbicide spraying treatments caused a significant decrease in the dry weight of weedy, as the 2,4-D herbicide treatment outperformed in recording the lowest average dry weight of Weedy, which amounted to 20.67 g m², compared to the vegetated treatment, which gave 48.22 g m². This is now the 2,4-D herbicide treatment, as the thin-leaved weeds were removed from the treatment, because the herbicide has an effect on the broad-leaved bushes only, which caused a decrease in the number of weeds in this treatment, which had an effect in reducing the dry weight of weedy. It is worth noting that there were no significant differences between the herbicide Reef Sulfuran, Trinity and Proponit, as their averages reached 36.56 g m², 34.33 g m² and 34.78 g m², respectively.

The interaction between hybrids and control treatments was significant, as the interaction treatment of 2,4-D with the hybrid Torro gave the lowest average dry weight of Weedy, reaching 19.33 gm², compared to the treatment of the thicket with the same hybrid, reaching 50.00 gm².

Table (4): Effect of herbicides on dry weight of Weeds (g m²).

Control treatments	Hybrids			Average
	Torro	Top	Tower	
Weedy	48.67	46	50.00	48.22
Trinity	35.00	33.67	34.33	34.33
Proponit	37.00	36.67	30.67	34.78
Reef Sulfuran	34.33	40.00	35.33	36.56
2,4-D	19.33	21.33	21.36	20.67
Weed free	00.00	00.00	00.00	00.00
Average	29.06	29.61	28.61	
L.S.D 0.05	hybrids	Control treatments	interaction	
	N.S	2.508	4.059	

The percentage of weed inhibition % .

The results of Table (5) showed no significant differences between the hybrids in the percentage of weedy inhibition. The herbicide spraying treatments caused a significant decrease in the percentage of weed inhibition, as the 2,4-D herbicide treatment outperformed in recording the highest average percentage of weed inhibition, reaching 56.76% compared to the weed treatment, which gave 00.00%. The reason for the superiority of the percentage of weed inhibition in this treatment is due to its superiority in reducing the dry weight of the weeds in (Table 4), which led to its superiority in the percentage of weed inhibition. It is worth noting that there were no significant differences between the herbicide Reef Sulfuran, Trinity, and Proponit, as their averages reached 23.52%, 28.32%, and 27.40%, respectively. The interaction between hybrids and control treatments was significant. The 2,4-D treatment with Torro hybrid gave the highest average weed inhibition percentage of 59.61% compared to the weed treatment with the same hybrid of 00.00%.

Table (5): Effect of herbicides on weed inhibition percentage (%).

Control treatments	Hybrids			Average
	Torro	Top	Tower	
Weedy	00.00	00.00	00.00	00.00
Trinity	27.01	26.58	31.37	28.32
Proponit	23.88	19.92	38.41	27.40
Reef Sulfuran	28.81	12.93	28.82	23.52
2,4-D	59.61	53.52	57.15	56.76
Weed free	100	100	100	100
Average	39.89	35.49	42.63	
L.S.D 0.05	hybrids	Control treatments	interaction	
	N.S	4.624	10.030	

Leaf area index

The results of Table (6) indicate the superiority of the Torro hybrid in Leaf area index trait, as it recorded the highest average of 2.975, while the Top hybrid gave a lower average of 1.967. The superiority of the same hybrid in the leaf area index trait, as well as the superiority of the weed free treatment and the herbicide treatment in the density of weeds and the percentage of weed control in (Table 3) and the rest of the weed density tables and the percentage of weed control, as it led to reducing the competition of weeds with the crop for the basic materials, moisture, sunlight and nutrients, which led to an increase in the process of light synthesis and its transfer to different parts of the plant and an increase in the vegetative group, which has a positive effect in intercepting sunlight. Now the rate of photosynthesis has a direct relationship with the leaf area index. These results agreed with [14]. Weed free treatment excelled in recording the highest average leaf area index, which amounted to 3.242, followed by the 2,4-D herbicide treatment, which gave 2.796, while the weedy treatment gave the lowest average for the leaf area index was 2.048, the interaction between the Torro hybrid and weedy treatment was superior in recording the highest area index, which was 3.915, while the interaction between the Top hybrid and Weedy treatment recorded a lower mean of 1.351.

Table (6): Effect of herbicides on the leaf area index for three maize hybrids.

Control treatments	Hybrids			Average
	Torro	Top	Tower	
Weedy	2.313	1.351	2.48	2.048
Trinity	2.691	1.987	2.936	2.538
Proponit	2.913	1.861	2.965	2.580
Reef Sulfuran	2.822	1.926	2.611	2.453
2,4-D	3.193	2.242	2.954	2.796
Weed free	3.915	2.434	3.377	3.242
Average	2.975	1.967	2.887	
L.S.D 0.05	hybrids	Control treatments	interaction	
	0.1827	0.2381	0.3977	

Chlorophyll index (SPAD) .

The results of Table (7) indicate the superiority of the Torro hybrid in the chlorophyll index trait, as it recorded the highest average of 54.22 (SPAD), while the Top hybrid gave a lower average of 51.37 (SPAD). The superiority of the same hybrid in the chlorophyll index page in (Table 6) and also the superiority of Weedy treatment and the herbicide treatment in the density of weeds and the percentage of weed control in (Table 3) and the rest of the tables of weed density and the percentage of weed control. These results agreed with those indicated by [15] that the manual weed free treatments and the herbicide treatment showed an increase in the chlorophyll index trait by 20% to 30%. Weedy treatment excelled in recording the highest average chlorophyll index,



which reached 59.18 (SPAD), followed by the 2,4-D herbicide treatment, which gave 57.13 (SPAD), while the weedy treatment gave the lowest average for the index trait. Chlorophyll index reached 41.73 (SPAD), and the interaction treatment between Torro hybrid and hoeing treatment was superior in recording the highest chlorophyll index which reached 60.43 (SPAD), while the interaction treatment between Tower hybrid and Weedy treatment recorded a lower average of 41.30 (SPAD).

Table (7): Effect of herbicides on the chlorophyll index (SPAD) for three maize hybrids.

Control treatments	Hybrids			Average
	Torro	Top	Tower	
Weedy	42.60	41.32	41.30	41.73
Trinity	55.50	52.53	47.87	51.97
Proponit	54.57	50.27	55.13	53.32
Reef Sulfuran	53.53	52.43	52.50	52.82
2,4-D	58.67	54.83	57.90	57.13
Weed free	60.43	56.83	60.27	59.18
Average	54.22	51.37	52.49	
L.S.D 0.05	hybrids	Control treatments	interaction	
	1.364	1.583	2.684	

Number of grains in the row (grain row⁻¹).

The results of Table (8) indicate the superiority of the hybrid Torro in the trait of number of grains in the row, as it recorded the highest average of 44.41 grains row⁻¹, while the hybrid Top gave a lower average of 39.21 grains row⁻¹, due to the superiority of the hybrid itself in the leaf area index recipe (Table 6) and the chlorophyll index recipe (Table 7), and also the superiority in controlling weeds, as the density and percentage of controlling weeds had a significant effect in reducing the competition of weeds for the crop, which led to an increase in the photosynthesis process, which had a positive effect on the various growth processes and yield traits. The hoeing treatment excelled in recording the highest average number of grains in the row, which reached 44.29 grains row⁻¹, followed by the 2,4-D herbicide treatment, which gave 43.07 grains row⁻¹, while the weedy treatment gave the lowest average number of grains in the row, which reached 36.90 grains row⁻¹. The interaction treatment between the hybrid Torro and Weedy treatment was superior in recording the highest number of grains per row, which reached 47.50 grains/row⁻¹, while the interaction treatment between the hybrid Top and Weedy treatment recorded a lower average of 33.40 grains/row⁻¹.

Table (8): Effect of herbicides on the number of grains per row for three maize hybrids.

Control treatments	Hybrids			Average
	Torro	Top	Tower	
Weedy	40.30	33.40	37.00	36.90
Trinity	43.87	40.53	43.73	42.71
Proponit	43.97	39.07	45.00	42.68
Reef Sulfuran	45.40	39.43	39.40	41.41
2,4-D	45.40	41.07	42.73	43.07
Weed free	47.50	41.73	43.63	44.29
Average	44.41	39.21	41.92	
L.S.D 0.05	hybrids	Control treatments	interaction	
	1.265	1.946	3.200	

Number of grains in the cob (grain. Earnous¹⁻).

The results of Table (9) indicate that the hybrid Torro is superior in the trait of number of grains in the cob, as it recorded the highest average of 697.8 grains cob⁻¹, while the hybrid Top gave a lower average of 603. grains cob⁻¹. This is due to the superiority of the hybrid itself in the trait of leaf area index (Table 6) and chlorophyll index (Table 7), which led to an increase in the high photosynthesis process, which has a positive effect on increasing the number of grains in the cob. the weed free treatment was superior in recording the highest average number of grains in the cob, which reached 728.1 grains cob⁻¹, while weedy treatment gave the lowest average number of grains cob⁻¹, which reached 523.5 grains cob⁻¹. The interaction treatment between the hybrid Torro and the hoeing treatment was superior in recording the highest number of grains in cob⁻¹, which reached 805.5 grains cob⁻¹, while the interaction treatment gave Among the hybrids Top with the fertilized treatment, a lower average was recorded, reaching 491.7 grains cob⁻¹.

Table (9): Effect of herbicides on the number of grains per cob for three hybrids of maize (grain per cob. Arnos¹⁻).

Control treatments	Hybrids			Average
	Torro	Top	Tower	
Weedy	553.8	491.7	525.0	523.5
Trinity	684.9	646.6	658.2	663.2
Proponit	686.7	606.9	728.9	674.2
Reef Sulfuran	724.6	598.8	636.8	653.4
2,4-D	731.6	615.7	694.9	680.7
Weed free	805.5	661.0	717.8	728.1
Average	697.8	603.5	660.3	
L.S.D 0.05	hybrids	Control treatments	interaction	
	33.89	34.71	60.05	



The results showed significant differences among the studied hybrids. Toro hybrid outperformed weed free treatments in plant height, leaf area, grain number per row, and grain number per ear, followed by 2,4-D treatments. In weed control, Toro hybrid outperformed weed-free treatments in leaf area index, chlorophyll index, grain number per row, and grain number per ear. There was a significant interaction between the studied factors, with weed free treatment outperforming Toro hybrid. This superiority suggests that Toro hybrid can be used as a high-yielding hybrid under herbicide stress, as it had significantly better growth Traits and higher grain number than Top and Tower. 2,4-D can also be used in maize cropping systems due to its effectiveness compared to other herbicides. Thank you and appreciation for your research support.

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