Effect of the Interaction Between Genotype and Weed Control Treatments on Weed traits and Vegetative Growth of Sorghum bicolor L.

Lizan Dara Yara Muhammad, Zakaria Mahmoud Muhammad

zakamahmod@uokirkuk.edu.iq akfm24019@uokirkuk.edu.iq

University of Kirkuk , College of Agriculture , Department of Field Crops

Abstract

This study was conducted during a field experiment carried out during the autumn growing season (2025) in the Forestry and Rangeland Directorate in Sulaymaniyah, located at longitude 45.43° East and latitude 35.55° North of the equator, to determine the effect of different weed management methods on the yield of four sorghum cultivars. These included (buhouth, Rabeh, Inkath, and Giza). In addition to weed control treatments (four treatments), the study included a control treatment (no control), a weed-free treatment (manual weed removal), weed control by tillage, and chemical control using the herbicide Castran after germination. The results of the study showed a clear and significant effect of weed control treatments on all weed characteristics and vegetative growth The chemical control treatment achieved the lowest values after manual weeding in weed density, recording 4.83 and 0.83 weeds.m² for narrow- and broad-leaved weeds, respectively. The dry weight of weeds reached 20.17 and 2.85 g.m² for narrow- and broad-leaved weeds, respectively. It also recorded the highest weed control efficiency, reaching 88.34% and 81.42% for narrow- and broad-leaved weeds, respectively. In contrast, the inhibition percentage reached 91.81% and 80.65% for narrow- and broad-leaved weeds, respectively, whereas the control treatment recorded the lowest inhibition percentage of 0.0%. As for the cultivars, they showed limited differences. In contrast, as the control treatment (no control) was in recording the highest density and biomass of weeds, with the number of narrow-leaved weeds reaching 19.25 weeds.m² and broad-leaved weeds reaching 3.25 weeds.m², while the dry weight recorded 263.30 and 22.24 g.m² respectively. No significant differences were found between the cultivars in some weed traits, indicating a similarity in their competitive ability. The interaction between control treatments and cultivars showed a clear significant effect. Buhouth cultivar excelled in the number of fine weeds (9.08 weeds.m2) and the highest inhibition rate (66.18%), while the Giza cultivar had the highest control rate (66.18%). Rabeh cultivar recorded the lowest values in some traits, while the Inkath cultivar excelled in plant height (115.81 cm). The control treatment with some cultivars recorded the highest weed density and weight (91.0 weeds.m2) for fine weeds, while the interaction between manual weeding and all cultivars achieved the lowest values. (0.0) and the highest control and inhibition rates reached 100%. Chemical treatment approached the efficiency of manual weeding for some cultivars, recording control rates of 89.70–91.20%. This was reflected in vegetative growth characteristics, as the manual weeding treatment resulted in a plant height of 126.88 cm and a leaf area of 3743.13 cm² plant^{-1}, compared to the control treatment (91.00 cm and 2007.66 cm² plant^{-1} , respectively). Furthermore, the combination of manual weeding with the Inkath cultivar achieved the highest plant

ISSN 2072-3857

height of 132.00 cm, while the combination of manual weeding with Rabeh cultivar resulted in the highest leaf area of 4150.12 cm² $plant^{-1}$.

Keywords: Sorghum, genotype, control treatments

Introduction

Sorghum (*Sorghum bicolor* L.) (Moench), belonging to the grass family (Poaceae), is a globally important economic crop. It ranks among the top five cereal crops in the world after wheat, barley, rice, and corn in terms of cultivated area and global grain production. This is due to its high environmental tolerance and efficiency in utilizing water and light resources, making it suitable for cultivation in arid and semi-arid regions suffering from water stress and high temperatures. It is also grown not only for grain production but also as green fodder, expanding its uses in feeding ruminants and poultry. Furthermore, parts of it can be converted into various industrial products such as ethanol, sugar-based products, and other industrial raw materials [16].. It is crucial to prioritize weed control in sorghum fields, as weeds are a major biological factor leading to significant yield reductions. Weeds compete with the crop for essential resources such as water, light, and nutrients, causing crop losses typically ranging from 25% to 40%. This is due to high weed density, which hinders plant growth and reduces its biological efficiency and productivity [14]. Weed control methods vary, including chemical methods using herbicides. These are among the most common, effective, efficient, and cost-efficient approaches when applied correctly, especially during the early stages of weed growth when they are most susceptible. Chemical control programs involve applying herbicides both before and after weed emergence, following precise technical recommendations to ensure optimal effect and minimize crop damage [10]. A study conducted by [29]. A field experiment was conducted at the research station of the College of Agriculture, University of Anbar during the autumn season of 2021 to evaluate the competitive ability of some sorghum cultivars (Lilo, Inkath, and Rabeh) against associated weeds under the effect of weed control treatments. The experiment included three hoeing treatments (one hoeing, two hoeings, and three hoeings), in addition to a control treatment, for three sorghum cultivars. The results showed a significant effect of the two study factors on weed density and weed dry weight. The Inkath cultivar recorded the lowest mean weed density, reaching, compared with the Lilo cultivar, which recorded the highest mean weed density of. Likewise, the Rabeh cultivar was superior in recording the highest dry weight of associated weeds, reaching, whereas the Inkath cultivar achieved the lowest mean dry weight of.The results of [7] study showed significant differences between sorghum cultivars in plant height and leaf area. Rabeh cultivar achieved the highest average plant height, reaching for the two study seasons, respectively. Meanwhile, the Inkath cultivar exhibited the highest average leaf area, reaching for the two study seasons, respectively. Given the nutritional and forage importance of sorghum, it has become essential to research scientific methods to increase its productivity and improve its production efficiency. The main objectives of this study can be summarized as follows: to evaluate the effectiveness of competitive weed-resistant cultivars, and to study the efficiency of integrated pest management using selective herbicides and early mechanical removal, with the aim of increasing yield, improving resource utilization, and reducing crop losses.

Materials and Methods: A field experiment was conducted during the autumn growing season (2025) in the Forestry and Rangeland Directorate in Sulaymaniyah, located at 45.43° East longitude and 35.55° North latitude, to determine the effect of different weed management methods on the yield of four sorghum cultivars. After determining the experimental site, soil samples were taken at a depth of 30 cm before planting and analyzed to determine their physical and chemical properties at the Agricultural Research Directorate laboratory in Sulaymaniyah, as shown in Table (1).

traits	**pH**	**Ds/m Ece**	**Soil separations**			**available nitrogen percentage mg/kg**	**Potassium mg/kg**	**Available Phosphorus mg/kg**	**texture**
			sand	**silt**	**clay**				
values	**9.08**	**1.84**	**86**	**11.80**	**2.20**	**14**	**160**	**9**	**loamy**

Study Factors

Factor 1 - Genotype: Four sorghum genotypes (buhouth, Rabeh, Inkath, and Giza)

Treatment 2: Weed Control Treatments (Four Treatments)

1. weedy treatment (no control).

2. Weed-free: Weed-free treatment (manual weed removal).

3. Tillage: Control by tillage.

4. Chemical control: Chemical control using Castran herbicide after germination.

The active ingredient is Atrazine + S-metolachlor, and the recommended application rate of the herbicide is 2.5– 4.0 L/ha

The herbicide was sprayed during the early growth stage (2-3 leaves) of the weed plants, when they are most sensitive to the herbicide and easier to control. Spraying was carried out early in the morning after the dew had dried to ensure optimal absorption and minimize herbicide loss, at a rate of 1-1.5 liters per hectare. A spreading agent (dishwashing liquid) was added to improve spraying efficiency. - Preparing the land for planting: The experimental land was plowed twice perpendicularly using a disc plow, and leveling and smoothing operations were carried out on it in order to prepare a suitable seedbed. The land was divided according to the field plan of the experiment in a factorial experiment according to the design of the randomized complete blocks (RCBD). It included (48) experimental units distributed in three replicates, with (16) experimental units per replicate. The area of the experimental unit was (3 x 2 m2) with 4 rows in each plot, the length of one row being 2 m, and the distance between one row and another being 75 cm, and between one plant and another being 25 cm. The experiment was planted on June 15, 2025. The crop was fertilized with urea (46% N) as the nitrogen source at a rate of 320 kg ha^{-1}, applied in two applications: the first at planting and the second one month later. Triple superphosphate (46%) was added as the phosphorus source at a rate of 160 kg P_2O_5 ha^{-1}, and potassium sulfate ($K_{2504522}$) was added as the potassium source at a rate of 120 kg ha^{-1} [20] in a single application after plowing and before harrowing. Seeds were sown at a rate of 2-3 seeds per hill to ensure germination, and the plants were thinned to one plant per hill one month after planting. Stem borer was controlled using diazinon granular insecticide applied as a 10% solution at a rate of 6 kg ha^{-1}, in two applications. Irrigation was carried out according to the crop's needs throughout the growing season. At the end of the season, the crop was harvested. The crop was obtained by selecting five plants from the two middle rows for each experimental unit, and the required data were taken according to the studied traits.

The studied traits:

1- Number of narrow and broad-leaved weeds ($plants.m^2$): A wooden square measuring one square meter was used and randomly placed in the experimental unit [5].

2- Dry weight of narrow and broad-leaved weeds (g): The dry weight of the weeds was calculated at the stage of physiological maturity. Weeds were cut at soil level, collected in perforated paper bags, and then placed in an oven at 70°C for 48 hours [1].

3- Percentage of weed control (%): Calculate the percentage of control after 60 and 90 days of spraying using the following equation [12].

$$\textbf{Percentage of control \%} = \frac{\textit{Number of weeds in the control treatment} - \textit{Number of wee}}{\textit{Number of weeds in the control tr}} \times \mathbf{100}$$

ISSN 2072-3857

4- Percentage of weed inhibition (%): Calculate the percentage of inhibition in dry weight using the following equation [12].

Percentage of inhibition=$100 - \frac{A}{B} \times 100$

Where: A = Dry weight of weeds in weed control treatments.

B = Dry weight of weeds in the weed-free treatment.

5- Plant height (cm^2):

Plant height was measured from soil surface to the highest point of the plant using a measuring tape [2].

6- Leaf area (cm^2): (Al-Sahouki, 1990) Measured for the average of five randomly selected plants at 100% flowering for each experimental unit. Area of a single leaf (cm^2) = Maximum length (cm) × Maximum width (cm) × 0.75

Leaf area of a plant (cm^2) = Area of a single leaf (cm^2) × Average number of leaves per plant

3-7- Statistical Analysis

The data were statistically analyzed using a Randomized Complete Block Design (RCBD) with a factorial experiment, as described by [6]. Significant differences between the means were then compared using Duncan's multiple range test at a significance level of 0.05. The SAS software was used for this analysis.

Results and Discussion

1- Number of Narrow-Leaf Weeds (plants.m^2)

The results in Table (2) indicate a significant effect of the average control treatments on the number of narrow-leaf weeds. The control treatment achieved the highest value for this trait, reaching 16.25 weeds.m^2, Compared with the chemical control treatment, which recorded a value of 4.83 weeds.m^2.This is attributed to the fact that in the control treatment (no control), the weeds are left to grow undisturbed, allowing them to complete their life cycle, reproduce, and produce seeds, thus increasing their density per unit area. In contrast, manual weeding leads to the mechanical removal of weeds along with their roots, which reduces the plant density of the bush and its ability to regrow, thus showing a significant difference in the number of weeds in favor of the manual weeding treatment. These results are consistent with those of [22]. The same table also shows that the Rabeh cultivar was superior, recording the lowest mean for this trait at 4.92 weeds.m^2, while the Buhouth cultivar exhibited the highest mean number of narrow-leaved weeds, reaching 6.08 weeds.m^2, with no significant differences compared with the other cultivars. This is attributed to the ability of different sorghum cultivars to compete with weeds, a crucial strategy in weed management. Studies have

ISSN 2072-3857

shown that cultivars with excelled vegetative characteristics, such as plant height, number of leaves, and larger leaf area, can contribute to weed control. [15]. The results demonstrate a significant interaction effect between control treatments and cultivars in yellow sorghum on the number of narrow-leaved weeds. The control treatment with Buhouth cultivar resulted in the highest number of narrow-leaved weeds, reaching 91.0 weeds.m2. In contrast, the weed control treatment. The lowest average weed count for all cultivars was 0.0 weeds.m2 (m^2).

Table (2) shows the effect of sorghum genotype and weed control methods on the number of narrow-leaved weeds (m^2).

Weed control treatments	**cultivars**				**average Weed control treatments**
	buhouth	**Rabeh**	**Inkath**	**Giza**	
control treatments	**21.00 a**	**17.33 b**	**18.67 b**	**19.00 b**	**19.25 a**
Manual weeding	**0.00 e**	**0.00 e**	**0.00 e**	**0.00 e**	**0.00 d**
one-time pudding	**6.67 cd**	**6.00 cd**	**5.67 d**	**8.00 c**	**7.58 b**
Chemical control	**4.67 de**	**5.33 de**	**4.34 de**	**5.00 de**	**4.83 c**
average cultivars	**9.08 a**	**7.92 b**	**7.93 b**	**8.75 ab**	
Similar letters indicate no significant differences					

2- Number of Broadleaf Weeds.m^2

The results in Table (3) The hand weeding treatment was superior by giving the lowest mean value for the trait, whereas the chemical control treatment recorded a mean of (0.83) broadleaf weeds m^{-2}, while the control treatment recorded the highest number of broadleaf weeds per square meter, reaching

ISSN 2072-3857

(3.25) weeds m $^{-2}$. The significant differences in the average weeds.m2 between the control treatments are attributed to the varying effectiveness of each treatment in reducing weed density and its ability to persist and grow. The hand-weeding treatment achieved a 100% control rate compared to the control treatment at 0% [13]. No significant differences were observed between the cultivars included in the study in the number of broadleaf weeds.m^2. The interaction between the hand-weeding treatment and the four cultivars achieved the lowest mean value for the number of broadleaf weeds per square meter, reaching (0.00) weeds m^{-2}. In contrast, the control treatment with the Buhuth cultivar gave the highest value for the number of broadleaf weeds per square meter, reaching (4.00) weeds m^{-2}.

Table (3) Effect of sorghum genotype and weed control methods on the number of broadleaf weeds (m^2)

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	4.00 a	3.33 ab	3.00 abc	2.67 abc	3.25 a
Manual weeding	0.00 e	0.00 e	0.00 e	0.00 e	0.00 d
one-time pudding	1.67 cd	2.00 bcd	1.67 cd	2.00 bcd	1.83 b
Chemical control	0.67 de	1.00 de	1.00 de	0.67 de	0.83 c
average cultivars	1.58 a	1.58 a	1.42 a	1.33 a	
Similar letters indicate no significant differences					

3- Dry Weight Trait of Narrow-Leafed Weeds

The results in Table (4) The manual weeding treatment gave an average of (0.0) g, while the chemical control treatment outperformed by recording the lowest average of (20.17) g. In contrast, the control treatment recorded the highest average of (263.30) g/m^2. Weed weight is an indicator of the intensity of

ISSN 2072-3857

competition between weeds and the crop for essential growth requirements such as water, nutrients, and light. The decrease in weed weight in the control treatment is attributed to the herbicide's effect in damaging the living tissues responsible for photosynthesis. This leads to an imbalance between anabolic and catabolic processes, favoring catabolic processes, and consequently, a decrease in dry matter accumulation in weed tissues. This result is consistent with the findings of [3]. No significant differences were observed between the different cultivars. The interaction between the chemical control treatment and the Buhoth cultivar achieved the lowest mean weight of weeds, reaching (17.07) g/m², whereas the control treatment with the four cultivars recorded the highest mean weights of narrow-leaved weeds, amounting to (263.47, 276.80, 235.57, and 277.37 g/m²), respectively.

Table (4) Effect of sorghum genotype and weed control methods on the dry weight of narrow-leaved weeds (g)

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	263.47 a	276.80 a	235.57 a	277.37 a	263.30 a
Manual weeding	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c
one-time pudding	43.93 bc	37.43 bc	20.60 bc	51.63 b	38.40 b
Chemical control	17.07 bc	22.67 bc	18.50 bc	22.43 bc	20.17 b
average cultivars	81.12 a	84.23 a	68.67 a	87.86 a	
Similar letters indicate no significant differences					

4- Dry Weight of Broadleaf Weeds (g)

ISSN 2072-3857

The results in Table (5) The chemical control treatment showed superiority by recording the lowest mean value for the trait after the manual weeding treatment, which gave an average of (2.85) g, whereas the control treatment recorded the highest mean value for the broad-leaved weed weight trait, reaching (22.24) g/m². No significant differences were observed between the different cultivars. This is attributed to the strong inverse relationship between the weed control percentage and weed weight. A decrease in weed biomass in control treatments leads to a higher calculated control percentage compared to the control treatment. Dry weight is an accurate indicator of infestation severity and treatment effectiveness in reducing actual weed growth [27] The interaction between the chemical control treatment and the Buhoth cultivar achieved the lowest arithmetic mean, reaching (0.37) g/m², whereas the interaction between the control treatment and the Rabih cultivar gave the highest mean for the broad-leaved weed weight trait, reaching (29.67) g/m².

Table (5) Effect of sorghum genotype and weed control methods on the dry weight of broadleaf weeds (g)

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	21.63 b	29.67 a	17.93 b	19.73 b	22.24 a
Manual weeding	0.00 d	0.00 d	0.00 d	0.00 d	0.00 c
one-time pudding	3.03 cd	6.37 cd	4.80 cd	9.43 c	5.90 b
Chemical control	0.37 d	4.27 cd	2.03 cd	4.73 cd	2.85 bc
average cultivars	6.26 a	10.08 a	6.19 a	8.48 a	
Similar letters indicate no significant differences					

5- Control Rate of Narrow-Leaf Weeds

Table (6) The results indicated the presence of significant differences among the mean values of weed control treatments in weed number, as the chemical control treatment achieved a control efficiency of 88.34%, compared to the

ISSN 2072-3857

control treatment which yielded a control rate of (0.0%). This is scientifically explained by the fact that manual removal uproots the plants completely, including their vegetative and sometimes root parts, thus halting vegetative growth and preventing regeneration. Consequently, the weed density per unit area is negligible. The control treatment (no control), on the other hand, allows the weeds to complete their life cycle unimpeded, maintaining their natural density and showing clear, significant differences in statistical analysis [25]. The Giza cultivar also demonstrated superiority, achieving the highest control rate of 66.18%. While Rabeh cultivar achieved the lowest control rate of 60.78%, with an insignificant difference from Buhouth and Inkath cultivars. This may be attributed to the fact that some sorghum possess structural and intrinsic characteristics that affect their competitiveness against weeds, such as total plant height, total leaf area, and vegetative growth rate. These traits lead to greater soil shading and inhibition of weed germination and growth, thus reducing weed density and dry mass compared to other, weaker-growing cultivars [23]. The binary interaction between weed control treatments and cultivars showed a significant effect on the weed control percentage trait for narrow-leaved weeds, as the chemical control treatment with the Giza cultivar achieved a control percentage of 66.18%. In contrast, the control treatment with all cultivars did not achieve any control percentage, recording 0.0%.

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Table (6) Effect of sorghum genotype and weed control methods on the control rate of narrow-leaved weeds

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	0.00 e	0.00 e	0.00 e	0.00 e	0.00 d
Manual weeding	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a
one-time pudding	58.00 d	58.37 d	54.20 d	76.97 c	61.88 c
Chemical control	89.70 ab	84.73 bc	91.20 ab	87.73 b	88.34 b
average cultivars	61.93 ab	60.78 b	61.35 ab	66.18 a	
Similar letters indicate no significant differences					

6- Broadleaf Weed Control Percentage (%)

The results in Table (7) The results indicated the presence of significant effects among the mean values of weed control treatments on the number of controlled weeds, as the chemical control treatment achieved a weed control percentage of 81.42%, compared with the control treatment, which recorded a broad-leaved weed control percentage of (0.0)%. This may be attributed to the fact that the chemical control treatment suppresses or kills weeds during their early growth stages before they reach a large size, whereas in the control treatment, weeds continue to grow and reproduce. This explains why the control percentage in the chemical control treatment can reach very high levels (e.g., 100%) compared with 0% in the control treatment.[8]. The results also indicated no significant differences between the cultivars included in the study regarding the broadleaf weed control percentage. The interaction between control

ISSN 2072-3857

treatments and cultivars was also significant. The manual weeding treatment with the four cultivars showed the highest average broadleaf weed control rate of 100.0%, while the control treatment with the four cultivars showed the lowest average broadleaf weed control rate of 0.0%.

Table (7) Effect of sorghum genotype and weed control methods on broadleaf weed control rate

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	0.00 e	0.00 e	0.00 e	0.00 e	0.00 d
Manual weeding	100.00 a	100.00 a	100.00 a	100.00 a	100 a
one-time pudding	38.87 d	38.10 d	60.53 cd	47.77 d	46.31 c
Chemical control	88.87 ab	84.20 abc	79.33 abc	73.30 bc	81.42 b
average cultivars	56.93 a	55.58 a	59.97 a	55.27 a	
Similar letters indicate no significant differences					

7- Weed Inhibition Percentage

The inhibition percentage (%) in dry weight represents the difference between the dry weight in the control treatments and the dry weight in the non-control treatment. It reflects the amount of reduction in dry matter accumulation resulting from the treatment. Table (8) The results showed significant differences among the study factors, as the chemical control treatment recorded the highest inhibition percentage of narrow-leaved weeds, reaching 91.81%, whereas the control treatment gave the lowest inhibition percentage of narrow-leaved weeds, reaching 0.0%. Under chemical control, the dry weight was nearly zero, resulting in an inhibition percentage of 81.42%, which indicates the high efficiency of the treatment in stopping photosynthesis and preventing dry matter formation. No significant differences were

ISSN 2072-3857

observed among the cultivars included in the study for the inhibition percentage trait of narrow-leaved weeds.

The interaction between weed control treatments and cultivars was also significant, as the chemical control treatment with the Enqath cultivar outperformed the other treatments by recording the highest mean inhibition percentage of narrow-leaved weeds, reaching 94.83%, whereas the control treatment with the four cultivars recorded the lowest mean inhibition percentage of narrow-leaved weeds, reaching 0.0%.

Table (8) Effect of sorghum genotype and weed control methods on narrow-leaved weed inhibition rates

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	0.00 f	0.00 f	0.00 f	0.00 f	0.00 d
Manual weeding	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a
one-time pudding	81.90 cd	86.23 bc	74.57 de	71.30 e	78.50 c
Chemical control	92.90 ab	91.27 ab	94.83 ab	88.23 bc	91.81 b
average cultivars	68.70 a	69.38 a	67.35 a	64.88 a	
Similar letters indicate no significant differences					

8- Broadleaf Weed Control Rate

The results in Table (9) The results showed significant differences among the study factors, as the chemical control treatment recorded the highest inhibition percentage of broad-leaved weeds, reaching 88.65%, whereas the control treatment gave the lowest inhibition percentage of broad-leaved weeds, reaching 0.0%. The superiority of the chemical control treatment is attributed to its high ability to reduce weed biomass, as it recorded the lowest dry weight of weeds and the highest weed control percentage for broad-leaved weeds compared with the other treatments. [18]. Buhouth cultivar also demonstrated superiority, achieving the highest control rate at 66.18%, which was not significantly different from the Giza and Rabeh cultivars, but differed significantly from the Inkath cultivar, which recorded the lowest control rate at 55.73%. Buhouth cultivar is the most competitive with weeds, which increases its ability to acquire resources (light, water, and nutrients) early. The interaction between weed control treatments and cultivars was also significant, as the chemical control treatment with the Buhoth cultivar recorded the highest mean inhibition percentage of broad-leaved weeds, reaching 68.95%, whereas the control treatment with all cultivars recorded the lowest mean inhibition percentage of broad-leaved weeds, reaching 0.0%.

Table (9) Effect of sorghum genotype and weed control methods on broadleaf weed inhibition rates

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	0.00 d	0.00 d	0.00 d	0.00 d	0.00 d
Manual weeding	100.00 a	100.00 a	100.00 a	100.00 a	100 a
one-time pudding	76.97 abc	75.70 abc	55.23 c	65.33 bc	68.30 c
Chemical control	98.83 a	86.57 ab	67.70 bc	69.50 bc	80.65 b
average cultivars	68.95 a	65.57 ab	55.73 b	58.71 ab	
Similar letters indicate no significant differences					

9- Plant Height (cm-1)

This is a quantitative trait influenced by both genetic and environmental factors. Its performance is determined by the interaction

ISSN 2072-3857

between the genotype and surrounding environmental conditions. Stem growth occurs longitudinally as a result of internodes elongation due to cell division and elongation in growth zones, particularly under the influence of growth regulators and environmental factors such as light, temperature, and nutrient availability. This leads to clear variation between genotypes in the rate and length of vegetative growth [28]. Table (10) showed significant differences between the study factors, as the manual weeding treatment recorded the highest plant height of (126.88) cm, while the control treatment gave the lowest plant height of (91.00) cm. This may be attributed to the efficiency of manual weeding in reducing the number of weeds and their dry weights (Tables 4 and 6), which contributed to providing a suitable growing environment for the crop by reducing the intensity of competition for basic growth requirements such as water, nutrients and light. This was reflected positively in enhancing the efficiency of the photosynthesis process and other physiological activities, which led to an increase in plant height. This result is consistent with what [18] indicated. As for the cultivars, the Inkath cultivar outperformed others, gave the highest value for the trait at 115.81 cm. This was not significantly different from Rabeh and Giza cultivars, which recorded averages of 112.52 and 109.40 cm, respectively. This contrasts with Buhouth cultivar, which had the lowest average at 102.50 cm. The difference between the cultivars in this trait may be attributed to variations in the number and length of internodes, as these are distinctive genetic characteristics of each cultivar, reflected in different aspects of growth and development. These results are consistent with those indicated by[20,9,26]. The interaction between control treatments and cultivars was also significant, with the Inkath cultivar outperforming the manual weeding treatment, recording the highest average height (132.00 cm), while Buhouth cultivar recorded the lowest average height (80.87 cm) under the control treatment.

ISSN 2072-3857

Table (10) Effect of sorghum genotype and weed control methods on plant height (cm plant-1)

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	80.87 e	94.67 de	104.67 cd	83.80 e	91.00 d
Manual weeding	123.40abc	122.93 abc	132.00 a	129.20 ab	126.88 a
one-time pudding	119.67abc	117.07 abc	116.87 abc	113.67 a-d	116.82 b
Chemical control	86.07 e	115.40 abc	109.70 bcd	110.93 bcd	105.53 c
average cultivars	102.50 b	112.52 a	115.81 a	109.40 ab	
Similar letters indicate no significant differences					

10- Leaf Area (cm²)

Leaf area is one of the most important plant physiological characteristics because it represents the surface area through which leaves absorb sunlight for photosynthesis. Leaf area directly contributes to determining plant productivity, as increasing leaf area increases the amount of carbohydrates produced, which are used in plant growth and the formation of economically important parts such as grains [11]. The results in Table (11) indicate significant effects of the average control treatments on leaf area. The manual weeding treatment achieved the highest average leaf area, reaching 3743.13 cm², compared to the control treatment, which gave the lowest average leaf area of 2007.66 cm². This increase is attributed to the positive effect of manual weeding in promoting cell division and cell elongation, as well as stimulating the growth and development of the root and shoot systems and extending their effective lifespan, which directly improves the plant's physiological processes. Furthermore,

ISSN 2072-3857

reducing competition between the crop and weeds for basic growth requirements contributed to an increase in leaf area compared to other treatments, ultimately leading to an improvement in overall yield. These results are consistent with [24].

Regarding genotypes, Rabeh genotype achieved the highest average for the trait at 3470.97 cm², significantly higher than the other genotypes. Conversely, the Giza genotype yielded the lowest average for the trait at 2736.50 cm². The genetic differences among cultivars in this trait are attributed to the unique genetic makeup of each cultivar, particularly concerning the length of the growing season. Extending the vegetative period contributes to increased cell division and improved vegetative growth, which positively impacts the final yield. This finding aligns with the findings of [19,21] . The results show a significant interaction between control treatments and genotype on leaf area. The manual weeding treatment with Rabeh genotype resulted in the highest average leaf area of 4150.12 cm², while the control treatment with the Giza genotype resulted in the lowest average leaf area of 1290.22 cm².

Table (11) Effect of sorghum genotype and weed control methods on plant leaf area (cm²):

Weed control treatments	cultivars				average Weed control treatments
	buhouth	Rabeh	Inkath	Giza	
control treatments	1656.40 c	3012.63 b	2071.37 c	1290.22 d	2007.66 c
Manual weeding	3540.93 ab	4150.12 a	3828.47 ab	3453.01 ab	3743.13 a
one-time pudding	3168.77 b	3604.26ab	3429.12 ab	3052.10 b	3313.56 b
Chemical control	3195.34 b	3116.86 b	3485.30 ab	3150.68 b	3237.04 b
average cultivars	2890.36 bc	3470.97 a	3203.56 ab	2736.50 c	

ISSN 2072-3857

Similar letters indicate no significant differences

Conclusions:

1- Significant differences were observed between the cultivars in the traits of the number of narrow-leaved weeds (m^2), the percentage of narrow-leaved weed control, the percentage of broad-leaved weed inhibition, plant height, and leaf area.

2- The manual weeding treatment was the most efficient, excelling in most of the studied traits and demonstrating the best reduction in weed weight, number, and inhibition percentage compared to the other treatments used in the study.

3- bi- interaction between the manual weeding treatment and Rabeh cultivar resulted in a higher plant leaf area.

Appendix (1) Analysis of variance represented by the mean squares for the studied traits

Sources of Variation S.O.V	**df**	**Number of narrow-leaved weeds per square meter**	**Narrow-leaved weed control percentage**	**Weight of narrow-leaved weeds (g(**	**Narrow-leaved weed inhibition percentage**	**Number of broad-leaved weeds per square meter**	**Broad-leaved weed control percentage**
R	**2**	**2.02**	**4.07**	**765.44**	**3.91**	**0.39**	**61.05**
V	**3**	**4.22 NS**	**72.48 NS**	**833.69 NS**	**47.20 NS**	**0.18 NS**	**55.29 NS**
mc	**3**	**651.61****	**23922.63****	**181234.42 ****	**25297.48 ****	**23.46****	**23234.79 ****
V * mc	**9**	**3.72 NS**	**88.30 NS**	**287.62 NS**	**38.29 NS**	**0.33 NS**	**135.13 NS**
Errar	**30**	**1.62**	**34.32**	**565.01**	**25.89**	**0.640**	**192.70**

ISSN 2072-3857

**Significant at 0.01, *Significant at 0.05, NS not significant

Analysis of variance represented by the mean squares of the studied traits

Sources of Variation S.O.V	df	Weight of broadleaf weeds (g(	Broadleaf weed inhibition percentage	Plant height (cm(	Leaf area (cm²(
R	**2**	**6.16**	**102.51**	**63.05**	**6.1736555**
V	**3**	**42.33 NS**	**443.60 NS**	**386.67 NS**	**1287956.27***
mc	**3**	**1189.89****	**22701.55****	**2850.10 ****	**6675184.97****
V * mc	**9**	**24.17 NS**	**174.49 NS**	**189.43 NS**	**311530.53 NS**
Errar	**30**	**21.62**	**175.29**	**112.00**	**226996.14**

**Significant at 0.01, *Significant at 0.05, NS not significant

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