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Research Article

Interactive Effects of Planting Dates and Herbicide Treatments on Weed Suppression and Grain Yield of Maize (*Zea mays* L.)

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ABSTRACT

Maize is a staple crop of global importance, ranking first in cultivated area and third in total production worldwide. Its growth and productivity are influenced by numerous factors, among which weed competition and shifts in planting dates due to climate change pose significant challenges to farmers. Therefore, this study was conducted to evaluate the effects of several modern chemical herbicides (Apple at 1 L ha^{-1}, Arrivo at 1.5 L ha^{-1}, and Ramses at 50 g ha^{-1}) on the growth and yield of maize (*Zea mays* L.), cultivar Drachma, sown at different spring planting dates (17 March, 26 March, and 5 April 2025). The experiment was arranged in a randomized complete block design with three replications. Herbicides were applied at the recommended rates 21 days after sowing, when the plants reached the 4-6 leaf stage. The results indicated that most of the herbicides significantly improved the studied traits. The herbicide Abel resulted in the lowest weed density (8.04 plants m^{-2}), the highest weed control efficiency (88.10%), and the greatest number of grains per row (34.24). Ramses produced the highest 500-grain weight (146.30 g). The first planting date (17 March 2025) recorded the tallest plants (185.81 cm), the largest leaf area (620.47 cm^2), and the highest grain yield (14.24 t ha^{-1}). Overall, the combined use of the earlier planting dates (17 and 26 March 2025) with the herbicides Abel and Ramses produced the most favorable results, enhancing vegetative growth and significantly increasing final grain yield.

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Introduction

Maize (*Zea mays* L.) ranks third in production after wheat and rice and is considered one of the most important cereal crops in the world due to its versatility (UN, 2009). It meets the protein and calorie needs of millions of people worldwide, especially in developing countries (Saritha et al., 2020), in addition to its use in various industrial applications, such as animal feed and biofuel (Sneha et al., 2024). Its economic importance lies in the fact that its grains contain carbohydrates (81%), protein (10.6%), and oil (4.6%), as well as vitamins E, B1, and B2 (Muhantesh, 2006). In Iraq, the yellow corn crop witnessed a remarkable improvement in the agricultural and production indicators for 2022 compared to 2023, with the cultivated area increasing from 83,594 to 89,812 ha and the crop area from 82,844 to 88,812 ha, and the production quantity increasing from 496,003 to 538,251 tons (Central Statistical

Organization, 2022 and 2023). Despite the increase in the cultivated area and production by 7.5% and 8.5% respectively, the quantity of the product per unit area only started at 0.9% monthly, which is far from the required level. This slight increase poses significant challenges to the cultivation of this crop to increase its production in a way that ensures sustainable development. The most prominent obstacle to good production is the presence of weeds accompanying the crop, as their presence leads to significant losses in the quality and quantity of the harvest as a result of their competition with agricultural crops for light, water and nutrients (Alsulami, 2024). Furthermore, it negatively impacts agricultural production costs by making soil preparation and harvesting more difficult in addition to reducing grain quality (Swanton et al., 2015). Losses in Iraq due to this problem range between 25% and 40% (Al-Khazalee et al., 2017). Therefore, it is essential to focus on controlling it to minimize its damage and regulate its growth. Various methods are employed, primarily chemical pesticides. Chemical pesticides are among the most effective and least expensive methods for controlling weeds that grow alongside crops (Ofosu et al., 2023). However, using the same type of herbicide for extended periods creates the problem of weed resistance, a phenomenon that threatens the sustainability of production. Therefore, researchers in the agricultural sector are constantly striving to change the types of pesticides used while introducing new pesticides (Pedroso and Mortti, 2025). Another factor determining corn growth and productivity is the need to plant it at a time that suits its growth. Due to accelerating climate change, it has become necessary to reevaluate the appropriate planting dates for most agricultural crops including yellow corn (Al-Mashhadani and Fakhr, 2015). Planting too early in the spring leads to germination failure or seedling death due to low temperatures, while delaying planting leads to economic losses represented by a significant reduction in the total grain yield due to high temperatures and low atmospheric humidity that coincide with the male and female flowering stages, which result in either failure of pollination and fertilization or the formation of shriveled grains that have no economic return (Ali, 2020). Accordingly, this study aimed to evaluate the effectiveness of three types of chemical pesticides on the growth and productivity of corn crop planted at three different spring dates.

Materials and Methods

A field experiment was conducted at the research station of the Department of Field Crops Sciences, College of Agriculture, University of Diyala, during the spring season of 2025, in soil. The chemical and physical properties of the soil are presented in Table 1. The prevailing climatic conditions in the study area were monitored throughout the the experiment, and the rates of monthly temperature, humidity and rainfall are shown in detail in Table 2.

The experiment was arranged in a randomized complete block design (RCBD) using a split-plot system with three replications. The main plots included three spring planting dates: the first on 17/3/2025, the second on 26/3/2025, and the third on 5/4/2025. The subplots included five treatments: weed-free, weedy without control, Arrow herbicide (SL 75%) at a rate of 1.5 L ha^{-1}, Abel herbicide (OD 30%) at a rate of 1.0 L ha^{-1}, and Ramses herbicide (SG 25%) at a rate of 50 g ha^{-1} as shown in Table 3. The structural composition of the tested pesticides is shown in Figures 1, 2 and 3.

The experimental field was prepared by plowing, leveling, and smoothing, then divided into three replications, each containing 15 experimental units with an area of 7.5 m^2 per unit. The field was fertilized with di-ammonium phosphate (DAP, P_2O_5 40%) as a phosphorus source at a rate of 400 kg ha^{-1} applied once before planting (Al-Jubouri and Mohammed, 2020). Urea fertilizer (N 46%) was applied as a nitrogen source at a rate of 320 kg ha^{-1} in two split applications: the first 20 days after planting and the second 20 days after the first application (Jiyad and Al-Sahoki, 2011).

Corn Seeds were planted by placing two seeds per hill, with a spacing of 25 cm between pit and 75 cm between rows, resulting in a plant density of 66,667 plants ha^{-1} (Assefa et al., 2021). The hole where germination failed was replanted 10 days after planting, and thinning was conducted three weeks after planting, leaving one plant per hill (General Authority for Agricultural Research, 2024). Manual hoeing was carried out periodically for the weed-free treatments (Obaid and Hussein, 2024).

The crop was irrigated as needed. To ensure reduction of grain moisture to the required level at harvest, irrigation was stopped 10 days before harvesting after the plants arrived the stage of physiological maturity, through yellowing of the leaves and hardening of the grains (Khalaf and Jassim, 2023).

Table 1. Physical and chemical properties of the soil for the 2025 growing season.

Property		Season 2025	unit
Soil particle-size distribution	Sand	26.1	%
	Clay	43.5	
	Silt	30.4	
Soil reaction(pH)		7.2	
Electrical conductivity (EC_e)		6.7	ds m^{-1}
Available nitrogen		7.41	Mg. kg^{-1}
Available phosphorus		15.3	
Available potassium		96	
Calcium carbonate		177.4	g. kg^{-1}
Organic matter		6.2	
Soil texture class		Clay loam	

Table 2. Average maximum and minimum temperatures, relative humidity, and rainfall during the experimental months.

Months	Maximum temperature °C	Minimum temperature °C	Average °C	% Humidity	Rainfall amount	photoperiod	Total solar radiation
March	23.81	8.99	16.4	55	44.4	10	456.89
April	30.88	14.91	22.90	47	3.5	11.4	500.54
May	38.58	19.27	29.93	34	7.2	11.9	667.49
June	42.37	22.47	32.42	20	0	14.7	779.6
July	44.93	26.55	35.74	18	0	14.4	743.22
August	44.58	25.14	34.86	19	0	13.6	634.98

Table 3. Herbicides used in the experiment.

Trade name	Active ingredient	Active ingredient concentration	Application rate	Chemical group
Arrivo	Rimsuper	*75%*	*1.5 L.ha*	Suifonylureas
Able	Atrazine Nicosulfuron Mesotrione	*30%*	*1 L.ha*	Suifonylureas
Ramses	Rimsulfuron	*25%*	*50 g.ha*	Sulfonylurea

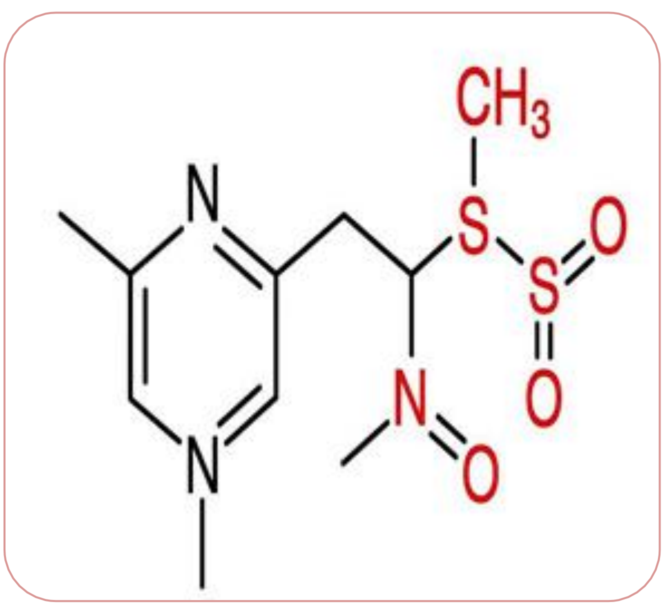

Figure 1. The structural composition of the pesticide Arrivo 75% SL.

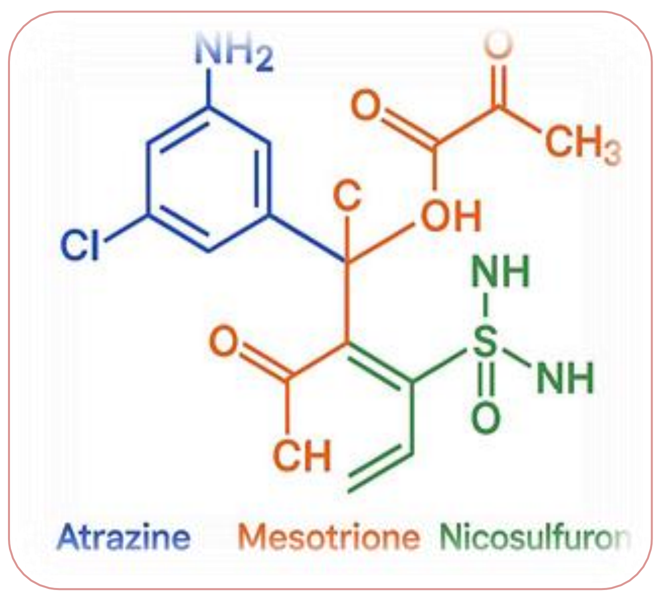

Figure 2. The structural composition of the pesticide Able 30% OD.

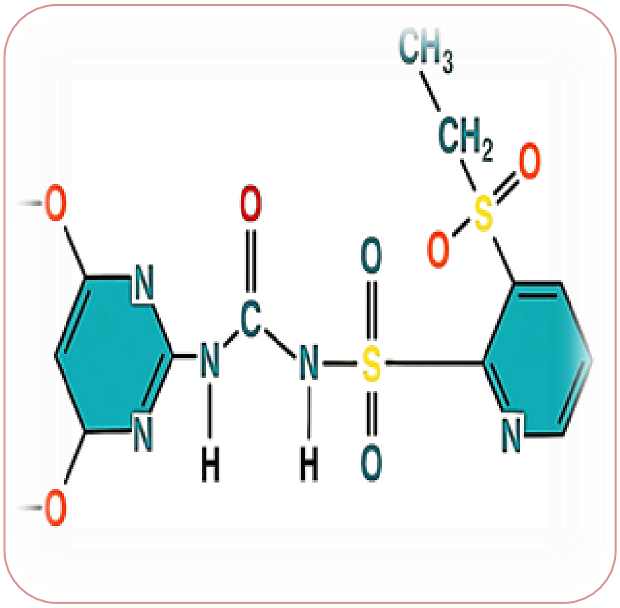

Figure 3. The structural composition of the pesticide Ramses 25% SG.

Studied Traits

Weed density 90 days after spraying (plants.m^{-2})

The weed species growing in the experiment were identified and are shown in Table 4 and their density was determined by counting the number of weeds present within 1 m^2 of each experimental unit using a wooden square (Gressel and Kogan, 2020).

Weed control percentage

The weed control percentage was calculated 30 days after herbicide application according to the equation (Al-Wagaa et al., 2018).

$$\text{Weed control percentage (\%)} = \frac{C - T}{C} \times 100$$

Where

C = Number of weeds in the untreated (weedy) control,

T = Number of weeds in the treated plot.

Plant height (cm)

Plant height was measured using a measuring tape, from the point of plant-soil contact up to the last node below the male inflorescence (tassel) (Momen et al., 2021).

Table 4. Weed species identified in the experiment during the spring growing season.

Scientific Name	Family	Leaf morphotype	Life cycle	Abundance
Rumex hypogaeus L.	Polygonaceae	Broadleaf	Annual	Very dense
Sonchus oleraceus L.	Asteraceae	Broadleaf	Annual	Dense
Corchorus olitorius L.	Malvaceae	Broadleaf	Annual	Low
Sorghum halepense L.	Poaceae	Grass/Slender	Perennial	Very dense
Cynodon dactylon L.	Poaceae	Grass/Slender	Perennial	Moderate
Cyperus rotundus L.	Cyperaceae	Sedge/Slender	Perennial	Low
Convolvulus arvensis L.	Convolvulaceae	Broadleaf	Perennial	Dense
Setaria viridis L.	Poaceae	Grass/Slender	Annual	Low
Alhagi maurorum L.	Fabaceae	Broadleaf	Perennial	Moderate
Malva parviflora L.	Malvaceae	Broadleaf	Annual	Low
Portulaca oleracea L.	Portulacaceae	Broadleaf	Annual	Dense
Euphorbia peplus L.	Euphorbiaceae	Broadleaf	Annual	Moderate

Leaf area (cm^2)

Leaf area was calculated using the equation (Al-Sahouki, 1990; Momen et al., 2021).

Leaf area (cm^2) = Maximum leaf length × Maximum leaf width × 0.75

Plant dry weight (g plant^{-1})

Crop plants were cut and air-dried until a constant weight was achieved (Momen et al., 2021).

Number of grain per row (grain row^{-1})

After selecting three ears randomly, the number of grain per row was determined manually (Momen et al., 2021).

Average weight of 500 (g)

Five hundred grains were manually counted by randomly selecting 3 ears of corn from each experimental unit as described by Momen et al. (2021).

Total grain yield (t ha^{-1})

Total grain yield was calculated in tons per hectare according to the equation described by Momen et al. (2021).

$$\text{Total grain yield (t ha} - {}^{1}) = \frac{\text{Plant density} \times \text{grain yield per plant (g)}}{1000000} \times 100$$

Statistical analysis

The data were statistically analyzed according to the randomized complete block design (RCBD) with a split-plot arrangement using the SAS program. Mean comparisons were performed using Duncan's Multiple Range Test at a 5% probability level (SAS Institute, 2012).

Results and Discussion

Impact of planting dates and chemical weed control on weed density 90 days after spraying (plants.m^{-2})

The results revealed that first planting date (17 March 2025) was superior in producing the lowest mean weed density associated with corn, reaching 9.43 plants m^{-2}, compared with the third planting date (5 April 2025), which recorded the highest weed density of 15.87 plants m^{-2} (Table 5). This means that because of certain environmental factors, there was more time for weeds to grow and spread when the corn planting date was delayed. These results align with those of Al-Tamimi (2021), who stated that the timing of spring planting affects the density of weeds in maize. Abel OD 30% herbicide treatment achieved the lowest weed density (8.04 plants m^{-2}) compared with the weedy (untreated), which recorded a density of 31.83 plants m^{-2}. The impact of the applied herbicides to the weeds results in a decrease in the units of area, the density of the weeds, hence; the weight of the weed in dry units is diminished. This result is consistent with the findings of Al-Kriti (2025), who reported that the use of chemical herbicides significantly reduced the density of weeds infesting maize crops.

Regarding the interaction effect, the Abel herbicide treatment at the first planting date (17 March 2025) recorded the lowest weed density at harvest (5.27 plants m^{-2}), whereas the weedy treatment at the third planting date (5 April 2025) resulted in the highest weed density (38.50 plants m^{-2}).

Table 5. Impact of planting dates and chemical weed control on weed density 90 days after spraying (plants m^{-2}).

Planting dates	Control treatments					Effect of Planting Dates
	Weed free	*Weedy*	Arrivo Herbicide (75% SL)	Abel Herbicide (30% OD)	Ramses Herbicide (25% SG)	
First date (17 March)	0.00 k	25.40 c	8.47 gh	5.27 J	8.00 h	9.43 C
Second date (26 March)	0.00 k	31.60 b	9.53 g	6.60 I	8.67 gh	11.28 B
Third date (5 April)	0.00 k	38.50 a	15.03 d	12.27 f	13.57 e	15.87 A
Control Treatments	0.00 E	31.83 A	11.01 B	8.04 D	10.08 C	

The means with the same letters are not statistically different from each other at 0.05.

Impact of planting dates and herbicides on weed control percentage

The data in Figure 4 shows that the initial planting date of 17 March 2025, achieved the highest level of weed control in maize, surpassing the second and third planting dates of 26 March and 5 Abril 2025, which recorded lower control rates. This superiority of the first planting date may be attributed to favorable environmental conditions for maize growth, such as ideal temperatures for germination and vegetative growth, as well as a suitable photoperiod that facilitated the completion of the various growth stages with effective control of the accompanying weeds.

Furthermore, Figure 4 shows that on the same initial planting date, the application of the chemical herbicide Abel resulted in the highest average weed control rate in maize, at 88.10%. In contrast, treatments using Ramses and Arrivo during this period recorded lower averages of 82.53% and 85.60%, respectively. These differences are likely due to the varying effectiveness of the active ingredients of each herbicide against weeds, along with Abel's notably high efficacy in eliminating weeds. Overall, all herbicide treatments appeared effective compared to the weed-free control group, which achieved 100% complete control.

Impact of planting dates and chemical weed control on corn plant height (cm)

According to the results presented in Table 6, the first planting date (17 March 2025) was the best in registering the highest mean plant height of 185.81 cm, while the third planting date (5 April 2025) recorded the lowest plant height of 172.80 cm. The advantage of the first planting date was likely due to the more favorable environmental conditions.

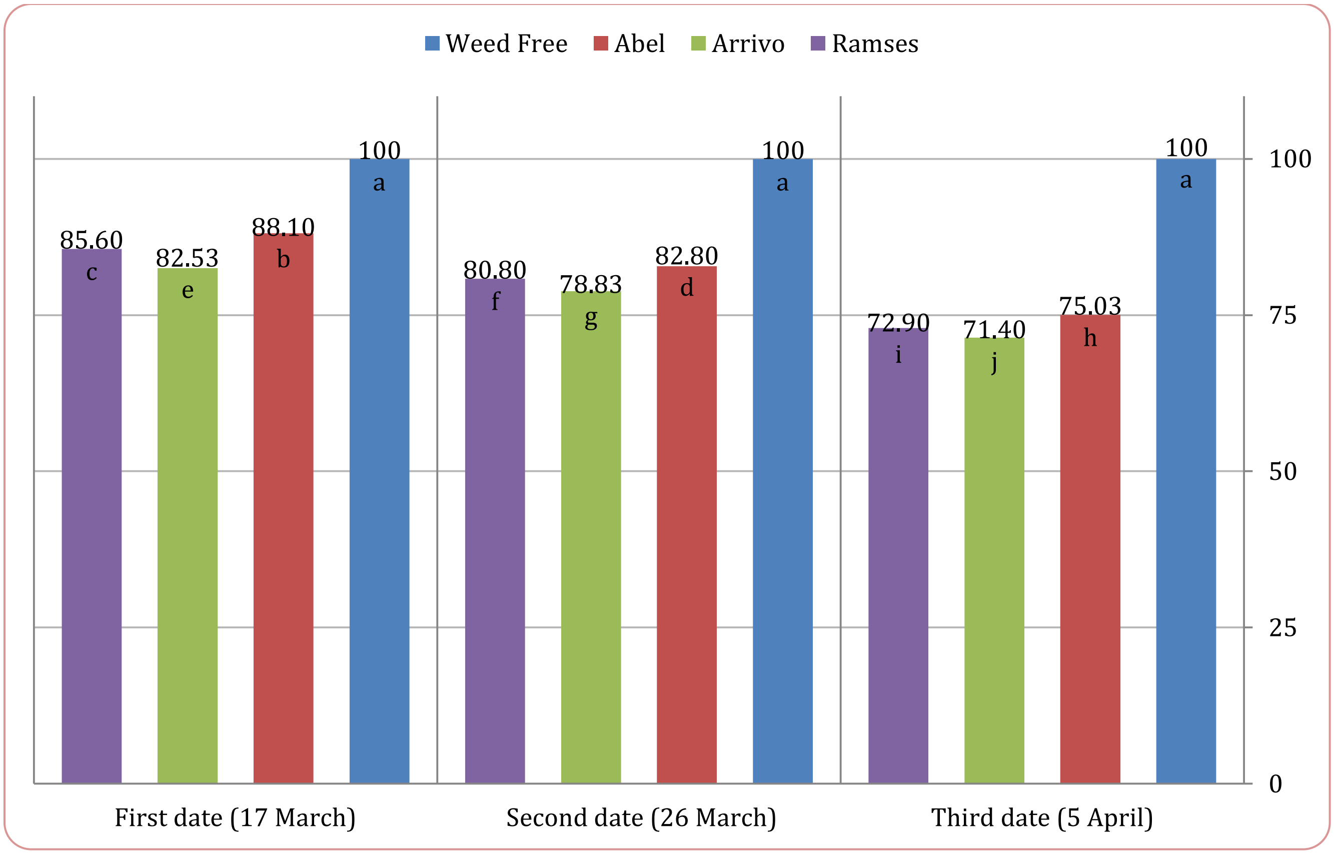

Figure 4. Impact of planting dates and herbicides on control percentage of weeds associated with corn (cv. Drachma).

The combination of a longer photoperiod and improved photosynthetic efficiency drove further advances in vegetative growth, especially in stem elongation. This matches with the conclusions of Hammoud et al., (2024) who determined variation of stem length in maize for different planting dates in spring. The Abel herbicide treatment also heightened the plant height of 181.51 cm compared to the weedy treatment which registered the shortest height of 173.82 cm. This gain can be probably explained by the action of the used herbicide to decrease the weed density of the crop zone and the fast growth of the maize plants that stimulated the acceleration of the canopy cover. The presence of weeds reduced the height of the plants by 6.68% compared to the treatment without weeds. This corroborates the findings of Al-Ubaidi (2020), who stated that weeds impact the height of maize negatively.

In terms of interaction, the Abel treatment for the first planting date (17 March 2025) had the greatest height of 187.70 cm, while the weedy treatment for the third planting date (5 April 2025) had the least height of 167.67 cm.

Table 6. Impact of planting dates and chemical weed control on corn plant height (cm).

Planting dates	Control treatments					Effect of Planting Dates
	Weed free	*Weedy*	Arrivo Herbicide (75% SL)	Abel Herbicide (30% OD)	Ramses Herbicide (25% SG)	
First date (17 March)	191.97 a	178.27 ef	185.53 bc	187.70 b	185.57 bc	185.81 A
Second date (26 March)	185.57 b	175.53 fg	180.47 de	183.17 cd	182.53 cd	181.73 B
Third date (5 April)	177.30 ef	167.67 h	172.37 g	173.67 g	173.00 g	172.80 C
Control Treatments	185.41 A	173.82 C	179.45 B	181.51 B	180.37 B	

The means with the same letters are not statistically different from each other at 0.05.

Impact of planting dates and chemical weed control on leaf area (cm^2) of corn plants

Table 7 revealed that the highest leaf area per plant (620.47 cm^2) was obtained with the first planting date (17 March 2025). This was better than the third planting date (5 April 2025) with mean leaf area of 484.29 cm^2. This can be attributed to the photosynthetic efficiency coupled with the physiological activity of the corn, in which the environment was favorable. This means that there was cellular division in the leaf tissues. In the corn plants, this was reflected in the increase in both the number and the size of the leaves of the plants. In the case of the Ramses herbicide treatment, the corn plants exhibited the greatest leaf area of 563.80 cm^2, whereas the weedy treatment exhibited the least leaf area of 501.39 cm^2. The leaf area in the presence of weeds was decreased compared to the weed-free treatment by 20.70%. This could be attributed to the fact that the competition by weeds in maize plots was reduced and thus, more resources including light, water and nutrients were available. Herbicide use was, however, effective in decreasing the weed population, thereby giving corn more room to grow and improving the available space, and this initiated more leaf growth.

The Abel herbicide treatment at the first planting date (17 March 2025) recorded the highest mean leaf area per plant (643.20 cm^2) and the weedy treatment at the third planting date (5 April 2025) recorded the lowest leaf area (435.13 cm^2). In general, when planting date and chemical weed control treatments are combined, they indicate less competition with weeds and therefore allow the corn plants to utilize their photosynthetic products elsewhere in their developmental processes instead of using them to adapt to the stress caused by the competition from weeds.

Table 7. Impact of planting dates and chemical weed control on the leaf area of corn (cm^2).

Planting dates	Control treatments					Effect of Planting Dates
	Weed free	*Weedy*	Arrivo Herbicide (75% SL)	Abel Herbicide (30% OD)	Ramses Herbicide (25% SG)	
First date (17 March)	656.77 a	555.40 de	622.27 abc	643.20 a	624.73 abc	620.47 A
Second date (26 March)	594.83 bcd	513.63 ef	547.47 de	575.43 cd	583.43 cd	562.96 A
Third date (5 April)	564.00 d	435.13 g	473.37 fg	465.73 fg	483.23 fg	484.29 B
Control Treatments	605.20 A	501.39 C	547.70 B	561.46 B	563.80 B	

The means with the same letters are not statistically different from each other at 0.05.

Impact of planting dates and chemical weed control on dry weight of corn plants (g $plant^{-1}$)

Based on the data from (Table 8), it is clear that the first planting date (17 March 2025) achieved the highest record, obtaining the highest plant dry weight of 422.50 g $plant^{-1}$, while in the third planting date (5 April 2025), the lowest plant dry weight of 345.30 g $plant^{-1}$ was recorded. The first planting date was attributed to the longer growing season, from the time of planting, that was combined with more favorable environmental conditions, allowing the plant to absorb more water and nutrients, which, in turn, increased photosynthetic efficiency, carbohydrate accumulation, and ultimately plant dry weight. The most significant corn dry weight (396.67 g $plant^{-1}$) was recorded from Ramses herbicide treatment while the weedy treatment recorded the least (343.83 g $plant^{-1}$). Weeds reduced the dry weight of corn by 16.43% in comparison to the weed-free treatment. This is the result of the competition of both the weeds and the corn plants for water, light, and nutrients. An effective weed control, especially during the early growth stages, alleviates competition, enabling an expansive root system, and promotes vegetative growth including increased height, number of leaves, and diameter of the stem, all leading to a higher total dry weight of the plant.

Regarding the interaction effect, the Ramses herbicide treatment at the first planting date (17 March 2025) achieved the highest mean plant dry weight (433.50 g $plant^{-1}$), whereas the weedy treatment at the third planting date (5 April 2025) resulted in the lowest dry weight of corn plants (310.50 g $plant^{-1}$).

Impact of planting dates and chemical weed control on number of grain per row (grain row^{-1})

Table 9 shows that the first planting date, 17 March, yielded the highest number of grains per row, reaching 42.88 per row^{-1}, compared to the third planting date, 5 April, which yielded the lowest number of grains per row, at 20.13 per row^{-1}. The superiority of the first planting date may be attributed to the availability of moderate temperatures, sufficient humidity, and a suitable photoperiod during the flower differentiation and ear formation stages. This increased the concentration of growth hormones such as auxins and cytokinins, stimulating the formation of female flowers and thus increasing the fertilization rate, which was reflected in the increased number of grains per row.

It is also noted that the Abel herbicide treatment achieved the highest number of grains per row, reaching 34.84 per row^{-1}, compared to the control treatment (weed), which recorded the lowest number of grains per row, at 31.24 per row^{-1}. The presence of weeds caused a decrease in the number of grains in each row. The number of grains in the ear increased by 19.33% compared to the weed-free treatment. This may be attributed to the positive effect of the herbicides used in suppressing the damage caused by weeds accompanying the crop. This improved the plant's photosynthetic efficiency and increased the nutrients directed to the female inflorescence, which in turn increased the efficiency of fruit set and fertilization. This led to the formation of a greater number of grains in each row of the ear. It was also noted that the interaction between the study factors was significant.

The Abel herbicide treatment at the first planting date of 17 March achieved the highest average number of grains per row, reaching 44.4333 per row^{-1}, compared to the weeded treatment at the third planting date of 5 April which achieved the lowest number of grains per row, reaching 18.43 per row^{-1}.

Table 8. Impact of planting dates and chemical weed control on the dry weight of corn plants (g plant^{-1}).

Planting dates	Control treatments					Effect of Planting Dates
	Weed free	*Weedy*	Arrivo Herbicide (75% SL)	Abel Herbicide (30% OD)	Ramses Herbicide (25% SG)	
First date (17 March)	439.00 a	386.50 b	421.00 a	432.50 a	433.50 a	422.50 A
Second date (26 March)	400.00 b	334.50 d	400.50 b	386.00 b	401.00 b	384.40 B
Third date (5 April)	362.00 c	310.50 e	350.50 cd	348.00 cd	355.50 c	345.30 C
Control Treatments	400.33 A	343.83 C	390.67 A	388.83 A	396.67 A	

The means with the same letters are not statistically different from each other at 0.05.

Table 9. Impact of planting dates and chemical weed control on grains per row (grains row^{-1}).

Planting dates	Control treatments					Effect of Planting Dates
	Weed free	Weedy	Arrivo Herbicide (75% SL)	Abel Herbicide (30% OD)	Ramses Herbicide (25% SG)	
First date (17 March)	46.63 a	38.53 de	41.83 c	44.43 b	42.97 bc	42.88 A
Second date (26 March)	42.63 bc	36.77 e	39.70 d	39.77 d	37.23 e	39.22 B
Third date (5 April)	22.57 f	18.43 h	19.53 gh	20.33 g	19.68 gh	20.13 C
Control Treatments	37.28 A	31.24 D	33.69 C	34.84 B	33.32 C	

The means with the same letters are not statistically different from each other at 0.05.

Impact of planting dates and chemical weed control on the average weight of 500 grain (g)

The results revealed that first planting date (17 March 2025) yielded the most significant mass of 500 grain corn (158.95 g), while the 3rd planting date (5 April 2025) yielded the lowest of 123.51 g (Table 10). Favorable environmental conditions may explain the first planting date advantage. Conditions likely prolonged the grain-filling period, enhancing the carbohydrate source-sink relationship. Furthermore, the moderate temperature likely ramped the activity of the starch/protein synthesis enzymes, increasing kernel weight. These results are in agreement with those of Khudair et al. (2024), who reported variations in the weight of 500 kernels due to the effect of different planting dates.

In terms of weed control treatments, the most significant weight of 500 grains (146.30 g) was recorded under the Ramses herbicide treatment as compared to Comparative Transactions the weedy, which recorded the lowest value (135.03 g). Weeds caused a 11.15%

reduction in weight of 500 grains in comparison to the weed free treatment. This reduction is due to the combination of the poor water, light, and nutrient availability caused by weeds. Thus, effective weed control, which reduced weed density per unit area, alleviated the competitive stress, and enhanced the ability of the plant to absorb nutrients and translocate nutrients to the grains, which increased kernel weight.

With respect to the interaction effect, the Abel herbicide treatment at the first planting date (17 March 2025) achieved the highest mean weight of 500 grains (160.73 g), whereas the weedy treatments at the third planting date (5 April 2025) recorded the lowest value of 118.10 g (Table 10).

Table 10. Impact of planting dates and chemical weed control on the mean weight of 500 grains (g).

Planting dates	Control treatments					Effect of Planting Dates
	Weed free	Weedy	Arrivo Herbicide (75% SL)	Abel Herbicide (30% OD)	Ramses Herbicide (25% SG)	
First date (17 March)	163.70 a	153.87 d	157.70 c	160.73 b	158.77 bc	158.95 A
Second date (26 March)	156.97 c	133.17 f	149.67 e	151.87 de	151.07 e	148.55 B
Third date (5 April)	129.57 g	118.07 j	121.20 i	122.63 i	126.07 h	123.51 C
Control Treatments	150.08 A	135.03 D	142.85 C	145.08 B	146.30 B	

The means with the same letters are not statistically different from each other at 0.05.

Impact of planting dates and chemical weed control on total grain yield (t ha^{-1})

The results in Table 11 show that first planting date (17 March 2025) was better than the other planting dates in attaining the highest total corn grain yield of 14.24 t ha^{-1}, as compared to the third planting date (5 April 2025), which recorded the lowest total corn grain yield (9.34 t ha^{-1}). This can be attributed to the positive effect of early planting on the length of the ear, the number of rows per ear, the number of grains per row, and the weight of 500 grains, which cumulatively increased the total grain yield of corn.

The highest total grain yield (12.22 t ha^{-1}) was also achieved by the Ramses herbicide treatment, while yield was the lowest in the weedy treatments (10.07 t ha^{-1}). The presence of weeds resulted in a reduction of 29.89% in total grain yield when compared to the yield in the weed-free treatment. All the herbicide treatments improved the corn grain yield when compared to the weedy. It can be attributed to the effectiveness of the applied herbicides in controlling or halting weed growth, which lowers the competition between the crop plants and weeds for important growth resources. This reduction in competition improved ear length, the number of rows per ear, the number of grains per row, and the weight of the grains, which significantly increased the total grain yield. This agrees with Al-Abbasi (2025), who observed differences in the total grain yield of maize as a result of the use of chemical herbicides.

Regarding the interaction effect, the Abel herbicide treatment at the first planting date (17 March 2025) recorded the highest mean total grain yield (14.83 t ha^{-1}), whereas the lowest yield (7.97 t ha^{-1}) was observed at the third planting date under the weedy treatments. The analyses of variance for all the evaluated traits are given in Table 12.

Table 11. Impact of planting dates and chemical weed control on total grain yield (t ha^{-1}).

Planting dates	Control treatments					Effect of Planting Dates
	Weed free	Weedy	Arrivo Herbicide (75% SL)	Abel Herbicide (30% OD)	Ramses Herbicide (25% SG)	
First date (17 March)	15.63 a	12.23 e	14.40 c	14.83 b	14.40 bc	14. 24A
Second date (26 March)	13.10 d	10.00 fg	12.37 e	12.03 e	12.53 e	12.01 B
Third date (5 April)	10.50 f	7.97 j	9.13 i	9.37 hi	9.73 gh	9.34 C
Control Treatments	13.08 A	10.07 D	11.87 C	12.08 BC	12.22 B	

The means with the same letters are not statistically different from each other at 0.05.

Table 12. The analyses of variance for the evaluated traits.

Source of Variation (S.O.V)	DF	Weed density (plants m^{-2})	Weed control percentage (%)	Plant height (cm)	Leaf area (cm^2)
Replications	2	2.45	0.18	58.22	6537.82
Planting Data(A)	2	165.23**	208.56**	663.92**	7010.05**
Error (A)	4	0.32	0.01	5.84	2825.91
Control	4	1254.36**	13665.80**	157.71**	1251.54**
Interaction A×B	8	17.50 **	35.20**	2.22 n.s	1087.82 n.s
Error (B)	24	0.51	0.01	4.13	712.22
Source of Variation (S.O.V)	**DF**	**Plant dry weight (g $plant^{-1}$)**	**Number of grain per row (grain row^{-1})**	**Average weight of 500 grain (g)**	**Total grain yield (t ha^{-1})**
Replications	2	629.70	9.12	48.81	0.09
Planting Data(A)	2	2231.23**	2239.16**	4979.41**	90.27**
Error (A)	4	86.35	1.52	13.69	0.08
Control	4	4730.04**	44.04**	272.14**	10.97**
Interaction A×B	8	141.19 n.s	3.47*	35.75**	0.29*
Error (B)	24	126.80	1.06	2.37	0.10

Authors' Contributions

ASARH and AHAA jointly conceived and designed the study. They played a central role in conducting the experiments, collecting data, and carrying out laboratory and field investigations. All authors were involved in analyzing the data and interpreting the findings. In addition, they contributed to writing, reviewing, and critically revising the manuscript to ensure its intellectual rigor. All authors reviewed and approved the final manuscript before submission.

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Conflict of Interest

The authors declare no conflict of interest.

Sustainable Development Goals Targeted

SDG 2: Zero Hunger
SDG 12: Responsible Consumption and Production
SDG 13: Climate Action

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