Role of Herbicides and Hoeing in the Growth, Yield, and Weed Management of Tow hybrid maize cultivars (Zea mays L.)

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Abstract

This experiment was conducted during the 2025 growing season to evaluate the effects of mechanical and chemical weed control methods on weed species accompanying a maize (Zea mays L.) crop in the eastern districts of Mosul city, across both the spring and autumn growing seasons. The experiment was laid out as a randomized complete block design (RCBD) in a two-factor factorial arrangement. The first factor comprised two imported hybrid maize cultivars, were Zp6120 and pioneer 900 while the second factor consisted of eight weed management treatments: three concentrations of the herbicide Burbon applied alone, manual hoeing applied alone or in combination with each herbicide concentration, and an untreated check (no herbicide). The traits assessed included total weed count, total weed dry weight, flag leaf area, number of kernels per row, number of kernels per ear, biological yield, grain yield per unit area, and harvest index.

The main findings were as follows. Treatment T6 (hoeing combined with the above-recommended herbicide rate) produced the lowest total weed count and total weed dry weight in both seasons, as well as the highest values for kernels per row, kernels per ear, and grain yield per unit area in the autumn season; T6 and T5 were superior for grain yield in the spring season. Treatments T3, T4, and T5 recorded the highest biological yield in the spring season, whereas all treatments outperformed the check for biological yield in the autumn. All weed management treatments surpassed the untreated check for flag leaf area in both seasons. For

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harvest index, all treatments performed better than the check in spring, while T8 showed the highest harvest index in autumn. At the cultivar level, no significant difference was detected between the two cultivars for total weed count, kernels per row, or harvest index; cultivar Zb6120 was superior for biological yield and grain yield in both seasons, as well as total weed dry weight and kernels per ear in autumn. Pioneer (900) produced higher values for harvest index and kernels per ear in the spring season. These results indicate that combining hoeing with the recommended or above-recommended herbicide rate maximises weed suppression efficiency and crop productivity.

Keywords: maize, herbicide, hoeing, weeds

1. Introduction

Maize (Zea mays L.) ranks third globally among grain crops in terms of harvested area and total production, surpassed only by wheat and rice. The crop is economically important in Iraq because of its high yield potential, its adaptability to double-cropping across spring and autumn seasons, and its relatively short maturation period [13]. Weed species that grow alongside maize compete with the crop for light, water, and mineral nutrients, suppressing plant growth and depressing final yield. Weed management is therefore considered an essential agronomic operation for creating conditions favourable to maize development.

Variation in planting date, regular use of hoeing operations, and systematic crop rotation all contribute to reducing the abundance of weeds that accompany maize. Weed control in maize is achieved either by hand labour in small-scale fields or by chemical means—through foliar application or pre-planting incorporation of herbicides into the soil [2]. Manual hoeing is a successful and efficient way to control annual weed, since a big percentage of actively growing weeds will be removed in the time of its application and no longer active weed propagules will be found in the soil. Hoeing is however, not as effective against the perennial weeds as it fails to eliminate all the plant organs and the root or rhizome that remain in the soil can regenerate [12].

It has been established that chemical herbicides are an effective

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and viable method of managing weeds. Specific herbicides sprayed on the weeds related to maize are specifically handy, as they can be easily applied, are less expensive in comparison with other techniques, and they help to optimize the yield [19]. The objective of the current study was to find the optimal herbicide level that reduces the weed density and enhances the yield of grain, as well as to establish the best hybrid in the multi-concentration herbicides with honeing. The experiment was carried out using two imported hybrid cultivars certified by the Iraqi ministry of Agriculture..

2. Materials and Methods

2.1 Experimental Site

The experiment was conducted during the 2025 growing season at Julaykhan, located east of Mosul city, across both the spring and autumn seasons.

2.2 Field Preparation

A mouldboard and disc plough was used to prepare the field and two parallel passes made to ensure that there was inversion of the soil. A disc harrow was then used to refine and level the seedbed then a ridger was used to ridge it. Two hybrid varieties of maize that were approved were planted: Pioneer 900 and Zb6120. The spring and autumn seasons were sown on 28 March and 6 July respectively. The spring and autumn crops were harvested on 2 August 2025 and 1 November 2025 respectively.

2.3 Experimental Design and Treatments

The experiment was designed into a two-factor factorial, randomized complete block design (RCBD) that used three replications. Experimental units in each block had treatments randomly allocated, resulting in the unit size being 2 x 3 m. The crop was planted in ridges, with each being 2m long experimental unit consisted of four ridges .The distance between ridges was[75cm,while the spacing between plants was 20cm he average number of plants in the field became 60,000 plants The former factor included two hybrid maize varieties: Pioneer 900 and Zb6120. The second factor consisted of eight weed control treatments:

T1 – Herbicide applied at 25% below the recommended rate Low dos 200 ml/da

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T2 – Herbicide applied at the recommended rate Recommended dose 250 ml/da

T3 – Herbicide applied at 25% above the recommended rate above the recommended rate300 ml/da

T4 – Herbicide at 25% below recommended rate + manual hoeing

T5 – Herbicide at recommended rate + manual hoeing

T6 – Herbicide at 25% above recommended rate + manual hoeing

T7 – Manual hoeing only (no herbicide)

T8 – Untreated check (no weed control) Manual harvesting method was used.

Table 1 presents the chemical composition and application details of the herbicide Burbon used in the experiment.

The manufacturer of the pesticide is the German company pioneer

Table 1. Chemical composition and application details of the herbicide Burbon used in the experiment.

Trade Name	**Common Name**	**Active Ingredient (%)**	**Application Rate (cm^3 a.i. ha^{-1})**	**Formulation Type**	**Chemical Group**
Burbon	Mesotrione + Nicosulfuron	Mesotrione 37.5 g L^{-1} + Nicosulfuron 15 g L^{-1}	0.75–1.0 L ha^{-1}	OD (Oil Dispersion)	Triketones + Sulfonylureas

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Table 2. The most important weeds present in both growing seasons according to their density.

Life cycle	Family	Scientific name
annual	Compositae	*Sonchus oleraceus L.*
annual	Compositae	*anthus L. Carthanus oxyac*
annual	Portulaceae	*Portulaco oleracea L*
perennial	Cyperaceae	*Cynodon dactylon L. pers*
Perennial	Poeceae	*Sorghum halepense L. pers*
annual	Poeceae	*Echinochloa crus-galli L. beanv*
Perennial	Cyperaceae	. *Cyperus rotundus L*
Perennial	Convolvulaceae	*Convolvulus arvensis L*
annual	Compositae	*Xanthium strumarium L.*
annual	Chenopodiaceae	*Beta vulgaris L.*
annual	Chenopodiaceae	*Atriples tataricum L.*

2.4 Traits Measured

The following growth and yield traits were recorded: total weed count (weeds m^{-2}), total weed dry weight (g m^{-2}), flag leaf area (cm^2), number of kernels per row, number of kernels per ear, biological yield (kg ha^{-1}), grain yield per unit area (kg ha^{-1}), and harvest index (%).

2.5 Statistical Analysis

Field data for all measured traits were analysed statistically using a two-factor factorial arrangement. Treatments were assigned at random to experimental units within each replication for both seasons, and the two seasons were analysed jointly for all traits. Computations were performed using GenStat software, and mean separation was carried out with

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the Duncan Multiple Range Test (DMRT) at $p \leq 0.05$, following the procedures described by Al-Rawi and Khalafalla [7].

3. Results and Discussion

3.1 Total Weed Count (weeds m^{-2})

Data in Table 2 for the spring season show that T6 produced the lowest total weed density, recording a mean of 11.33 weeds m^{-2}, compared with the untreated check T8, which yielded the highest mean of 38.67 weeds m^{-2}; the control efficiency of T6 was 70%. In the autumn season, T6 again recorded the lowest mean weed density at 22.50 weeds m^{-2}, against a maximum of 56.17 weeds m^{-2} in T8, with a control efficiency of 59%. The reduction in weed density under herbicide-treated plots is attributable to the inhibitory effect of the active ingredients on key biosynthetic pathways within weed plants. The herbicide suppresses the synthesis of branched-chain amino acids—leucine, isoleucine, and valine—by inhibiting the enzyme acetohydroxyacid synthase (AHAS, also referred to as acetolactate synthase, ALS). Because these amino acids are indispensable for protein synthesis and the formation of new cells and specialised tissues, their depletion arrests normal plant growth [1, 8].

For the interaction between weed control treatments and cultivars in the spring season, T6 recorded the lowest weed count for both cultivars, with means of 11.33 and 11.33 weeds m^{-2}, respectively, and did not differ significantly from T3 or T5. The highest spring density was recorded under T8 for both cultivars, at 39.33 and 38.00 weeds m^{-2}, with control efficiencies of 71% and 70%, respectively. In the autumn season, T6 applied to cultivar Zb6120 produced the lowest weed density at 22.00 weeds m^{-2} and was statistically comparable to T6 applied to Pioneer 900. The check treatment T8 for Zb6120 reached 56.67 weeds m^{-2} with a control efficiency of 61%, while Pioneer 900 under T8 reached 55.67 weeds m^{-2} with an efficiency of 58%. This suppression reflects the overall efficacy of the herbicide in eliminating weed vegetation. Cultivar means showed no significant difference between the two cultivars for total weed count in either season.

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Table 2. Effect of weed control treatments and cultivars on total weed count (weeds m^{-2}) for the spring and autumn seasons**.**

Spring Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	18.00 cd	19.00 c
T2 – Herbicide at recommended rate	17.00 cde	17.33 cde
T3 – Herbicide above recommended rate	13.33 fg	14.67 ef
T4 – Hoeing + herbicide below recommended rate	15.67 def	15.67 def
T5 – Hoeing + herbicide at recommended rate	14.33 efg	13.67 fg
T6 – Hoeing + herbicide above recommended rate	11.33 g	11.33 g
T7 – Hoeing only	25.33 b	26.33 b
T8 – No control (check)	38.00 a	39.33 a
Cultivar mean	19.12 a	19.67 a
Autumn Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	33.00 cd	34.00 c

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T2 – Herbicide at recommended rate	29.33 ef	30.00 de
T3 – Herbicide above recommended rate	25.67 h	26.00 gh
T4 – Hoeing + herbicide below recommended rate	29.00 efg	30.00 de
T5 – Hoeing + herbicide at recommended rate	25.33 h	26.33 fgh
T6 – Hoeing + herbicide above recommended rate	23.00 hi	22.00 i
T7 – Hoeing only	38.33 b	38.00 b
T8 – No control (check)	55.67 a	56.67 a
Cultivar mean	32.42 a	32.88 a

3.2 Total Weed Dry Weight (g m^{-2})

Results from Table 3 show that in the spring season, T6 recorded the lowest total weed dry weight at 24.43 g m^{-2}, while T8 produced the highest value of 60.63 g m^{-2}; the control efficiency was 59%. In the autumn season, T6 again produced the lowest weed dry weight at 25.93 g m^{-2} and was not significantly different from T3 or T5. The untreated check recorded the highest value of 63.60 g m^{-2}, with a control efficiency of 59%. This reduction in dry weight is a consequence of herbicide-mediated suppression of weed growth, which diminished both weed population size and photosynthetic capacity, thereby reducing carbon assimilation and the uptake of mineral nutrients, and ultimately curtailing weed biomass accumulation [3, 9].

At the cultivar–treatment interaction level for the spring season, T6 yielded the lowest dry weight for both cultivars, with means of 24.60

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and 24.27 g m⁻ ², compared with T8 values of 61.63 and 59.63 g m⁻ ², giving control efficiencies of 60% and 59%, respectively. In the autumn season, all herbicide treatments outperformed T7 (hoeing only) and T8 (check), both of which recorded the highest dry weights at 64.17 and 63.03 g m⁻ ², respectively. For cultivar means in the spring season, no significant difference existed between the two cultivars. In the autumn season, cultivar Zb6120 recorded a higher mean of 35.89 g m⁻ ², while Pioneer 900 produced a slightly lower mean of 36.64 g m⁻ ².

Table 3. Effect of weed control treatments and cultivars on total weed dry weight (g m⁻ ²) for the spring and autumn seasons.

Spring Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	36.37 c	36.13 cd
T2 – Herbicide at recommended rate	33.50 cde	33.13 c–f
T3 – Herbicide above recommended rate	29.83 fg	28.40 g
T4 – Hoeing + herbicide below recommended rate	31.60 efg	32.77 def
T5 – Hoeing + herbicide at recommended rate	28.57 g	28.87 g
T6 – Hoeing + herbicide above recommended rate	24.27 h	24.60 h
T7 – Hoeing only	44.27 b	45.90 b
T8 – No control (check)	59.63 a	61.63 a

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Cultivar mean	36.00 a	36.43 a
Autumn Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	34.57 c	33.57 cd
T2 – Herbicide at recommended rate	32.03 cde	31.57 cde
T3 – Herbicide above recommended rate	28.13 cde	27.77 cde
T4 – Hoeing + herbicide below recommended rate	31.53 cde	30.23 cde
T5 – Hoeing + herbicide at recommended rate	28.63 cde	27.57 de
T6 – Hoeing + herbicide above recommended rate	26.27 e	25.60 e
T7 – Hoeing only	48.93 b	46.63 b
T8 – No control (check)	63.03 a	64.17 a
Cultivar mean	36.64 a	35.89 a

3.3 Flag Leaf Area (cm^2)

Data from Table 4 show that in the spring season, all weed management treatments produced significantly higher flag leaf area than the untreated check T8, which recorded the lowest mean of 551.5 cm^2. In the autumn season , T6, T5 and T2 had the highest value of flag leaf area all above T8. The rise in the flag leaf area of plots treated with herbicides is explained by a better

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canopy formation caused by the reduction of weed competition. The decrease in the pressure of the weed enhances the accessibility of the mineral nutrients in the soil which consequently promotes the growth of the leaf [14, 17, 10, 6, 11, 15].

In the spring season interaction, T2 on cultivar Pioneer 900 had the highest flag leaf area of 645.8 cm 2, but was not significantly different with all other treatment-cultivar interactions.

Both cultivars had the lowest value under T8 of 555.1 and 548.0 cm 2 and a control efficiency of 15%. T6 applied on Zb6120 in the autumn season gave the highest flag leaf area in all of the treatment-cultivar combinations, and T2 on Pioneer 900 also did the same in comparison to T8. This growth can be attributed to the better vegetative performance of maize plants with less competition with the weeds. On cultivar means, Pioneer 900 was more successful than Zb6120 in both seasons with 613.1 and 606.0 cm 2 respectively, as compared to 600.4 and 593.1 cm 2 of Zb6120. This disparity can be explained by the genotypic factors of Pioneer 900 that provide a greater level of competitive ability.

In a larger scale, the increase in the area of flag leaves would mean that there is an increase in the ability to intercept solar radiation, which positively affects the rate of carbon fixation during photosynthesis and has a positive direct relationship with the increase in grain yield [4].

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Table 4. Effect of weed control treatments and cultivars on flag leaf area (cm^2) for the spring and autumn seasons.

Spring Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	604.0 abc	610.2 ab
T2 – Herbicide at recommended rate	645.8 a	587.7 bcd
T3 – Herbicide above recommended rate	628.3 ab	618.3 ab
T4 – Hoeing + herbicide below recommended rate	615.8 ab	604.7 abc
T5 – Hoeing + herbicide at recommended rate	621.0 ab	612.3 ab
T6 – Hoeing + herbicide above recommended rate	636.7 ab	615.3 ab
T7 – Hoeing only	605.3 abc	599.3 abc
T8 – No control (check)	548.0 d	555.1 cd
Cultivar mean	613.1 a	600.4 b
Autumn Season		
Treatment	**Pioneer 900**	**Zb 6120**

T1 – Herbicide below recommended rate	597.9 c	569.5 d
T2 – Herbicide at recommended rate	640.7 a	575.6 cd
T3 – Herbicide above recommended rate	634.8 ab	605.1 bc
T4 – Hoeing + herbicide below recommended rate	608.7 bc	601.4 bc
T5 – Hoeing + herbicide at recommended rate	628.3 b	612.6 b
T6 – Hoeing + herbicide above recommended rate	604.8 c	642.4 a
T7 – Hoeing only	600.6 bc	564.6 d
T8 – No control (check)	532.2 de	573.9 cd
Cultivar mean	606.0 a	593.1 b

3.4 Number of Kernels per Row

Table 5 results suggest that T6 had the greatest mean number of kernels per row of 35.45 kernels in the spring season and was not significantly different to T5. A minimum spring was obtained at T8 of 29.58 kernels and the control efficiency of 16%. During the fall season, T6 was the highest with 39.78 kernels per row and was statistically similar to T3, T4 and T5; the lowest fall figure was 33.77 kernels under T8 and the control efficiency was 15 percent. This can be attributed to the fact that the weed management treatments have been known to lower the weed density therefore enabling the maize plants to grow in less competitive environments as was observed by Shahin [19]. For the spring interaction, T6 applied to Zb6120 recorded the highest value at 35.63 kernels per row and did not differ significantly from T5 for the

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same cultivar. The check produced the lowest value for Zb6120 at 29.70 kernels, with a control efficiency of 16.6%. For Pioneer 900, T6 and T5 jointly achieved the highest means of 35.27 and 35.03 kernels and were comparable to T4; the lowest value under T8 was 29.47 kernels, with efficiencies of 16% and 16.6% for T6 and T5, respectively. In the autumn interaction, T6 with Zb6120 produced the maximum value of 40.37 kernels per row and was comparable to T2, T3, and T5 for the same cultivar, as well as to T2, T4, T5, and T6 for Pioneer 900. The check recorded 33.70 and 33.83 kernels for the two cultivars, with a control efficiency of 16.2% for Zb6120. Cultivar means showed no significant difference between the two cultivars for kernels per row in either season.

Table 5. Effect of weed control treatments and cultivars on number of kernels per row for the spring and autumn seasons**.**

Spring Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	31.20 cd	31.07 cd
T2 – Herbicide at recommended rate	31.93 c	32.17 c
T3 – Herbicide above recommended rate	33.00 bc	32.53 bc
T4 – Hoeing + herbicide below recommended rate	34.20 ab	33.03 bc
T5 – Hoeing + herbicide at recommended rate	35.03 a	34.47 ab
T6 – Hoeing + herbicide above recommended rate	35.27 a	35.63 a
T7 – Hoeing only	31.27 cd	31.70 c

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T8 – No control (check)	29.47 d	29.70 d
Cultivar mean	32.67 a	32.54 a
Autumn Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	36.33 c	37.47 bc
T2 – Herbicide at recommended rate	37.97 abc	37.90 abc
T3 – Herbicide above recommended rate	37.73 bc	38.60 abc
T4 – Hoeing + herbicide below recommended rate	39.07 ab	37.50 bc
T5 – Hoeing + herbicide at recommended rate	38.63 abc	38.73 abc
T6 – Hoeing + herbicide above recommended rate	39.20 ab	40.37 a
T7 – Hoeing only	36.40 c	37.10 bc
T8 – No control (check)	33.70 d	33.83 d
Cultivar mean	37.38 a	37.69 a

3.5 Number of Kernels per Ear

Data from Table 6 show that in the spring season, T6 recorded the highest mean kernel number per ear at 528.1 kernels and was not significantly different from T5; the untreated check T8 yielded the lowest mean of 402.8 kernels, with a control efficiency of 23%. In the autumn season, T6 again produced the highest mean of 620.3 kernels per ear and was statistically

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comparable to T3, T4, and T5; T8 recorded the lowest autumn value of 475.9 kernels, with an efficiency of 23%. The mechanism underlying this increase is that lower weed density in the treated plots promoted superior vegetative growth, which elevated the accumulation of carbohydrates, proteins, enzymes, and phytohormones during the flowering period. The adequate supply of these metabolites supported successful pollination and fertilisation, leading to a greater number of set kernels [5, 16].

For the spring interaction, T6 ranked highest for both cultivars with means of 527.3 and 529.0 kernels per ear, respectively, and did not differ significantly from T5 for Zb6120 or from T3, T4, and T5 for Pioneer 900. The lowest values were 391.1 kernels for Zb6120 under T8, with a control efficiency of 25.8%, and 414.5 kernels for Pioneer 900 under T8, with an efficiency of 21.6%. In the autumn interaction, T6 with Zb6120 recorded the highest mean at 629.0 kernels per ear and was not significantly different from T2, T3, T4, and T5 for the same cultivar, or from T3, T4, T5, and T6 for Pioneer 900. The check recorded 495.2 and 456.5 kernels for the two cultivars, with a control efficiency of 21%. For cultivar means in the spring season, Pioneer 900 outperformed Zb6120 with 472.7 versus 460.9 kernels per ear. In the autumn season, Zb6120 showed higher performance at 575.9 kernels compared with 561.3 for Pioneer 900.

Table 6. Effect of weed control treatments and cultivars on number of kernels per ear for the spring and autumn seasons.

Spring Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	449.8 d–g	420.0 fgh
T2 – Herbicide at recommended rate	464.1 c–f	452.5 d–g

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T3 – Herbicide above recommended rate	491.0 a–d	471.5 b–e
T4 – Hoeing + herbicide below recommended rate	483.2 a–e	470.9 b–e
T5 – Hoeing + herbicide at recommended rate	513.8 ab	504.3 abc
T6 – Hoeing + herbicide above recommended rate	529.0 a	527.3 a
T7 – Hoeing only	435.9 e–h	448.8 d–g
T8 – No control (check)	414.5 gh	391.1 h
Cultivar mean	472.7 a	460.9 b
Autumn Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	547.4 cd	560.9 bcd
T2 – Herbicide at recommended rate	569.4 bcd	586.2 a–d
T3 – Herbicide above recommended rate	587.5 a–d	593.5 abc
T4 – Hoeing + herbicide below recommended rate	596.1 abc	582.1 a–d
T5 – Hoeing + herbicide at recommended rate	589.3 abc	609.1 ab
T6 – Hoeing + herbicide above recommended rate	611.5 ab	629.0 a

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T7 – Hoeing only	532.5 de	551.5 cd
T8 – No control (check)	456.5 f	495.2 ef
Cultivar mean	561.3 b	575.9 a

3.6 Biological Yield (kg ha⁻ ¹)

Results from Table 7 show that in the spring season, T3, T4, and T5 produced the highest biological yield at 449.8, 433.2, and 438.3 kg ha^{-1}, respectively, compared with T8, which yielded the lowest value of 372.5 kg ha^{-1}; the corresponding control efficiencies were 17%, 14%, and 15%. In the autumn season, all weed management treatments outperformed the untreated check T8, which recorded the lowest biological yield of 514.7 kg ha^{-1}.

For the spring interaction, T6 with Pioneer 900 yielded the highest biological yield at 453.3 kg ha^{-1} compared with the check value of 365.0 kg ha^{-1}, representing an efficiency of 19%. For Zb6120, T6 and T3 jointly achieved the highest biological yields at 446.3 and 443.3 kg ha^{-1}, respectively, and were comparable to T2 for the same cultivar and to T3 and T5 for Pioneer 900. The check for Zb6120 recorded 380.0 kg ha^{-1}, with efficiencies of 14.8% and 14.2% for T6 and T3, respectively. T6 and T5 with Zb6120 gave the highest values in the autumn interaction of 645.0 and 649.7 kg ha -1 and was similar to T2, T3, T4 and T7 of the same cultivar and all treatments of Pioneer 900. The check had 514.7 kg ha -1 in both cultivars, with the control efficiencies of 20.2% and 20.7% in T6 and T5 with Zb6120, respectively. Zb6120 performed better than Pioneer 900 at the cultivar mean level, which had 414.3 and 604.8 kg ha -1 in spring and autumn respectively, whereas Pioneer 900 had 412.5 and 600.0 kg ha -1 respectively. This advantage demonstrates the stability of Zb6120 and its contact with Iraqi environmental conditions, which increased its competitive abilities with weeds and led to increased garnering of dry biomass.

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Table 7. Effect of weed control treatments and cultivars on biological yield (kg ha^{-1}) for the spring and autumn seasons.

Spring Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	398.3 d–g	391.7 fgh
T2 – Herbicide at recommended rate	399.3 d–g	423.3 a–e
T3 – Herbicide above recommended rate	433.3 abc	443.3 a
T4 – Hoeing + herbicide below recommended rate	411.3 b–f	406.3 c–g
T5 – Hoeing + herbicide at recommended rate	438.0 ab	428.3 a–d
T6 – Hoeing + herbicide above recommended rate	453.3 a	446.3 a
T7 – Hoeing only	401.7 d–g	395.0 efg
T8 – No control (check)	365.0 h	380.0 gh
Cultivar mean	412.5 b	414.3 a
Autumn Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	616.3 ab	571.3 bc

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T2 – Herbicide at recommended rate	602.0 ab	613.3 ab
T3 – Herbicide above recommended rate	627.3 ab	637.7 ab
T4 – Hoeing + herbicide below recommended rate	600.7 ab	604.7 ab
T5 – Hoeing + herbicide at recommended rate	609.0 ab	649.7 a
T6 – Hoeing + herbicide above recommended rate	631.0 ab	645.0 a
T7 – Hoeing only	599.0 ab	602.0 ab
T8 – No control (check)	514.7 c	514.7 c
Cultivar mean	600.0 b	604.8 a

3.7 Grain Yield per Unit Area (kg ha^{-1})

Data from Table 8 show that in the spring season, T5 and T6 produced the highest grain yield values of 7,140 and 7,414 kg ha^{-1}, compared with T8, which recorded the lowest value of 6,180 kg ha^{-1}; the corresponding efficiencies were 13% and 16.6%. In the autumn season, T6 yielded the highest grain output at 9,934 kg ha^{-1} and was not significantly different from T2, T3, T4, or T5. The check recorded 8,580 kg ha^{-1} in autumn, with a control efficiency of 13.6%. The yield advantage in the treated plots is attributed partly to the higher plant stand density per unit area, which compensated for any reduction in individual plant yield, and partly to the suppression of weed competition at high plant densities [6].

For the spring interaction, T6 applied to both cultivars recorded the highest values of 7,440 and 7,389 kg ha^{-1} and were comparable to T5 for both cultivars; T8 produced the lowest yields of 6,171 and 6,189 kg ha^{-1} with efficiencies of 17% and 16.2%, respectively. In the autumn interaction, T6 with Zb6120 recorded the highest

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grain yield of 9,994 kg ha^{-1} and was comparable to T1, T2, T3, T4, and T5 for both cultivars; the check for Zb6120 yielded 8,914 kg ha^{-1} with an efficiency of 10.8%. At the cultivar mean level, Zb6120 outperformed Pioneer 900 in both seasons, recording 6,692 and 9,576 kg ha^{-1} versus 6,628 and 9,405 kg ha^{-1}. This superiority is attributed to the inherent competitive capacity and genetic constitution of Zb6120, which enhanced the efficiency of physiological processes and contributed to higher final yield (Al-Qaisi, 2017).

Table 8. Effect of weed control treatments and cultivars on grain yield per unit area (kg ha^{-1}) for the spring and autumn seasons.

Spring Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	6343 def	6291 ef
T2 – Herbicide at recommended rate	6411 def	6566 def
T3 – Herbicide above recommended rate	6669 c–f	6823 bcd
T4 – Hoeing + herbicide below recommended rate	6703 b–e	6651 c–f
T5 – Hoeing + herbicide at recommended rate	7114 abc	7166 ab
T6 – Hoeing + herbicide above recommended rate	7389 a	7440 a
T7 – Hoeing only	6206 ef	6429 def

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T8 – No control (check)	6189 f	6171 f
Cultivar mean	6628 b	6692 a
Autumn Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	9463 abc	9531 abc
T2 – Herbicide at recommended rate	9429 a–d	9737 abc
T3 – Herbicide above recommended rate	9686 abc	9634 abc
T4 – Hoeing + herbicide below recommended rate	9754 abc	9600 abc
T5 – Hoeing + herbicide at recommended rate	9583 abc	9789 ab
T6 – Hoeing + herbicide above recommended rate	9874 ab	9994 a
T7 – Hoeing only	9206 cd	9411 bcd
T8 – No control (check)	8246 e	8914 d
Cultivar mean	9405 b	9576 a

3.8 Harvest Index (%)

Results from Table 9 indicate that in the spring season, all weed management treatments produced a higher harvest index than the untreated check. In the autumn season, T8 recorded the highest harvest index at 32.72% and was not significantly different from all other treatments; the lowest autumn value was 29.71% under T2. The elevated

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harvest index observed in T8 during the autumn season may be related to the fact that in the absence of weed control, the crop allocates a greater proportion of assimilates to reproductive organs as an adaptive response to competitive stress during the critical growth period [18].

For the spring interaction, no significant differences were detected among any of the treatments. In the autumn interaction, T8 with Zb6120 recorded the highest harvest index at 33.92%, which was statistically comparable to T1, T2, T4, T5, and T6 for Zb6120 and to all treatments for Pioneer 900. The lowest autumn value was 29.39% under T3, with a control efficiency of 13.3%. Cultivar means showed no significant difference between the two cultivars for harvest index in either season.

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Table 9. Effect of weed control treatments and cultivars on harvest index (%) for the spring and autumn seasons.

Spring Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	31.09 a	31.25 a
T2 – Herbicide at recommended rate	31.21 a	30.22 a
T3 – Herbicide above recommended rate	30.02 a	29.97 a
T4 – Hoeing + herbicide below recommended rate	31.74 a	31.83 a
T5 – Hoeing + herbicide at recommended rate	31.65 a	32.58 a
T6 – Hoeing + herbicide above recommended rate	31.76 a	32.43 a
T7 – Hoeing only	30.07 a	31.66 a
T8 – No control (check)	33.07 a	31.59 a
Cultivar mean	31.33 a	31.44 a
Autumn Season		
Treatment	**Pioneer 900**	**Zb 6120**
T1 – Herbicide below recommended rate	29.89 ab	32.55 ab
T2 – Herbicide at recommended rate	30.50 ab	30.88 ab

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T3 – Herbicide above recommended rate	30.02 ab	29.39 b
T4 – Hoeing + herbicide below recommended rate	31.57 ab	30.87 ab
T5 – Hoeing + herbicide at recommended rate	30.72 ab	29.36 b
T6 – Hoeing + herbicide above recommended rate	30.51 ab	30.18 ab
T7 – Hoeing only	29.89 ab	30.42 ab
T8 – No control (check)	31.52 ab	33.92 a
Cultivar mean	30.58 a	30.95 a

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