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**RESEARCH ARTICLE**

# Effect of irrigation levels and weed control treatments on weeds, quality and water use efficiency of sugarcane

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## Abstract

The current study was conducted at El-Mattana Agriculture Research Station, Luxor Governorate, Egypt, in 2021/2022 and 2022/2023 (two plant-cane). In order to examine the effects of various irrigation levels and integrated weed control managements, as well as their interactions, on weed growth, water use efficiency and quality traits of sugarcane. The lowest dry weight of weeds when the irrigation level was 60% while the greatest value was recorded in the first and second seasons when the irrigation level was 100%. The results demonstrated that the irrigation levels, weed control treatments and their interactions were significant influences on dry weight of weeds at 105 days (grassy, broad-leaved and total weeds) in both seasons. The third level of irrigation (I3), Hoeing thrice (T11) and their interaction gave the lowest dry weight of grassy, broad-leaved and total weeds but the first irrigation (I1), un-weeded (T12) and their interaction had the maximum dry weight one in both seasons. For sugarcane traits, all quality traits were insignificantly affected by irrigation levels, weed control treatments and their interactions except sugar yield and seasonal water consumptive use under irrigation levels and percentage of brix and sucrose under weed control treatments in the two seasons. The first irrigation level (I1), Hoeing thrice (T11) and their interaction gave the highest values for most traits under study in the first and second seasons.

***Keywords*:** sugarcane, irrigation levels, weeds, herbicides, hand hoeing

## 1. *Introduction*

Sugarcane is a vital strategic industrial crop in Egypt, ranking second only to wheat in importance. In 2024, the cultivated area reached approximately 300,000 feddans (Sugar Crops Council, Ministry of Agricultural, Egypt). About 75% of the sugarcane stalk consists of water, which is essential for the uptake and transport of nutrients from the soil to various parts of the plant. Egypt's agricultural sector is currently facing significant challenges, particularly due to shortages of both food and water. Water is crucial for the absorption and translocation of nutrients within the plant. Sugarcane is primarily cultivated in Upper Egypt (Minya, Sohag, Qena, Luxor, and Aswan) where the crop is commonly infested by numerous noxious weeds. These weeds compete with sugarcane for vital resources such as nutrients, water, light, carbon dioxide, and space, and may also release allelochemicals that further hinder crop growth. Agriculture production is limited by water, particularly in the recent past due to climate change and rising temperatures, which have affected water requirements. As a result, it was vital to provide crops with the necessary amount of irrigation without compromising their productivity (Amer et al., 2017). An increase in irrigation levels for sugarcane crops results in higher crop yields as well as higher quantities of sugar and sucrose (Wiedenfeld and Enciso, 2008; Neana and Abd El Hak, 2014). Cultural, mechanical, biological, chemical, and integrated weed management techniques make up the majority of weed control techniques. Due to their tiny holdings, Egypt's emerging communities choose to employ chemical and cultural approaches, which are the most widely used, important, and successful weed management techniques in our environment for sugarcane weeds. Following planting, hand hoeing produced the lowest weed density and weed dry matter,

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making it incredibly effective (Manuel and Panneerselvam; 2005, Singh and LAL Menhi; 2008, Fakkar et al; 2009 and Ramesh et al., 2017). The application of herbicides following sugarcane planting, combined with hoeing, significantly and negatively affected the fresh and dry weights of grassy and broad-leaved weeds, as well as the total weed biomass, compared to the unweeded control plots (De Cerqueira et al.; 2018, Gadallah and El-Kareem; 2020 and Khan et al.; 2021). In this investigation some irrigation levels and weed control treatments were applied to study their effect on weed performance, some quality tratits and water use efficiancy of sugar cane as well as study the efficiency of the used herbicides..

## 2. Materials and Methods

The present experiment was carried out at El-Mattana Agric. Res. Sta., Luxor Governorate, Egypt in 2021/2022 and 2022/2023 seasons (two plant-cane crops) to study the influence of some irrigation levels and integrated weed control managements and their interactions on weeds growth, water use efficiency and quality traits of sugarcane. The sugarcane crop variety 2004/27 was used with three budded sets of cutting from cane planting, which was planted in each furrow by dry methods on 31$^{th}$ March for both seasons. Sugarcane was harvested in 15th and 13th of April in the 1$^{st}$ and 2nd seasons, respectively. The experiment was laid out in a randomized complete block design (RCBD) with spilt-plot arrangement with three replicates. The plot area was 10.5 m2 (3 furrows, 3.5 m long and 100 cm apart). Irrigation treatments were randomized in main plots while weed control treatments were allotted to the sub-plots.

The treatments were as follows

A- Main plots (Irrigation levels):

$I_1$ = Irrigation at 100 % field capacity (FC).

(A total number of 22 irrigations with an average interval of 15 days between irrigations).

$I_2$ = Irrigation at 80 % field capacity (FC). (A total number of 18 irrigations with an average interval of 18 days between irrigations).

$I_3$ = Irrigation at 60% field capacity (FC). (A total number of 14 irrigations with an average interval of 25 days between irrigations). Sub-plots (Weed control treatments):

$T_1$; CBP = Covering with black plastic for 6 weeks after planting.

$T_2$; CWP = Covering with white plastic for 6 weeks after planting.

$T_3$; Dinamic pre = Amicarbazone (Dinamic) 70% WG as pre-emergence at 700 g/fed.

$T_4$; Lumax pre = 75% SL sprayed as pre-emergence at 1.7 L/ fed.

$T_5$; Dinamic post = Dinamicas post-emergence after 45 DAP at the rate of 700 g/ fed;

$T_6$; Lumax post = Lumaxas post- emergence after 45 DAP at the rate of 1.7 L/ fed.

$T_7$; Dinamic pre + post = Dinamicas pre-emergence + post-emergence after 45 DAP.

$T_8$; Lumax pre + post = Lumaxas pre-emergence + post-emergence after 45 DAP.

$T_9$; Hoeing once + Dinamic = Hand hoeing once at 18 DAP + Dinamicas post-emergence after 45 DAP at the rate of 700 g/fed.

$T_{10}$; Hoeing once+Lumax = Hand hoeing once at 18 DAP + Lumaxas post-emergence after 45 DAP at the rate of 1.7 L/fed.

$T_{11}$; Hoeing thrice = Hand hoeing thrice at 18, 30 and 45 DAP.

$T_{12}$; (Control) = Un-weeded check.

Phosphorus fertilizer was applied during soil preparation in the form of calcium superphosphate (15.5% $P_2O_5$) at a rate of 150 kg/feddan. Nitrogen, in the form of urea (46% N), was applied at a total rate of 200 kg N/feddan, divided into two equal doses applied 50 and 90 days after planting. Potassium fertilizer was applied once as potassium sulfate (48% $K_2O$) at a rate of 100 kg/feddan, coinciding with the second nitrogen application. Soil chemical and mechanical analysis of the experimental site revealed that the top 30 cm of soil was classified as sandy loam. In the first and second seasons, respectively, the soil composition was as follows: sand content of 56.34% and 51.57%, silt content of 28.44% and 26.30%, and clay content of 15.22% and 22.13%. Nutrient levels were 24.0 and 21 ppm for nitrogen (N), 11.7 and 12.2 ppm for phosphorus (P), and 210 and 186 ppm for potassium (K), with soil pH values of 7.5 and 7.6. All other standard agricultural practices for sugarcane cultivation were carried out in accordance with recommended guidelines for sugarcane production.

### *2.1. Data recorded*

#### *2.1.1. Weed parameters*

Weeds were hand pulled randomly from square meter of each experimental unit after 105 days from planting. A sample of 100 g/m2 was taken from each experimental unit were sun dried and then oven dried at 73º for 72 hours to a constant dry weight to estimate the dry weight of annual broad-leaved, grassy and their total weeds as g/m2.

#### *2.1.2.* **Sugarcane traits**

Ten cane stalk sample were taken at random from each experimental unit, cane stalks were hand stripped and cleaned, then crushed and juice screened and mixed thoroughly then one-liter sample of the juice was placed in a measuring cylinder and left for 15-20 minutes for analysis. The juice qualities were determined as following:

1-Sucrose (%): it was determined using "Saccharemeter" according to A.O.A.C. (2005).

2-Brix (%): it was determined using, Brix Hydrometer standardized at 20oC.

3-Purity (%): it was calculated as follows:

Where: brix% was determined using brix Hydrometer standardized at 20

4. Sugar recovery (%): it was determined by the equation outlined by Yadav and Sharma (1980) as follows:

Sugar recovery (%) = [Sucrose - 0.4 (Brix – Sucrose)] × 0.73.

5. Sugar yield (t/fed): It was calculated according to the following equation as by Mathur (1981).

6. Sugar yield (t/fed) = cane yield (t/fed.) × theoretical sugar yield%.

#### *2.1.3. Water relation*

Soil moisture at field capacity (FC) was determined using the following method:

A 1.5 × 1.5 m² plot was thoroughly saturated with water, and after six hours, it was covered with a plastic sheet. Soil samples were then collected every 12 hours to measure moisture content. Field capacity was defined as the percentage of moisture retained in the soil against gravitational forces after 48 hours.

Irrigation water was applied when the soil moisture content in each treatment reached the designated field capacity. To prevent water seepage between treatments, 1.5 m-wide border ditches were established. Irrigation treatments commenced after planting and the first post-planting irrigation. Irrigation was stopped one month prior to harvest.

##### *2.1.3.1. Actual water consumptive use*

Actual water consumption (evapotranspiration) was estimated using the soil sampling method, following the technique provided by the Ministry of Agriculture in Egypt. The calculation was performed using the following formula:

$CU = D \times Bd \times (Q1 - Q2)/100$ Where:

CU = Actual evapotranspiration (mm)

D = Irrigation soil depth (mm)

Bd = Bulk density of the soil ($g/cm^3$)

Q1 = Soil moisture percentage before the next irrigation.

Q2 = Soil moisture percentage two days after irrigation.

To convert the result into cubic meters per feddan, the following equation was used:

$CU (m^3/fed) = CU (mm) \times 4.2$

Soil samples were taken from the ground surface using a normal augur at 15 cm depths (0–15, 15–30, 30-45 and 45–60 cm) in order to determine the moisture content of the soil.

After being immediately weighed, the samples were oven-dried at 105 until they reached a consistent weight. Using oven dry weight, the percentage of soil moisture at each of the four soil depths was determined. The difference between the soil moisture content before and after the subsequent irrigation was used to calculate the quantity of water used each of irrigation.

##### *2.1.3.2. Water use efficiency (WUE)*

It calculated for the different treatments according to following formula:

(WUE) = Can yield (Kg/fed)/water consumptive use (m3/fed) = Kg cane/m3 (Vites 1965). The consumptive use of water is considered as the amount of water actually applied for the different treatments. Water use efficiency was also calculated based on sugar yield (WUE) = sugar yield (Kg/fed)/water consumptive use (m3/fed.) = Kg sugar/$m^3$.

***2.2. Residue analysis of tested herbicides:***

***2.2.1. Extraction of herbicides***

Residues of Dinamic and Lumax herbicides in grain samples were extracted following the method described by El Beit et al. (1978). Fifty grams of each homogenized sample were placed into a 250 ml shaking bottle with 150 ml of methylene chloride. The mixture was shaken for one hour, then filtered through Whatman No. 1 filter paper and dried over anhydrous sodium sulfate.

The filtrate was evaporated to dryness, and the residue was quantitatively transferred to small vials using 5 ml of acetone. The acetone was allowed to evaporate at room temperature. The vials containing the residues were stored at 10 °C for cleanup. Extracts were further purified using the method of Jarczyk (1983). Residues of Dinamic and Lumax were analyzed using High Performance Liquid Chromatography (HPLC).

***2.2.2. Cleanup of herbicides***

The cleanup of Dinamic and Lumax residues from the extracts was performed following the method of Jarczyk (1983). A small amount of glass wool was placed at the bottom of a chromatographic column (1.5 cm diameter), and the tube was half-filled with methanol. Ten grams of silica gel were slurred with methanol and packed into the column, followed by a 2 g layer of anhydrous sodium sulfate on top. Air bubbles were removed using a glass rod. Approximately 50 ml of methanol were allowed to drain through the column until the solvent level just covered the silica gel. The herbicide residues were dissolved in 10 ml of methanol and carefully applied to the top of the column. The cleaned extracts were then collected in 10 ml volumetric flasks.

***2.2.3. Determination of active ingredient of the tested herbicides***

The active ingredients of Dinamic and Lumax were quantified using High-Performance Liquid Chromatography (HPLC), following the method described by Luke et al. (1981). A reverse-phase HPLC system was employed for the analysis. An Agilent Technologies 1260 Infinity HPLC instrument was used equipped with a degasser, quaternary pump, UV-DAD (diode array) detector, Rheodyne injection system, and a Vectra model computer for data processing. The stationary phase was an Agilent Zorbax SB-C18 stainless-steel column [5 µm, 4.6 × 250 mm]. Analysis conditions specific to each herbicide are detailed in Table 1.

***2.3. Statistical analysis***

Data were analyzed using analysis of variance with the MSTAT-C statistical software (Nissen, 1989). Treatment means were compared using the Least Significant Difference (LSD) test at the 0.05 significance level.

**Table 1**. HPLC conditions for Dinamic and Lumax determinations

| Herbicides | Conditions | | | |
|---|---|---|---|---|
| | Mobile phase | Flow rate (m l / min | Wave length (nm) | Retention time (min) |
| Dinamic | Methanol (MeOH): Acetoniltrile (AcN): H2O 30%: 60% :10% | 3.726 | 235 | 0.8 ml |
| Lumax | Methanol (MeOH): Acetoniltrile (AcN): H2O 30%: 60% :10% | 2.565 | 235 | 0.7 ml |

**3. Results and Discussion**

***3.1.* Effect of irrigation levels, weed control treatments and their interactions on:**

***3.1.1. Dry weight of weeds at 105 days***

Data in Tables 2 and 3 showed that irrigation levels were significantly on dry weight of grassy, broad-leaved and total weeds (g/m$^2$) in both seasons. Dry weight of total weeds was significantly affected by irrigation regimes were also reported by Verma *et al.* (2015). Applying irrigation at the rate of 60% FC showed minimum dry weight of grassy (193.29 and 171.84 g/m2), while maximum one (252.69 and 225.86 g/m2) was as a result of applying an irrigation level at 100% FC in the 1st and 2nd leaved and total weeds by 23.51, 21.74 and 22.61% in the first season and by 23.92, 32.84 and 24.27% in the second season, respectively compared with irrigation level at 100% FC.

The obtained results were in accordance with those recorded with Verma *et al*. (2015); Muthu *et al* (2016), Le and Morell (2021) and Fazli *et al*. (2022) which pointed out that there was a progressive increment in weed density and biomass with the increment in irrigation level.

**Table 2.** Effect of irrigation levels, weed control treatments and their interaction on dry weight of weeds (g/m$^2$) at 105 DAP in 2021/2022 season.

| Weed control treatments | Dry weight at 105 DAP (g/m$^2$) in 2021/2022 season | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry weight of grassy weeds | | | | Dry weight of broad-leaved weeds | | | | Dry weight of total weeds | | | |
| | Irrigation levels | | | | Irrigation levels | | | | Irrigation levels | | | |
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean |
| $T_1$ | 150.00 | 146.63 | 138.50 | 145.04 | 136.33 | 148.67 | 130.33 | 138.44 | 286.33 | 295.30 | 268.83 | 283.49 |
| $T_2$ | 148.67 | 143.20 | 121.17 | 137.68 | 126.00 | 132.50 | 125.67 | 128.06 | 274.67 | 275.70 | 246.83 | 265.73 |
| $T_3$ | 206.00 | 195.00 | 160.10 | 187.03 | 196.67 | 216.67 | 170.00 | 194.45 | 402.67 | 411.67 | 330.10 | 381.48 |
| $T_4$ | 196.33 | 189.00 | 158.00 | 181.11 | 190.67 | 200.00 | 172.00 | 187.56 | 387.00 | 389.00 | 330.00 | 368.67 |
| $T_5$ | 216.33 | 205.00 | 176.67 | 199.33 | 233.33 | 233.33 | 183.00 | 216.55 | 449.67 | 438.33 | 359.67 | 415.89 |
| $T_6$ | 213.67 | 200.00 | 164.33 | 192.67 | 225.00 | 224.67 | 155.67 | 201.78 | 438.67 | 424.67 | 320.00 | 394.45 |
| $T_7$ | 191.00 | 185.67 | 155.33 | 177.33 | 188.33 | 180.00 | 153.67 | 174.00 | 379.33 | 365.67 | 309.00 | 351.33 |
| $T_8$ | 182.57 | 149.00 | 148.67 | 160.08 | 140.50 | 155.00 | 134.33 | 143.28 | 323.07 | 304.00 | 283.00 | 303.36 |
| $T_9$ | 135.00 | 129.67 | 108.33 | 124.33 | 132.00 | 127.67 | 120.00 | 126.56 | 267.00 | 257.33 | 228.33 | 250.89 |
| $T_{10}$ | 133.33 | 126.00 | 96.67 | 118.67 | 127.67 | 122.33 | 115.00 | 121.67 | 261.00 | 248.33 | 211.67 | 240.33 |
| $T_{11}$ | 98.67 | 86.00 | 77.67 | 87.45 | 115.67 | 112.67 | 110.00 | 112.78 | 214.33 | 198.67 | 187.67 | 200.22 |
| $T_{12}$ | 1160.67 | 925.67 | 814.00 | 966.78 | 1317.00 | 1088.33 | 879.33 | 1094.89 | 2477.67 | 2014.00 | 1693.33 | 2061.67 |
| Mean | 252.69 | 223.40 | 193.29 | - | 260.76 | 245.15 | 204.08 | - | 513.45 | 468.56 | 397.37 | - |
| I | 36.11 | | | | 32.37 | | | | 58.92 | | | |
| T | 36.11 | | | | 51.67 | | | | 58.92 | | | |
| I × T | 164.33 | | | | 89.50 | | | | 102.05 | | | |

$I_1$ = Irrigation at 100% FC, $I_1$ = Irrigation at 80% FC and $I_1$ = Irrigation at 60% FC. $T_1$= CBP, $T_2$ = CWP, $T_3$= Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamic pre + post, $T_8$ = Lumax pre + post, $T_9$ = Hoeing once + Dinamic, $T_{10}$ = Hoeing once + Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = (Control; Un-weeded).

**Table 3**. Effect of irrigation levels, weed control treatments and their interaction on dry weight of weeds (g/m$^2$) at 105 DAP in 2022/2023 season.

| Weed control treatments | Dry weight at 105 DAP (g/m$^2$) in 2022/2023 season | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry weight of grassy weeds | | | | Dry weight of broad-leaved weeds | | | | Dry weight of total weeds | | | |
| | Irrigation levels | | | | Irrigation levels | | | | Irrigation levels | | | |
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean |
| $T_1$ | 139.67 | 120.63 | 138.50 | 122.06 | 160.87 | 108.53 | 90.33 | 119.91 | 300.53 | 229.17 | 196.20 | 241.97 |
| $T_2$ | 126.85 | 116.67 | 121.17 | 115.68 | 150.00 | 105.20 | 85.60 | 113.60 | 276.85 | 221.87 | 189.13 | 229.28 |
| $T_3$ | 200.00 | 139.33 | 160.10 | 155.40 | 201.87 | 153.00 | 123.53 | 159.47 | 401.87 | 292.33 | 250.40 | 314.87 |
| $T_4$ | 190.00 | 134.33 | 158.00 | 147.81 | 185.20 | 142.00 | 121.17 | 149.46 | 375.20 | 276.33 | 240.27 | 297.27 |
| $T_5$ | 241.67 | 191.67 | 176.67 | 202.31 | 268.53 | 266.77 | 151.97 | 229.09 | 510.20 | 458.43 | 325.57 | 431.40 |
| $T_6$ | 233.33 | 183.33 | 164.33 | 196.40 | 260.07 | 250.00 | 149.60 | 219.89 | 493.40 | 433.33 | 322.13 | 416.29 |
| $T_7$ | 159.20 | 130.30 | 155.33 | 135.12 | 179.50 | 116.67 | 95.50 | 130.56 | 338.70 | 246.97 | 211.37 | 265.68 |
| $T_8$ | 150.93 | 126.93 | 148.67 | 129.58 | 170.87 | 111.53 | 91.27 | 124.56 | 321.80 | 238.47 | 202.13 | 254.13 |
| $T_9$ | 94.00 | 100.87 | 108.33 | 97.79 | 133.33 | 93.63 | 83.63 | 103.53 | 227.33 | 194.50 | 182.13 | 201.32 |
| $T_{10}$ | 91.42 | 95.50 | 96.67 | 93.97 | 113.33 | 88.53 | 80.83 | 94.23 | 204.75 | 184.03 | 175.83 | 188.20 |
| $T_{11}$ | 83.20 | 80.00 | 77.67 | 79.40 | 91.67 | 78.53 | 76.87 | 82.36 | 174.87 | 156.87 | 153.53 | 161.76 |
| $T_{12}$ | 1000.00 | 883.33 | 814.00 | 882.88 | 1013.63 | 883.53 | 816.67 | 904.61 | 2013.63 | 1766.87 | 1581.97 | 1787.49 |
| Mean | 225.86 | 191.91 | 171.84 | - | 244.07 | 199.83 | 163.91 | - | 469.93 | 391.60 | 355.89 | - |
| I | 16.67 | | | | 4.58 | | | | 17.28 | | | |
| T | 16.67 | | | | 8.06 | | | | 17.28 | | | |
| I × T | 28.87 | | | | 13.96 | | | | 29.94 | | | |

$I_1$ = Irrigation at 100% FC, $I_1$ = Irrigation at 80% FC and $I_1$ = Irrigation at 60% FC. $T_1$= CBP, $T_2$ = CWP, $T_3$= Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamic pre + post, $T_8$ = Lumax pre + post, $T_9$ = Hoeing once + Dinamic, $T_{10}$ = Hoeing once + Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = (Control; Un-weeded).

All treatments of weed control led to significant decrease in dry weight of grassy, broad-leaved and total weeds (g/m$^2$) at 105 DAP compared to un-weeded treatment in the first and second seasons (Tables 2 and 3). Among treatments of weed control in the first and second seasons, respectively, $T_{11}$ (Hoeing thrice) produced minimum dry weight of grassy (87.45 and 79.40 g/m2), broad-leaved (112.78 and 82.36 g/m2) and total weeds (200.22 and 161.76 g/m$^2$), which were statistically at par with $T_{10}$ (Hoeing once + Lumax) in the first season. While the maximum dry weight of grassy (966.78 and 882.88 g/m$^2$), broad-leaved (1094.89 and 904.61 g/m2) and total weeds (2061.67 and 1787.49 g/m2) were produced by the T12 (Control; Un-weeded) in the first and second seasons, respectively (Tables 2 and 3). The present findings were in accordance with Fakkar et al (2009), Almubarak et al (2012), Pratap et al. (2013); Shyam and Singh (2015), Ombase et al. (2019) and Kadam et al. (2023) who found that post emergence application of weed control treatments led to significantly lowest weed dry weight of grassy weed compared to un-weeded control. The interaction effect of irrigation levels × weed control treatments (I × T) demonstrated significant variation on dry weight of weeds at 105 DAP in 2021/2022 and 2022/2023 seasons (Table 2 and 3, respectively). In the first season, the minimum dry weight of grassy, broad-leaved and total weeds were observed at $I_3 \times T_{11}$ (Irrigation at 60% FC × Hoeing thrice), which were 77.67, 110.00 and 187.67 g/m$^2$, respectively (Table 2). Likewise, the interaction $I_3 \times T_{11}$ gave the minimum of the same traits in the second season, which were 77.67, 76.87 and 153.53 g/m$^2$, respectively (Table 3). On the other hand, the maximum dry weight of grassy, broad-leaved and total weeds was demonstrated at I1 × T12, which were 1160.67, 1317.00 and 2477.67 g/m$^2$, respectively in the first season (Table 2). In the second season, the interaction was the same trend as in the first season (Table 3). Similar results were observed by Verma *et al*. (2015), Gad *et al*. (2018), Ombase *et al*. (2019), Gadallah and El-Kareem (2020), Le and Morell (2021), Fazli *et al*. (2022) and Kadam *et al*. (2023). According to Muthu et al (2016) who mentioned that modern irrigation along Atrazine + 2,4-D + Metribuzin led to the lowest dry weight of grassy in sugarcane.

### *3.2. Effect of irrigation levels, weed control treatments and their interactions on juice quality percentages*

#### *3.2.1. Brix percentage*

The results in Table 4 revealed that the brix percentage was insignificantly affected by irrigation levels as well as interaction between the irrigation rate and weed control treatments in 2021/2022 and 2022/2023 seasons. Similar results were registered by Batista et al (2024) found that brix did not show significant differences in relation to the water regime.

**Table 4**. Effect of irrigation levels, weed control treatments and their interaction on brix percentage in 2021/2022 and 2022/2023 seasons

| Weed control treatment | 2021/2022 | | | | 2022/2023 | | | |
|---|---|---|---|---|---|---|---|---|
| | Irrigation level | | | Mean | Irrigation level | | | Mean |
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | |
| $T_1$ | 19.93 | 19.54 | 19.24 | 19.57 | 18.12 | 18.46 | 17.92 | 18.17 |
| $T_2$ | 20.28 | 20.25 | 19.87 | 20.13 | 19.10 | 18.78 | 18.32 | 18.73 |
| $T_3$ | 20.57 | 19.71 | 19.98 | 20.09 | 19.00 | 18.45 | 18.15 | 18.53 |
| $T_4$ | 20.17 | 19.82 | 19.96 | 19.98 | 19.09 | 17.92 | 18.42 | 18.48 |
| $T_5$ | 20.23 | 19.65 | 19.82 | 19.90 | 19.31 | 18.45 | 18.55 | 18.77 |
| $T_6$ | 19.98 | 19.69 | 19.48 | 19.72 | 18.30 | 18.05 | 18.38 | 18.24 |
| $T_7$ | 20.39 | 19.99 | 20.07 | 20.15 | 18.42 | 18.91 | 18.68 | 17.67 |
| $T_8$ | 20.41 | 20.13 | 20.23 | 20.26 | 18.70 | 18.89 | 19.10 | 18.98 |
| $T_9$ | 20.47 | 20.44 | 20.20 | 20.37 | 19.10 | 19.45 | 19.01 | 19.19 |
| $T_{10}$ | 20.57 | 20.61 | 20.58 | 20.59 | 19.20 | 19.58 | 19.15 | 19.31 |
| $T_{11}$ | 20.69 | 20.79 | 20.46 | 20.65 | 19.85 | 19.86 | 19.25 | 19.63 |
| $T_{12}$ | 20.08 | 19.46 | 19.90 | 19.81 | 17.47 | 17.28 | 17.73 | 17.49 |
| Mean | 20.31 | 20.00 | 19.98 | - | 18.81 | 18.67 | 18.55 | - |
| $LSD_{0.05}$ | | | | | | | | |
| I | | | | NS | | | | NS |
| T | | | | 0.61 | | | | 0.45 |
| I × T | | | | NS | | | | NS |

I = Irrigation levels ($I_1$ = at 100% field capacity, $I_2$ = at 80% field capacity and $I_3$ = at 60% field capacity). T = Weed control treatments ($T_1$ = CBP, $T_2$ = CWP, $T_3$ = Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamicpre+post, $T_8$ = Lumaxpre+post, $T_9$ = Hoeing once +Dinamic, $T_{10}$ = Hoeing once +Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = Control).

Conversely, significant highest brix percentage was influenced by different levels of irrigation (Rahman *et al.,* 2008; Abdul Ghaffar *et al.*, 2013). Brix percentage in both the first and second seasons was significantly influenced by the applied weed control treatments (Table 4). The highest brix values were recorded under treatment $T_{11}$ (three hand hoeings), which effectively eliminated weed competition and provided optimal growing conditions for the sugarcane. These results were statistically comparable to those of $T_{10}$ (one hoeing + Lumax) and $T_9$ (one hoeing + Dinamic) in both seasons. The enhanced growing environment under these treatments likely promoted greater photosynthesis and sugar accumulation in the stalks. In contrast, the lowest brix percentages were observed in cane plants subjected to severe weed competition due to the absence of weed control. These values were statistically similar to those recorded under treatment $T_1$ (CBP) in both seasons (Table 4). These results align with the findings of Fakkar *et al*. (2009), El-Shafai *et al*. (2010), Baker *et al*. (2017), and Mohamed and Marzouk (2019), who reported that all tested herbicides significantly increased brix percentage compared to the untreated control. However, contrasting evidence was presented by Kadam *et al*. (2023), who observed that weed management treatments had no significant effect on Brix in comparison to the weedy check. Similarly, Ghodke *et al*. (2020) found that Brix was unaffected by hand weeding, mechanical weed control, or herbicide application.

**3.2.2. Sucrose percentage**

Sucrose percentage was insignificantly affected by irrigation levels as well as interaction between the irrigation rate and weed control treatments in 2021/2022 and 2022/2023 seasons. In contrast, significant highest sucrose percentage was influenced by different levels of irrigation (Rahman *et al.,* 2008, Neana and Abd El-Hak, 2014 and Aabad *et al.,* 2017). Comparing all weed control treatments with the un-weeded ($T_{12}$; control); it was found that all treatments had significantly ($p<0.05$) higher in sucrose percentage than the control ($T_{12}$; un-weeded) in both seasons. However, $T_{11}$ gave the highest sucrose percentage (18.12 and 17.79%) compared with the $T_{12}$; un-weeded, which was statistically at par with $T_{10}$ (18.11 and 17.50%) and $T_9$ (18.04 and 17.34%) in both seasons, respectively (Table 5). In contrast, the lowest values of the studied quality characteristics were observed in sugarcane plants that experienced intense competition from uncontrolled weed growth or were subjected to black plastic mulching. These conditions likely hindered optimal plant development, negatively affecting juice quality and sugar accumulation. These results are in line with those stated by Fakkar *et al.* (2009), El-Shafai *et al* (2010), Aabad *et al* (2017), Baker *et al.*, (2017) and Mohamed and Marzouk (2019)**,** who found that all the tested herbicides significantly increased the sucrose percentage compared to the control treatment. In contrast, Ghodke *et al* (2020) reported that sucrose percentage was not affected by hand weeding, mechanical weed control and application of any herbicide.

**3.2.3. Purity percentage**

Data in Table 6 demonstrated that purity percentage was insignificantly influenced by the irrigation intervals in both seasons while in both seasons (Table 6). Similar results were demonstrated by Rahman *et al.,* (2008); Neana and Abd El-Hak (2014); and Aabad *et al.* (2017) who reported non-significant variation in purity percentage at varied level of irrigations. Among weed control treatments, there were also significantly ($p<0.05$) variations in purity percentage in the second season only. $T_7$ (Dinamic pre + post) gave the highest values (86.17%) of purity percentage, which was statistically at par with $T_8$ (Lumax pre + post). On the other hand, the lowest value (83.68%) of purity percentage in the second season was produced by $T_{11}$ (Hoeing thrice) and $T_{12}$ (without weed treatment), respectively (Table 6). Purity percentages of sugarcane were insignificantly varied due to the combination between the two tested factors ($I \times T$) of study in the two seasons (Table 6). Same conformity was reported by Fazli *et al*. (2022) who found that purity percentage was not affected by irrigation systems and weed control treatments.

***3.2.4. Sugar recovery percentage***

The influence of irrigation intervals on sugar recovery percentage of sugarcane was significant during both seasons as demonstrated in Table 7. In the first season, irrigation at 60% achieved the highest values of sugar recovery percentage without a significant difference between the 60% and 80% treatments, while in the second season; irrigation at 100% achieved the highest values of sugar recovery percentage.

**Table 5.** Effect of irrigation levels, weed control treatments and their interaction on sucrose percentage in 2021/2022 and 2022/2023 seasons

| Weed control treatments | Irrigation levels | | | Mean | Irrigation levels | | | Mean |
|---|---|---|---|---|---|---|---|---|
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | |
| $T_1$ | 14.25 | 17.48 | 17.21 | 16.31 | 16.96 | 16.67 | 16.29 | 16.64 |
| $T_2$ | 17.95 | 17.86 | 18.09 | 17.96 | 17.36 | 17.18 | 16.62 | 17.05 |
| $T_3$ | 18.01 | 17.55 | 17.89 | 17.81 | 17.15 | 16.63 | 16.37 | 16.72 |
| $T_4$ | 17.91 | 17.63 | 17.80 | 17.78 | 17.44 | 15.90 | 16.53 | 16.62 |
| $T_5$ | 17.76 | 17.57 | 17.91 | 17.75 | 17.59 | 16.86 | 16.67 | 17.04 |
| $T_6$ | 17.62 | 17.57 | 17.62 | 17.60 | 17.08 | 16.13 | 16.60 | 16.60 |
| $T_7$ | 17.93 | 17.88 | 17.96 | 17.92 | 17.28 | 17.10 | 17.27 | 17.22 |
| $T_8$ | 18.03 | 17.81 | 18.08 | 17.97 | 17.20 | 17.15 | 17.33 | 17.23 |
| $T_9$ | 18.05 | 17.95 | 18.12 | 18.04 | 17.47 | 17.37 | 17.17 | 17.34 |
| $T_{10}$ | 17.96 | 18.16 | 18.21 | 18.11 | 17.46 | 17.72 | 17.32 | 17.50 |
| $T_{11}$ | 18.04 | 18.15 | 18.19 | 18.12 | 17.96 | 17.98 | 17.43 | 17.79 |
| $T_{12}$ | 17.70 | 17.58 | 17.85 | 17.71 | 15.68 | 15.55 | 16.30 | 15.84 |
| Mean | 17.60 | 17.77 | 17.91 | - | 17.22 | 16.85 | 16.83 | - |
| $LSD_{0.05}$ | | | | | | | | |
| I | | | | NS | | | | NS |
| T | | | | 0.92 | | | | 0.45 |
| I × T | | | | NS | | | | NS |

I = Irrigation levels ($I_1$ = at 100% field capacity, $I_2$ = at 80% field capacity and $I_3$ = at 60% field capacity).
T = Weed control treatments ($T_1$ = CBP, $T_2$ = CWP, $T_3$ = Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamicpre+post, $T_8$ = Lumaxpre+post, $T_9$ = Hoeing once +Dinamic, $T_{10}$ = Hoeing once +Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = Control).

**Table 6.** Effect of irrigation levels, weed control treatments and their interaction on purity percentage in 2021/2022 and 2022/2023 seasons

| Weed control treatments | 2021/2022 | | | | 2022/2023 | | | |
|---|---|---|---|---|---|---|---|---|
| | Irrigation levels | | | Mean | Irrigation levels | | | Mean |
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | |
| $T_1$ | 81.49 | 82.74 | 82.79 | 82.34 | 87.03 | 83.84 | 84.62 | 85.17 |
| $T_2$ | 81.12 | 81.10 | 84.08 | 82.32 | 84.18 | 84.84 | 84.33 | 84.45 |
| $T_3$ | 80.11 | 82.30 | 82.62 | 81.87 | 83.64 | 83.72 | 83.87 | 83.74 |
| $T_4$ | 81.10 | 82.10 | 82.45 | 82.18 | 84.61 | 82.60 | 84.90 | 84.03 |
| $T_5$ | 80.99 | 82.72 | 83.47 | 82.39 | 84.31 | 84.84 | 83.44 | 84.20 |
| $T_6$ | 81.42 | 82.51 | 83.68 | 82.54 | 86.78 | 83.15 | 83.93 | 84.62 |
| $T_7$ | 81.06 | 82.10 | 82.63 | 82.10 | 87.20 | 84.46 | 85.86 | 86.17 |
| $T_8$ | 81.40 | 81.67 | 82.44 | 81.84 | 85.37 | 84.14 | 84.06 | 84.52 |
| $T_9$ | 81.28 | 81.03 | 82.78 | 81.71 | 84.74 | 82.62 | 83.72 | 83.69 |
| $T_{10}$ | 80.41 | 81.17 | 83.02 | 81.53 | 84.21 | 83.66 | 83.74 | 83.87 |
| $T_{11}$ | 80.25 | 80.44 | 81.99 | 80.10 | 83.56 | 83.62 | 83.86 | 83.68 |
| $T_{12}$ | 81.38 | 83.57 | 82.90 | 82.62 | 83.74 | 83.98 | 85.66 | 84.46 |
| Mean | 81.16 | 82.02 | 82.90 | - | 84.95 | 83.87 | 84.33 | - |
| $LSD_{0.05}$ | | | | | | | | |
| I | | | | NS | | | | NS |
| T | | | | NS | | | | 1.73 |
| I × T | | | | NS | | | | NS |

I = Irrigation levels ($I_1$ = at 100% field capacity, $I_2$ = at 80% field capacity and $I_3$ = at 60% field capacity).
T = Weed control treatments ($T_1$ = CBP, $T_2$ = CWP, $T_3$ = Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamicpre+post, $T_8$ = Lumaxpre+post, $T_9$ = Hoeing once +Dinamic, $T_{10}$ = Hoeing once +Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = Control).

The results in Table 7 revealed that the applied weed control treatments had significant effects on sugar recovery percentage in 1st and 2nd seasons. The highest mean sugar recovery percentage was recorded with the application of treatment $T_2$ (CWP) at 11.19% in the first season, and treatment $T_{11}$ (hand hoeing three times) at 11.28% in the second season, compared to the un-weeded control. The superior performance of hand hoeing thrice is attributed to effective weed removal, which minimized competition and provided favorable conditions for sugarcane growth. This, in turn, enhanced photosynthetic efficiency and promoted greater sugar accumulation in the stalks. Conversely, the lowest sugar recovery percentage were observed in the untreated plots, where intense weed competition negatively affected plant growth and sugar production throughout both seasons

(Table 7). These results are in line with those stated by Fakkar *et al.* (2009); El-Shafai *et al*. (2010); Baker *et al*. (2017); Mohamed and Marzouk (2019).

**Table 7**. Effect of irrigation levels, weed control treatments and their interaction on sugar recovery percentage in 2021/2022 and 2022/2023 seasons

| Weed control treatments | 2021/2022 Irrigation levels | | | | 2022/2023 Irrigation levels | | | |
|---|---|---|---|---|---|---|---|---|
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean |
| $T_1$ | 10.84 | 10.96 | 10.81 | 10.87 | 11.26 | 10.64 | 10.52 | 10.81 |
| $T_2$ | 11.07 | 10.98 | 11.52 | 11.19 | 11.10 | 11.08 | 10.68 | 10.95 |
| $T_3$ | 10.97 | 10.94 | 11.18 | 11.03 | 10.90 | 10.61 | 10.47 | 10.66 |
| $T_4$ | 11.09 | 10.97 | 11.11 | 11.06 | 11.21 | 10.02 | 10.70 | 10.64 |
| $T_5$ | 10.87 | 11.01 | 11.31 | 11.07 | 11.25 | 10.90 | 10.59 | 10.91 |
| $T_6$ | 10.85 | 10.98 | 11.18 | 11.00 | 11.29 | 10.23 | 10.61 | 10.71 |
| $T_7$ | 10.98 | 11.18 | 11.23 | 11.13 | 11.48 | 11.13 | 11.30 | 11.30 |
| $T_8$ | 11.09 | 11.00 | 11.27 | 11.12 | 11.17 | 10.97 | 11.07 | 11.07 |
| $T_9$ | 11.08 | 10.99 | 11.35 | 11.14 | 11.24 | 10.89 | 10.93 | 11.02 |
| $T_{10}$ | 10.90 | 11.12 | 11.44 | 11.15 | 11.16 | 11.24 | 11.02 | 11.14 |
| $T_{11}$ | 10.92 | 11.00 | 11.26 | 11.06 | 11.36 | 11.39 | 11.10 | 11.28 |
| $T_{12}$ | 10.89 | 11.15 | 11.20 | 11.08 | 10.04 | 9.99 | 10.67 | 10.24 |
| Mean | 10.96 | 11.02 | 11.24 | - | 11.12 | 10.76 | 10.80 | - |
| $LSD_{0.05}$ | | | | | | | | |
| I | | | | 0.24 | | | | 0.07 |
| T | | | | NS | | | | 0.38 |
| I × T | | | | NS | | | | NS |

I = Irrigation levels ($I_1$ = at 100% field capacity, $I_2$ = at 80% field capacity and $I_3$ = at 60% field capacity).
T = Weed control treatments ($T_1$ = CBP, $T_2$ = CWP, $T_3$ = Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamicpre+post, $T_8$ = Lumaxpre+post, $T_9$ = Hoeing once +Dinamic, $T_{10}$ = Hoeing once +Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = Control).

Generally, the interaction between irrigation level and weed control treatments had not significant effect on sugar recovery percentage in 2021/22 and 2022/23 seasons.

### *3.2.5. Sugar yield (ton/fed)*

The influences of irrigation levels on mean sugar yield were significant during in both seasons (Table 8). Irrigation level at 100% FC ($I_1$) resulted in maximum (5.58 and 5.71 ton/fed.) and significantly higher sugar yield than other irrigations in the first and second seasons, respectively. Rahman *et al* (2008), Abdul Ghaffar *et al* (2013) and Aabad *et al* (2017) observed that a highly significant effect of the water regime on sugar yield. Irrigation levels at 100 and 80% increased sugar yield by 3.05 and 13.08% in 2021/2022 season and by 4.55 and 39.05% in 2022/2023 season, respectively. This might be due to exposure of the crop to much suitable moisture condition as compared to the other irrigations. Vice-versa irrigation level at 60% FC recorded the The minimum value (4.85 and 3.48 ton/fed.) of this character in both seasons, respectively (Table 8). Weed control treatments significantly influenced average of sugar yield in both seasons as observed in Table 8. Fakkar *et al*. (2009); Baker *et al*. (2017); Mohamed and Marzouk (2019); Kadam *et al*. (2023) demonstrated that weed control treatments significantly affected sugar yield. Concerning the effect of weed control treatments, it was indicated that treating with any of weed control treatments remarkably increased sugar yield compared to the un-weeded treatment. The highest sugar yield value was obtained by $T_{11}$; hoeing thrice (6.54 and 6.27 ton/fed.) in the first and second season, respectively. Conversely, the lowest plant height (3.02 and 3.07 ton/fed) was observed in $T_{12}$; un-weeded in $1^{st}$ and $2^{nd}$ season, respectively, as depicted in Table 8. Similar results were obtained by Fakkar *et al* (2009); El-Shafai *et al*. (2010); Mohamed and Marzouk (2019); Kadam *et al*. (2023). This result is in accordance with Rahman *et al*. (2008); Abdul Ghaffar *et al* (2013); Neana and Abd El-Hak (2014); Aabad *et al*. (2017) and Fazli *et al*. (2022) who found that

**Table 8**. Effect of irrigation levels, weed control treatments and their interaction on sugar yield (ton/fed) in 2021/2022 and 2022/2023 seasons

| Weed control treatments | 2021/2022 | | | | 2022/2023 | | | |
|---|---|---|---|---|---|---|---|---|
| | Irrigation levels | | | | Irrigation levels | | | |
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean |
| $T_1$ | 4.04 | 4.06 | 3.17 | 3.76 | 4.48 | 4.26 | 2.98 | 3.91 |
| $T_2$ | 6.16 | 6.05 | 5.54 | 5.92 | 6.07 | 5.95 | 3.49 | 5.17 |
| $T_3$ | 5.54 | 5.39 | 4.96 | 5.30 | 5.69 | 5.45 | 3.11 | 4.75 |
| $T_4$ | 5.65 | 5.78 | 4.39 | 5.27 | 5.95 | 5.26 | 3.26 | 4.82 |
| $T_5$ | 5.03 | 5.17 | 4.19 | 4.80 | 5.49 | 5.20 | 2.72 | 4.47 |
| $T_6$ | 5.22 | 5.26 | 4.25 | 4.91 | 5.59 | 4.96 | 2.81 | 4.45 |
| $T_7$ | 5.87 | 5.79 | 5.15 | 5.60 | 6.14 | 5.88 | 3.63 | 5.22 |
| $T_8$ | 6.02 | 5.72 | 5.34 | 5.69 | 6.01 | 5.85 | 3.59 | 5.15 |
| $T_9$ | 6.39 | 6.24 | 5.83 | 6.16 | 6.35 | 6.07 | 3.76 | 5.40 |
| $T_{10}$ | 6.35 | 6.67 | 6.10 | 6.37 | 6.37 | 6.46 | 4.72 | 5.85 |
| $T_{11}$ | 6.70 | 6.66 | 6.25 | 6.54 | 6.84 | 6.79 | 5.19 | 6.27 |
| $T_{12}$ | 3.08 | 2.99 | 2.98 | 3.02 | 3.50 | 3.25 | 2.46 | 3.07 |
| Mean | 5.51 | 5.48 | 4.85 | - | 5.71 | 5.45 | 3.48 | - |
| $LSD_{0.05}$ | | | | | | | | |
| I | | | | 0.31 | | | | 0.16 |
| T | | | | NS | | | | 0.22 |
| I × T | | | | 0.15 | | | | 0.38 |

I = Irrigation levels ($I_1$ = at 100% field capacity, $I_2$ = at 80% field capacity and $I_3$ = at 60% field capacity).
T = Weed control treatments ($T_1$ = CBP, $T_2$ = CWP, $T_3$ = Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamicpre+post, $T_8$ = Lumaxpre+post, $T_9$ = Hoeing once +Dinamic, $T_{10}$ = Hoeing once +Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = Control).

increasing irrigation intervals significantly decreased sugar yield per feddan in both seasons. Regarding interaction effects, the data presented in Table 8 indicate that the interaction between irrigation levels and weed control treatments significantly influenced sugar yield of sugarcane in both seasons. The highest sugar yields (6.90 and 6.84 tons per feddan) were achieved with the combination of 100% irrigation and three hand hoeings ($I_1 \times T_{11}$) in the first and second seasons, respectively. In contrast, the lowest sugar yield (2.98 and 2.46 tons per feddan) was recorded under the 60% irrigation level without any weed control. These findings are consistent with those reported by Rahman *et al*. (2008) and Fazli *et al*. (2022), who also noted the importance of adequate irrigation and effective weed management in maximizing sugarcane productivity.

### 3.3. Effect of irrigation levels, weeds control treatments and their interactions on water use efficiency (WUE kg/m3)

#### 3.3.1. Water consumptive use (CU)

Seasonal water consumptive use was significantly affected by irrigation levels in both years (Table 9). Data observed in Table 9 show that irrigation at 100% recorded the highest seasonal water consumptive use by sugarcane crop (9752.9 and 9776.1 $m^3$/fed) in the 1st and 2nd seasons, respectively. The results also pointed out that the irrigation 100% increased water consumptive use by 950.1 and 3300.1 $m^3$/fed compared to the irrigation 80% and the irrigation 60% in the 1st season, corresponding to 955.2 and 3312.7 $m^3$/fed, respectively, in the 2nd season. Among weed control treatments, there were also significantly ($p<0.05$) variations in Seasonal water consumptive use in the second season only. The mean seasonal water consumptive use (Table 9) on various weed control treatments revealed that crop treated by $T_{12}$ (without treated) produced significantly maximum (8553.3 $m^3$) water consumptive use while significantly minimum (8075.7 $m^3$) water consumptive use were found when crop was treated by $T_{11}$ (Hoeing thrice) in 2022/2023 season. Concerning, the interaction effect of I × T, the obtained data in the same previous table focus that the interaction failed to be significant at a 5% level of probability.

**Table 9.** Seasonal water consumptive use ($m^3$) as affected by irrigation levels and weed control treatments 2021/22 and 2022/2023 seasons

| Weed control treatments | 2021/2022 | | | | 2022/2023 | | | |
|---|---|---|---|---|---|---|---|---|
| | Irrigation levels | | | | Irrigation levels | | | |
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean |
| $T_1$ | 9900 | 8921 | 6541 | 8454.0 | 9930 | 8935 | 6555 | 8473.3 |
| $T_2$ | 9750 | 8802 | 6450 | 8334.0 | 9770 | 8835 | 6465 | 8356.7 |
| $T_3$ | 9845 | 8878 | 6507 | 8410.0 | 9885 | 8884 | 6515 | 8428.0 |
| $T_4$ | 9830 | 8864 | 6499 | 8397.7 | 9870 | 8875 | 6505 | 8416.7 |
| $T_5$ | 9890 | 8912 | 6535 | 8445.7 | 9915 | 8935 | 6550 | 8466.7 |
| $T_6$ | 9880 | 8904 | 6529 | 8437.7 | 9910 | 8917 | 6542 | 8456.3 |
| $T_7$ | 9810 | 8848 | 6487 | 8381.7 | 9825 | 8860 | 6500 | 8395.0 |
| $T_8$ | 9800 | 8840 | 6482 | 8374.0 | 9830 | 8870 | 6495 | 8398.3 |
| $T_9$ | 9480 | 8584 | 6289 | 8117.7 | 9470 | 8600 | 6294 | 8121.3 |
| $T_{10}$ | 9440 | 8552 | 6265 | 8085.7 | 9455 | 8570 | 6276 | 8100.3 |
| $T_{11}$ | 9410 | 8528 | 6247 | 8061.7 | 9428 | 8545 | 6254 | 8075.7 |
| $T_{12}$ | 10000 | 9000 | 6603 | 8534.3 | 10025 | 9025 | 6610 | 8553.3 |
| Mean | 9752.9 | 8802.8 | 6452.8 | - | 9776.1 | 8820.9 | 6463.4 | - |
| $LSD_{0.05}$ | | | | | | | | |
| I | | | | 0.24 | | | | 0.07 |
| T | | | | NS | | | | 0.38 |
| I × T | | | | NS | | | | NS |

I = Irrigation levels ($I_1$ = at 100% field capacity, $I_2$ = at 80% field capacity and $I_3$ = at 60% field capacity).
T = Weed control treatments ($T_1$ = CBP, $T_2$ = CWP, $T_3$ = Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamicpre+post, $T_8$ = Lumaxpre+post, $T_9$ = Hoeing once +Dinamic, $T_{10}$ = Hoeing once +Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = Control).

### *3.3.2. Water Use Efficiency (WUE) on cane yield basis*

Data presented in Table 10 showed that the highest value of WUE (6.67 kg cane stalks/$m^3$ water) was obtained when irrigation was applied at 60% ($I_3$) followed by 5.65 and 5.14 kg cane stalks/$m^3$ water, which was recorded as irrigation was given at 80% and 100%, respectively, in the 1st season. Corresponding in the 2nd season, the highest value of WUE (5.72 kg cane stalks/$m^3$ water) was obtained when irrigation was applied at 80% ($I_2$) followed by 5.23 and 4.96 kg cane stalks/$m^3$ water which was recorded as irrigation was given at 100% and 60%, respectively.

**Table 10.** Water use efficiency on cane yield basis (kg cane stalks/$m^3$ water consumed) as affected by irrigation levels and weed control treatments 2021/22 and 2022/2023 seasons.

| Weed control treatments | 2021/2022 | | | | 2022/2023 | | | |
|---|---|---|---|---|---|---|---|---|
| | Irrigation levels | | | | Irrigation levels | | | |
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean |
| $T_1$ | 3.77 | 4.15 | 4.47 | 4.08 | 4.32 | 4.01 | 4.48 | 4.25 |
| $T_2$ | 5.71 | 6.27 | 7.44 | 6.35 | 5.06 | 5.60 | 6.08 | 5.63 |
| $T_3$ | 5.13 | 5.55 | 6.81 | 5.72 | 6.09 | 5.28 | 5.79 | 5.27 |
| $T_4$ | 5.19 | 5.95 | 6.09 | 5.68 | 4.68 | 5.38 | 5.92 | 5.39 |
| $T_5$ | 4.68 | 5.26 | 5.66 | 5.14 | 3.92 | 4.92 | 5.34 | 4.81 |
| $T_6$ | 4.87 | 5.38 | 5.82 | 5.29 | 3.74 | 4.99 | 5.44 | 4.91 |
| $T_7$ | 5.45 | 5.85 | 7.06 | 6.01 | 4.93 | 5.45 | 5.96 | 5.49 |
| $T_8$ | 5.54 | 5.88 | 7.31 | 6.11 | 4.99 | 5.47 | 6.01 | 5.54 |
| $T_9$ | 6.09 | 6.61 | 8.18 | 6.81 | 5.48 | 5.97 | 6.48 | 6.02 |
| $T_{10}$ | 6.17 | 7.00 | 8.53 | 7.08 | 6.84 | 6.04 | 6.71 | 6.48 |
| $T_{11}$ | 6.52 | 7.08 | 8.88 | 7.33 | 7.48 | 6.38 | 6.98 | 6.87 |
| $T_{12}$ | 2.83 | 2.99 | 4.03 | 3.20 | 3.49 | 3.47 | 3.60 | 3.52 |
| Mean | 5.14 | 5.65 | 6.67 | - | 4.96 | 5.23 | 5.72 | - |

I = Irrigation levels ($I_1$ = at 100% field capacity, $I_2$ = at 80% field capacity and $I_3$ = at 60% field capacity).
T = Weed control treatments ($T_1$ = CBP, $T_2$ = CWP, $T_3$ = Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamicpre+post, $T_8$ = Lumaxpre+post, $T_9$ = Hoeing once +Dinamic, $T_{10}$ = Hoeing once + Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = Control).

The results showed that the weed control treatments differed in the values of water use efficiency (Table 10). In the two seasons, using hoeing three times ($T_{11}$) gave the highest values of water use efficiency, followed by the treatment of hand hoeing twice + using Lumax pesticide ($T_{10}$). In contrast, the lowest values of water use efficiency were from the control treatment ($T_{12}$) in both seasons (Table 10). Results in Table 10 displayed that the highest values of water use efficiency were observed in the interaction $I_3 \times T_{11}$ (8.88 cane stalks/m$^3$ water) in the first season and $I_1 \times T_{11}$ (7.48 cane stalks/m$^3$ water) in the second season followed by $I_3 \times T_{10}$ (8.53 cane stalks/m$^3$ water) and $I_1 \times T_{11}$ (7.48 cane stalks/m$^3$ water) in first and second seasons, respectively. On the other side, the lowest values of water use efficiency (2.83 cane stalks/m$^3$ water in the first season and 3.47 cane stalks/m$^3$) were obtained by $I_1 \times T_{12}$ and $I_2 \times T_{12}$, respectively (Table 7).

### *3.3.3. Water Use Efficiency (WUE) on sugar yield basis*

The results (Table 11) cleared that the highest value of WUE (0.75 kg sugar/m3 water) was obtained when irrigation was applied at 60% followed by 0.62 and 0.56 kg sugar/m3 water when irrigation was applied at 80 and 100%, respectively, in the 1st season. While in the second season, the highest value of water use efficiency was obtained when irrigating at a rate of 80%, followed by using 100 and then 60%. Regarding weed control treatments differed in the values of water use efficiency. Using hoeing three times gave the highest values of water use efficiency, followed by the treatment of hand hoeing twice + using Lumax pesticide, while the lowest values of water use efficiency were obtained from the control treatment.

**Table 11.** Water use efficiency on sugar yield basis (kg sugar/m$^3$ water consumed) as affected by irrigation levels and weed control treatments 2021/22 and 2022/2023 seasons

| Weed control treatments | 2021/2022 | | | | 2022/2023 | | | |
|---|---|---|---|---|---|---|---|---|
| | Irrigation levels | | | | Irrigation levels | | | |
| | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean | $I_1$ 100% | $I_2$ 80% | $I_3$ 60% | Mean |
| $T_1$ | 0.41 | 0.46 | 0.48 | 0.44 | 0.45 | 0.45 | 0.48 | 0.46 |
| $T_2$ | 0.63 | 0.69 | 0.86 | 0.71 | 0.54 | 0.62 | 0.67 | 5.63 |
| $T_3$ | 0.56 | 0.61 | 0.76 | 0.63 | 0.48 | 0.58 | 0.61 | 0.56 |
| $T_4$ | 0.57 | 0.65 | 0.68 | 0.63 | 0.50 | 0.60 | 0.59 | 0.57 |
| $T_5$ | 0.51 | 0.58 | 0.64 | 0.57 | 0.42 | 0.55 | 0.58 | 0.53 |
| $T_6$ | 0.53 | 0.59 | 0.65 | 0.58 | 0.43 | 0.56 | 0.56 | 0.53 |
| $T_7$ | 0.60 | 0.65 | 0.79 | 0.67 | 0.56 | 0.62 | 0.66 | 0.62 |
| $T_8$ | 0.61 | 0.65 | 0.82 | 0.68 | 0.55 | 0.61 | 0.66 | 0.61 |
| $T_9$ | 0.67 | 0.73 | 0.93 | 0.76 | 0.60 | 0.67 | 0.71 | 0.66 |
| $T_{10}$ | 0.67 | 0.78 | 0.97 | 0.79 | 0.75 | 0.67 | 0.75 | 0.72 |
| $T_{11}$ | 0.71 | 0.78 | 1.00 | 0.81 | 0.83 | 0.73 | 0.79 | 0.64 |
| $T_{12}$ | 0.31 | 0.33 | 0.45 | 0.35 | 0.37 | 0.35 | 0.36 | 0.36 |
| Mean | 0.56 | 0.62 | 0.75 | - | 0.54 | 0.58 | 0.62 | - |

I = Irrigation levels ($I_1$ = at 100% field capacity, $I_2$ = at 80% field capacity and $I_3$ = at 60% field capacity).
T = Weed control treatments ($T_1$ = CBP, $T_2$ = CWP, $T_3$ = Dinamic pre, $T_4$ = Lumax pre, $T_5$ = Dinamic post, $T_6$ = Lumax post, $T_7$ = Dinamicpre+post, $T_8$ = Lumaxpre+post, $T_9$ = Hoeing once +Dinamic, $T_{10}$ = Hoeing once + Lumax, $T_{11}$ = Hoeing thrice and $T_{12}$ = Control).

### *3.4. Residue analysis*

As shown in Table 12, High-Performance Liquid Chromatography (HPLC) did not detect any residues of the two applied herbicides—Amicarbazone (Dinamic 70% WG) and the mixture of S-Metolachlor 37.5%, Terbuthylazine 12.5%, and Mesotrione 3.75% (Lumax 53.75% SL)—in the sugarcane juice. This suggests that both herbicides had degraded within the plants by the time of sampling, rendering them undetectable by HPLC. However, when the herbicides were applied twice, trace amounts were recorded by HPLC. These residue levels were still below the established maximum residue limits (MRLs), indicating that their presence did not pose a risk to food safety. These results agree with those obtained Singh *et al.* (2008) and Mitwaly (2012) who found that the residues of Amicarbazone and S-Mtoachlor 37.5%+Terbuthylazin 12.5%+ Mesotrione 3.75%)

and S-Mtoachlor 37.5%+Terbuthylazin 12.5%+ Mesotrione 3.75%) were not detected in the soil after 70 days from application at the recommended rates.

**Table 12**. Residues for Dinamic and Lumax in sugar cane juice

| Sample No. | Herbicides | Residual (ppm) | MRL (mg/kg) |
|---|---|---|---|
| Sample (1) | Dinamic | Not detected (ND) | 0.03 |
| Sample (2) | Dinamic (pre.) + Dinamic (post) | Not detected (ND) | 0.07 |
| Sample (3) | Lumax | Not detected (ND) | 0.02 |
| Sample (4) | Lumax (pre) + Lumax (post) | Not detected (ND) | 0.06 |

## 4. Conclusion

Our results demonstrated that the irrigation levels, weed control treatments and their interactions were significant influence on dry weight of weeds at 105 days (grassy, broad-leaved and total weeds) in both seasons. The third levels of irrigation ($I_3$), Hoeing thrice ($T_{11}$) and their interaction gave the minimum dry weight of grassy, broad-leaved and total weeds but the first irrigation ($I_1$), un-weeded ($T_{12}$) and their interaction had the maximum dry weight one in both seasons. For sugarcane traits, all quality traits were insignificantly affected by irrigation levels, weed control treatments and their interactions except sugar yield and seasonal water consumptive use under irrigation levels and percentage of brix and sucrose under weed control treatments in the two seasons. The first irrigation level ($I_1$), Hoeing thrice ($T_{11}$) and their interaction gave the highest values for most traits under study in the first and second seasons.

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*Data presented in this study are available on fair request from the respective author.*

**Ethics Approval and Consent to Participate**
*Not applicable*

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*The authors disclosed no conflict of interest.*

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