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RESEARCH ARTICLE

Effect of irrigation levels and weed control treatments on weed performance and sugarcane productivity

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Abstract

Two field experiments were carried out at El-Mattana Agriculture Research Station, Luxor Governorate, Egypt during 2021/2022 and 2022/2023 seasons (two plant-cane). The experiments aimed to study the influence of some irrigation levels and integrated weed control treatments and their interactions on weeds performance and the growth, yield and its attributes of sugarcane. The irrigation level 100% resulted in a significant increase in stalk height, stalk diameter, number of internodes/stalk, number of millable canes and sugar yields in both seasons. The lowest number of grassy, broad-leaved and total weight of weeds were a result of applying an irrigation level of 60%, while the highest one was registered with applying an irrigation level of 100 % in both seasons. Weed control treatments decreased significant dry weight of grassy, broad-leaved and total weight of weeds at 75 days after planting (DAP) in both seasons compared to un-weeded treatment. Applying hoeing thrice, hoeing once + Lumax at a rate of 1.7 l/ fed and hand hoeing once + Dinamic decreased significant dry weight of grassy, broad-leaved and total weight of weeds in both seasons, compared with un-weeded treatment. Weed control treatments increased significantly stalk height, stalk diameter, number of internodes/stalk, number of millable canes and sugar yields. Results showed that interaction between irrigation levels and weed treatments decreased significantly effect on dry weight of grassy, broad-leaved and total weight of weeds at 75 DAP and gave highest values attributes of sugarcane in both seasons.

***Keywords*:** sugarcane, irrigation levels, weeds, black and white plastic mulching, herbicides, hand hoeing

1. Introduction

Sugarcane crop is one of the strategic industrial agricultural crops, which ranks after the wheat crop in Egypt. It is concentrated in Upper Egypt (El-Menia, Sohag, Qena, Luxor and Aswan). The cultivated area reached 300.00 fed in 2024 (Sugar Crops Council, Ministry of Agricultural, Egypt). In Egypt, the agriculture sector faces many challenges like a shortage of food and water as well as subjected to infestation with many noxious weeds which might interfere with the crop plants through competition for water, nutrients and light weeds compete with crop plants for nutrients, moisture, light and space. Water plays a crucial role in agricultural output, particularly in recent years due to climate change and rising temperatures, which have consequently influenced the water needs. Therefore, it was necessary to go as far as possible towards providing the amount of irrigation needed for crops without affecting their productivity (Amer *et al*., 2017). Application of herbicides, mechanical and mulching techniques, either separately or in combination, was an effective way to control weeds (Chauhan *et al*., 1994). Verma *et al*. (2015) and De Cerqueira *et al*. (2018) reported that dry weight of weeds was significantly affected by irrigation regimes. The application of irrigation at 80 mm CPE (cumulative pan evaporation) resulted in the lowest dry weight of weeds. Ramesh *et al* (2017); De Cerqueira *et al*. (2018); Gadallah and El-Kareem (2020); Khan *et al*. (2021) reported that applied of herbicides efficiently controlled weeds. This investigation was conducted to study the effect of irrigation levels and some weed

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control treatments on weed performance and sugarcane productivity.

2. Materials and Methods

This investigation used the sugarcane variety Giza-2004/27, which cultivated at El-Mattana Agriculture Research Station, Luxor Governorate, Egypt during 2021/2022 and 2022/2023 seasons (two plant-cane) to determine the effect of three irrigation levels and weed control treatments on weed performance and sugarcane yield and its attributes. A randomized complete block design (RCBD) with three replications and a split-plot arrangement was used in the experiment. Irrigation levels were a randomized in main plots and weed control treatments in sub-plots. Plot area of the trial was 10.5 m^2 (3 × 3.5 m).

The treatments were as follows:

1- Main plots (Irrigation levels):

I_1= Irrigation at 100% field capacity (FC): Applying a total number of 22 irrigations with an average interval of 15 days between irrigations).

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

I_3= Irrigation at 60% field capacity (FC): Applying a total number of 14 irrigations with an average interval of 25 days between irrigations).

2- 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 = S-Mtoachlor 37.5%+Terbuthylazin 12.5% + Mesotrione 3.75% (Lumax) 53.75% 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=Dinamicpre+post = Dinamicas pre-emergence + post-emergence after 45 DAP.

T_8=Lumaxpre+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.

The planting date was on 15th March in the first and the second season and harvested after 12 months in both experiments. The recommended cultural practices of sugarcane production were adopted throughout in the two seasons.

2.1. Data recorded

The data was recorded during the growing seasons in both experiments.

2.1.1. Observation on weed parameters

Weeds were hand pulled randomly from square meter of each experimental unit after 75 days from planting. A sample of 100 g/m^2 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/m^2.

2.1.2. Observation on sugarcane traits

Growth traits:

b_1 Stalk height (cm): It was measured from soil surface to the top visible dewlap.

b_2. Stalk diameter (cm): It was measured at the middle part of stalks.

b_3. Number of internodes/stalks.

2.1.3. Millable cane and cane yield/fed

Plants of the four guarded rows were harvested, cleaned, topped and weighed to estimate the following parameters:

C_1. Number of millable canes/fed.

C_2. Cane yield (ton/fed).

Statistical analysis:

The data were analyzed by analysis of variance using MSTAT-C Statistical software by Nissen (1989). The least significant difference (LSD) test at 0.05 levels was used to compare differences among treatment means.

3. Results and Discussion

The major weed flora found in sugarcane field were Common purslane (*Portulacaoleracea* L.), Mexican fire plant spurge (*Euphorbia granulate* Ortega), Nulta jute (*Corchorusolitorus* L.), Morning glory (*Ipomeaeriocarpa),*weedbur (*Xanthium strumarium* L.) and Redroot pig weed (*Amaranthus spp.) the droad-leaved weeds and* Jungile rice (*Echinocholacolonum* L.) and Signal grass (*Brachiariareptans* L.) the grassy weeds.

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

3.1.1. Dry weight of weeds (g/m^2)

Data presented in Tables 1 and 2 demonstrated that dry weight of grassy, broad-leaved weeds and total weeds (g/m^2) at 75 days after planting were significantly affected by irrigation levels. Verma *et al.* (2015) stated that dry weight of weeds was significantly affected by irrigation regimes. Irrigation levels at 80 and 60% of sugarcane favorable decrease the dry weight of grassy weeds by 2.38 and 24.33%, broad-leaved weeds by 15.92 and 39.85% as well as total weeds by 8.21 and 31.39% in the first season, respectively, and by 20.42 and 21.87%, 20.49 and 34.87% as well

Table 1. Average effect of irrigation levels, weed control treatments and their interaction on dry weight of grassy, broad-leaved weeds total weeds (g/m^2) in 2021/22 season.

Weed control treatments	Dry weight at 75 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	EF%	I_1 100%	I_2 80%	I_3 60%	Mean	EF%	I_1 100%	I_2 80%	I_3 60%	Mean	EF%
T_1	146.90	149.40	102.57	132.96	78.61	155.67	119.67	74.67	116.67	81.90	302.57	269.07	177.23	249.62	80.28
T_2	139.40	146.73	98.40	128.18	79.37	131.67	91.67	71.33	98.22	84.76	271.07	238.40	169.73	226.40	82.12
T_3	181.4	178.20	150.03	169.88	72.66	184.33	165.67	110.83	153.61	76.17	365.73	343.87	260.87	323.49	74.45
T_4	173.07	160.73	117.07	150.29	75.82	172.00	146.83	108.17	142.33	77.92	345.07	307.57	225.23	292.62	76.89
T_5	252.57	205.33	185.53	214.48	65.49	203.67	193.50	123.67	173.61	73.07	406.23	398.83	309.20	371.42	70.66
T_6	193.47	195.90	167.57	185.65	70.13	192.67	169.00	117.33	159.67	75.23	386.13	364.90	284.90	345.31	72.73
T_7	161.90	156.07	115.37	144.45	76.76	165.00	142.67	99.00	135.56	78.97	326.90	298.73	214.37	280.00	77.88
T_8	155.07	154.60	111.73	140.47	77.40	158.00	128.63	86.67	124.43	80.70	313.07	283.23	198.40	264.90	79.08
T_9	110.07	125.43	92.73	109.41	82.39	113.00	80.67	65.00	86.22	86.63	223.07	206.10	157.73	195.63	84.55
T_{10}	110.57	122.00	90.73	107.77	82.66	82.00	69.67	62.67	71.45	88.92	192.57	191.67	153.40	179.21	85.85
T_{11}	89.90	102.80	78.07	90.26	85.48	72.33	64.67	56.67	64.56	89.99	162.23	167.47	134.73	154.81	87.77
T_{12}	695.40	655.27	513.73	621.47	0.00	790.67	663.00	480.33	644.67	0.00	1486.07	1318.27	994.07	1266.14	0.00
Mean	200.81	196.04	151.96			201.75	169.64	121.36			398.39	365.68	273.32		
$LSD_{0.05}$															
I				16.68					10.95					20.87	
T				37.06					31.13					60.60	
I × T				64.19					53.92					104.97	

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, $_{T11}$ = Hoeing thrice and T_{12} = Control).

Table 2. Effect of irrigation levels, weed control treatments and their interaction on dry weight of grassy, broad-leaved weeds total weeds (g/m^2) in 2022/2023 season.

Weed control treatments	Dry weight at 75 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	I_2	I_3	Mean	EF%	I_1	I_2	I_3	Mean	EF%	I_1	I_2	I_3	Mean	EF%
	100%	80%	60%			100%	80%	60%			100%	80%	60%		
T_1	96.46	69.82	71.67	79.32	89.18	100.33	58.00	45.33	67.89	91.16	196.79	127.82	117.00	147.20	90.20
T_2	76.85	67.65	59.47	67.99	90.72	91.67	56.67	43.33	63.89	91.68	168.52	124.32	102.80	131.88	91.22
T_3	150.00	90.98	83.60	108.19	85.24	141.67	100.00	91.67	111.11	85.54	291.67	183.60	182.65	219.31	85.39
T_4	143.33	83.32	77.20	101.28	86.18	125.00	83.33	84.33	97.55	87.30	268.33	167.65	160.53	198.84	86.76
T_5	182.5	135.98	120.00	146.16	80.05	206.67	195.33	108.33	170.11	77.86	389.17	315.33	244.32	316.27	78.94
T_6	170.00	132.65	119.34	140.66	80.81	200.00	186.67	117.67	168.11	78.12	370.00	306.01	250.32	308.78	79.43
T_7	107.53	77.98	76.67	87.39	88.07	116.67	65.00	58.33	80.00	89.59	224.20	142.98	135.00	167.39	88.85
T_8	97.60	70.98	72.40	80.33	89.04	110.00	60.00	51.33	73.78	90.40	207.60	130.98	123.73	154.10	89.74
T_9	51.67	62.32	48.79	54.26	92.60	71.67	56.00	38.33	55.33	92.80	123.33	118.32	87.13	109.59	92.70
T_{10}	49.75	59.65	43.08	50.83	93.06	55.00	53.67	31.67	46.78	93.91	104.75	113.32	74.74	97.60	93.50
T_{11}	38.20	45.98	19.68	34.62	95.28	36.67	25.00	20.00	27.22	96.45	74.87	70.98	39.68	61.84	95.88
T_{12}	796.25	662.65	739.53	732.81	0.00	866.67	747.6	691.67	768.65	0.00	1662.92	1487.13	1354.32	1501.46	0.00
Mean	163.35	130.00	127.62			176.84	140.61	115.17			340.18	274.04	239.35	340.18	
$LSD_{0.05}$															
I				13.15					18.37					23.05	
T				14.02					17.70					22.05	
I × T				24.29					30.65					38.19	

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).

as 19.44 and 29.64% in the second season, respectively, compared with irrigation levels at 100% (Table 1). The decrease in dry weight of grasses may be the result of insufficient light, water, and nutrients for grass development. As shown in Table 1 and 2, the lowest values of weed dry weight (151.96 and 127.62 g/m^2) were registered with the 1st irrigation rate (60% FC), while the highest one (200.81 and 163.35g/m^2) was recorded with the 3rd irrigation level (100% FC) in the first and second seasons, respectively. Increased irrigation water may have had the primary impact of making agricultural plants and weeds fiercely compete for natural resources like light, water, and nutrients. As a result, weeds became more robust than those resulting from less irrigation water. Verma *et al.* (2015); Muthu *et al* (2016); Le and Morell (2021); Fazli *et al* (2022) have also reported that reducing irrigation level led to reduces in the dry weight of weeds compared to the higher irrigation level. Weeding control treatments had a significant reduction in dry weight of grassy, broad-leaved weeds and total weeds at 75 days after planting (ADP) compared to un-weeded (control) plots in both seasons. A significant influence of the applied weed treatments on dry weight in sugarcane was observed by Fakkar *et al* (2009) and El-Shafai *et al* (2010). In the 1st season (Table 1), T_{11} (Hoeing thrice) gave the highest desirable decrease in dry weight of grassy weeds, broad-leaved weeds and total weeds (90.26, 64.56 and 154.81 g/m^2, respectively) compared to the control (Un-weeded), which were statistically at par with T_{10} (Hoeing once + Lumax) and T_9 (Hoeing once + Dinamic). The results in the second season showed a similar pattern to that of the first season (Table 2). Similar results were also reported by Fakkar *et al*. (2009), Almubarak *et al*. (2012); Pratap *et al*. (2013); Shyam and Singh (2015); Ombase *et al*. (2019). Kadam *et al*. (2023) stated that post emergence application of 2, 4-D amine salt 58% SL at 1.4 kg/ha + Metribuzin 70% WP at 0.875 kg/ha at 30 DAP led to lowest weed count, weed index and weed dry weight with maximum weed control efficiency over the control. Interaction

between the irrigation levels and weed control treatments on dry weight of grassy, broad-leaved weeds and total weeds at 75 days after planting was significant in the two seasons (Tables 1 and 2). Verma *et al.* (2015) who observed that dry weight of weeds was significantly affected by irrigation regimes and weed management practices. In the first and second seasons, respectively, I_{60} × T_{11} (Irrigation at 60% × hoeing thrice) gave the maximum dry weight of grassy (78.07 and 19.68 g/m^2), broad-leaved weeds (56.67 and 20.00 g/m^2) and total weeds (134.73 and 39.68 g/m^2) at 75 DAP. These results are in good line with that of Verma *et al.* (2015); Le and Morell (2021); Fazli *et al* (2022). Muthu *et al* (2016) found that the lowest dry weight in sugarcane was recorded in modern irrigation along Atrazine + 2, 4-D + Metribuzin.

3.2. Effect of irrigation levels, weed control treatments and their interactions on growth traits of sugarcane:

3.2.1. Stalk height (cm)

The results in Table 3 demonstrated that stalk heiht was significantly affected by irrigation levels in 2021/2022 and 2022/2023 seasons.

Table 3. Effect of irrigation levels, weed control treatments and their interaction on stalk length (cm) in 2021/2022 and 2022/2023 seasons

Weed control treatments	2021/2022				2022/2023			
	Irrigation levels				Irrigation levels			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	100%	80%	60%		100%	80%	60%	
T_1	296.93	295.00	280.27	290.73	284.33	268.67	246.67	266.56
T_2	305.33	291.33	295.07	297.24	306.00	284.67	289.33	293.33
T_3	280.27	291.73	278.13	283.38	300.33	266.07	252.00	272.80
T_4	284.93	277.33	296.47	286.24	290.67	262.27	262.67	271.87
T_5	274.33	277.87	273.27	275.16	272.00	243.67	220.00	245.22
T_6	292.33	284.80	270.27	282.47	277.33	254.33	236.00	255.89
T_7	299.67	289.80	291.47	293.64	293.33	275.67	262.67	272.22
T_8	309.33	294.00	277.27	293.53	302.33	286.33	278.67	289.11
T_9	304.33	296.53	296.27	299.04	305.00	313.00	316.00	311.33
T_{10}	308.00	300.53	296.13	301.56	307.33	311.40	325.33	314.69
T_{11}	314.33	306.00	306.13	308.82	326.73	316.67	326.33	323.24
T_{12}	240.33	246.33	234.93	240.53	261.33	238.33	209.33	236.33
Mean	292.51	287.60	282.97		293.89	276.76	268.75	
$LSD_{0.05}$								
I				5.32				6.31
T				6.53				12.25
I × T				11.30				21.23

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 I_1 (Irrigation level at 100%) gave the highest mean values of stalk (292.51 and 293.89 cm) in the first and second seasons, respectively, and this trend of length (287.60 cm) was followed by the I_2 (Irrigation level at 80%) in the first season (Table 3). But the shortest plants (282.97 and 268.75 cm) was produced by I_3 (Irrigation level at 60%) in the 1st and 2nd seasons, respectively (Table 3). These results are in agreement with those found by Rahman *et al* (2008); Hossain *et al*. (2009); Neana and Abd El-Hak (2014); Aabad *et al.* (2017); Wu *et al*. (2022). The results pointed out that stalk length were significantly affected by weed control treatments in the 1st and 2nd seasons. The highest values of stalk length (308.82 and 323.24 cm) were obtained by practicing T_{11} (Hoeing thrice) in the first and second seasons. This indicates that this treatment led to get rid of the associated weeds with sugarcane, which decreased weeds growth and hence their competition to cane plants. In contrast, the lowest values of stalk length trait were recorded under control (Un-weeded) in both

seasons. This reflects due to the severe competition of weeds with sugarcane plants. These results agree with those found by Fakkar *et al.* (2009)), Singh *et al* (2012), Mansuri *et al*. (2014), Gad *et al* (2018), Mohamed and Marzouk (2019), Ombase *et al*. (2019), Krishnaprabu (2020) and Kadam *et al* (2023). The interaction between irrigation levels and weed control treatments was significant effect on millable cane length. Irrigating sugarcane plants by 100% FC and hoeing three times ($I_1 \times T_{11}$) displayed the tallest mean values (314.33 and 326.73 cm) of millable cane length in the first and second seasons, respectively, which were at par with $I_2 \times T_{11}$, $I_3 \times T_{11}$, $I_1 \times T_{10}$ and $I_1 \times T_2$. While, $I_3 \times T_{12}$ (Irrigation at 60% × control) interaction gave the shortest mean values of the same trait in the first and second seasons, respectively (Table 3). Similar results were obtained by Aabad *et al*. (2017).

3.2.2. Stalk diameter (cm)

The results in Table 4 exhibited that stalk diameter was significantly affected by irrigation levels in 2021/2022 and 2022/2023 seasons. Irrigation level at 100% (I_1) was registered high thickness values of the stalk diameter (2.67 and 2.62 cm) in the first and second seasons, respectively. On the other hand, the thinnest diameter of values (2.58 and 2.53 cm) was observed under the irrigation levels at 60% in the 1st and 2nd seasons, respectively. The positive effect of 100% FC irrigation level provides may be related to the sufficient moisture in the root zone and more availability of nutrients that led to increase growth and yield of the crop as reported by Rahman *et al* (2008), Neana and Abd El-Hak (2014), Muthu *et al* (2016), Wu *et al*., (2022) and Batista *et al* (2024). The data showed that stalk diameter was significantly affected by weed control treatments in the 1st and 2nd seasons. The highest values of stalk diameter (2.83 and 2.73 cm, respectively) were obtained by practicing T_{11} (Hoeing thrice) in the first and second seasons. This indicates that this treatment led to get rid of the associated weeds with sugarcane, which decreased weeds growth and hence their competition to cane plants. Conversely, the lowest values of stalk diameter trait were recorded under control (Un-weeded) in both seasons (Table 4). This reflects due to the severe competition of weeds with sugarcane plants. These results agree with those found by Fakkar *et al.* (2009), El-Shafai *et al*. (2010), Muthu *et al*. (2016) and Mohamed and Marzouk (2019). The interaction between irrigation levels and weed control treatments was significant effect on stalk diameter. With regard to stalk diameter, the high thickness values of the stalk diameter (2.89 and 2.78 cm, respectively) were registered by $I_1 \times T_{11}$ (Irrigation level at 100% × Hoeing thrice) followed by $I_1 \times T_{11}$ (2.85 cm) and $I_1 \times T_{10}$ (2.74 cm) in the first and second seasons, respectively. While $I_3 \times T_{12}$ (Irrigation level at 60% × control) had the thinnest diameter of stalk diameter value (2.46 and 2.33 cm) in the 1st and 2nd seasons, respectively (Table 4). Similar results were obtained by Muthu *et al*. (2016).

3.2.3. Number of internodes/stalks

Results showed that irrigation levels were significant effects on the number of internodes/stalk during the two seasons (Table 5). Sugarcane plants irrigated by a level of 100% (I_4) showed maximum number of internodes/stalk (17.25 and 17.42), while the minimum number of internodes/stalks (15.89 and 15.86) was associated with those irrigated by irrigation level at 60% in the 1st and 2nd seasons, respectively (Table 5). At 100% irrigation regime increase the amount of moisture in the root zone and enhance nutrient availability, which boosts sugarcane crop development and production also reported by several of workers (Hossain *et al*., 2008; Rahman *et al*., 2008; Abdul Ghaffar *et al*., 2013; Wu *et al*., 2022). All weed control treatments used led to a significant increase on the number of internodes/stalk compared to un-weeded plants in both seasons (Table 5). Among the various weed control treatments, T_{11} (Hoeing thrice) showed superiority in number of internodes/stalk (20.22 and 19.56), followed by T_{10} (Hoeing once + Lumax) (18.89 and 18.78) in the 1st and 2nd seasons, respectively compared to the all other treatments. These results agreed with Jeyaraman *et al*. (2002), Singh *et al*. (2012), Mansuri *et al*. (2014), Ghodke *et al*. (2020), Yadav *et al*. (2020).

Table 4. Effect of irrigation levels, weed control treatments and their interaction on stalk diameter (cm) in 2021/2022 and 2022/2023 seasons

Weed control treatments	Irrigation levels			Mean	Irrigation levels			Mean
	I_1	I_2	I_3		I_1	I_2	I_3	
	100%	80%	60%		100%	80%	60%	
T_1	2.59	2.57	2.52	2.56	2.55	2.58	2.45	2.53
T_2	2.60	2.59	2.58	2.59	2.55	2.51	2.55	2.54
T_3	2.57	2.61	2.56	2.58	2.54	2.55	2.53	2.54
T_4	2.61	2.60	2.59	2.60	2.62	2.60	2.54	2.58
T_5	2.62	2.57	2.50	2.56	2.53	2.57	2.47	2.52
T_6	2.70	2.54	2.52	2.58	2.57	2.55	2.51	2.54
T_7	2.72	2.60	2.55	2.62	2.65	2.56	2.52	2.58
T_8	2.72	2.60	2.62	2.64	2.66	2.57	2.53	2.59
T_9	2.76	2.68	2.67	2.71	2.68	2.63	2.60	2.64
T_{10}	2.80	2.72	2.70	2.74	2.74	2.69	2.64	2.69
T_{11}	2.89	2.85	2.74	2.83	2.78	2.72	2.69	2.73
T_{12}	2.51	2.48	2.46	2.49	2.52	2.50	2.33	2.45
Mean	2.67	2.62	2.58		2.62	2.59	2.53	
$LSD_{0.05}$								
I				0.03				0.03
T				0.04				0.04
I × T				0.06				0.07

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).

Concerning I × T interaction (irrigation levels × weed control treatments), the obtained data in the same previous tables focus that the interaction failed to be significant at a 5% level of probability. This may be explained by optimum moisture levels and reduced weed density, which enhanced sugarcane yield and crop growth. These results were obtained by Muthu *et al* (2016).

Table 5. Effect of irrigation levels, weed control treatments and their interaction on number of internodes/stalk in 2021/2022 and 2022/2023 seasons

Weed control treatments	Irrigation levels			Mean	Irrigation levels			Mean
	I_1	I_2	I_3		I_1	I_2	I_3	
	100%	80%	60%		100%	80%	60%	
T_1	15.67	16.00	14.33	15.33	16.33	15.00	14.33	15.22
T_2	16.67	16.00	15.67	16.11	16.67	16.67	15.33	16.22
T_3	16.33	17.00	15.67	16.33	16.33	16.33	15.33	16.00
T_4	16.67	17.33	15.00	16.33	16.67	16.33	15.67	16.22
T_5	16.33	16.00	14.67	15.67	16.00	15.00	14.33	15.11
T_6	16.67	16.67	14.67	16.00	17.00	15.67	14.67	15.78
T_7	17.00	16.33	15.33	16.22	17.00	16.00	16.00	16.33
T_8	17.67	17.33	16.67	17.22	18.00	17.33	16.67	17.33
T_9	18.67	18.67	17.67	18.33	19.33	18.33	17.67	18.44
T_{10}	19.67	19.33	17.67	18.89	19.67	19.00	17.67	18.78
T_{11}	20.67	20.67	19.33	20.22	20.67	19.67	18.33	19.56
T_{12}	15.00	15.67	14.00	14.89	15.33	15.00	14.33	14.89
Mean	17.25	17.25	15.89		17.42	16.69	15.86	
$LSD_{0.05}$								
I				0.60				0.52
T				0.66				0.70
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).

3.2.4. Number of millable canes (thousand/fed)

In this study, mean value of number of millable cane was significantly affected by irrigation levels as observed in Table 6 in both seasons. Batista *et al* (2024) who observed that mean stalk diameter was influenced by the water regime. The highest value (44.55 and 45.39 thousand/fed, respectively) of the number of millable cane was obtained from the I_1 (Irrigation level at 100%) in the first and second seasons. Furthermore, the number of millable cane gradually decreased when the irrigation level was extended from I_2 (Irrigation level at 80%) to irrigation level at 60%. In the first season, from the first irrigation to 80 and 60% levels, the number of millable cane decreased by 2.47 and 13.33%, respectively but in the second season, it were 3.99 and 23.31%, respectively (Table 6). In contrast, the lowest values (38.61 and 34.81 thousand/fed, respectively) of the number of millable cane were obtained from I_3 (Irrigation level at 60%). Bhunia *et al*. (2014), Neana and Abd El Hak (2014), Ballyan *et al*. (2015), Muthu *et al* (2016) and Batista *et al*. (2024) reported that the highest number of millable cane was attained with the highest irrigation level. Average number of millable cane was significantly affected by weed control treatments in the two seasons (Table 6). Fakkar *et al*. (2009), Mansuri *et al* .(2014), Begum and Bordoloi (2016) and Kadam *et al*. (2023) demonstrated that weed control treatments significantly affected number of millable in both seasons. Data regarding number of millable cane given in Table 6 demonstrated that the T_{11} (Hoeing thrice) produced the highest number of millable cane (52.81 and 47.84 thousand/fed, respectively). On the other hand, the lowest number of millable cane (29.49 and 33.49 thousand/fed, respectively) was obtained when plants un-weeded (control). It was evident that the number of millable cane was increased by treating with hoeing thrice (T_{11}) in both seasons (Table 6). These results are in conformity with the findings of Fakkar *et al*. (2009), Mansuri *et al*. (2014), Ballyan *et al*. (2015), Begum and Bordoloi (2016), Muthu *et al*. (2016), Mohamed and Marzouk (2019), Ombase *et al* (2019) and Kadam *et al*. (2023).

Table 6. Effect of irrigation levels, weed control treatments and their interaction on number of millable canes (thousand/fed in 2021/2022 and 2022/2023 seasons

Weed control treatments	Irrigation levels				Irrigation levels			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	100%	80%	60%		100%	80%	60%	
T_1	35.53	31.25	30.63	32.47	35.00	37.30	32.00	34.77
T_2	48.47	38.77	42.10	43.11	46.83	45.76	36.36	42.98
T_3	44.17	37.17	39.00	40.11	44.92	43.76	33.22	40.63
T_4	44.57	46.70	35.07	42.11	45.83	44.48	34.05	41.54
T_5	40.63	41.90	32.93	38.49	41.83	41.04	29.09	37.32
T_6	41.97	42.87	33.77	39.53	52.50	41.60	29.92	38.01
T_7	45.23	47.33	40.27	44.28	46.08	44.80	35.70	42.20
T_8	45.37	48.03	41.57	44.99	46.50	45.04	36.03	42.53
T_9	50.17	50.12	44.93	48.41	48.50	47.20	38.18	44.63
T_{10}	52.00	53.37	46.63	50.67	50.00	47.68	40.08	45.92
T_{11}	55.83	54.27	48.33	52.81	52.11	50.40	40.99	47.84
T_{12}	30.67	29.67	28.13	29.49	34.55	33.84	32.08	33.49
Mean	44.55	43.45	38.61		45.39	43.58	34.81	
$LSD_{0.05}$								
I				1.55				0.95
T				2.39				1.08
I × T				4.14				1.88

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).

With regard to the effect of interaction between the irrigation levels and weed control treatments on the number of millable cane, the interaction effect of I × T showed significant variation on number of millable cane in both seasons (Table 6). It was proved that the highest number (55.83 and 52.11 thousand/fed) was produced from applying I_1 × T_{11}; (irrigation at level of 100% with hoeing

thrice), followed by irrigation level 80% with hoeing thrice (54.27 and 50.40 thousand/fed) in the 1st and 2nd seasons, respectively. These results are in accordance with the findings of Muthu *et al* (2016).

2.2.5. Cane yield (ton/fed)

The results obtained that the differences among the studied irrigation levels were significantly in both seasons (Table 7). Rahman *et al* (2008) and Aabad *et al* (2017) revealed that the significantly highest cane yield trait was influenced by different levels of irrigation. The highest cane yield (50.17 and 51.16 ton/fed) was recorded by I_1 (irrigation level at 100%) in the first and second seasons, respectively. The increment in cane yield may due to sufficient water around plants with 100% compared with the other irrigation levels 80% and/or 60%. Conversely, irrigation level at 60% gave the lowest cane yield (43.03 and 32.75 ton/fed) in the first and second seasons, respectively (Tables 7). The present results were in accordance with that of Rahman *et al*. (2008); Hossain *et al*. (2008); Neana and Abd El-Hak (2014); Muthu *et al*. (2016); Aabad *et al*. (2017); Fazli *et al*. (2022); Batista *et a.l* (2024). Results in Table 7 indicated that weed control treatments had a significant effect on cane yield/fed in both seasons. These were obtained by several workers (Baker *et al*., 2017, Mohamed and Marzouk 2019 and Patil *et al.*, 2024). It is show that the mean value of millable yield was increased due to apply the different weed control treatments compared to the control. The highest values of cane yield (59.11 and 55.52 ton/fed) were obtained as a result of applying T11 (hoeing thrice) in the 1st and 2nd seasons, respectively. But the minimum values of can yield (27.27 and 30.13 ton/fed) were recorded with the un-weeded plants in the 1st and 2nd seasons, respectively. This was in agreement with findings of Begum and Bordoloi (2016), Baker *et al*. (2017); Aabad *et al*. (2017); Mohamed and Marzouk (2019), Ombase *et al*. (2019); Ghodke et al (2020), Krishnaprabu (2020); Kadam *et al*. (2023); Patil *et al*. (2024). The interaction effect of I × T showed significant variation on cane yield in the second season but it was insignificant in the first season. Muthu *et al*. (2016) found that the interaction effect of irrigation techniques + weed management practices significantly influenced the cane yield. The maximum cane yield was observed at $I_1 \times T_{11}$, which was 60.17 ton/fed. On the other hand, the minimum cane yield was showed at $I_3 \times T_{12}$, which was 23.10 ton/fed (Table 7). These results are supported by Muthu *et al*. (2016); Fazli *et al*. (2022).

Table 7. Effect of irrigation levels, weed control treatments and their interaction on cane yield (ton/fed) in 2021/2022 and 2022/2023 seasons

Weed control treatments	Irrigation levels				Irrigation levels			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	100%	80%	60%		100%	80%	60%	
T_1	37.29	37.03	29.26	34.53	39.80	40.00	28.30	36.03
T_2	55.66	55.15	48.02	52.94	54.70	53.70	32.70	47. 0
T_3	50.50	49.23	44.30	48.10	52.20	51.40	39.66	44.42
T_4	50.98	52.76	39.58	47.74	53.10	52.50	30.46	45.35
T_5	46.26	46.91	37.02	43.40	48.80	47.70	25.66	40.72
T_6	48.07	47.86	38.02	44.65	49.50	48.50	24.46	41.49
T_7	53.43	51.78	45.82	50.34	53.50	52.80	32.06	46.12
T_8	54.27	51.94	47.38	51.20	53.80	53.30	32.38	46.49
T_9	57.70	56.77	51.42	55.30	56.50	55.70	34.46	48.89
T_{10}	58.28	59.90	53.46	57.21	57.10	57.50	42.93	52.51
T_{11}	61.34	60.40	55.50	59.11	60.17	59.63	46.77	55.52
T_{12}	28.30	26.90	26.60	27.27	34.80	32.50	23.10	30.13
Mean	50.17	49.72	43.03		51.16	50.44	32.75	
$LSD_{0.05}$								
I				1.28				1.38
T				2.37				1.40
I × T				NS				2.42

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).

4. Conclusion

All studied traits were significantly affected by irrigation levels, weed control treatments and their interactions in both seasons. The results exhibited that irrigation levels at 100%, hoeing thrice and their interaction between them of all dry weight of weeds traits gave the lowest values but it gave the highest value of millable cane and cane yield traits.

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