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Flora, Density and Efficiency of Weed Affected Sugarcane Controlled by Chemical Herbicides

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Authors' contributions

This work was carried out in collaboration among all authors. Author IEAA initiated the experiments, collected the data, performed the statistical analysis. Author SOY designed the study, managed the literature review and wrote the first drafts of the manuscript. Author MAH assisted with statistical analysis and contributed to the final draft. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aims of the study was to determine the weed flora, weed density and weed control efficiency of different weed types affect sugarcane as plant cane crop.
Study Design: Experimental design of the study was a Completely Randomized Design (CRD) with four replication.
Place and Duration of Study: A field experiment was conducted in two experimental sites in Sugarcane Research Center Farm at Guneid, Sudan during 2019-2020.
Methodology: Four chemical herbicides treatments; W_1: un weeded (control), W_2: Ametryne (3.8 L/ha) + Atrazine (3.8 L/ha), W_3: Atrazine (3.0 L/ha)+Pendimethalin (2.9 L/ha) and W_4: and Metribuzin (5.21 L/ha)+Pendimethalin (3.57 L/ha) was used for sugarcane. A knapsack sprayer

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(CP_3) with a capacity of 16 liter was used for applying herbicides. Weed flora, density and efficiency was determined in the field.

Results: The results related to weed flora for plant cane crop in the two different experimental sites identified about 15 weed species classified into two categories; grasses and broad-leaves weed with the dominance of broad leaves weed. The total average number of weed in the un weeded plots in the two different experimental sites ranged between 13 to 17 % of the total weeds were grasses and the rest were broad-leaved weeds which ranged between 87 to 83 %. The experiment revealed that treatment W_4: (Metribuzin 5.21 l/ha + Pendimethalin 3.57 l/ha) recorded significant value at ($p<0.05$) with the lowest weed density, and the highest weed control efficiency percent compared to the other chemical herbicide's treatments and the control in plant cane crop in the two different experimental sites.

Conclusion: the findings of the study showed that there was about 15 weed species classified into two categories; grasses the rest were broad-leaved weed.The broad leaves weed were dominance over grass weed. The treatment W_4: (Metribuzin 5.21 l/ha + Pendimethalin 3.57 l/ha) was the best for weed control in sugarcane in the two sites.

Keywords: Chemical herbicides; Sudan; sugarcane; Saccharum officinarum L.; weed density; weed flora.

1. INTRODUCTION

In sugarcane (*Saccharum officinarum* L.) cultivation the weed problem is quite different from other crops because it is planted 30-45 days for complete germination and another 60-75 days for developing full canopy cover, this provides ample opportunity for weed to occupy the vacant spaces between rows and offer serious crop weed competition [1]. Initial slow growth and wider spacing of sugarcane provide ideal conditions for weeds that pose heavy interference with sugarcane; these conditions are conducive to weed growth and competition during the first 3-4 months of growth [2]. Critical periods of crop-weed competition vary depending on crop, weed, weather, growing conditions, soil type and tillage [3]. Weeds reduce sugarcane yields by competing for moisture, nutrients and light during its growing period [4]. Weeds that infest sugarcane plant include grasses, broad-leaf weeds and sedges which can cause loss in sugarcane yield by 20-90 % [5]. Shehata et al. [6] reported that weeds remove 4 times of N and P and 2.5 times of K as compared to sugarcane during the first seven weeks period which reflects negatively on crop yield. Weeds are generally handled by manual, biological, mechanical and chemical methods. The traditional method for controlling weeds in sugarcane in Sudan is hand weeding which is labor intensive, tedious, laborious, time consuming, and therefore an expensive operation where done by hired labor. However, with the scarcity of manual labor and intensive crop production, introduction of chemical weed control was necessary to replace traditional weed control measures, more effective in controlling weeds without adverse effect on cane quality and is time saving [1,7-10]. Herbicides are chemicals that kill or alter the normal growth of weeds. They can be divided into two main groups: selective and non-selective. Furthermore, there are several efficient herbicides on market herbicides, like, Ametryn, Diuron, and Atrazine etc. which registered for weed control in sugarcane [11]. Very few herbicides are selective when applied at post-emergence to sugarcane. Triazines like atrazine and recently, trifloxysulfuron found to be effective post-emergent herbicides for sugarcane. Atrazine is very effective against annual grasses and broad-leaf weeds but when supplemented with hoeing operation give better control for perennial weeds [1,7]. In Sudan, weeds are the major constraint to crop production in all cultivated areas, unrestricted weed growth promotes soil degradation in cultivated lands and reduces yield of the main crop by 50-100 % [12]. In Sudan, chemical herbicides can be useful and economical tools in increased sugarcane production. Abdel et al. [13] reported that the standard weed control treatment in sugarcane is composed of the rather application of (Gesapax + Gesaprim) and (Stomp + Gesaprim). Recently, there were recommended and registered chemical herbicides combination applied in sugarcane farms. These chemical herbicides include (Ametrine + Atrazine), (Atrazine + Pendimethalin) and (Metribuzin + Pendimethalin) so as to achieve a good control of weeds and increase sugarcane yield. Herbicide mixtures, which contain two or more herbicides with different modes of action, can be an effective and economical tool for controlling diverse weeds that vary in morphology and physiology, and emerge at different stages of growth in a number of crops [14]. Therefore, the main objective of this study was to classify and identify weed flora, weed density and weed control on sugarcane as plant cane to improve weed control process and sugarcane production.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was conducted in Sugar Research Center Farm at Guneid– Sudan on the East Bank of the Blue Nile, 117 km south of Khartoum, latitude 15^0 North, and longitude 33^0 East during seasons 2019/2020 in two different experimental sites which differ in some chemical and physical soil properties [13]. The soil was vertisol with moderate chemical fertility. The objective of the study was to determine the weed flora, weed density and weed control efficiency of different weed types affect sugarcane as plant cane crop. The climatic zone of the experimental research area is continental which is characterized by hot summer, relatively cool winters, low rainfall, low relative humidity and the potential evapo-transpiration exceeding precipitation in most parts of the year [Genied Annual reports 2019-2022]. The average maximum temperature is recorded as 42.2 C^0 in April during the study period 2019- 2020. The average minimum temperature is recorded was 15.8, 19.8 and 15.1 C^0 in February during the study period from 2019 to 2020 respectively. The average maximum Relative humidity (RH %) is recorded was 76.4 and 79.3 % in August during the study period 2018- 2019 respectively. The average minimum Relative humidity (RH %) recorded was 18.5 and 18.5 % in April month during the study period 2018- 2019 respectively. The average maximum rainfall recorded was 91.4 (September), 129.7 and 142.1 mm (August) during the study period from 2019 to 2020 respectively [metrological data in study area].

2.2 Experimental Details

Two field experiments for plant cane crop were conducted in two different experimental sites in season 2019\2020 and harvested at the age of 14 months. Experimental design was a Randomized Completely Block Design (RCBD) with four chemical herbicides treatments; W_1: un weeded (control), W_2: Ametryne 3.8 l/ha + Atrazine 3.8 l/ha. W_3: Atrazine 3.0 l/ha + Pendimethalin 2.9 l/ha and W_4: Metribuzin 5.3 l/ha + Pendimethalin 3.6 l/ha.

2.3 Plant Cane Cultural Practices

All the standard cultural practices adopted for sugarcane cultivation in the Sudanese Sugarcane Farms were followed in this experiment. The plant cane experimental sites were left fallow for the previous year and were prepared according to the standard preparation methods followed for the commercial sugarcane production. Up-rooting of the previous crop stools, deep plowing with heavy disc plough, harrowing, leveling, and furrowing at distance of 1.5 m. The plot size for the two different plant cane experiments was 4 furrows ^{x} 8 m row long ^{x} 1.5 m width = (48 m^2). Three eyed cane sets were taken from ten months old plant cane of the variety Co 6806, and planted with the end to end method of planting. The sets in the furrows were lightly covered with soil manually and irrigated immediately. All chemical herbicides treatments were applied prior to the second irrigation as aqueous spray using a knap-sack sprayer at volume rate of 80 l/fed. Un-weeded control was included for comparison. Subsequent irrigations were applied at 10 days intervals except during hot and rainy periods when the interval was adjusted as required.

2.4 Weed Parameters

2.4.1 Weed flora

At 4, 8, and 12 weeks from sugarcane planting, a quadrate of (0.5 m x 0.5 m) was thrown randomly in each experimental unit four times and green weed plants not affected by herbicides species were identified, categorized into grasses and broad-leaved weeds and counted to categorized the weed species present in the sugarcane field.

2.4.2 Weed density

At 4, 8, 12 weeks after application a quadrant of (0.5 m x 0.5 m) was thrown randomly in each experimental unit four times and green weed plants not affected by herbicides were counted and averaged for calculating weed density. At every sampling, two categories of weeds viz., grasses and broad-leaved weeds were separated and expressed as numbers per m^{-2}.

2.4.3 Weed control efficiency

It denotes the efficiency of the applied herbicides or herbicidal treatments for comparison purposes. It was worked out by using the formula and expressed in percentage.

$$WCE = \frac{DMC - DMt}{DMC} \times 100$$

Where,

WCE - Weed control efficiency in percentage,
DMC -Dry matter (g m^{-2}) in un weeded control and
DMT -Dry matter (g m^{-2}) in treated plot.

2.5 Statistical Analysis

Experimental data collected were analyzed statistically using analysis of variance (ANOVA) technique to evaluate the differences among treatments, and the means were separated using the least significant difference (LSD) at the 5% level of significance [15].

3. RESULTS AND DISCUSSION

Experimental results in Table 1 related to weed flora for plant cane crop in the two different experimental sites at Sugarcane Research Center Farm at Guneid were identified in about 15 weed species were classified into two categories; grasses and broad-leaved weeds. The total average number of weeds in the un weeded plots in the two different experimental sites ranged between 13 to 17% of the total weeds were grasses and the rest were broad-leaved weeds which ranged between 87 to 83%. The predominant grass weeds were *Bracharia eruciformis* and *Echinochloa colonum.* The predominant broad-leaved weeds were *Digera alternifolia, Ipomoea cordofana*, *Rhyncosia memnonia*, *Corchorus fascicularis*, *Trianthema pentandra, Phyllanthus maderaspatensis, Solanum dubium and Momordica balsamina*. Comparison of relative densities of grasses and broad-leaved weeds at all stages of observation revealed that broad- leaved weeds dominated over grasses in the two different experimental sites for plant cane crop. These results obtained similar to that of Waghmare et al. [16], who reported that dominance of broad-leaved weed was due to their faster growth and deep root system and thus promoted the absorption of soil moisture. The experimental results obtained for weed flora were in the same line to that of Waghmare et al. [16], who reported that broadleaf weed were predominant and particularly cause trouble some to sugarcane crop.

The obtained experimental results in Table 2 for plant cane crop in the two different experimental sites showed a significant difference at (p< 0.05) between different weed types weed density. All chemical herbicides treatments applied recorded better results in minimizing weed density compared to the un weeded treatment. Treatment W_4: (Metribuzin 5.21 l/ha + Pendimethalin 3.57 l/ha) recorded significantly at (p< 0.05) the lowest weed density compared to the other chemical herbicide's treatments and the control in the two different experimental sites Figs. 1 and 2. The obtained results for weed density were similar to those of Lal et al. [17] who reported that good control of weeds decreases weed density and dry matter percent. These results also, confirmed to those of Pratap et al. [18], who concluded that application of Metribuzin herbicide was found most effective in minimizing weeds density and dry matter than the control. The obtained results also, agreed with Mishra et al. [19], who reported that application of Metribuzin significantly reduced weed density and weed dry matter in sugarcane. Also, similar findings were also reported by Singh et al. [20].

The results obtained in Table 3 for weed control efficiency in plant cane crop in the two different experimental sites showed a significant difference at (p<0.05) between different weed types. These results might be due to the control of initial weed growth due to the application of chemical herbicides, [10], and [1] and similar to that of Mishra et al. [19] who reported high weed control efficiency (WCE%) as a result of the application of metribuzin herbicide in sugarcane crop. The increase in percentage inhibition of weeds by herbicides may be due to control of most types of weeds because of its use in the early stages of crop growth as well as late emergence of other types of weeds that makes them weak in growth and lower accumulation of dry matter due to low efficiency of photosynthesis because of the shading effect of sugarcane on weeds [21].

In general, application of the treatment which contain (Metribuzin + Pendimethalin) in plant cane crop recorded an excellent experimental result for all weed data parameters in minimizing weed density and weed dry matter percent and increasing control efficiency percent (WCE %) compared to the other treatments for plant cane in the two different experimental sites in the study.

Table 1. Weed flora in sugarcane research farm at Guneid, Sudan

Scientific name	Local name	Type	Family
Bracharia ercuiformis	Um koreaat	G*	Poaceae
Echinochloa colonum	Difra	G	Paniceae
Ipomoea cordofani	Tabar	BL#	Convolvulaceae
Corchorus fascicularis	Khodra	BL	Poaceae
Trianthema pentandra	Rabaa	BL	Aizoaceae
Phyllanthus niruri	Soreeb	BL	Phyllanthaceae
Digera allternifolia	Lablab	BL	Amaranthaceae
Euphorbia convoluloides	Labana	BL	Euphorbiaceace
Aristolochia bracteolate	Umglagel	BL	Poaceae
Rhynchosia memnonia	Adana	BL	Leguminasae
Ocimum basilicum	Rehan	BL	Laminaceae
Portulaca oleracea	Regla	BL	Phyllanthaceae
Sonchus cornutus	Molata	BL	Asteraceae
Hibiscus esculetus	Pamea	BL	Malvaceae
Tribulus terrestris	Derassa	BL	Zygophyllaceae
Eclipta prostrate	Tamer Elgnam	BL	Asteraceae
Solanum dubium	Gubain	BL	Streptophyta

**G: Grass weed*
#BL: Broad-leaved weed

Table 2. Weed density percent (WD%) in sugarcane research farm at Guneid, Sudan

Weeds	Weed Type	Weed Density Percent (WD%)	
		Site one	Site two
Bracharia ercuiformis	Grass	5.0[ab]	13.3[a]
Echinochloa colonum	Grass	5.5[a]	18.7[a]
Ipomoea cordofani	Broad-leaved	5.8[a]	10.5[ab]
Corchorus fascicularis	Broad-leaved	0.3[bc]	3.4[bc]
Trianthema pentandra	Broad-leaved	0.0[c]	0.0[c]
Phyllanthus niruri	Broad-leaved	0.0[c]	0.6[c]
Digera allternifolia	Broad-leaved	0.3[bc]	0.5[c]
Euphorbia convoluloides	Broad-leaved	0.2[bc]	1.1[bc]
Aristolochia bracteolate	Broad-leaved	0.13[bc]	0.2[c]
Rhynchosia memnonia	Broad-leaved	1.1[abc]	2.0[bc]
Ocimum basilicum	Broad-leaved	0.0[c]	0.0[c]
Portulaca oleracea	Broad-leaved	0.1[c]	0.2[c]
Sonchus cornutus	Broad-leaved	0.0[c]	0.3[c]
Hibiscus esculetus	Broad-leaved	0.0[c]	0.0[c]
Tribulus terrestris	Broad-leaved	0.0[c]	0.1[c]
Eclipta prostrate	Broad-leaved	0.0[c]	0.0[c]
Abutilon glaucum	Broad-leaved	0.0[c]	0.0[c]
Solanum dubium	Broad-leaved	0.0[c]	0.1[c]

Plant cane experimental results data related to weed density (Number/m^2) in Table 4 showed that there was a significant difference between chemical herbicides treatments in the two different experimental sites. Treatment W_1: (un weeded - the control) recorded significantly at ($P \leq 0.05$) the higher grass weeds density values (103.4-98.1) and the higher broad-leaved weeds density values (73.9-81.7) in the two different experimental sites respectively. Treatment W_2: (Ametryne 3.8 l/ha + Atrazine 3.8 l/ha) recorded grass weeds density values (54.4-49.4) and broad-leaved weeds density values (11.3-46.4). Treatment W_3: (Atrazine 3.0 l/ha + Pendimethalin 2.9 l/ha) recorded grass weeds density values (2.3-3.4) and broad-leaved weeds density values (12.3-5.3) in the two different experimental sites respectively. Treatment W_4: (Metribuzin 5.21 l/ha + Pendimethalin 3.57 l/ha) recorded significantly at ($P \leq 0.05$) the lowest grass weeds density values (0.4-11.9) and the lowest broad-leaved weeds density values (5.3-0.9) in the two different experimental sites respectively. The obtained results for weed density were similar to those of Lal et al. [17] who reported that good control of weeds decreases weed density and dry matter percent. These results also, confirmed to those of [18] who concluded that application of Metribuzin herbicide was found most effective in minimizing weeds density and dry matter than the control. The obtained results also, agreed with Mishra et al. [19] who reported that application of Metribuzin significantly reduced weed density and weed dry matter in sugarcane. Also, similar findings were also reported by Singh et al. [3].

Plant cane experimental results data related to weed control efficiency percent (WCE%) in Table 5 showed that there was a significant difference at ($P \leq 0.05$) between treatments. The treatment W_1: (un weeded - the control) recorded significantly at $P \leq 0.05$) the lowest grass weed control efficiency percent (WCE%) values (0.0-0.0%) and lowest broad leaved (WCE%) values (0.0-0.0 %) in the two different experimental sites respectively. Treatment W_2: (Atrazine 3.0 l/ha + Pendimethalin 2.9 l/ha) recorded grass WCE% values grass WCE % values (48.8-46.8%) and broad-leaved WCE % values (74.3-42.8%) in the two different experimental sites respectively. Treatment W_3: (Atrazine 3.0 L/ha + Pendimethalin 2.9 L/ha) recorded grass WCE % values (97.6-81.5%) and broad leaved WCE% values (72.1-72.5%) in the two different experimental sites respectively. Treatment W_4: (Metribuzin 5.21 l/ha + Pendimethalin 3.57 l/ha) recorded significantly at ($P \leq 0.05$) the highest grass WCE% values (99.7-92.1%) and the highest broad-leaved WCE% values (87.8-78.1%) in the two different experimental sites, respectively. The results obtained for weed control efficiency in plant cane crop in the two different experimental sites might be due to the control of initial weed growth due to the application of chemical herbicides [10] and similar to that of Mishra et al. [19] who reported high weed control efficiency (WCE %) as a result of the application of metribuzin herbicide in sugarcane. The increase in percentage inhibition of weeds by herbicides may be due to control of most types of weeds because of its use in the early stages of crop growth as well as late emergence of other types of weeds that makes them weak in growth and lower accumulation of dry matter due to low efficiency of photosynthesis because of the shading effect of sugarcane on weeds [21]. In general, application of the treatment which contain (Metribuzin + Pendimethalin) in plant crop recorded an excellent experimental result for weed data parameters in minimizing weed density and increasing control efficiency percent (WCE%) compared to the other treatments for plant cane crop in the two different experimental sites in the study.

Table 3. Weed flora and weed control efficiency percent (WCE%) in Sugarcane Research Farm at Guneid- Sudan

Weeds	Weed Type	Weed density percent (WD%)	
		Site one	Site two
Bracharia ercuiformis	Grass	85.9^{abc}	51.1^{abc}
Echinochloa colonum	Grass	90.0^{ab}	63.015^{ab}
Ipomoea cordofani	Broad-leaved	69.6^{bc}	50.1^{abc}
Corchorus fascicularis	Broad-leaved	97.2^{ab}	71.5^{ab}
Trianthema pentandra	Broad-leaved	100.0^{a}	75.0^{ab}
Phyllanthus niruri	Broad-leaved	98.9^{a}	72.7^{ab}
Digera allternifolia	Broad-leaved	95.5^{ab}	69.2^{ab}
Euphorbia convoluloides	Broad-leaved	92.5^{ab}	72.1^{ab}
Aristolochia bracteolate	Broad-leaved	36.6^{d}	0.0^{c}
Rhynchosia memnonia	Broad-leaved	57.1^{cd}	31.2^{bc}
Ocimum basilicum	Broad-leaved	100.0^{a}	100.0^{a}
Portulaca oleracea	Broad-leaved	73.1^{abc}	69.3^{ab}
Sonchus cornutus	Broad-leaved	98.6^{ab}	75.0^{ab}
Hibiscus esculetus	Broad-leaved	75.0^{abc}	100.0^{a}
Tribulus terrestris	Broad-leaved	100.0^{a}	75.0^{ab}
Eclipta prostrate	Broad-leaved	100.0^{a}	75.0^{ab}
Abutilon glaucum	Broad-leaved	100.0^{a}	75.0^{ab}
Solanum dubium	Broad-leaved	100.0^{a}	50.0^{abc}

Table 4. Effect of chemical herbicides on plant cane weeds density

Treatments	Grass weeds		Broad-leaved weeds	
	Site one	Site two	Site one	Site two
W_1	103.4^{a}	98.1^{a}	73.9^{a}	81.7^{a}
W_2	54.4^{b}	49.4^{b}	41.3^{b}	46.4^{b}
W_3	2.3^{c}	3.4^{c}	12.3^{c}	5.3^{c}
W_4	0.4^{c}	0.6^{c}	5.3^{c}	0.9^{c}
Mean	40.0	37.9	18.2	33.8
LSD $_{(P<0.05)}$	35.8	35.8	4.7	37.4

W_1: Unweeded (control), W_2: Ametryne 3.8 L/ha + Atrazine 3.8 L/ha, W_3: Atrazine 3.0 l/ha + Pendimethalin 2.9 l/ha, W_4: Metribuzin 5.21 l/ha + Pendimethalin 3.57 l/ha., G: Grasses, BL: Broad-leaved. Values sharing same letter(s) in a column do not differ at 5 % probability level

Table 5. Effect chemical herbicides on plant cane weeds control efficiency percent

Treatments	Grass weeds		Broad-leaved weeds	
	Site one	Site two	Site one	Site two
W_1	0.0^{c}	0.0^{b}	0.0^{c}	0.0^{b}
W_2	48.8^{b}	46.8^{a}	74.3^{b}	42.8^{a}
W_3	97.6^{a}	81.5^{a}	72.1^{b}	77.5^{a}
W_4	99.7^{a}	82.1^{a}	87.8^{a}	78.1^{a}
Mean	61.5	52.6	58.5	49.6
LSD $_{(P<0.05)}$	8.2	36.6	8.5	37.4

W_1: Un weeded (control), W_2: Ametryne 3.8 L/ha + Atrazine 3.8 L/ha, W_3: Atrazine 3.0 l/ha + Pendimethalin 2.9 l/ha, W_4: Metribuzin 5.21 l/ha + Pendimethalin 3.57 l/ha., leaved.
Values sharing same letter(s) in a column do not differ at 5 % probability level

Fig. 1. Un weeded treatment (the control)

Fig. 2. W_2: Metribuzin 5.3 L/ha Pendimethalin 3.6 L/ha

4. CONCLUSION

In this study the weed flora for plant cane crop in the two different experimental sites identified about 15 weed species classified into two categories; grasses which ranged between 13 to 17 % of the total weed and the rest were broad-leaved weed which ranged between 87 to 83% . The broad leaves weed were dominance over grass weed . The treatment W_4: (Metribuzin 5.21 l/ha + Pendimethalin 3.57 l/ha) recorded significantly at ($p<0.05$) with the lowest weed density, and the highest weed control efficiency percent compared to the other chemical herbicide's treatments. The application of chemical herbicides give good result.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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