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Effects of Fluazifop-P-Butyl and Glyphosate on Yield and Weed Control in Okra Vegetable (*Abelmeschus esculentus* (L) Moench) in North Sudan

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Abstract

The herbicides experiment was conducted for two consecutive summer seasons (2014, 2015) at Altraa village, Sharg Elneel Unit, Dongola Locality, Northern State, Sudan located within latitude 16° and 22°N and longitude 20° and 32°E to determine fresh pod yield loss due weed competition and to evaluate and compare the effects of Fusilade applied as post-emergence at 0.7, 1.1, 1.3 and 1.5 l/fed and glyphosate applied pre-emergence at 0.3, 0.4, 0.5 and 0.6 l/fed and applied post-emergence at the same rates. Results obtained from this experiment indicated that, unrestricted weed growth significantly reduced fresh pod yield (kg/fed) by 67.40% in both summer seasons.

Results obtained from this experiment reported that, Fusilade herbicide was the best in controlling graminae weeds while glyphosate herbicide was the best in controlling broad-leaved weeds in both summer seasons. Also results obtained from this experiment reported that, among the two herbicides treatments the best weed control was achieved by glyphosate which applied post-emergence at 0.6 l/fed while Fusilade at 1.5 l/fed treatment applied post-emergence gave higher fresh pod yield in both summer seasons. The use of the two herbicides treatments reduced significantly weed biomass (g/m^2).

Keywords: Herbicides; Weed free; Graminae; Broad leaved weeds

Introduction

Okra (*Abelmeschus esculentus* (L) Moench) sometimes called Gumbo, is a tall, handsome, tropical annual from the Nile Vally, with a much-branched coarse stem that grows to a height of three feet and produce large-petaled flowers and long slender, pointed seed pods [1]. It is one of the most important and popular vegetables grown in the Sudan and the world. It is a member of the plant family Malvaceae cultivated in Sudan, it is ranking third after onion and tomato with annual average area and yield of 58014 feddans and 291376 tons, respectively. It grows well under irrigation and rainfed area, in most parts of the country [2,3]. It is grown mainly for its green pods which are used as vegetable, fresh canned cooked with meat (weika) making a favorable and popular dish by most Sudanese (umrogaiga and tagalia) or conserved by drying and grinding into powder. The leaves are also cooked in many areas. It is a typical food in combination with sorghum bread (kisra). The seeds, roasted and ground to powder, are used as a substitute of coffee. Okra is used principally in soups and stews. It is grown in the tropical and subtropical area, almost in all parts of the country. It's main producing countries are India, Nigeria, Pakistan and Ghana, where India at the top with a total production of 3,550,000 metric tons (Mt) [4]. The world production of okra as fresh fruit vegetable is estimated at 6 million tonnes per hectare [5].

One of the main problems that affect yield and quality of crops such as okra is weed interference and their competition with the crop. Weeds in okra must be controlled [6]. In developing countries manual weeding is the most common method of weed control but in many instances the available labor is unable to remove weeds from vast areas of land during critical periods, thus, the use of herbicides is a necessity [7-9]. Herbicides play a major role in controlling weeds in crop production. They constitute a new and highly efficient technique for controlling weeds, increasing yield, improving quality and reducing labour in crop production [9,10].

In Sudan okra vegetable received little attention and the available information is inadequate especially in area of weed control. Thus, this study was conducted to assess the magnitude of fresh pod yield losses in okra due to the weed infestation and to evaluate and compare the effects of two pre and post-emergence herbicides in Sudan, namely, glyphosate and Fuzilade fort on tolerant and fresh pod yield of okra in an endeavour to determine the most suitable weed control treatment that secure high fresh pod yield.

Materials and Methods

A field experiment was conducted during two consecutive summer seasons of the years 2014 and 2015 at Altra-Dongola locality-Northern State-Sudan. The area is located within latitudes 16° and 22°N, and longitude 20° and 32°E. Dongola locality is a true desert, is characterized by extremely high temperatures and radiation in summer, low temperature in winter, scarce rainfall and high wind speed. The mean maximum and minimum temperatures are 36.8 and 19.5°C, respectively. The climate is hyper arid with a vapor pressure of only 10.8 mb and a relative humidity of less than 20%. The soil in the experimental site is a sandy clay loam, with 57.34% sand, 19.83% silt and 22.50% clay. The herbicides treatments were: fluazifop-p-butyl as Fusilade (150 g) Ec, applied post-emergence at 0.7, 1.1, 1.3 and 1.5

litre/fed., (1 fed=0.42 ha); glyphosate as Touchdown 41% Ec applied pre-emergence at 0.3, 0.4, 0.5 and 0.6 litre/fed., and post-emergence at 0.3, 0.4, 0.5 and 0.6 litre /fed [11-13].

Full season weed free and full season weedy treatments were included for comparison. Pre-emergence herbicides were applied, immediately after sowing, with a knapsack sprayer at a volume rate of 80 liters per feddan, application of the pre-emergence herbicides was followed by irrigation while the post-emergence herbicides were applied at 4 weeks after crop sowing. Treatments were arranged in a randomized block design (RBC), with four replications. In each season the experimental site was ploughed, disc harrowed, leveled and divided into 3 × 3.5 m plots. Each plot was made of five rows. Okra, variety khartuomia was planted by hand in rows on flat, three seeds/hole in rows 70 cm a part and 25 cm between holes, on 23 February for both summer seasons. The seedlings were later thinned to two plants per hole, to give a population of approximately 48000 plants per feddan. Nitrogen fertilizer, as urea, was applied at a rate of 2 N (80 lb of nitrogen/fed). In the weed free treatments, weeds were removed frequently by repeated hand weeding to keep the crop free from weeds up to harvest. However, in the weedy full season treatment, weeds were left to grow, unrestrictedly, with the crop until harvest. Visual observations of phytotoxicity of the herbicides treatments on the crop were assessed periodically. The effect of treatments on weeds was assessed by counting the individual weed species at 4 weeks after herbicides application. This was done by randomly placing 1 × 1 m quadrate in each plot. Weeds inside each quadrate were identified and individual weed species counted. The percentage control of grassy and broad-leaved weeds, as compared with the un-weeded control, for each treatment was calculated in a meter square quadrate 4 weeks after sowing. Weed species and their dry weights were also determined. At ten weeks after sowing ten plants were randomly selected from the three inner rows in each plot to determine Plant height (cm), number of branches/plant, number of leaves/plant, leaf area index/m^2 and shoot dry weight(g)/plant. At each picking ten plants were randomly selected in each plot to determine mean number of pods/plant and mean fresh pod yield (kg/fed). Two rows in each plot were left unpicked or unharvested until the harvest, ten plants were randomly selected in each plot from those rows which were left unharvested, their pods were cut and threshed in bulk to determine number of seeds/pod and 100 seed weight (g) [14].

The procedure described by Gomez and Gomez was used to estimate the combined analysis of variance (ANOVA), was performed using the statistical analysis system (SAS) computer package for SAS Institute Inc., 1990, to detect significant effects among the treatments and populations. Mean squares for treatments or populations were calculated. Simple statistics including mean, standard deviation, standard error and coefficient of variation (CV %) were also calculated [15].

Results and Discussion

Visual observations showed that, glyhosate treatments which applied post - emergence at 0.4, 0.5 and 0.6 l/fed were toxic to the okra crop. In both summer seasons. Okra plants were attacked by aphids in both summer seasons which controlled by Folimat. The infection by aphids was heavy in the first summer season. The weed flora in the experimental site consisted of grassy and broad-leaved weeds. In both summer seasons broad-leaved weeds were predominant. The same result was found by Mukhtar and Suhair [16]. The dominant weed species were:

Chenopodium album (L.), *Malva parviflora* (L), *Convolvulus arvensis*(L.), *Amaranthus graecizans*, *Sorghum arundinaceum*, *Gynandropsis gynandra* (L.) Briq, *Sinapis arvensis* (L.), *Tribulus terrestris* (L.), *Datura stramonium* (L.), *Cynodon dactylon* (L.) Pers, *Cyperus rotundus* (L.), *Eruca sativa*, *Portulaca oleracea* L., *Dactyloctenium aegyptium* (L.)Beauv., *Sporobolus pyramidatus* (Lam.) Hitchc., *Sonchus oleraceus*, L. *Hyoscyamus reticulates*, *Echinochloa colona* (L.) Link, *Tephrosia apollinea* (Del.), *Cassia italica* (Mill.) Lam. Ex Steud, *Calotropis procera* (Ait.) Ait. f., *Aerva javanica* (Burm. f.), *Aerva javanica* (Burm. f.), *Rhynchosia memnonia* (Del.) cooke and *Lotus arabicus* L.

The mean of both summer seasons confirmed that, Fusilade treatment which applied post-emergence at 0.7, 1.1, 1.3 and 1.5 l.a.i/fed achieved excellent control of graminae weeds. However, glyphosate treatments which applied pre-emergence at 0.3, 0.4, 0.5 and 0.6 l.a.i/fed gave moderate control of gramina weeds while glyphosate treatments at the same mention rates which applied post-emergence gave poor control of graminae weeds (Table 1). Fusilade herbicide was the best between the two herbicides used which achieved effective control of graminae weeds.

The mean of both summer seasons, indicated that, Fusilade treatments which applied post- emergence at 0.7, 1.1, 1.3 and 1.5 l/fed did not achieve any control of broad-leaved weeds. However, glyphosate treatments which applied pre and post-emergence gave poor to good control of broad-leaved weeds, respectively (Table 1). Glyphosate herbicide was the best between the two herbicides used. Glyphosate herbicide at the rate of 0.6 l.a.i/fed was the best treatment among the treatments of the two herbicides used which achieved good control of broad leaved weeds while Fusilade treatment at 1.5 l.a.i./fed was the best between the treatments of the two herbicides used which gave the best fresh pod yield (kg/fed). Similar results were found by Ramachandra et al., Kumar and Charanjit, Tiwari et al. and Covindra et al. [17-20].

The combined analysis of both summer seasons, showed that, Fusilade treatments at 0.7, 1.1, 1.3 and 1.5 l.a.i/fed significantly decreased weed biomass (g/m^2) as compared to the weedy full season treatment (Table 1). Fusilade herbicide was the best between the two herbicides used which gave lowest dry weight of weeds (Table 1). These findings are in line with those obtained [21,22].

Treatments	Herbicide rate kg a.i/fed	Percentage graminae weed control	Percentage broad-leaved weed control	Weed biomass
Fusilade post	0.7	89.39	0	47 c
Fusilade post	1.1	92.18	0	41.5 c
Fusilade post	1.3	92.21	0	45.5 c
Fusilade post	1.5	91.39	0	43 c
Glyphosate pre	0.3	53.36	18.98	71 ab
Glyphosate pre	0.4	59.65	30.8	96.5 a
Glyphosate pre	0.5	64.88	9.99	56 bc
Glyphosate pre	0.6	63.69	21.33	71 ab
Glyphosate post	0.3	45.07	46.52	74 ab

Glyphosate post	0.4	33.73	52.84	75 ab
Glyphosate post	0.5	44.79	54.1	61.25 c
Glyphosate post	0.6	48.84	64.63	66 ab
Weed free full	-	100	100	89.5 ab
Weedyfull	-	0	0	-
C.V%	-	-	0	44.79%
S.E%	-	-	0	15.0704%

Table 1: Effects of herbicides treatments on percentage graminae, percentage broad leaved weeds control and weed biomass (g/m^2) during summer seasons (2014, 2015) combined. Treatment means in the same column with the same letters are not significantly different at p (0.05) according to Duncan's Multiple Range Test. a1=Active Ingredient, Kg=Kilogram.

The combined analysis of both summer seasons showed that, Fusilade herbicide treatments at 0.7, 1.3 and 1.5 l.a.i/fed and the weed free full season treatment significantly increased plant height (cm) as compared to the weedy full season treatment. These treatments of Fusilade herbicide gave plant height (cm) comparable to that obtained in the weed free full season treatment (Table 2). The combined of both summer seasons indicated that, all herbicides treatments and the weed free full season treatment did not significantly increased number of branches/plants as compared to the weedy full season treatment (Table 2). The combined analysis of both summer seasons indicated that, Fusilade herbicide treatments at 0.7, 1.1 and 1.5 l.a.i/fed and the weed free full season treatment significantly increased number of leaves/plant as compared to the weedy full season treatment (Table 2). The combined analysis of both summer seasons showed that, Fusilade at 0.7 and 1.5 l.a.i/fed treatments and the weed free full season treatment significantly increased leaf area index/m^2 as compared to the weedy full season treatment (Table 2).

The combined analysis of both summer seasons showed that, the weed free full season treatment only significantly increased shoot dry weight (g)/plant as compared to the weedy full season treatment (Table 2). Similar findings mentioned that, the herbicides significantly increased okra crop growth components. Also, these results were in line with those obtained by Ramachandra et al. who indicated that, okra growth components were positively affected by herbicides treatments, growth components were significantly increased in treated plots as compared to the weedy full season treatment [17].

Treatments	Herbicide rate kg a.i/fed	Plant height (cm)	Number of branches/ plant	Number of leaves/ plant	Leaf area index/m^2	Shoot dry weight (g)/ plant
Fusilade post	0.7	86.8 ab	1.9 abc	26.1 bc	8.8 bc	25.1 bc
Fusilade post	1.1	83.5 abc	2.4 ab	26.5 bc	8.5 bc	32.0 bc
Fusilade post	1.3	86.4 ab	2.1 abc	24.6 bcd	9.3 b	30.4 5 bc
Fusilade post	1.5	84.7 ab	2.0 abc	28.3 b	8.3 bc	39.4 ab
Glyphosate pre	0.3	65.0 de	1.8 abc	18.5 e	5.8 cdef	21.2 bc
Glyphosate pre	0.4	80.8 bc	1.8 abc	19.3 de	5.5 cdef	26.6 bc
Glyphosate pre	0.5	63.1 de	1.6 bc	15.6e	4.8 def	20.9 bc
Glyphosate pre	0.6	74.8 bcd	1.9 abc	20.9 cde	7.0 bcde	27.0 bc
Glyphosate post	0.3	66.6 de	1.6 bc	18.3 e	4.5 def	38.8 ab
Glyphosate post	0.4	62.6 de	1.6 abc	17.4 e	4.3 ef	16.4 c
Glyphosate post	0.5	58.9 e	1.4 c	17.4 e	3.8 ef	15.0 c
Glyphosate post	0.6	63.3 de	1.9 abc	17.5 e	2.5 f	18.5 bc
Weed free full	-	97.3 a	2.6 a	43.3 a	16.8 a	55.4 a
Weedyfull	-	70.3 cde	1.9 abc	20.de	7.8 bcd	24.6 bc
C.V%		17.28%	41.00%	23.40%	30.00%	65.40%
S.E%		6.4	0.3985	2.6	1.01	9.1

Table 2: Effects of herbicides treatments on okra vegetable growth components during summer seasons (2014, 2015), combined. *Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT. ai=Active ingredient. Kg=Kilogram.

The combined analysis of both summer seasons showed that, the weed free full season treatment only significantly increased number of pods/plant and number of seeds/pod as compared to the weedy full season treatment (Table 3). The combined analysis of both summer seasons indicated that, all herbicides treatments and the weed free full season treatment did not significantly increased 100 seed weight (g) as compared to the weedy full season treatment (Table 3).

Fresh pod yield (kg/fed)	100 seed weight (g)	No. of seeds/pod	No. of pods/plant	Herbicide rate kg a.i/fed	Treatments
2846bc	6.0 a	59.9 ab	16.9 b	0.7	Fusilade post
2131cd	6.0 a	60.6 ab	15.9bc	1.1	Fusilade post
2316c	5.8 a	60.1 ab	15.3 bcd	1.3	Fusilade post
3193.b	5.3 a	59.0 ab	16.1 bc	1.5	Fusilade post
1065e	6.0 a	58.6 ab	11.8 e	0.3	Glyphosate pre
2059cd	6.0 a	60.3 ab	13.6 cde	0.4	Glyphosate pre
1427de	5.8 a	57.6 ab	12.6 de	0.5	Glyphosate pre
1298de	6.0 a	59.5 ab	13.5 cde	0.6	Glyphosate pre
804e	5.5 a	52.5 bc	13.6 cde	0.3	Glyphosate post
1053e	5.8 a	53.6 bc	13.1 de	0.4	Glyphosate post
740.e	5.8 a	47.1 cd	12.5 e	0.5	Glyphosate post
761e	5.8 a	45.6 d	13.0 de	0.6	Glyphosate post
4199a	6.0 a	65.3 a	19.9 a	-	Weed free full
1369de	5.3 a	54.4 bc	14.4 bcde	-	Weedyfull
45.30%	12.00%	12.40%	16.30%	-	C.V%
408.3	0.4	3.5	1.21	-	S.E%

Table 3: Effects of herbicides treatments on okra vegetable fresh pod yield components during summer seasons (2014, 2015), combined. Treatment means in the same column with the same letters are not significantly different at p (0.05) according to Duncan's Multiple Range Test. a.i=Active ingredient. Kg=Kilogram.

The combined analysis of both summer seasons indicated that, the Fusilade treatments at 1.3 and 1.5 l.a.i/fed and the weed free full season treatment significantly increased fresh pod yield (kg/fed) as compared to the weedy full season treatment (Table 3). The combined analysis of both summer seasons indicated that, within the two herbicides the best fresh pod yield was achieved with Fusilade at 1.5 l.a.i/fed which applied post-emergence. These increases could be attributed to the use of herbicides treatments which conspicuously suppressed weeds and freed okra to reach its potential length as more nutrients, water, light and space which increased plant growth parameters such as plant height, leaf area index and shoot dry weight(g)/plant and reflected in an increased okra fresh pod yield. Also, these increases may be because of the beneficial effects of other cultural operations such as the fertilizer uptake and various pests' control [5,17,18].

Conclusions and Recommendations

1. The following conclusions were obtained:
2. Unrestricted weed growth significantly reduced fresh pod yield (kg/fed) by 67.40%.
3. Within the two herbicides treatments the best fresh pod yield (kg/fed) was achieved with Fusilade treatment at 1.5 l.a.i./fed.
4. Among the two herbicides treatments the best significantly weed control was a achieved in terms of total weed biomass reduction with Fusilade treatments at 0.7, 1.1, 1.3 and 1.5 l.a.i/fed.
5. The positive effect of herbicides on weed control lead to a significant increase in okra vegetable fresh pod yield (kg/fed).
6. The following recommendations were obtained:
7. Weed control in okra should be carried out by Fusilade treatment at 1.5 l.a.i./fed., as post-emergence.

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