Comparison of diuron and butachlor for weed control in okra

Obiazi C. C.

Department of Agronomy, Delta State University, Abraka, Nigeria

Correspondence Author: Obiazi C. C.

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Abstract

Okra (*Abelmoschus esculentus* (L.) Moench) yields are decreased by weed interference. Manual weeding is mostly used in okra productivity and it is associated with high cost and drudgery, different from what obtains in the use of herbicides. Herbicides identified for weed management in okra productivity are small in number and scarce. The objective of this experiment is to compare development and tolerance of okra to the two frequently used herbicides. Diuron and butachlor were tested each at 2.0 kg a.i./ha and screened for okra tolerance and weed control efficacy. Un-weeded plots (WDC) and Hoe-Weeded (HWC) served as controls. Collected data were statistically analysed. Level of okra establishment followed the order of 91.8% (HWC)> 89.0% (butachlor)> 86.8% (WDC) > 51.9% (diuron). Diuron at 3.6 kg was not safe on okra it was severely phytotoxic (7.8), on 0-10 scale. Butachlor at 2.0kg a.i./ha was not phytotoxic on okra. Okra grown in butachlor plots had mean shoot biomass of 7.4g/plant which was similar to what was obtained in HWC, 7.9g/plant and was greater than 1.4g/plant in plots sprayed diuron. Diuron and butachlor had good weed control efficacy which were better than WDC. Okra had greater tolerance for butachlor which had no phytotoxic effect on okra at 2.0 kg a.i./ ha and had shoot biomass and okra establishment similar to what was obtained in HWC and should be among the herbicides considered for weed management in okra plots.

Keywords: screening of herbicides, okra establishment, weed management, shoot biomass

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is rich in iodine, vitamins and iron, yet its development and growth are greatly restricted by weed interference, mostly during the early growth stage. A loss of fresh pod yield of 50.1% was reported by Adeyemi et al. (2014) [1] due to unchecked weed interference. In most locations, the most practiced weed control method in okra production is manual weeding. Traditionally, the use of cutlass and hoe is the standard method for weed control (Obiazi and Ojobor, 2013) [6]. Weeds are ever-present and substantially decrease quality and yield of crops (Obiazi, 2022) [5]. Under large–scale farming, herbicide use is a suitable method of managing weeds. Herbicides labeled for weed control in okra as reported by Dittmar & Stall (2019) [2] are highly limited. Butachlor and diuron are herbicides that are commonly used for weed management in crops grown in Nigeria's rainforest zone. A frequently used pre-emergence herbicide for weed control in the production of upland or paddy rice is butachlor. Butastar which is one of the herbicide formulations tested in this study has butachlor as its active ingredient and it is the first listed herbicide for paddy rice or upland rice production. Some herbicides are combined with butachlor and used as post emergence spray to control most annual weeds (NACWC, 1994) [4].

Weeds in the following crops: pineapple, sugarcane, plantain, yam and banana and cassava are suppressed for a prolonged period by diuron (Konlan et al. (2016) [3]. Diuron is broad-spectrum herbicide efficient for the control of broadleaf and annual grassy weeds both as a pre-emergence and post-emergence weed control. The experiment was established to compare the efficacy of diuron and butachlor for okra production by evaluating their weed control efficacy and selectivity on okra. Butachlor and diuron have been identified to give effective weed control in crops that are commonly produced in the rainforest ecology.

Materials and Methods

Experimental site

The study was carried out in the field at the Department of Agronomy Teaching and Research farm of Delta State University, Asaba Campus located in Asaba, Nigeria during the 2013 and 2014 rainy seasons. Asaba is in the Southern Nigeria in the rainforest zone within latitude 6^0 14^1N and longitude 6^0 49^1E. Sandy loam was the textural class of the soil, it was adequate in phosphorus and potassium, with of 1.1 and 1 total N, 5.9 and 6 pH value in the year 2013 and the year 2014, respectively. A 50kg N /ha rate was applied each year; 25kg N /ha was applied at 3 weeks growth stage, the other 25kg N /ha was applied at 3 weeks later.

Procurement of seeds

Early maturing okra cultivar called Ozigolo, commonly grown in the locality was bought from Agbor in Oki market and used as test crop for the study. The manually prepared land was divided into fifteen plots; each plot was 2m x 2m with 1m separating the plots within a block and 1.5m separating the blocks. Diuron at 3.6 kg a.i./ha and butachlor at 2.0 kg a.i./ha applied pre-emergence were the experimental treatments. Three plots were hoe-weeded at three and six Weeks After Sowing (WAS) and served as hoe-weeded control, the other control was weedy check where weeds were not controlled throughout the study, the three plots served as weedy check to estimate the decrease in growth as a result of uncontrolled weeds associated with the crop. Weeds in hoe-weeded control plots were removed with the use of hoes at three and six weeks after sowing. The four treatments were replicated three times and Randomized Complete Block Design was used to lay out the treatments.

Seed protection treatments

To enhance germination of the seeds, they were put in water overnight and placed under shade the following day for air-drying. Apron star which has fungicide and insecticide was used for the protection of okra against diseases and pests. The active ingredients of Apron star are 20g/Kg Difenoconazole, 200g/Kg Metalaxyl–M and 200g/Kg Thiamethoxam (Syngenta, 2017) [8]. Ten grams of Apron star was used to dress the air-dried okra seeds at the rate of ten grams of Apron star per 4 kg of the seeds.

Plant protection treatments

The okra plants were protected from pests by spraying Cypermethrin at three, five and seven weeks after sowing. One ml of Cypermethrin was used per litre of water.

Sowing of seeds

Each hole received three okra seeds with a planting depth of 2 cm at a spacing of 50 x 50 cm, each plot had 16 stands resulting in 40,000 stands/ha. Thinning to one seedling/ stand after phytotoxicity rating had been taken place was carried out at three weeks after sowing.

Application of fertilizer

The soil was sandy loam; it had pH of 5.9, total N of 1.1 g/kg in 2013 and had pH of 6.0, total N of 1.0 g/kg in 2014. Nitrogen was applied in the form of urea at the rate of 50 kg of N/ha, half of the urea was applied when the okra plants were three weeks old, while the remaining dosage was applied when the okra [plats attained six-week growth stage.

Herbicide application

The herbicides were applied using A CP knapsack sprayer, fitted with polijet nozzle and delivering 265 l/ha.

Experiment duration

In the year 2013, the study was started on the 10^{th} of May while in 2014 the experiment was started on the 6th of May, when the pre- emergence application of diuron and butachlor were carried out after the planting of okra. Observation of the effects of pre-emergence applications on the grown and development of okra was taken for eight weeks.

Data gathered

Phytotoxicity rating

Phytotoxicity score at three weeks growth stage on okra seedlings was recorded on 0-10 the scale, where zero denotes no damage and ten depicts total kill.

Okra establishment

At eight weeks growth stage, okra establishment was taken by counting the established stands in each plot.

Okra growth parameters

The growth parameters taken when okra plants were eight weeks old were, number of leaves and number of branches/plant, diameter of stems at 10 cm height, height of stems and shoot biomass. Four stands of okra plants located in the central rows in each plot were tagged; data indicating okra tolerance and growth were taken from the tagged stands. Response from the plot is the resultant average from the four measurements.

Weed control efficacy

Treatment effects on weed control efficacy for butachlor and diuron were evaluated by taking weed biomass data four, six and eight weeks after sowing using a quadrat of 50 cm x 50 cm dimension. Two places were randomly located per plot where quadrats were placed; collection of all weeds inside the quadrats was made. The weeds were dried to a constant weight in the oven at 70 ^{0}C. Citizen Electronic Balance was used to weigh the dry weeds, the electronic balance has 2 000 g as its maximum capacity.

Each of the treatment's weed control efficacy was computed based on Prachand et al. (2015) [7] as shown below:

$$\text{WCE \%} = \frac{\text{WDc - WDt}}{\text{WDc 1}} \text{x } 100$$

Where,

Weed Control Efficacy (%) = WCE

The weedy control plot weed biomass (g/m^2) = WDc

The treated plot weed biomass (g/m^2) = WDt

Statistical analysis

Least Significant Difference tests were used at 5 % level of probability to separate treatment means after the data were subjected to analysis of variance.

Results

Shoot biomass

Average of okra shoot biomass was significantly affected by pre-emergence application of butaclhor and diuron. The highest average okra shoot biomass produced in this experiment was 7.9 g/plant in plots hoe-weeded at three and six weeks after sowing. Diuron plots produced okra shoot biomass of 1.4 g/plant which was the least. Treatments outcome in terms of average okra shoot biomass followed the order of Hoe-weeded (7.9 g/plant) = Butachlor (7.4 g/plant) > Weedy (3.5 g/plant) > Diuron (1.4 g/plant).

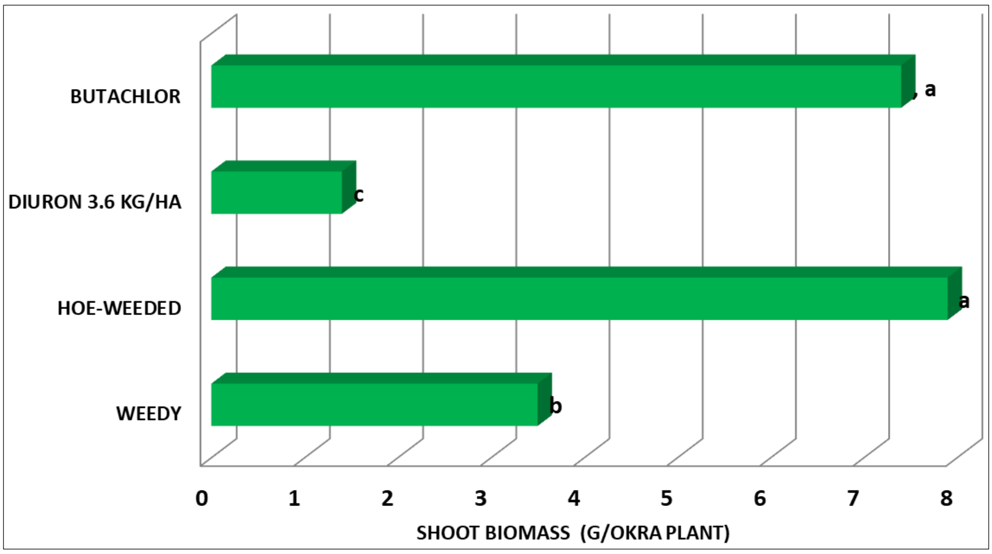

Fig 1: Influence of pre-emergence herbicide applications on okra shoot biomass at eight weeks after sowing

Stem height

Pre-emergence applications of butachlor and diuron resulted in significant difference in okra stem height at eight weeks after sowing (Table 1). Okra grown in butachlor treated plots had longer stems in 2013 and 2014 as well as in the computed average than the ones established in diuron treated plots. The stems in the control plots (hoe-weeded and un-weeded control plots) were even superior to the ones grown in diuron sprayed plots. Hoe-weeded control plots consistently produced plants which were taller than the ones established in un-weeded control plots in the two cropping seasons; however, in the computed average for the two seasons, the stem height was similar for the controls.

Stem diameter

There was significant effect on stem diameter of the pre-emergence spray of butachlor and butachlor in okra plots (Table 1). Okra stem diameter ranged from 0.7 cm in diuron treated plots in 2013 to 3.1 cm in plots subjected to hoe-weeding at three and six weeks growth stage. Plants grown in butachlor sprayed plots had similar average stem diameter of okra stems with the ones grown in hoe-weeded plots. In the same way, diuron and weedy control plots had okra stems with similar stem diameter at eight weeks growth stage.

Number of leaves per plant

Number of leaves per plant ranged from 4.0 diuron treated plots in 2013 to 11.0 in plots hoe-weeded in 2013 (Table 1). The number of leaves in okra per plants in 2014 ranged from 7.3 to 9.7 and they were similar. Okra in hoe-weeded plots had the highest number of leaves per plant, while the ones grown in diuron treated plots were the least.

Okra establishment

The treatments had significant effect on okra establishment at eight weeks after sowing (Table 2). Butachlor treated plots consistently had similar percentage okra establishment with the untreated plots. Okra establishment ranged from 45.7 to 96.5% in 2013 and 53.5 to 86.2% in 2014. Diuron treated plots consistently had the least percentage okra establishment at eight weeks after sowing; these were 45.7 and 53.5%, in 2013 and 2014, respectively, and they were significantly less than what was obtained in the other treatments in their respective years. Okra establishment was significantly affected by weed control method used (Table 2). Okra establishment average ranged from 49.4 percent in plots treated with diuron to 90.4 percent in un-weeded plots. The highest average okra establishment of 90.4 percent was observed in plots hoe-weeded at three and six weeks after sowing, it was similar to 89.5 percent observed in un-weeded plots and also similar to what was observed in butachlor treated plots with 89.4 percent okra establishment. A percentage of 49.4 was the least in average okra establishment at eight weeks after sowing in this study and it was observed in okra plants grown in diuron treated plots. Between butachlor and diuron, average okra establishment of 89.4 percent in butachlor sprayed plots used at 2.0 kg a.i./ha was significantly higher than 49.4 percent establishment observed in plots where diuron was applied at 3.6 kg a.i./ha.

Table 1: Effects of pre-emergence applications of butachlor and diuron on stem height, stem diameter and number of leaves per okra plant at eight weeks after sowing

Weed control method	Stem height (cm)	Stem diameter (cm)	Number of leaves/plant
2013			
Butachlor 2.0 kg	78.1 a	2.4 a	7.3 b
Diuron 3.6 kg	20.0 d	0.7 c	4.0 c
Hoe-weeded	52.1 b	3.1 a	11.0 a
Weedy	36.9 c	0.8 c	7.0 b
SE ±	3.48	0.4 1	1.21
2014			
Butachlor 2.0 kg	67.8 a	2.3 a	9.7 a
Diuron 3.6 kg	28.2 c	1.0 b	7.3 a
Hoe-weeded	57.0 a	2.9 a	9.3 a
Weedy	41.7 b	0.9 b	9.3 a
SE ±	5.25	0.44	1.48
Average			
Butachlor 2.0 kg	73.0 a	2.4 a	8.5 b
Diuron 3.6 kg	24.1 d	0.9 c	5.7 c
Hoe-weeded	54.6 b	3.0 a	10.2 a
Weedy	39.3 a	0.9 c	8.2 b
SE ±	2.21	0.21	0.75

Means in a column with the same letter(s) in the same year do not differ significantly at 5% level of probability using DMRT.

Phytotoxicity rating

The treatments had significant effect on phytotoxicity rating on okra at eight weeks after sowing (Table 2). It was easy to identify the plots which received pre-emergence spray of diuron in the field because only okra plants grown in them showed phytotoxicity, all the other weed control treatments and the control hah no phytotoxic effect on the okra plants. An average phytotoxicity rate of 7.8 and 7.7 were displayed by the plants in 2013 and 2014, respectively; on a 0 to 10 scale.

Number of branches

The treatments had significant effect on nimbler of branches per okra plant at eight weeks after sowing (Table 2). Plants which were grown in plots hoe-weeded at 3 and 6 weeks after sowing consistently had an average two stems per plant in the first and second cropping, these were not greater than the 1.3 and 1.7 stems per plant in okra plants grown in plots sprayed butachlor in the first and second cropping seasons, respectively. Plots treated to diuron and the weedy control plots had okra plants with no branches.

Weed control efficacy

There was a high level of consistency of weed control efficacy in the hoe-weeded plots right from four weeks up to eight weeks after sowing (Table 3); this was not the case in the herbicide treated plots where there was gradual decline in weed control efficacy from week four to week eight. At four weeks after sowing, the hoe-weeded control plots and the two herbicides had similar weed control efficacy which were significantly greater than what was observed in weedy check. At six weeks, the weed control efficacy was similar in butachlor, diuron treated plots as well as in the hoe weeded control plots, and they ranged from 70.9 to 84.2 %.

Weed biomass

All the weed control treatments and the un-weeded control had greater weed biomass in their plots than the butachlor or diuron treated plots at 4, 6 and 8 weeks after sowing in the two cropping seasons (Table 3). Hoe-weeded plots and the plots treated with butachlor and diuron had similar weed biomass in 2013 and 2014 at four and six weeks growth stage and these were significantly less than what was observed in the weedy control plots; their weed biomass ranged from 1.2 to 2.4 g/m^2 at week four and 11.0 to 21.4 g/m^2 at six weeks after sowing. It was observed that there was tremendous increase in weed biomass between four weeks and six weeks growth stages. At eight weeks after sowing, the weed biomass in the herbicide treated plots had increased to a level where they were now significantly greater than what was obtained in the hoe-weeded control plots; the herbicide treated plots had 54.3 to 61.6 g/m^2 compared to 12.2 g/m^2 in hoe-weeded plots in 2013, while in 2014 the herbicides had 63.9 and 65.4 g/m^2 which were significantly greater than 14.4 g/m^2 obtained in hoe-weeded plots. Both in 2013 and 2014 growing seasons, the weedy control plots had greater weed biomass than all the herbicide treatments. Similarly, Obiazi (2022) [5] reported that on the average, weedy check had the highest weed biomass among the treatments evaluated.

Table 2: Effects of pre-emergence applications of butachlor and diuron on okra establishment, phytotoxicity rate and number of branches per okra plant at eight weeks after sowing

Weed control method	Okra establishment (%)	Phytotoxicity rate	Number of branches/plant
2013			
Butachlor 2.0 kg	95.5 a	0.0 b	1.3 a
Diuron 3.6 kg	45.7 b	7.8 a	0.0 b
Hoe-weeded	94.6 a	0.0 b	2.0 a
Weedy	96.5 a	0.0 b	0.0 b
SE ±	5.83	0.12	0.31
2014			
Butachlor 2.0 kg	84.7 a	0.0 b	1.7 a
Diuron 3.6 kg	53.5 b	7.7 a	0.0 b
Hoe-weeded	86.2 a	0.0 b	2.0 a
Weedy	82.5 a	0.0 b	0.0 b
SE ±	5.42	0.14	0.29
Average			
Butachlor 2.0 kg	89.4 a	0.0 b	1.5 a
Diuron 3.6 kg	49.4 b	7.8 a	0.0 b
Hoe-weeded	90.4 a	0.0 b	2.0 a
Weedy	89.5 a	0.0 b	0.0 b
SE ±	5.41	0.15	0.34

Means within a column followed by the same letter(s) in the same year do not differ significantly at 5% level of probability using LSD.
Kg = kg active ingredient (a.i.) / ha

Table 3: Effects of pre-emergence applications of butachlor and diuron on weed control efficacy and weed biomass in okra plot

	Weed control efficacy (%)			Weed biomass (g/m^2)		
Weed control method	Weeks After Sowing			Weeks After Sowing		
	4	6	8	4	6	8
2013						
Butachlor 2.0 kg	91.5 a	75.1 bc	40.1 b	1.8 b	17.5 b	61.6 b
Diuron 3.6 kg	92.5 a	84.2 a	48.6 b	1.6 b	11.2 b	54.3 b
Hoe-weeded	94.3 a	71.0 c	90.3 a	1.2 b	18.3 b	12.2 c
Weedy	0.0 b	0.0 d	0.0 c	21.2 a	70.3 a	102.3 a
SE ±	4.43	2.91	5.36	1.63	4.02	4.79
2014						
Butachlor 2.0 kg	88.8 a	76.0 a	41.0 b	2.4 b	17.8 b	65.4 b
Diuron 3.6 kg	91.6 a	78.9 a	42.4 b	1.8 b	15.5 b	63.9 b
Hoe-weeded	89.3 a	70.8 a	87.0 a	2.3 b	21.4 b	14.4 c
Weedy	0.0 b	0.0 b	0.0 c	21.4 a	73.5 a	110.8 a
SE ±	5.91	5.38	2.29	1.27	4.25	5.53
Average						
Butachlor 2.0 kg	90.2 a	75.6 ab	40.6 b	2.1 b	17.7 b	63.5 b
Diuron 3.6 kg	92.1 a	81.6 a	45.5 b	1.7 b	13.4 b	59.1 b
Hoe-weeded	91.8 a	70.9 b	88.7 a	1.8 b	19.9 b	13.3 c
Weedy	0.0 b	0.0 c	0.0 c	21.3 a	71.9 a	106.6 a
SE ±	5.17	4.15	3.83	1.45	4.14	5.16

Means in a column with the same letter(s) in the same year do not differ significantly at 5% level of probability using DMRT.
Butachlor 2.0 kg = Butachlor at 2.0 kg active ingredient/ha
Diuron 3.6 kg = Diuron 3.6 at kg active ingredient/ha

Discussion

The shoot biomass, phytotoxic effects of herbicides on okra, number of leaves/plant, okra stands survival and stem diameter in plots treated with butachlor were similar with the ones grown in hoe-weeded plots. In evaluating the growth and development of okra in butachlor at 2.0 kg a.i./ha and diuron used at 2.0 and 3.6 kg a.i. /ha, diuron significantly ($p < 0.05$) diminished shoot biomass and stem diameter, number of the crop seedlings per plot and number of leaves/plant.

Diuron was phytotoxic to the crop; okra displayed sensitivity to diuron sprayed pre-emergence at 3.6 kg a.i./ha. Butachlor did not have any phytotoxic effect on okra plant when it was used at 2.0 kg a.i./ ha. Butachlor suppressed weed and caused no detrimental effect on the okra plant hence it had shoot biomass which was similar to the ones grown in hoe- weeded plots. Okra had significantly a greater number of leaves per plant, stem diameter and stem height at eight weeks growth stage in butachlor treated plots than in plots treated with diuron, this beyond the issue of weeds competing with okra for plant growth resources in the environment. When the experiment was terminated at eight weeks growth stage the butachlor and diuron applied pre-emergence were similar average weed control efficacy of 40.1 – 48.6 % and 39.5 – 42.7 % in 2013 and 2014, respectively. Similarly, average weed biomass of 54.3 – 61.6 in 2013 and 63.9 – 67.0 g/m^2 in 2014, yet diameter and stem height of okra plants in butachlor were significantly greater than what was obtained in okra plants grown in diuron treated plots. This outcome of the study indicates an instance of diuron displaying more phytotoxic effect on okra than butachlor. This is not a situation where weed competition with okra plant is causing reduction in the growth and development of okra. A plant that is injured does not grow vigorously. Okra plants in butachlor treated plots were not injured hence they grew vigorously, it was not the same case with the crops grown in diuron treated plots, they developed and grew less vigorously hence had less okra biomass.

Conclusion

Being that phytotoxicity was displayed by okra plants grown in diuron treated plots at 3.6 kg a.i./ha, does not eliminate the possibility of the using diuron in okra production. Diuron at certain lower rates may have non-phytotoxic effect on okra plants and still significantly control weed for a profitable yield of okra; suggestion is therefore made of such trials. No phytotoxic effect of butachlor was seen on okra plants, they grew well in the plots sprayed with butachlor at 2.0kg a.i./ha and had okra shoot biomass, okra establishment and stem diameter similar to what was obtained in plots hoe-weeded at 3 and 6 weeks after sowing, A significantly better weed management by butachlor than weedy check was provided. Recommendation is therefore made that butachlor should be considered as an herbicide for pre-emergence weed management in okra production in Asaba in the rain forest ecology of Nigeria.

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