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Screening of herbicides for weed control, growth and yield of irrigated onion (*Allium cepa* L.) in tropical Savanna climate

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Key words: herbicides, hoe weeding, onion, weed control.

Abstract: Field experiments were conducted during the 2006/2007 and 2007/2008 dry seasons at Sudan Savanna Nigeria to study the effects of herbicides on weeds and growth of irrigated onion (*Allium cepa* L.). The field was laid out in a randomized complete block design (RCBD) and the treatments included four rates (with and without supplementary hoe weeding - SHW) of oxadiazon 25 EC, butachlor 50 EC, pendimenthalin 50 EC, bullet 700 SC (atrazine + acetochlor + terbuthylazine), eight rates (with or without SHW) of oxyfluorfen 41 FW, hoe weeded at 3 and 6 weeks after transplanting (WAT) and untreated control. The treatments were replicated three times. The results indicated that application of oxadiazon 25 EC at 4 l/ha and oxyfluorfen 41FW at 6 l/ha both followed by SHW gave low weed dry weight, larger bulb diameter, higher mean bulb weight and bulb yield per hectare compared to the hoe-weeded control.

1. Introduction

Onion (*Allium Cepa* L.) belongs to the family Alliaceae in the genus *Allium* (Friensen, *et al*., 2006; Brewster, 2008). In Nigeria, onion is grown mainly for its bulb which is used in virtually every home on a daily basis to flavour and season a wide variety of dishes. As a constituent of a meal, both the green leaves and bulbs can be eaten raw or cooked in soups and salads. It is claimed to minimize high blood pressure and other heart diseases due to its favourable action on the elasticity of blood vessels. As an item of world trade, onion ranks second in importance after tomatoes among vegetables in Nigeria, where annual production stands at 621 000 t, making it the 36th highest producing country in the world. The genus *Allium* constitutes "bulb crops" and these are weak competitors with weeds which emerge among the crops (Boydston and Seymour, 2002). Weeds are known to reduce available moisture, nutrients, sunlight and growing space needed by crop plants. Subsequently, weeds can reduce growth, quality and yield of crops and make harvesting difficult. Onion seedlings are weak competitors with weeds because of their slow growth, small stature, shallow roots and thin canopy. In addition, their cylindrical upright leaves do not shade the soil enough to suppress weed growth. Weed interference was observed to be more devastating than insect (*Thrips tabaci*) infestations on onion dry bulb yield (Ghosheh and Al-Shannag, 2000). Herbicides may be applied before planting or after planting. Pre-plant application of a soil residual herbicide such as oxadiazon has proved effective for weed control in onion (Amrutkar *et al*., 2002). Oxyfluorfen and pendimenthalin were reported to have significantly reduced the weed population and increased onion yield to levels comparable to yields of weed control in a relay cabbage-onion cropping system (Sanjeev *et al.,* 2003). Onions are sown at densities that exceed 20 plants/m^2, and hand weeding operations are practiced with great care. On the other hand, high costs, lack of manpower and low economic returns are currently pushing onion farmers to consider herbicides as an alternative weed management option in onion production. The reliance on unstructured or non-sequenced weed management programs by farmers, especially in a country like Nigeria where agricultural commodities are still inexpensive, is also very common. Therefore, the objective of this study was to evaluate the efficacy of weed control using single herbicide applications. Although not all the herbicides used in this experiment were registered for onion production, producers might be tempted to use those available and at the lowest cost.

2. Materials and Methods

Field experiments were conducted during the 2006/2007 and 2007/2008 dry seasons at the Irrigation Research Station, Kadawa, of the Institute for Agricultural Research,

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Ahmadu Bello University, Zaria, Nigeria (11° 39’N, 08° 02’E and 500 m above sea level). Meteorological data on temperature, relative humidity and sunshine hours, as well as physical and chemical characteristics of the soil of the experimental site were collected December 2006-April 2007 and December 2007-April 2008 (Tables 1, 2 and 3).

Table 1 - Meteorological data showing mean minimum and maximum temperatures, relative humidity and sunshine hours during 2006/2007 dry season at Kadawa

Month	Days	Air temperature (°C)		Relative humidity (%)	Sunshine hours
		Min.	Max.		
December 2006	1-10	14.0	33.5	25.1	7.2
	11-20	13.2	32.6	27.2	7.4
	21-31	13.5	33.0	27.4	7.0
January 2007	1-10	11.7	31.6	28.3	6.8
	11-20	14.9	35.7	29.5	7.0
	21-31	13.4	34.3	29.8	6.1
February 2007	1-10	16.2	36.3	32.0	6.1
	11-20	19.7	35.9	34.1	5.8
	21-29	19.5	37.1	35.8	5.0
March 2007	1-10	19.2	35.8	37.1	6.2
	11-20	19.4	38.3	36.1	6.8
	21-3	20.4	41.4	36.7	5.7
April 2007	1-10	19.6	40.7	36.9	5.4
	11-20	18.6	39.1	37.5	5.6
	21-30	22.3	40.9	37.6	6.0
Total		255.6	546.2	491.1	95.1
Average		17.04	36.42	32.74	6.34

Source: Meteorological Unit of the Institute for Agricultural Research, Samaru, Zaria.

Land preparation involved ploughing, harrowing and ridging (75 cm apart). The plot size was 12 m^2 (4 x 3 m) representing the planting basin. Planting was done in rows at spacing of 15 x 30 cm within and between rows. The onion variety used, D77, has a maturity period of 120 to 130 days and potential yield of 5-15 t/ha. Plots were irrigated by surface flooding before transplanting a day after herbicide application. Subsequent irrigation was applied once a week by surface irrigation of the basin to field capacity, resulting in approximately 15-20 applications to supply about 350-550 mm of moisture as needed by the plant per growing season. In the two seasons, Single Super Phosphate (SSP) fertilizer at a rate of 19.8kg P/ha and Muriate of Potash (Potassium) at 10.4 kg K/ha were incorporated into the basin as basal fertilizer before transplanting. Nitrogen (45 kg N/ha) was applied by broadcasting

Table 2 - Meteorological data showing mean minimum and maximum temperatures, relative humidity and sunshine hours during 2007/2008 dry season at Kadawa

Month	Days	Air temperature (°C)		Relative humidity (%)	Sunshine hours
		Min	Max		
Dececember 2007	1-10	13.6	35.0	26.9	6.0
	11-20	14.0	33.3	23.4	6.4
	21-31	14.5	32.0	27.2	5.4
January 2008	1-10	15.1	34.3	27.9	5.0
	11-20	13.6	32.7	28.0	5.7
	21-31	NA	NA	30.1	6.0
February 2008	1-10	17.3	38.3	34.3	5.0
	11-20	15.6	34.7	30.8	4.5
	21-29	14.8	35.9	32.0	4.5
March 2008	1-10	15.7	34.5	29.9	5.0
	11-20	18.9	32.3	32.3	6.1
	21-31	23.3	39.4	36.3	6.8
April 2008	1-10	25.7	42.8	38.3	5.4
	11-20	23.9	41.1	36.9	6.0
	21-30	25.7	41.2	37.6	6.0
Total		251.7	507.4	471.9	83.8
Average		18.00	36.24	31.46	5.59

Source: Meteorological Unit of the Institute for Agricultural Research, Samaru, Zaria.
NA= not available.

Table 3 - Physico-chemical properties of the 0-20 cm depth of soil at the experimental site during the 2006/2007 and 2007/2008 dry seasons at Kadawa

Composition	Dry season 2006/2007	Dry season 2007/2008
Physical properties		
Sand (%)	56.0	58.0
Silt (%)	30.0	30.0
Day (%)	14.0	12.0
Textural class	Sandy-loam	Sandy-loam
Chemical properties		
pH in H_2O	5.70	5.80
pH in 0.01 m $cacl_2$(1:2.5)	5.10	5.32
Organic carbon (g/kg)	0.58	0.56
Total nitrogen (g/kg)	1.20	1.30
Available phosphorus	0.90	1.20
Exchangeable cations (cmd/kg soil)		
Calcium	1.88	0.60
Sodium	0.81	0.73
Potassium	0.21	0.37
Magnesium	3.13	2.97
C.E.C.	6.70	6.90

using urea (46%W) as split doses at two and six weeks after transplanting (WAT).

Treatments consisted of the following rates, each applied with and without supplementary hoe weeding (SHW) for a total of four treatments per herbicide: oxadiazon 25 EC (4 and 6 l/ha), butachlor 50 EC (5 and 6 l/ha), pendimenthalin 50 EC (5 and 6 l/ha) and bullet 700 SC 9 (1.04 and 1.4 l/ha) (atrazine + acetochlor + terbuthylazine), eight treatments (4, 6, 8 and10 l/ha with and without SHW) of oxyfluorfen 41 flowable (FW), and an untreated control; hoe weeding was carried out at 3 and 6 weeks after transplanting (WAT). These treatments were laid out in a randomized complete block design (RCBD) with three replications. All herbicides were applied a day before transplanting using a conventional CP3 knapsack sprayer with a green deflector nozzle at a pressure of 2.1 kg/m^2 to deliver a spray volume of 200 l/ha. Supplementary hoe weeding was imposed at 6 WAT on some plots as indicated in the treatment because some herbicides have short persistence in the soil and therefore cannot exhibit long season weed control. In the Nigerian savanna, despite high labour requirements and cost of inputs, some workers have emphasized the need to supplement pre-emergence herbicide treatments with hoe weeding for long season weed control for increased yields in various crops (Adigun *et al.*, 1987; Magani, 2008; Oluwafemi, 2013). Onion bulbs were harvested manually at 16 WAT.

Data on weed dry weight, mean bulb diameter, bulb weight and bulb yield per hectare were assessed and subjected to statistical analysis of variance (ANOVA) as described by Snedecor and Cochran (1967). Differences between treatment means were compared using Duncan Multiple Range Test (DMRT) (Duncan, 1955) at 5% level of probability.

3. Results

Weather and soil conditions

Meteorological data on temperature, relative humidity and sunshine hours during the study periods (2006/2007 and 2007/2008) are shown in Tables 1 and 2 respectively, while physical and chemical characteristics of the soil of the experimental sites for the same period are presented in Table 3. The average maximum temperature was 36.42 and 36.24°C in 2006/2007 and 2007/2008 respectively, while for the same periods the relative humidity was 32.74 and 31.46% and sunshine hours were 6.34 and 5.59. With regard to the soil of the experimental sites, it was classified as sandy loam in both study periods, and the organic carbon, total nitrogen and available phosphorus were, respectively, 0.58, 1.20 g/kg^{-1} and 0.90 mg/kg^{-1} in 2006/2007 and 0.56, 1.30 g/kg^{-1} and 1.20 mg/kg^{-1} in 2007/2008.

Weed dry weight

The untreated control had significantly (P≤M0.05) higher weed dry weight than all the other treatments except for oxadiazon at 4 and 6 l/ha in 2006/2007 and for the combined mean (Table 4). The hoe-weeded control in the 2006/2007 study period resulted in significantly lower weed dry weight, comparable to the application of oxadiazon at 4 l/ha followed by supplementary hoe weeding (fbSHW), oxyfluarfen at 10 l/ha fbSHW, butachlor at 6 l/ha fbSHW and pendimenthalin at 5 l/ha fbSHW (Table 4). In 2007/2008, all the herbicides and their rates, including the untreated control, gave statistically comparable weed dry weight. The application of oxadiazon at 6 l fbSHW had significantly ($P \leq 0.05$) higher weed dry weight than butachlor at 6 l/ha and the hoe-weeded control which gave statistically similar weed dry weights (Table 4).

Table 4 - Effects of rates of herbicides on weed dry weight in onion during dry seasons of 2006/2007, 2007/2008 and combine at Kadawa

Herbicides	Rates (l/ha)	Weed dry weight (kg/ha) 2006/2007	Weed dry weight (kg/ha) 2007/2008	Combined mean
Oxadiazon	4	101.70 a	17.47 a-c	59.58 ab
	4 fbSHW	34.60 l-g	11.23 a-c	22.93 ef
	6	82.07 a	15.90 a-c	49.00 a-c
	6 fbSHW	38.60 c-f	21.00 a	29.85 d-f
Oxyfluorfen	4	56.37 b-e	8.57 a-c	30.08 c-f
	4 fbSHW	41.8 c-f	13.96 a-c	27.85 d-f
	6	57.70 b-e	14.90 a-c	36.32 c-f
	6 fbSHW	38.10 c-f	15.10 a-c	28.60 d-f
	8	45.97 l-f	13.96 a-c	29.97 d-f
	8 fbSHW	49.59 b-c	9.60 a-c	29.55 d-f
	10	62.33 b-e	16.37 a-c	39.35 c-e
	10 fbSHW	33.90 d-g	17.7 a-c	25.80 d-f
Butachlor	5	45.57 c-f	14.30 a-c	29.93 d-f
	5 fbSHW	38.40 c-f	14.46 a-c	26.43 d-f
	6	48.37 b-f	6.13 bc	27.25 d-f
	6 fbSHW	21.27 fg	14.97 a-c	18.12 fg
Bullet	1.04	57.20 b-e	13.03 a-c	35.12 c-f
	1.04 fbSHW	42.60 c-f	10.53 a-c	26.57 d-f
	1.4	46.80 c-f	14.20 a-c	30.50 d-f
	1.4 fbSHW	29.17 e-g	17.70 a-c	23.43 e-f
Pendimenthalin	5	67.70 b-d	19.43 a-c	43.57 b-d
	5 fbSHW	33.47 d-g	21.30 a-c	27.40 d-f
	6	69.27 bc	20.20 a-c	44.73 a-d
	6 fbSHW	62.33 b-e	14.46 a-c	38.55 c-e
Hoe weeded	3 + 6WAT	3.70 g	5.00 c	6.13 g
Untreated check		109.03 a	12.66 a-c	60.85 a
SE(±)		10.203	3.847	5.533

Means followed by same letter(s) within a column are not significantly different at 5% (P=0.05) using DMRT.
fbSHW= Followed by supplementary hoe weeding.
WAT= Weeks after transplanting.

Mean bulb diameter

Table 5 shows mean bulb diameter for the herbicide treatments. The results reveal a larger bulb size in the first study season compared to the second season. The application of oxyfluorfen at 4 l/ha produced larger bulbs for all treatments in 2006/2007 and for the combined mean (2006/2007-2007/2008); the values were comparable with the hoe-weeded control in both cases. In 2007/2008, the use of oxadiazon at 6 l/ha fbSHW resulted in bigger bulbs compared with those produced by oxadiazon at 4 l/ha (with or without SHW), pendimethalin at 6 l/ha without SHW and the hoe-weeded control. Oxadiazon at 6 l/ha and the untreated control gave comparable but smaller onion bulbs for the combined mean (Table 5).

Table 5 - Effects of rates of herbicides on mean bulb diameters in onion during dry seasons of 2006/2007, 2007/2008 and combine at Kadawa

Herbicides	Rates (l/ha)	Mean bulb diameter (cm)		Combined mean
		Dry season 2006/2007	Dry season 2007/2008	
Oxadiazon	4	19.52 ab	9.49 b-d	14.51 a-d
	4 fbSHW	19.13 ab	9.36 b-d	14.64 a-d
	6	14.85 b-f	7.99 d	11.42 d
	6fbSHW	17.68 a-e	16.40 a	17.04 ab
Oxyfluorfen	4	21.60 a	12.88 a-d	17.24 a
	4 fbSHW	16.93 a-f	15.75 ab	16.17 a-c
	6	14.43 b-f	11.87 a-d	13.15 a-d
	6fbSHW	15.75 b-f	10.65 a-d	13.20 a-d
	8	13.37 ef	13.12 a-d	12.75 b-d
	8fbSHW	13.53 l-f	10.77 a-d	12.15 cd
	10	15.79 b-f	10.95 a-d	13.37 a-d
	10fbSHW	17.99 a-c	14.13 a -d	16.06 a-c
Butachlor	5	13.19 d-f	13.22 a-d	13.23 a-d
	5 fbSHW	17.37 a-f	12.25 a-d	14.81 a-d
	6	14.76 b-f	9.97 a-d	12.36cd
	6 fbSHW	17.55 a-f	14.18 a-d	15.87 a-c
Bullet	1.04	15.67 b-f	8.49 cd	12.06 cd
	1.04 fbSHW	19.54 ab	13.23 a-d	16.38 a-c
	1.4	16.92 a-f	12.43 a-d	14.67 a-d
	1.4 fbSHW	16.60 a-f	13.00 a-d	14.80 a-d
Pendimenthalin	5	16.52 a-f	11.15 a-d	13.84 a-d
	5 fbSHW	19.15 a-c	14.64 a-c	16.90 ab
	6	17.02 a-f	9.76 b-d	13.34 a-d
	6 fbSHW	18.08 a-c	12.19 a-d	15.14 a-d
Hoe weeded	3 + 6WAT	18.96 a-d	9.78 b-d	14.37 a-d
Untreated check		11.87 f	10.05 a-d	10.90 d
SE (±)		1.673	1.903	1.269

Means followed by same letter(s) within a column are not significantly different at 5% (P=0.05) using DMRT.
fbSHW= Followed by supplementary hoe weeding.
WAT= Weeks after transplanting.

Mean bulb weight

Mean bulb weight appeared higher in the 2006/2007 dry season compared with the following year (Table 6). In the former, hoe weeded control yielded a significantly ($P \leq 0.05$) higher mean bulb weight, compared with oxadiazon at 4 l/ha (with or without SHW) and bullet (atrazine + acetochlor + terbuthylazine) at 1.04 l/ha fbSHW. The untreated control gave the lowest mean bulb weight, although it was comparable to some herbicide treatments.

Table 6 - Effects of rates of herbicides on mean bulb weight of onion during dry seasons of 2006/2007, 2007/2008 and combine at Kadawa

Herbicides	Rates (l/ha)	Mean bulb weight (g)		Combined mean
		Dry season 2006/2007	Dry season 2007/2008	
Oxadiazon	4	77.48 a-c	20.72 c	49.10 a-f
	4 fbSHW	86.03 ab	35.63 a-c	60.83 a-d
	6	48.34 c-h	19.38 c	33.89 fg
	6fbSHW	68.26 b-e	71.03 a	69.65 a
Oxyfluorfen	4	33.51 f-h	43.41 a-c	38.46 c-g
	4 fbSHW	58.97 b-g	64.45 ab	61.71 a-c
	6	37.38 e-h	33.08 a-c	35.23 fg
	6fbSHW	50.88 c-h	31.59 bc	41.23 c-g
	8	27.65 gh	43.70 a-c	35.68 e-g
	8fbSHW	35.77 f-h	27.61 bc	31.69 fg
	10	52.89 c-h	25.65 c	39.27 c-g
	10fbSHW	62.05 b-f	50.05 a-c	56.05 a-f
Butachlor	5	41.59 d-h	45.48 a-c	43.53 b-g
	5 fbSHW	48.60 c-h	48.27 a-c	48.44 a-f
	6	43.57 d-h	36.86 a-c	40.21 c-g
	6 fbSHW	47.36 c-h	45.87 a-c	46.62 a-f
Bullet	1.04	50.18 c-h	21.95 c	36.06 d-g
	1.04 fbSHW	77.25 a-c	43.19 a-c	60.22 a-e
	1.4	44.89 d-h	37.96 a-c	41.43 b-g
	1.4 fbSHW	68.58 b-e	38.24 a-c	53.41 a-f
Pendimenthalin	5	55.15 c-g	24.67 c	39.91 c-g
	5 fbSHW	52.96 c-h	55.03 a-c	53.00 a-f
	6	60.68 b-f	22.81 c	43.75 b-g
	6 fbSHW	69.19 b-d	33.68 a-c	51.44 a-f
Hoe weeded	3 + 6WAT	103.06 a	28.46 bc	65.77 ab
Untreated check		22.87 h	20.03 c	21.45 g
SE (±)		9.126	11.171	7.189

Means followed by same letter(s) within a column are not significantly different at 5% (P=0.05) using DMRT.
fbSHW= Followed by supplementary hoe weeding.
WAT= Weeks after transplanting.

The application of oxadiazon at 6 l/ha followed by supplementary hoe weeding (fbSHW) in 2007/2008 and combined mean resulted in the highest mean bulb weight, but it was comparable to oxadiazon at 4 l/ha (with and without supplementary hoe weeding), oxyfluorfen at 4 and 10 l/ha fbSHW, pendimenthalin at 5 and 6 l/ha fbSHW and the hoe-weeded control (Table 6). The untreated control consistently maintained the lowest mean bulb weight in both years of study and in the combine mean.

Onion bulb yield

In 2006/2007, the use of oxadiazon at 4 l/ha fbSHW, oxyfluorfen at 6 l/ha and pendimentalin at 5 and 6 l/ha fbSHW resulted in statistically similar but significantly (P≤0.05) higher bulb yield compared with oxyfluorfen at 4, 8 and 10 l/ha and the untreated control. The differences in bulb yield between all other herbicides and their rates including the untreated control were not significant (P≤0.05) statistically (Table 7). The effect of the herbicides and their rates on onion bulb yield was not significant in 2007/2008. The application of pendimenthalin at 5 l/ha fbSHW resulted in significantly (P≤0.05) higher bulb yield compared with oxyfluorfen at 8 and 10 l/ha and the untreated control for the combined mean. All the other herbicides and their rates gave statistically similar bulb yields (Table 7).

Table 7 - Effects of rates of herbicides on onion bulb yield during dry seasons of 2006/2007, 2007/2008 and combine at Kadawa

Herbicides	Rates (l/ha)	Onion bulb yield (t/ha)		Combined mean
		Dry season 2006/2007	Dry season 2007/2008	
Oxadiazon	4	6.00 a-c	0.73	3.37 a-d
	4 fbSHW	6.93 a	0.83	3.88 a-c
	6	3.78 a-d	0.66	2.22 a-d
	6fbSHW	4.30 a-d	2.66	3.44 a-d
Oxyfluorfen	4	2.17 b-d	2.27	2.22 a-d
	4 fbSHW	3.06 a-d	2.60	2.83 a-d
	6	7.05 a	1.13	4.09 ab
	6fbSHW	3.90 a-d	0.70	2.30 a-d
	8	1.78 cd	2.13	1.96 b-d
	8fbSHW	3.68 a-d	0.93	2.30 a-d
	10	2.05 cd	0.88	1.46 cd
	10fbSHW	5.22 a-d	1.90	3.58 a-c
Butachlor	5	3.22 a-d	2.07	2.65 a-d
	5 fbSHW	5.05 a-d	2.13	3.59 a-c
	6	3.22 a-d	1.90	2.58 a-d
	6 fbSHW	3.58 a-d	1.40	2.48 a-d
Bullet	1.04	3.45 a-d	0.92	2.19 a-d
	1.04 fbSHW	5.39 a-d	1.20	3.30 a-d
	1.4	2.83 a-d	2.13	2.48 a-d
	1.4 fbSHW	4.22 a-d	1.00	2.61 a-d
Pendimenthalin	5	4.61 a-d	0.47	2.54 a-d
	5 fbSHW	6.56 a	2.93	4.75 a
	6	4.00 a-d	0.53	2.27 a-d
	6 fbSHW	6.92 a	1.20	4.06 ab
Hoe weeded	3 + 6WAT	5.78 a-c	0.47	3.12 a-d
Untreated check		1.22 d	0.73	0.98 d
SE (±)		1.279	0.762	0.737

Means followed by same letter(s) within a column are not significantly different at 5% (P=0.05) using DMRT.
fbSHW= Followed by supplementary hoe weeding.
WAT= Weeks after transplanting.

4. Discussion and Conclusions

Weed dry weights were very high in the untreated control compared to the herbicide-treated plots in 2006/2007 and combined means, except for oxadiazon at 4 and 6 l/ha without fbSHW. This could be due to a higher weed intensity resulting from no hoe weeding and herbicide treatment. Lower weed dry weights and herbicide suppression of weeds in crops has been demonstrated in many studies (Ibrahim, 2001; Ishaya, 2004; Adekpe *et al.*, 2007).

The statistically similar weed dry weight found in the present study for hoe weeded control and oxadiazon at 4 l/ha fbSHW, oxyfluorfen at 10 l/ha fbSHW, butachlor at 6 l/ha fbSHW and pendimnthalin (5 l/ha fbSHW) demonstrates herbicide competitiveness with conventional hoe weeding in weed management practices. Similar observations have been made in other related studies (Adekpe *et al.*, 2007; Shinggu *et al*, 2009; Oluwafemi, 2013). Bulb size was higher with the application oxyfluorfen at 4 l/ha compared to to hoe-weeded control in both 2006/2007 and combined data. Numerical differences in bulb size (diameter) were observed and in some cases not statistically significant, reflecting the within treatment variability encountered in the study. The use of oxyfluorfen has been reported to increased onion performance (Ghosheh, 2004)

Onion mean bulb weight and bulb yield (t/ha) were observed to be better with oxyfluorfen (6 l/ha fbSHW) and pendimenthalin at 5 and 6 l/ha fbSHW. This observation may not be unconnected with the observed favourable weed control, higher bulb diameter influenced by these herbicides. The weed control must have helped in the reduction of competition for both the above and underground growth factors by the weeds, thereby providing an adequate environment for the growth and bulb yield of onion. The high total nitrogen and available phosphorus found in the soil of the experimental sites might have contributed to high bulb yield in these low weed-infested plots. The use of oxyfluorfen, oxadiazon and pendimethalim has been reported to improve performance in some bulb and root vegetable crops (Amrutkar *et al.*, 2002; Sanjeev *et al.*, 2003; Adekpe *et al.*, 2007; Adekpe *et al.*, 2012).

It can be concluded from the present study that the use of oxadiazon at 4 and 6 l/ha fbSHW and oxyfluorfen at 6 l/ha fbSHW gives the lowest weed dry weight, higher bulb diameter, higher mean bulb weight and bulb yield per hectare compared to the hoe-weeded control.

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