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Weed Infestation, Growth and Yield of Maize (*Zea mays* L.) as Influenced by Periods of Weed Interference

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Abstract

Field trials were conducted at the Teaching and Research Farm of the Kwara State University, Nigeria, during the 2013 and 2014 cropping seasons. The aim was to determine the effect of periods of weed interference on weed infestation, maize growth and yield. The experiment consisted of 10 treatments, namely, plots initially kept weed-free for 3, 6, 9 and 12 Weeks After Sowing (WAS) and subsequently left weedy until harvest and plots initially left weedy for 3, 6, 9 and 12 Weeks After Sowing (WAS) and subsequently kept weed--free till harvest. There were two control plots, one left weedy and the other kept weed-free till harvest. The treatments were laid out in randomized complete block design (RCBD) and replicated three times. Parameters measured were weed dry weight, maize plant height, leaf area, number of leaves/plant, cob weight, number of kernel rows/cob, 100 seed weight and grain yield. Results show that weed interference in maize for 6 WAS and beyond significantly depressed growth parameters and grain yield. Plots left weedy for only 3 WAS produced significantly higher yield which was comparable to the maximum. Therefore, it is required that maize plot be kept weed-free between 3 and 6 WAS which is the critical period of weed interference, in other to get optimal yield.

Keywords: Maize; Period of weed interference; Weed infestation; Grain yield

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice [1]. It is an important cereal crop in Nigeria with a total production of about 7.3 million tons in 2009 [2]. The savanna zone of West and Central Africa has the greatest potential for its production due to relatively higher incidence of solar radiation and lower incidence of pests and diseases during the cropping season [3]. Currently, more maize is produced annually than any other grain and is the most important cereal crop in sub-Saharan Africa and Latin America [4].

Maize is a leading commercial crop of great value. The crop is also widely considered the greatest potential among food crops for attaining food security in the savanna zone of West and Central Africa [5]. Maize provides staple food to large number of human population in the world. In the developing countries, maize is a major source of income to many farmers [6]. Maize is used in Nigeria for beer brewing for fabric manufacturing, adhesives and in the pharmaceutical industries [7].

Despite its importance, the yield of maize obtained in Nigeria is far below expectation due to numerous factors which include weed infestation, low soil fertility and unavailability of labour. Maize is highly susceptible to weed competition particularly at the early stage of growth. In Nigeria, yield losses as high as 51 to 100% have been sustained in maize due to weed competition [8]. Also, Lagoke et al. [9] reported yield losses of 60-81% in maize due to weed infestation. Evans et al. [10] reported that ear number per plant and 100-seed weight of grains decreased linearly with increasing duration of weed interference. They also found out that seed number per ear was the most sensitive yield component to weed interference and nitrogen rate. Therefore weed control is an important management practices for maize production that should be carried out to ensure optimum grain yield.

The critical period of weed interference is the maximum length of time during which weeds emerging soon after crop planting can co-exist with the crop without causing unacceptable yield loss, and also the weed-free period or the minimum length of time required for the crop to be maintained weed-free before yield loss caused by the late emerging weeds is no longer a concern [10,11]. The knowledge of critical period of weed interference could help reduce yield losses due to weed [12].

Previous studies carried out include the work of Del Pino and Covarelli [13] who reported that a weed-free duration of 2 weeks starting 3 weeks after crop emergence is enough to provide acceptable grain yield. Also, Tunku et al. [14] reported that keeping popcorn weed-free for the initial 6 weeks after planting will be desirable to obtain yield comparable to the maximum in the southern Guinea savanna of Nigeria. There is need to conduct this study in order to provide information to farmers on the precise time they need to carry out weed control in maize. This will not only lead to reduction of weeding frequency and cost of weed control, it will also ensure effective weeding and higher maize yield. Therefore the objectives of this study are:

- To determine the effects of duration of weed interference on maize growth and yield
- To determine the critical period of weed interference in maize under the growing conditions of the southern Guinea savanna of Nigeria.

Materials and Methods

The experiment was conducted during the 2013 and 2014 cropping seasons at Kwara State University Teaching and Research Farm, Malete, (Lat. 08°71'N; Long. 04°44'E) in the southern Guinea savanna

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ecological zone of Nigeria. The experimental site is characterized by a bimodal rainfall pattern that peaks in June and September. The soil of the experimental site is sandy with low water holding capacity. The experiment consisted of ten treatments consisting of two components. The first component consisted of periods of weed interference such that plots were kept weed-free for initial 3,6,9 and 12 weeks after sowing (WAS) and subsequently left weedy until harvest, while the second component comprised of plots left weedy for initial 3, 6, 9 and 12 WAS and subsequently kept weed-free until harvest. There were two control treatments, namely plots left weedy and weed-free until harvest. These treatments were laid out in a randomized complete block design (RCBD) and replicated three times.

After ploughing and harrowing of the experimental field, it was leveled and marked out into plots of 4 m by 4 m each. A space of 0.5 m was left between plots, while a distance of 1 meter was left between replicates. Nutrients at the rate of 120 kg N, 60 kg P_2O_5 and 60 Kg k_2O was applied to each plot in two split doses, using 15:15:15 fertilizer. The first dose of fertilizer was applied before planting consisting of the full doses of phosphorus and potassium and half dose of nitrogen, while the second dose of nitrogen using urea was applied as top dressing at 6 WAS. Sowing was done on the 3rd of July, 2013 and 28th of June, 2014, using treated seeds of maize variety SUWAN-1-SR obtained from Kwara Agricultural Development Programme (ADP) Ministry of Agriculture, Ilorin, Kwara State. Three seeds were planted per hole at a depth of 2 cm and the resultant seedlings were thinned to one plant per stand at a spacing of 75 cm × 25 cm at 3 WAS. The harvesting was done on the 17th of November and 5th of November 2013 and 2014 respectively. Parameters measured included the following.

Plant height (cm)

This was determined by measuring the height of 5 randomly selected plants per plot at 9 WAS and at harvest using graduated tape from the soil level to the tip of the tassel.

Weed dry matter (Kg/ha)

Weed dry matter was determined by using 1 m^2 quadrat, randomly placed in three locations within each plot to harvest weeds. The weeds were put in a well labeled polythene bags and later oven-dried to a constant weight at 80°C for 2 days.

Relative important value (RIV %) and weeding efficiency (%)

The Relative Importance Value (RIV%) was determined after the weeds were collected from the quadrats and before they were oven-dried by using the formula:

$$RIV\% = \frac{RF + RD}{2}$$

Where RF=Relative frequency of each species and RD=relative density of each species.

Weeding efficiency

Weeding efficiency was calculated based on the method suggested by Bhattacharya and Mandal [15] as follows: Dry weed weight of unweeded control (DWWT)-DWWT of treatment/DWWT of unweeded × 100.

Leaf area (Cm^2)

The leaf area was determined at 9 WAS and harvest by measuring the length and breadth of the top, middle and bottom leaves of five randomly selected plants from each plot and the average of these measurements was multiplied by a factor 0.75 to give the leaf area/plant [16].

Cob weight (g)

The weight of five samples of maize cob randomly selected was taken after weighing on a weighing balance. The average of the total cob weights was recorded as the cob weight/plot.

Number of leaves/plant

The number of leaves/Plant was determined at 9 WAS and at harvest. Five randomly selected plants and the number of leaves on them were counted and the average of the total number of leaves was recorded.

100-Seed weight

This was determined by counting 100 seeds from the grains harvested from each net plot, which was weighed on an electronic balance.

Number of kernel rows/ cob

The kernel rows of maize cobs randomly selected per plot was counted and the average of the total number of rows was recorded.

Grain yield

This was determined by weighing the grains harvested from each net plot which was converted to kilograms per hectare using the equation below:

$$\frac{Grain\ yield\ /\ net\ plot\ (g) \times 10{,}000}{net\ plot\ (m^2)}$$

Percentage yield loss

Percentage yield loss was calculated as follows: Combined weed-free grain yield- Combined treatment yield/ Combined Weed- free grain yield × 100

Data analysis

All Data collected excluding relative importance value, weeding efficiency and percentage yield loss were subjected to analysis of variance (ANOVA) and where F was significant, means were separated using Duncan's Multiple Range Test.

Results

Effect of period of weed interference on weed infestation, relative importance value and weeding efficiency

Weed dry matter: The effect of period of weed interference on weed dry matter is presented on Table 1. It shows that in 2013, plots kept weed-free for 3,6,9 and 12 WAS and that left weedy for only 3 WAS reduced weed dry matter significantly, which was comparable to weed-free until harvest. However, plots left weedy for 6,9,12 WAS and until harvest supported significant higher weed dry matter. The same trend was observed in 2014 and the combined except that plots kept weed-free for 3 WAS, produced comparative weed dry matter with those left weedy for 6,9 and 12 WAS. Plots left weedy until harvest produced significant highest weed dry matter values compared with the rest of the treatments.

Relative Importance Value (RIV %): The relative importance value of weed species are presented in Table 2. A total of twenty five weed species were found to interfere with maize on the experimental field. These consisted of 11 broad leaved (BL) weeds, 8 grass weeds and 6 sedges. Paspalum scobuculatum Linn (RIV, 22. 8%) followed by Digitaria horizontalis (RIV,10.6%) had the highest relative importance value. The longer weeds were allowed to interfere with maize the higher is the number of weed species competing with the crop (Table 2).

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Weeding efficiency: Table 3 shows the effect of period of weed interference on weeding efficiency. In 2013, the weeding efficiency of plots kept weed-free for 3,6,9 and 12 WAS and the one left weedy for only 3 WAS had higher weeding efficiency, while plots left weedy for 6,9, 12 WAS and until harvest had lower weeding efficiency. The same trend was observed in 2014 and the combined, except that the weeding efficiency was reduced in plots kept weed-free for only 3 WAS.

	Weed Dry Matter kg/ha		
Treatment	2013	2014	Combined[2]
Wf -3-wd[3]	1066.7e[1]	2182.2b	1624bc
Wf -6-wd	476.7e	414.0c	445.3c
Wf -9-wd	180.7e	127.7c	154.2c
Wf -2-wd	79.3e	105.5c	92.4c
Wd-0-wf[5]	10.0e	0.0c	5.0c
Wd-3-wf[4]	280.6e	266.3c	273.5c
Wd-6-wf	1168.7d	1903.1b	1535.9bc
Wd-9-wf	1915.2c	2019.2b	1967.2ab
Wf -12-wd	2636.7b	2521.1b	2578.9a
Wf -0-wd[6]	3832.1a	4562.2a	4197.2a
SE(±)	143.68	331.03	427.8

1=Means followed by the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability; 2=Means of two years data; 3=Weed free for n period and subsequently left weedy until harvest; 4=Weedy for n period and subsequently kept weed-free until harvest; 6=Weed-free till harvest; 7=weedy till harvest

Table 1: Effect of Period of Weed Interference on Weed Dry Matter, 2013 and 2014.

Effect of period of weed interference on growth of maize

Plant height: Table 4 presents the effect of period of weed interference on plant height at 9 WAS and at harvest. It shows that plant height was significantly affected by period of weed interference at 9 WAS in 2013 but not in 2014. In 2013, and the combined, plots kept weed-free for 3,6,9, 12 WAS and that left weedy for 3 WAS produced plants that were significantly taller than plots left weedy for 6, 9, 12 WAS and until harvest. The same trend was observed at harvest in 2013, 2014 and the combined.

Number of leaves / plant: The effect of period of weed interference on the number of leaves/plant is presented on Table 5. It shows that period of weed interference had significant effect on number of leaves/ plant at 9 WAS in 2013 and the combined and at 12 WAS in both years and the combined. Plots kept weed-free for 3, 6,9,12 WAS and that left weedy for 3 WAS produced significantly higher number of leaves than those left weedy for 6 WAS and beyond. Similar pattern was observed at harvest in both years and the combined.

Leaf area: At 9 WAS, in both years and the combined, weed-free till harvest produced significantly larger leaf area which was comparable to plots left weedy for 3 WAS and plots kept weed-free for 6 and 9 WAS. However, plots left weedy for 6,9,12 WAS and until harvest produced leaf area that was significantly smaller in both years and the combined. At 12 WAS, similar trend was recorded with maize kept weed-free for 3,6,9,12 WAS and weedy for 3 WAS producing comparable significant larger leaf with plots kept weed-free till harvest. Plots left weedy for 6 WAS and beyond produced significantly smaller leaf area in 2013 and the combined (Table 6).

Weed species	Wf-3-wd	Wf-6-wd	Wf-9-wd	Wf-12-wd	Wd-3-wf	Wd-6-wf	Wd-9-wf	Wd-12-wf	Wd-0-wf	RIV% Overall
Relative Importance Value (RIV %)										
Sedges (S)										
Kyllinga squamatulata Thonn ex VahL.	-	-	4.6	2.7	-	-6.6	-	-	-	1.7
Cyperus esculetus Linn.	5.3	7.1	-	6.0	-	7.0	4.8	5.2	2.6	4.5
Cyperus rotundus Linn.	-	-	4.9	-	-	1.5	3.0	-	-	1.1
Mariscus alternifolius VahL.	4.0	3.4	5.8	6.1	-	-	3.8	12.4	3.8	4.7
Kullnga erecta Schumach var. erecta	1.5	-	6.8	-	-	-	16.2	4.5	3.9	3.9
Cyperus haspan	-	-	-	-	-	-	-	1.5	-	.2
Broad Leaf (BL)										
Gomphrena celosoides Mart	1.4	-	-	-	2.4	2.5	1.0	9.1	-	1.9
Hyptis suaveolens Poit	5.3	6.5	10.0	5.5	14.6	5.8	6.5	3.7	2.7	7.2
Fuirenaciliaris (Linn) Roxb	-	-	-	-	0.15	-	-	-	-	0.01
Pycreus lanceolatus (Poir) C.B.CL.	-	-	-	-	9.8	-	-	-	-	1.2
Unodntified broad leaf	-	-	-	-	-	-	0.1	-	-	.01
Boerharia diffusa	-	-	-	-	-	-	1.9	4.2	-	0.73
Portulaca oleracea Linn	-	-	-	4.9	-	-	-	-	-	0.6
Commeliania benghalesis L.	-	-	-	-	10.5	.8	-	-	-	1.3
Commehana diffusa Burm	-	-	-	-	-	.8	.9	-	-	.2
Leucas martinicensis (Jacq.) Ait.	-	3.4	-	-	-	-	-	1.2	0.1	0.6
Cleome viscosa L.	-	-	-	-	-	1.5	-	-	-	.2
Grasses (G)										
Grasses (Unedentified)	-	-	-	-	52.8	-	-	-	-	6.3
Chloris pilosa Schumach	3.7	-	4.8	5.0	15.7	14.3	9.3	12.5	-	7.2
Digitaria horizontalis Willd.	20.6	43.0	-	7.1	3.9	11.4	9.9	-	31.4	15.1
Dactyloctenium aegyptium (Linn)	7.3	-	-	7.9	-	22.3	7.8	5.5	5.4	6.7
Seteria Barbata (Lam.)	7.1	-	4.7	4.8	-	7.6	19.3	31.5	14.2	10.6
Rottboelia Cochinc Chenentis) Lour.) Clayton	-	3.2	-	-	-	9.0	1.1	3.3	3.5	1.3
Erograstis tremulla	-	-	-	-	-	-	1.0	-	-	1.0
Paspalum Scrobiculatum Linn.	44.0	30.1	58.2	59.4	-	-	13.6	13.1	33.1	22.8

Species Richness **10** **7** **8** **10** **8** **14** **16** **13** **10**

Wd-n-wf=weedy for n period and subsequently kept weed-free till harvest; Wf-n-wd=weed-free for n period and subsequently left weedy till harvest.

Table 2: Species richness and relative importance values (RIV%) of weed Species identified under the various periods of weed interference in 2014.

Effect of period of weed interference on yield components

Cob weight and seed rows/cob: Period of weed interference had significant effect on cob weight seed rows per cob in both years and their combined (Table 7). Plots kept weed-free for 3,6,9,12 WAS and that left weedy for 3 WAS gave cobs that were significantly heavier than those from plots left weedy for 6,9,12 WAS and until harvest but were comparable with cobs from weed-free until harvest. Similar pattern was observed with the number of seed rows per cob in both years and the combined, as plots kept weed-free for 3,6,9,12 WAS and that left weedy for only 3 WAS and weed-free until harvest supported significantly higher number of seed rows compared with plots left weedy for 6,9,12 WAS and weedy till harvest, which produced significantly lower number of seed rows (Table 7).

	Weeding Efficiency (%)		
Treatment	2013	2014	Combined
Wf -3-wd	72.2	52.2	62.2
Wf -6-wd	87.6	90.9	89.3
Wf -9-wd	95.3	97.2	96.3
Wf -12-wd	97.9	97.7	97.8
Wd-0-wf	99.7	100	98.9
Wd-3-wf	92.7	94.2	93.2
Wd-6-wf	69.5	58.3	63.9
Wd-9-wf	50.0	56.2	53.1
Wd-12-wf	31.0	44.7	37.9
Wf -0-wd	100	100	100

Table 3: Effect of period of weed interference on weeding efficiency, 2013 and2014.

Effect of period of weed interference on 100-seed weight grain yield and percentage yield reduction

100-seed weight was significantly affected by period of weed interference in both years and their combined (Table 8). Plots kept weed-free until harvest produced seeds that were significantly heavier in both years and the combined but which were comparable with weed-free for 6,9,12 WAS and plots left weedy for only 3 WAS. However, treatments kept weed free for 3 WAS and plots left weedy for 6,9,12 WAS and weedy until harvest gave significantly lighter seeds.

Weed-free until harvest resulted in maximum grain yield in 2013 which was comparable with treatments kept weed-free for 3,6,9,12 WAS and weedy for only 3 WAS (Table 8). Plots left weedy for 6,9,12 WAS and until harvest gave grain yields that were significantly lower. The same trend was observed in 2014 and the combined, however, weed-free for 3 WAS produced significantly lower yield compared to the maximum. Plots kept weed-free for 6 and 9 WAS and weedy for only 3 WAS resulted in low percentage yield reduction of 5%, 3.9% and

Treatment	Plant height (cm)					
	9 WAS[1]			12 WAS		
	2013	2014	Combined[3]	2013	2014	Combined
Wf -3-wd[4]	175.3a[2]	124.0	149.7	172.7a	174.3ab	173.5a
Wf -6-wd	177.8a	152.2	165.0	178.6a	201.2a	189.9a
Wf -9-wd	180.1a	127.5	153.8	180.6a	193.1ab	186.9a
Wf -12-wd	167.3a	147.0	157.2	167.9a	185.3ab	176.6a
Wd -0-wf[6]	175.5a	163.8	169.7	176.1a	190.1ab	183.1a
Wd -3-wf[5]	172.0a	131.1	151.6	175.9a	183.8ab	179.9a
Wd-6-wf	84.2b	108.7	96.5	98.3b	161.4ab	129.8b
Wd-9-wf	79.9b	111.6	95.8	80.3b	141.5d	110.9b
Wd-12-wf	65.2b	132.2	98.7	68.6c	154.8bc	111.7b
Wf -0-wd[7]	68.7b	100.5	84.6	68.8c	147.7cd	108.2b
SE(±)	5.13	2.01	3.37	6.65	6.47	10.90

1=Weeks after sowing; 2=Means followed by the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability; 3=Means of two years data; 4=Weed free for n period and subsequently left weedy until harvest; 5=Weedy for n period and subsequently kept weed-free until harvest; 6=Weed-free till harvest; 7=weedy till harvest.

Table 4: Effect of period of weed Interference on plant height, 2013 AND 2014.

Treatment	Number of leaves/plant					
	9 WAS[1]			12 WAS		
	2013	2014	Combined[3]	2013	2014	Combined
Wf -3-wd	11.8a[2]	11.9	11.8ab	12.1a	13.1a	12.6a
Wf -6-wd	11.7a	12.3	12.0ab	12.3a	13.4a	12.8a
Wf -9-wd[4]	12.1a	13.4	12.6a	12.5a	12.5ab	12.5a
Wf-12-wd	12.7a	13.5	13.1a	13.1a	12.4bc	12.7a
Wd-0-wf[5]	12.5a	13.0	12.7a	13.1a	13.1ab	13.0a
Wd-3-wf	12.2a	13.2	12.6a	12.8a	12.8ab	12.8a
Wd -6-wf[5]	9.8b	11.8	10.6bc	10.2b	11.0d	10.6b
Wd -9-wf	7.7c	12.9	9.8de	8.0c	12.0c	10.0b
Wd-12-wf	7.8c	13.2	10.0cd	9.2c	12.3bc	10.2b
Wf -0-wd[6]	6.6c	10.9	8.3e	6.9c	12.3bc	9.6b
SE(±)	0.35	0.26	0.49	3.69	0.21	0.43

1=Weeks after sowing; 2=Means followed by the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability; 3=Means of two years data; 4=Weed free for n period and subsequently left weedy until harvest; 5=Weedy for n period and subsequently kept weed-free until harvest; 6=Weed-free till harvest; 7=Weedy till harvest.

Table 5: Effect of period of weed interference on number of leaves/plant, 2013 and 2014.

Treatment	Leaf area (cm²)					
	9 WAS[1]			12 WAS		
	2013	2014	Combined[3]	2013	2014	Combined
Wf-3-wd[4]	471.4b[2]	360.0ab	415.7bc	329.9ab	361.4ab	345.6ab
Wf-6-wd	529.7ab	374.9ab	452.3bc	350.4ab	455.7a	403.1a
Wf-9-wd	472.4b	459.0ab	465.7bc	319.2b	386.6ab	352.9ab
Wf-12-wd	492.3ab	399.9ab	446.1bc	412.6a	363.7ab	374.8ab
Wd-0-wf[6]	563.5a	722.1a	642.8a	354.3ab	369.0ab	361.7ab
Wd-3-wf[5]	543.5ab	470.6ab	521.8ab	380.0ab	397.6ab	388.8a
Wd -6-wf	275.4c	217.9b	246.6d	197.0c	250.1ab	223.8d
Wd-9-wf	243.7c	343.6b	293.7cd	179.9c	192.7b	186.3d
Wd-12-wf	227.1c	376.3ab	301.7cd	177.8c	359.1ab	268.4bc
Wf -0-wd[7]	214.0c	267.4b	240.7d	166.2c	339.6ab	252.9cd
SE(±)	18.69	42.8	40.75	19.10	23.4	23.8

1=Weeks after sowing; 2=Means followed by the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability; 3=Means of two years data; 4=Weed free for n period and subsequently left weedy until harvest; 5=Weedy for n period and subsequently kept weed-free until harvest; 6=Weed-free till harvest; 7=weedy till harvest.

Table 6: Effect of period of weed interference on leaf area, 2013 and 2014.

Treatment	Cob Weight (g)			Seed Row/Cob		
	2013	2014	Combined[2]	2013	2014	Combined
Wf -3-wd[3]	162.2ab[1]	127.3a	144.8ab	11.6bc	14.9a	13.3a
Wf -6-wd	191.7a	160.0a	175.8a	12.3ab	13.7ab	13.2a
Wf -9-wd	176.2a	155.3a	165.8a	13.5a	14.0ab	13.7a
Wf-12-wd	166.3ab	128.0ab	168.7a	12.7ab	14.5a	13.6a
Wd -0-wf[5]	188.1a	149.3a	147.1ab	13.6a	13.8ab	13.7a
Wd -3-wf[4]	188.9a	153.3a	171.1a	12.5ab	14.7a	13.6a
Wd-6-wf	119.7bc	92.7d	106.2cd	10.5c	12.7bc	11.4b
Wd-9-wf	97.6cd	62.0d	79.8d	8.2d	11.7cd	9.9c
Wd-12-wf	65.4de	86.7d	76.1d	7.1d	12.7bc	9.9c
Wf-0-wd[6]	48.8e	38.0f	43.4e	7.0d	10.6d	8.8c
SE(±)	10.33	13.4	14.92	0.25	0.43	0.60

1=Means followed by the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability; 2=Means of two years data; 3=Weed free for n period and subsequently left weedy until harvest; 4=Weedy for n period and subsequently kept weed-free until harvest; 5=Weed-free till harvest; 6=weedy till harvest.

Table 7: Effect of period of weed interference on cob weight and number of seed rows/cob, 2013 and 2014.

	100-Seed weight			100-Seed weight		
Treatment	2013	2014	Combined[2]	2013	2014	Combined
Wf -3-wd[3]	32.2ab[1]	21.9c	27.1ab	2978.1ab	2640.7bc	2809.4bc
Wf-6-wd	32.5ab	23.9ab	28.2ab	3893.7a	3832.8ab	3863.3a
Wf-9-wd	34.6a	25.3ab	30.0a	3798.7a	4017.0a	3907.9a
Wf-12-wd	33.6a	22.8bc	28.2ab	2949.6ab	4316.6a	3633.1a
Wd-0-wf[5]	34.3a	26.7a	25.4ab	4045.6a	4084.9a	4065.2a
Wd-3-wf	34.6a	24.3ab	29.4a	3101.9ab	3845.5ab	3473.7ab
Wd-6-wf[4]	31.8ab	22.6bc	27.2ab	2370.0c	2403.6cd	2403.5c
Wd-9-wf	29.9bc	18.2d	24.1ab	985.9c	1083.0de	1034.5d
Wd-12-wf	27.8c	22.5bc	25.2ab	612.2c	1291.6de	951.9d
Wf -0-wd[6]	26.9c	16.5d	21.7b	361.1c	937.9e	649.5d
SE(±)	0.8	0.96	0.8	215.26	422.41	420.25

1=Means followed by the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability; 2=Means of two years data; 3=Weed free for n period and subsequently left weedy until harvest; 4=Weedy for n period and subsequently kept weed-free until harvest; 5=Weed-free till harvest; 6=weedy till harvest.

Table 8: Effect of period of weed interference on 100-seed weight and grain yield.

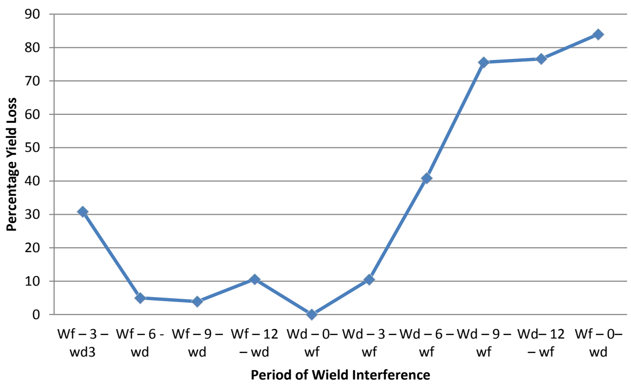

Figure 1: Effect of Period of Weed Interference on Percentage yield loss of maize, 2013 and 2014. **Key:** Wf-n-wd=Weed-free for n weeks after sowing (WAS) and subsequently left weedy till harvest; Wd-n-wf=Weedy for n WAS and subsequently kept weed free till harvest; Wd-0-wf=Weed-free till harvest; Wf-0-wd=Weedy till harvest.

14.5% respectively, while percentage yield reduction increased with increase in period of weed interference with weedy until harvest having the highest percentage yield loss of 84.0% (Figure 1).

Discussion

The effect of period of weed interference on weed infestation and weeding efficiency

Plots left weedy for 6,9,12 WAS and until harvest produced significantly higher weed dry matter in both years and the combined. This could be due to the prolonged period weeds were allowed to interfere with the crop which resulted in the accumulation of weeds, higher weed density and weed dry matter with plots kept weed-free until harvest. Plots kept weed-free or only 3 WAS supported comparable lower weed dry matter in 2013, however, in 2014 and combined, this treatment produced significantly higher weed dry matter comparable to weedy till harvest. This could be due to prolonged period of drought in 2013, which did not promote much weed growth. However, the higher rainfall recorded the following year, could have cause increase in weed infestation and weed dry matter. The above finding is similar to that of Iyagba et al. [17] who reported higher quantity of weeds resulting from prolonged weed interference in Okra. It also agrees with Shinggu that keeping plots weed free till 9 WAS and beyond supported the production of lower weed dry matter. The weeds with the highest relative importance value (RIV 22.8%) were *Paspalum scrobiculata* and *Digitaria horizontalis*. This suggest that grasses were more dominant than broadleaved weeds and could have competed more with the maize crop compared with broad leaved weeds. Grass weeds have been reported to be more competitive and damaging in a grass-leaf crop than in broad-leaf crops [18].

The lower weeding efficiency observed in plots left weedy for 6,9,12 WAS, weedy until harvest and plots kept weed-free for only 3 WAS suggests that the longer weeds are allowed to interfere with maize, the lower will be the weeding efficiency. This agrees with Iyagba et al. [17] who reported a low weed control efficiency in Okra as it was infested with weeds for 5 WAS.

Effect of period of weed interference on growth of maize

Weed-free for 6,9,12 WAS and weedy for only 3 WAS supported significantly higher maize plant height, leaf area, number of leaves per plant which were comparable with the maximum in both years and the combined. This could be due to the prevention of weeds from interfering with the crop for a long time, especially at the critical period of crop growth, which resulted in significantly lower weed dry matter, higher weed control efficiency and minimum competition between the weeds and the maize for growth resources of light, moisture, soil nutrients and assimilate which promoted better crop performance. Plots left weedy for 6,9,12 WAS and until harvest resulted in poor growth performance of maize due to prolonged period weeds were allowed to interfere with maize which probably resulted in higher weed dry matter, lower weeding efficiency, intense competition with crop for growth resources during the critical period of growth. This led to poor crop growth performance. This agrees with the report of Usoroh and Tunku [14,19] that keeping crop weed infested for 6 Weeks and beyond resulted in significant growth depression.

Effect of period of weed interference on yield components and grain yield of maize and percentage yield reduction

Weed-free plots for 6,9,12 WAS and weedy for only 3 WAS produced significantly heavier cobs, higher number of seed rows/cob and heavier seeds which were comparable to the maximum. This could be because weeds were removed at critical period of crop growth, which could have minimized weed competition and enhanced the utilization of growth resources for optimal production of photosynthates for better performance. However, plots left weedy for 6 WAS and beyond gave significantly lower crop performance. This confirms the depressive effect of weeds on maize when allowed to interfere with maize at critical period of crop growth.

Similarly, weed-free plots for 6,9,12 WAS and weedy plot for only 3 WAS gave yield values that were significantly higher than the rest of the treatments but comparable with the weed-free until harvest in both years and the combined. This is probably due to the ability of the above treatments to reduce weed dry matter significantly and increased the utilization of growth resources which significantly increased plant height, leaf area, number of leaves/plant, number of seed rows/cob, 100-seed weight which culminated in significantly higher grain yields.

Weed-free for 3WAS produced comparable yield with the maximum in 2013, however in 2014 and the combined, the yield was significantly reduced compared with the maximum. This could have resulted from the higher rainfall in 2014 which promoted higher weed infestation, more intense weed competition and lower grain yield.

Although plots left weedy for only 3 WAS produced comparable significant grain yield with the maximum in both years of study and the combine, this treatment resulted in 14.5% grain yield loss. This shows that even though weeds associated with maize for 3 weeks, the competition between weeds and maize was not too adverse. However further increase in the period of weed interference to 6 WAS caused a yield loss of 40.9%, whereas when kept weed-free for 6 WAS and beyond, grain yield significantly increased and reduction in yield were minimized to 5% and 3.9% respectively.

This finding agrees with Sodangi et al. [20] that when weeds were allowed to grow with soybeans for 45 days after sowing (DAS), 6 WAS or longer, soy beans yield reduction were severe due to intense weed competition.

Conclusion

Therefore for higher yield of maize, maize plot has to be kept weed-free for a minimum of 6 WAS. However, for economic reason and to avoid high frequency of weeding and drudgery, the critical period of weed interference in maize has been found to be between 3 and 6 WAS and weeding twice at 3 and 6 WAS is recommended.

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