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Dynamics of weed biomass on yield and yield component stability of maize under various weed management strategies

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Weed is a very significant enemy of crop production. Its density, diversity and the interaction complexes on the yield and yield component of maize cv "Quality protein" were investigated in the present study. The experiment was laid out in randomized complete block design (RCBD) containing five weed management strategies and a weedy check as treatments in 2015 and 2016. Data were collected on weed density, yield and yield components of maize for the two years. For the years and the treatments, a mixed model factorial in RCBD was employed for the analysis of variance of the data. Significant ($P \leq 0.05$) variation exists among the two years; the six treatments and their interaction for the grain yield and its components. The use of Pendimenthalin (330 EC) at 3.0 kg a.i.ha^{-1} supported the highest grain yield (2.4 tons ha^{-1}); hoe weeding and mulching was next with significantly ($P \leq 0.05$) lower grain yield of 2.2 tons ha^{-1}. The weedy check had the lowest grain yield of 1.2 tons/ha. An average yield loss of 42% was obtained by comparing the weed control methods with each of the weedy check. By Shukla variance estimate, maize-soybean intercrop gave the most stable grain yield for the two years. Year 2016 significantly ($P \leq 0.05$) favoured grain yield, its components and weed density. The proportion of weed categories in the study was: Broadleaves (52.38%), grasses (33.33%) and sedges (14.28%). Broad leaves and grasses density measured at interval displayed a significant linear trend. The sixth week after planting was most critical for grain yield determination in the tested maize cultivar.

Key words: Weed management strategies, maize, grain yield, interaction complexes.

INTRODUCTION

The productive potentials of crops are hindered by a number of factors, one of which is weed interference. Weeds compete with corn and other crops for resources such as light, nutrients, space and moisture that influence its morphology and phenology, reduce the yield, lower value of soil and land, make harvesting difficult, mar the quality of harvested products, increase the cost of production, reduce the returns on productions, etc. (Vernon and Parker, 1983; Perry et al., 1983; Knezevic et al., 1994; Kremer, 2004). According to Randall (2016), only 9,855 of the 40,874 referenced weeds listed in the database have scores indicating their level of risk in

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agricultural production. Among those whose presence constitutes risks to crop production in West African fields are: 263 species belonging to 38 plant families in the category of broad-leaved, grasses and sedges according to Chikoye and Ekelemo (2001).

The perpetual low maize productivity of 2.2 ton/ha from smallholder farmers' fields whose output accounts for more than 90% of the total production in the sub Saharan Africa has been of great concern. Chikoye et al. (2005) had indicted weed infestation to be the most supreme biotic factors that are responsible for low maize grain yield and reported the highest loss potential of about 37%, compared to 18, 16 and 2% loss potentials from animal pests, fungal and bacterial pathogens and viruses, respectively. Corn-weed competitive interaction is usually very severe during the early growing period which is characterized by slow rate of plant growth. Weed species, densities, and their interactions influence corn yield loss (Scholes et al., 1995; Fausey et al., 1997) through competition. Therefore, to realize the yield potential of corn, weed management is indispensable (Mitchell et al., 2014) especially during the critical periods.

Different weed control methods have been utilized to manage weeds; mechanical and chemical methods are more frequently used than any other methods (Tesfay et al., 2015). Meanwhile, none of the two methods has satisfactorily provided season long effect on weed control when used alone (Badmus et al., 2006; Lagoke et al., 2014). Reasons for the poor success from the use of either of the two methods have been documented by Adigun et al. (1992) and Chikoye et al. (2002). Moreover, weed management strategies vary in their suppressive potential. The growing of two or more crop species simultaneously in the same field during a growing season is a common practice to prevent total crop losses, an investigation of its possible role in weed control is rare (Takim, 2012; Amujoyegbe et al., 2012). Similarly, the art of covering the soil around the crop with dried plant residues is another eco-friendly cultural operation which is not popular in maize production. We deemed it meaningful in the present investigation to assess the potentiality of intercropping and mulching along with mechanical and chemical weed control methods.

Maize (*Zea mays* L.) is a member of the family Poaceae and one of the most important cereal crops used as staple food for man, feed for livestock and essential raw material in confectionaries, pharmaceuticals and agro allied industries (Adigun and Lagoke, 1999; IITA, 2012). Its cultivation is globally wide and occupies a very vital position in global food security and economy. All the Nigerian agro-ecologies support the cultivation and production of maize; this makes her a very relevant producer in Africa. Maize production is wide spread in Ekiti State (Southwestern Nigeria) with average annual growth rate of 2.33% (World Data Atlas, 2018).

The reports of Tesfay et al. (2015) had identified grasses, broadleaved and sedges to be the major weed categories in maize plots. Owing to the awareness that functional interactive complexes exist among different weed species and soil characteristics, climate, cultural practices and different weed control methods (Kremer, 2004), a kin look at the prospective roles of different weed categories on yield and yield components of corn in Ikole-Ekiti, Southwestern Nigeria was thought worthwhile to assess the relative scoring of the negative potentials of the different weed types. Due to the differences in environmental factors accompanying different years, weed development dynamics and complexes of crop-weed type interactions, the present study therefore seek to: assess population of different weed categories in maize plot and understand their impacts on the yield and yield component of maize in Ikole-Ekiti, Ekiti State, Nigeria.

MATERIALS AND METHODS

Two years field trials were conducted in the late wet seasons of 2015 and 2016 to evaluate weed density, their biomass production and their influence on kernel yield and yield component of maize at the Teaching and Research Farm of the Federal University Oye-Ekiti, Ikole-Ekiti Campus (7° 48'N and 5° 29'E) Ekiti State, Nigeria. In the two years trials, the land was ploughed and later harrowed after two weeks. The experiment, containing six weed management strategies as treatments (Table 1) was laid out in a randomized complete block design (RCBD) of three replications. The test crop was a hybrid maize variety "quality protein".

For the treatments involving maize-legume intercropping, cowpea (cv. Oloyin, ART 98/SW1) and soybean (cv. TGX 1740) obtained from the Institute of Agricultural Research and Training (IAR & T), Ibadan, Nigeria were used. Seeds of maize were planted at 0.75 m × 0.5 m while the seeds of cowpea and soybean were planted at 0.75 × 0.30 m and 0.75 × 0.05 m, respectively. In each of the two intercropping cases, maize and cowpea or soybean lied side by side along rows on the flat. Planting was done on the same day. At germination, thinning was done to two plants stand^{-1} for each crop. NPK (15:15:15) fertilizer and urea were applied as side dressing for maize at 3 and 6 WAP at the rate of 120 and 60 kg ha^{-1}, respectively.

Data on weed characters such as species composition, level of occurrence and dry matter production (g) were recorded using plants from the two central rows of each plot based on 0.5 m^2 quadrat capture at 6, 9 and 12 WAP. Weed species within the quadrant area were separated into broadleaves, grasses and sedges and later identified following the weed species guide by Akobundu et al. (2016). Weed samples were oven-dried to a constant weight at 60°C for 48 h to obtain the dry matter production. Data collected on maize at harvest included: net plot yield (g), 100 seed weight, weight of ten cobs (g), grain yield of ten cobs (g), total grain yield (kgha^{-1}) and shelling percentage which was estimated as the proportional percentage of the kernel to the whole cob.

For the data analysis, the two years data for the six treatments were treated as a factorial in RCBD. Data collected on weed density, grain yield and yield components were subjected to analysis of variance (ANOVA) using SAS version 9.4 (SAS, 2011). Significance by comparison of the means of the levels of each main effects was tested using least significant difference (LSD) at P = 0.05. The significant year by treatment interaction component from the ANOVA for grain yield and yield related traits was further partitioned for stability test using the Shukla variance estimate

Table 1. Description of the six weed management strategies.

S/N	Treatment codes	Description
1	T1	Maize-Cowpea inter-rows intercrop followed by one supplementary hoe weeding at 6 WAP
2	T2	Maize-Soybean inter-rows intercrop followed by one supplementary hoe weeding at 6 WAP
3	T3	Mulching with grass straw (*Digitaria ciliaris* [Retz.]) Koel at 5 tons ha^{-1} followed by hoe weeding at 6 WAP
4	T4	Pendimenthalin (330 EC) at 3.0 kg a.i / ha followed by hoe weeding at 6 WAP
5	T5	Two hoe weedings at 3 and 6 WAP
6	T6	Weedy check (negative) control.

WAP: Weeks after planting.

Table 2. Common weed species found in the experimental plots of maize and their level occurrence.

S/N	Weed species	Family	Level of occurrence	
	Broadleaves		**2015**	**2016**
1	*Amaranthus spinosus* (Linn.)	Amaranthaceae	***	**
2	*Biden pilosa* L.	Asteraceae	***	***
3	*Cassia hirsuta* (L.)	Leguminosae	*	**
4	*Cassia obtusifolia* (L.)	Leguminosae	**	-
5	*Corchorus olitorius* (L.)	Tiliaceae	***	-
6	*Euphorbia heterophylla* (L.)	Euphorbiaceae	*	**
7	*Fleurya aestuans* [Linn] ex Miq.	Urticaceae	***	*
8	*Physalis angulata* (Linn.)	Solanaceae	**	-
9	*Solanum nigrum* (L.)	Solanaceae	-	*
10	*Solanum torvum* (SwartzL.)	Solanaceae	**	-
11	*Spigelia anthelmia* (Linn.)	Loganiaceae	***	*
	Grasses			
12	*Andropogon tectorum* schum & Thonn	Poaceae	-	***
13	*Commelina bengalensis* (L.)	Commelinaceae	*	**
14	*Commelina nodiflora* (L.)	Commelinaceae	***	*
15	*Digitaria abyssnica* (A, Rich) Stapf	Poaceae	**	**
16	*Eleusine indica* (L.) Gaertn	Poaceae	-	*
17	*Panicum maximum* (Jacq.)	Poaceae	***	****
18	*Setaria longista* (P. Beauv.)	Poaceae		
	Sedges			
19	*Cyperus esculentus* (Linn.)	Cyperaceae		
20	*Cyperus rotundus* (Linn.)	Cyperaceae		
21	*Mariscus alternifolius* (Vahl.)	Cyperaceae		

(Shukla, 1972). Weed population responses for broadleaves, grasses and sedges for the three periods of measurements (that is, at 6, 9 and 12 weeks after planting (WAP) were investigated for the six weed management strategies by trend analysis. Furthermore, for each of the three different periods of sampling the weed type populations, the means of a pair of the six weed management strategies were compared for significance testing by LSD (0.05). The relationship between the different weed populations and the grain yield and yield components was investigated by Pearson correlation.

RESULTS AND DISCUSSION

From Table 2, the occurrence of three categories of weed species in the experimental unit at Ikole-Ekiti, Nigeria was in the percentage of: 52.38% (Broadleaves), 33.33% (Grasses) and 14.28% (Sedges). The percentages of occurrence of the three categories in the present study differed from what Tesfay et al. (2014) obtained; they reported 72.7% broadleaved weeds, 9.09% grasses and18.19% sedges weeds in their experiment with maize at West Showa, Ethiopia. It is clear from their studies and ours that the broadleaves weeds usually predominate in cultivated maize field. The variation for the second and third place in the present study and theirs by grasses or sedges could be due to the variation in the environment.

The analysis of variance result (Table 3) revealed highly

Table 3. The variance components of the different sources of variation for grain yield and yield components of the studied maize variety.

Sources of variation	Df	Mean squares					
		100Swt	Wt10cobs	Gy_10_Cobs	NPY	GY/ha	%Shelling
Rep	3	263.95	31.29	0.00091	1896.47	2.90	263.9495
Years	1	319.01***	210.99***	0.23***	12984.36***	27.02**	319.01***
Treatments	5	668.76***	1438.36***	0.43***	19592.67***	19.09***	668.76***
Years×Treatments	5	76.89***	80.21***	0.008***	709.03***	5.57***	76.89***
Error	33	5.95	4.21	0.0001	21.91	0.17	5.92

Table 4. Mean performances of maize for each of the two years under the six weed management strategies and proportion of losses in performance of each treatment compared to the check.

Years	100Swt	Wt10cobs	Gy_10_Cobs	NPY	Grain yield/ha	%Shelling
2015	13.56[b]	616.21[b]	482.91[b]	0.788[b]	1720.07[b]	77.55[a]
2016	14.49[a]	667.81[a]	524.76[a]	0.923[a]	2049.02[a]	76.05[b]
Treatments						
T1	13.92[b]	590.32[c]	460.17[d]	0.72[c]	1603.25[c]	78.84[c]
T2	13.82[b]	569.48[c]	457.51[d]	0.71[c]	1595.16[c]	77.78[c]
T3	14.49[a]	691.69[b]	582.06[c]	1.01[b]	2248.03[b]	82.34[b]
T4	14.38[a]	705.62[b]	595.94[b]	1.03[b]	2284.44[b]	84.43[a]
T5	14.56[a]	764.30[a]	648.11[a]	1.13[a]	2400.98[a]	84.84[a]
T6 (Check)	12.97[c]	530.64[d]	279.23e	0.53[d]	1175.40[d]	52.56[d]
Proportion (%) of losses compared to the check						
T5 - T6	10.92	30.57	56.92	53.1	51.04	38.05
T4 - T6	9.81	24.8	53.14	48.54	48.55	37.75
T3 - T6	10.49	23.28	52.03	47.52	47.71	36.17
T2 - T6	6.55	7.32	63.85	33.96	35.71	47.98
T1 - T6	6.82	10.11	39.32	26.39	26.69	33.33
Average	8.88	20.12	49.12	42.39	41.99	35.62

Means with the same letter are not significantly different and mean comparison is along each column.

significant ($P \leq 0.01$) variations for the two main effects (years and weed management strategies) for the yield and yield components and the three different weed type population densities. However, some of the traits equally exhibited significant year by weed management interaction. For the six grain yield characters, performance was much and significantly ($P \leq 0.05$) higher in 2016 for all the characters except shelling percentage (Table 4). In the present result, 2016 greatly supported grain yield, its determinants and the densities of the three weed categories compared to 2015. This seems to approve that two environments does not display the same characteristics and thus affect the same biological phenomenon differently. Environmental factors such as moisture availability and daily temperature which differ from year to year play a key role in influencing the performance of specific crop genotypes under different weed type regime in a particular season (Mwendwa et al., 2016). An Australian wheat-weed competition evaluation trial by Mwendwa et al. (2016) equally indicted the environment (location and year) as a very prominent factor which influences wheat competitive traits, grain yield and suppressive capability of weed management strategies.

T5 (a treatment involving weeding twice with hoe at 3 and 6WAP) most significantly ($P \leq 0.05$) supported the five grain yield attributes including grain yield (Table 4). Treatments 4 and then 3 supported the yield parameters in succession behind treatment 5. The weed management strategy check (with no weeding), that is, T6, provided the least support to the six grain yield parameters (Table 4). Weeding with hoe provides an immediate zero maize-weed competition; the same situation enhances optimum utilization of available moisture and nutrients resources by the crop. Hoe weeding at the 3rd and 6th weeks after seedling emergence in the present study coincided with

Table 5. Stability estimates of the interaction of the six treatments and two years.

Treatment	Wgt100	Wt10cobs_g	Yld_Kg_ha	Shelling	Gy_10_Cob	NPY
1	0.061	0.651	0.882	-0.378	-1.281	0.345
2	-0.038	-0.208	-0.136	-0.288	1.052	-0.053
3	-0.037	-0.025	-0.924	-0.253	-5.768	-0.164
4	0.029	-0.454	-0.485	-0.181	-6.021	0.049
5	-0.036	-0.473	0.663	-0.368	-5.988	-0.186
6	-0.026	0.033	-1.021	1.090	11.936	-0.249

NPY: Net plot yield, Gy: grain yield, Yld_Kg_ha: grain yield in Kilogram per hectare, Wgt100: 100 seed weight, Wt10cobs_g: weight of seeds from 10 cobs in grammes. Interpretation is based on absolute values and dimension is not relevant. Higher values of the variance estimate imply low stability. Source: Shukla (1972).

the critical period of maize vulnerability to yield loss (that is, weeks one to eight) as identified by Perry et al. (1983), Vernon and Parker (1983) and Jhala et al. (2014). In the present result, it was equally noted that keeping maize from weed competition within this period especially at the 6th week significantly and positively enhanced grain yield and its components.

The support of treatments four (herbicide usage) and five (mechanical method) for grain yield and its component and weed suppression was relatively the same in this study; although chemical control method distinguishes itself in the suppressive pattern for the three weed categories. However, the evolution of herbicide resistant weed biotypes has always been the problem from the continuous use of registered herbicide. Heap (2016), cited in Mwendwa et al. (2016) reported that weeds have evolved resistance to 22 of the 25 known herbicide modes of action and to 160 different herbicides globally. Therefore, the incorporation of other strategies with sole herbicides usage could help to reduce the trend of evolution of resistance of weeds to herbicides.

The performance of the yield and yield related characters in Table 4 by the maize cultivar, "Quality protein" under intercrop conditions (that is, T1 and T2) was not different, however, both significantly ($P \leq 0.05$) outperformed the check. In the comparison of each of the five treatments with the check in Table 4, the highest (56.92%) proportion of loses was between T5 and T6, followed by the percentage loss between T4 and T6, then T3 and T6, T2 and T6 and lastly T1 and T6. However, for grain yield of ten cobs and shelling percentage, the highest percentage loss was between T2 and T6 (Table 4). With the aggregate mean loss of 42% in this study from the comparison of each treatment to the check, it is imperative that control of weeds in the fields of maize is very essential to be able to obtain good harvest.

No significant difference was observed in the weed type population between the use of either cowpea or soybean as companion crop with maize in this study. This seems to suggest that the two may have related smothering activity for the three weed categories in the maize field. However, loses in the grain yield and its component was least in the comparison between the check with maize-cowpea intercrop. The wider intra-row space between maize and cowpea in the intercrop seems most relevant to explain for the limited compensatory loss. Mitchell et al. (2014) had suggested that closer row planting patterns could lead to more effective weed management in corn and hence increased reduction of grain yield loss. Although mulching and hand hoeing are two cultural methods, however, their efficacy for weed control distinctly differs in all the stages of the crop growth.

Generally, within the two years of evaluations, only grain yield of ten cobs showed much higher values for the Shukla stability variance, most of the other characters had values less than a unit (Table 5). Moreover, among the six treatments for the two years, treatments 2 had the lowest Shukla variance estimate for grain yield/ha and grain yield of 10 cobs while treatment 4 had the lowest values for shelling percentage and NPY (Table 5). The most stable treatments for weight of ten cobs and 100 seed weight in this study were treatments 3 and 6, respectively because they had the lowest value each (Table 5); this makes them the most stable treatments. A long-term analysis (1996-2011) by Ferrero et al. (2017) showed that the combined effects of internal and external processes involving weed diversity were strongly associated with soybean and maize yield fluctuations. Furthermore from their work, while maize seems to be more sensitive to environmental variation, soybean seems to have stronger regulation in its production with varied environment. In the present two-year research, the least affected treatment by the variation in the year effect for maize grain yield was the intercrop programme involving maize with soybean. Weed diversity has significant association with different crop species, with reference to soybean and maize according to Ferrero et al. (2017). In our result therefore, the presence of soybean with maize may have a conditioning influence in regulating the environmental factors such that the yield from maize was stable for the two years.

Different weeds species in the classes of broadleaves, grasses and sedges can be obtained in a single

Table 6. Annual means density of the three weed categories evaluated at sixth, ninth and twelfth week after planting

6th week	Broadleaved	Grasses	Sedges
2015	51.62[b]	7.62[b]	2.50[b]
2016	53.04[a]	9. 47[a]	3.36[a]
9th week			
2015	55.55[a]	3.74[b]	2.60[b]
2016	64.60[a]	4.75[a]	3.51[a]
12th week			
2015	169.64[b]	3.51[b]	1.82[b]
2016	196. 49[a]	4.32[a]	2.31[a]

Means with the same letter are not significantly different and mean comparison is along each column.

Table 7. Trend of different weed population measured at three intervals during the growing period of the maize variety

Sources of variation	DF	Broad leaves	Grasses	Sedges
		Mean squares		
Treatments	17	5380.98**	21.45	2. 46
Weed Control Strategy (WCS)	5	3841.72**	37.32*	3.83
Intervals (In)	2	32275.55***	40.09	1.74
In-Linear	1	51270.13***	64.52*	2.24
In-Quadratic	1	13280.97**	15.65	1.23
Error	10	771.68	9.81	1.92

experimental site (Mehmeti et al., 2012); each one and their complexes differ in competitive potential to affect crop yield. From Table 6, higher weed densities were observed for broadleaves, grasses and sedges at each of the three weeks interval of measurements in 2016 compared to 2015. For the broadleaf weed type, increase in density was clearly observable from the sixth week to the twelfth week for each of the two years; the observed difference between 6 and 9th was small compare to the difference between 9 and 12th week (Table 6). For grasses in the two years, population declined from the 6 and 12th week. Sedges population at the 9th week was slightly higher than what was obtained in the 6th week, however, the recorded density for the same at the 12th week for the two years was lowest compared to the two earlier periods of population density evaluation (Table 6). Higher population of broadleaves and grasses at 6 WAP in a maize field was highly detrimental to all the grain yield components and the yield of maize. Among the three weed types, the influence of sedges was most minimal.

The six treatments and the three intervals of measuring the population density of the three weed types were investigated by trend analysis, the result is presented in Table 7. Significant ($P \leq 0.05$) differences were obtained among the six treatments in the population of broadleaves and grasses (Table 7). The two categories of weeds equally exhibited significant ($P \leq 0.05$) positive linear and quadratic (broadleaves) and negative linear (grasses) responses along the two intervals of 6 to 9th and 9 to 12th. Moreover, broadleaves weed type additionally exhibited significant quadratic response (Table 7). The expressed dynamics for increase or decrease in the weed type population with the interval of measurement were unique in this experiment: it was both linear and quadratic for broadleaves, linear for grasses but the pattern of response by sedges was not well defined. The positive linear trend exhibited by the broadleaved weed species with the intervals (6 to 9th weeks) seems to reflect the usual vigour characteristic by weed species during their vegetative and early reproductive growth stages. However, the noted negative quadratic trend for the same group within the interval of 6 to 12th weeks after planting seem to reflect the nature of the ephemerals plant species; whose vegetative, reproductive developmental stages and senescence occurs within short time. Akobundu (1987) had long

Table 8. Paired mean comparison of the six weed management strategies for the three different weed type population densities measured at three periodic weeks interval.

Parameter	B_Leaf6WAP					Grass6WAP					Sedge6WAP				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
T2	0.57					3.71**					0.63*				
T3	17.71**	17.14**				6.40**	2.69**				1.00**	0.38*			
T4	13.72**	13.15**	3.99*			9.15**	5.44**	2.75**			0.05	0.58*	0.96**		
T5	17.71**	17.14**	0.00	3.99*		7.99**	4.28**	1.59**	1.16**		1.97**	2.60**	2.98**	2.02**	
T6	4.63*	5.20*	22.34**	18.35**	22.34**	8.91**	12.62**	15.31**	18.06**	16.90**	0.77*	1.40**	1.77**	0.82**	1.20**
LSD0.05			3.15					0.97					0.27		
	B_Leaf9WAP					**Grass9WAP**					**Sedge9WAP**				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
T2	1.57					0.07					0.43				
T3	2.06	0.49				0.14	0.07				0.87*	0.44*			
T4	0.72	2.29	2.78			3.49**	3.42**	3.36**			3.59**	3.16**	2.72**		
T5	0.45	1.12	1.61	1.17		0.03	0.04	0.11	3.46**		0.15	0.28	0.72**	3.44**	
T6	78.58**	77.01**	76.52**	79.30**	78.13**	2.76**	2.83**	2.90**	6.26**	2.79**	4.59**	4.16**	3.72**	1.00**	4.44**
LSD0.05			4.27					0.44					0.43		
	B_Leaf12WAP					**Grass12WAP**					**Sedge12WAP**				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
T2	1.04					0.20					0.14				
T3	23.82**	22.78**				1.14**	1.34**				0.05	0.19			
T4	19.68**	18.63**	4.15			1.79**	1.99**	0.65*			3.52**	3.66**	3.46**		
T5	23.28**	22.23**	0.55	3.60		1.60**	1.80**	0.46	0.19		1.45**	1.59**	1.39**	2.07**	
T6	99.33**	98.28**	75.50**	79.65**	76.05**	7.44**	7.64**	6.30**	5.65**	5.84**	3.03**	3.17**	2.98**	0.49*	1.58**
LSD0.05			6.20					0.59					0.24		

remarked that majority of broadleaves weeds are ephemeral in nature. The positive linear nature of the trend analysis for grasses at the interval (6 to 12th) weeks after planting seems to indict the supportive role of the perennating organs in grasses which support their continual survival after establishment.

Table 8 presents paired comparison of differences between two treatment means using LSD at P = 0.05. At the 6, 9 and 12th WAP, significant ($P \leq 0.05$) differences existed for the population of broadleaves, grasses and sedges between T6 (the check) and the other five treatments. Except for grasses and sedges population at the 6^{th} week, there were no significant differences between intercropping maize with either soybean or cowpea (Table 8). For the two cultural management practices (T3 and T5), population of sedges at 6, 9 and 12th WAP and grasses at 6 WAP differed significantly ($P \leq 0.05$). Furthermore, in Table 8, chemical weed control (T4) was significantly ($P \leq 0.05$) different from other treatments at the different stages for the three weed types except treatments (T1, T2 and T3 at 9WAP) for broadleaves category, T1 (Sedge at 6 WAP) and T3 (Broadleaves at 12 WAP). The competitive role of grasses and broadleaves at 6 and 9th WAP on maize would need to be further investigated to be able to ascertain the contributory impact of the

Table 9. Correlation between grain yield and yield components with periodical weed type densities.

Correlation	GR6	SDG6	BL9	GR9	SDG9	BL12	GR12	SDG12	WT100	Wt10cobs	Gy10Cobs	NPY	Yld/ha	Shelling
BL6	0.829*	0.124	0.558	0.546	0.221	0.287	0.301	-0.063	-0.894*	-0.963**	-0.911*	-0.971**	-0.971**	-0.714
GR6		-0.098	0.881*	0.825*	0.439	0.716	0.706	0.138	-0.952**	-0.846*	-0.960**	-0.912*	-0.923**	-0.948**
SDG6			-0.248	-0.243	-0.076	-0.337	-0.379	-0.421	0.031	-0.304	-0.081	-0.162	-0.102	0.142
BL9				0.739	0.725	0.954**	0.948**	0.485	-0.866*	-0.612	-0.831*	-0.701	-0.714	-0.977**
GR9					0.078	0.632	0.574	-0.165	-0.711	-0.590	-0.717	-0.661	-0.692	-0.781
SDG9						0.782	0.824*	0.874*	-0.530	-0.280	-0.476	-0.331	-0.317	-0.642
BL12							0.993***	0.614	-0.679	-0.357	-0.630	-0.457	-0.472	-0.869*
GR12								0.688	-0.683	-0.349	-0.625	-0.454	-0.469	-0.861*
SDG12									-0.222	0.102	-0.125	0.019	0.016	-0.349
WT100										0.910*	0.989***	0.955**	0.962**	0.948**
Wt10cobs											0.946**	0.987***	0.977***	0.763
Gy10Cobs												0.978***	0.978***	0.928**
NPY													0.997***	0.834*
Yld/ha														0.845*

BL6, BL9 and BL12: Density of broadleaves weed at 6, 9 and 12 weeks after planting (WAP); GR6, GR9 and GR12: density of grasses at 6, 9 and 12 WAP; SDG6, SDG9 and SDG12: density of sedges at 6, 9 and 12 WAP; NPY: net plot yield; Gy: grain yield, Yld/ha: grain yield in kilogram per hectare; WT100: 100 seed weight; Wt10cobs: weight of seeds from 10 cobs in gram.

two intervals on the yield of maize.

At 6 WAP, significant ($P \leq 0.05$) positive correlation ($r = 0.829$) existed between broad-leaves and grasses (Table 9). The correlation between grass at 6 WAP with broadleaves at 9 WAP ($r = 0.881$) and grasses 9 WAP ($r = 0.825$) were both positive and significant ($P \leq 0.05$). Our result strongly indicted broadleaves and grasses weeds categories to be very prominent in causing yield reduction in maize. Moreover, broadleaves and grasses at 6 WAP had very strong ($r > 0.8$), significant ($P \leq 0.05$) but negative correlation with: 100 seed weight, weight of ten cobs, grain yield of ten cobs, net plot yield, grain yield per hectare and shelling percentage (Table 9). Broadleaves population at 9 WAP significantly ($P \leq 0.01$) and positively correlated with the population of broadleaves and grasses at 12 WAP ($r = 0.954$ and 0.948, respectively). The association between sedges population at 9 WAP with grasses and sedges population at 12 WAP was strongly ($r > 0.8$) significant ($P \leq 0.05$). Moreover, broadleaves population at 9 WAP significantly ($P \leq 0.05$) but negatively affected 100 seed weight ($r = - 0.866$), grain yield of ten cobs ($r = - 0.831$) and shelling percentage ($r = - 0.977$). At 12 WAP, broadleaves and grasses population significantly ($P \leq 0.05$) and negatively supported shelling percentage (Table 9). Summarily, from Table 9, the five grain yield components and the grain yield exhibited strong ($r > 0.8$), positive and significant ($P \leq 0.05$) correlation. Our report notably corroborated that of Ferrero et al. (2017) which stated that: maize usually have highly diverse weed community which greatly affects its yield and yield components. Kremer (2004) had earlier indicted possible functional interactive complexes which exist among different weed species and maize to be responsible for maize yield reduction or losses.

Weed competition in maize plots should be avoided in order to prevent more than 50% losses in production. All the weed control strategies evaluated in this study had better performances than the control with significant positive enhancement on the grain yields of the maize cultivar. Thus either of the weed management strategies could be employed for improved maize yield not minding the initial capital or labour constraints. The resultant support from their involvement in maize production will provide a tradeoff for all initial expenses to be incurred.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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