Journal of Plant Development
Vol. **31**, Dec **2024**: 105-115
DOI: 10.47743/jpd.2024.31.1.960
ISSN 2065-3158 print / e-ISSN 2066-9917
Available online: www.plant-journal.uaic.ro
Research Article

ASSESSING DIFFERENT STRATEGIES FOR CONTROLLING WEEDS IN MAIZE CULTIVATION WITHIN THE DERIVED SAVANNA AGRO-ECOLOGY IN NIGERIA

Olagbemi Peter AFON[1], Oluwakemi Olajumoke AJAYI[1*],
Adesike Oladoyin OLAYINKA[2], Emmanuel Ajibola OLAGUNJU[1],
Gabriel Olulakin ADESINA[1]

[1] Ladoke Akintola University of Technology, Department of Crop and Environmental Protection Ogbomoso Oyo State – Nigeria.
[2] Ladoke Akintola University of Technology, Department of Crop Production and Soil Science Ogbomoso Oyo State – Nigeria.
[*] Corresponding author. E-mail: ooajayi63@lautech.edu.ng, ORCID: 0009-0004-9748-9662

Abstract: Maize is the second most cultivated crop in Nigeria in terms of hectares of land. In the world it ranks fourth amongst cultivated cereals. However, its cultivation is faced with different challenges ranging from biotic to abiotic factors. Weeds are one of the biotic factors that threaten maize yield.in the field because of the cost and labor associated with it control. Hence, using Randomized Complete block Design, a two-year study was carried out to assess different strategies that are used in controlling weeds in the derived savanna agroecological zone of Nigeria at Ogbomoso Girls High School, Ogbomoso (8°9′N, 4°15′E) and Surulere North LCDA Igbon (8°14′N, 4°18′E). The total land area used was 13 m x 23 m with plot size 2 m x 3 m in three replicates. Eight treatments were used which are weedy plots, weed free, manual I, manual II, Pre-emergence herbicide (Glyphosate-1.08 kg a.i ha^{-1}), Post-emergence herbicide (Nicrosulfuron- 0.12 kg a.i ha^{-1}), Cowpea+Maize and Potato+Maize) to give 24 plots. Data collected were on weed parameters and maize yield. Weed parameters include: weed population, dry weed biomass and weed control ratio at 3, 6 and 9 weeks after sowing. Parameters on maize yield include number of seeds per cob, grain weight of seeds per cob, cob length, weight of 100 seeds per plot, grain weight per plot and grain weight per hectare. The result on weed parameters shows that there is no significant difference in the weed control rating and the dry weed biomass of manual weeding, pre-emergence herbicide, post emergence herbicide, cowpea+ maize, and potato + maize. Though there was significant difference in the weed population among the treatments. For maize yield (GWH), there was no significant difference between Manual II and the use of post emergence herbicide. Also the yield obtained from pre-emergence herbicide, potato+maize, cowpea+maize were not significantly different. Hence, it is recommended that legumes and potatoes can be used rotationally to control weeds in maize plots.

Keywords: maize, maize yield parameters, weed control strategies, weed parameters.

Introduction

Maize (*Zea mays* L.) is a staple crop extensively cultivated in tropical regions, where various environmental factors, farming practices, and genetic considerations shape its performance. It is a staple food in Nigeria, where maize occupies the largest area under cereal cultivation [ABAH & al. 2021; WOSSEN & al. 2023]. The production area for maize in Nigeria continues to expand [OLANIYAN, 2015], driven by technological advancements [HARUNA & al. 2023]. Globally, maize production has consistently averaged over 1,000 million metric tons (MMT) in recent decades. With an annual output of 11 MMT, Nigeria is considered the second-largest maize producer in Africa, following South Africa, while Ethiopia ranks third.

Received: 30 October 2024 / ***Revised***: 4 December 2024 / ***Accepted***: 9 December 2024

Together, these three countries – South Africa, Nigeria, and Ethiopia – accounted for approximately 39% of Africa's total maize production in 2019 [ERENSTEIN & al. 2022; MAKAMA & al. 2022].

Maize serves as a staple food for millions of people, particularly in Africa, Latin America, and Asia, where it is consumed in various forms, such as maize flour, tortillas, polenta, and whole grain. According to POOLE & al. (2021), maize provides essential nutrients like carbohydrates, proteins, and fats, making it a vital food source for ensuring food security in many developing nations. BOUIS & al. (2011) underscore the role of biofortified maize in addressing malnutrition. A large proportion of global maize production is also used as animal feed. NUSS & TANUMIHARDJO (2010) noted that maize's high starch content makes it an excellent feed for energy-intensive livestock production, contributing to the global meat and dairy industries. Additionally, maize is a key feedstock for ethanol production, especially in the United States, where it plays a significant role in biofuel production. LU & MOSIER (2008) pointed out that the biofuel industry increases demand for maize, promoting energy security and reducing greenhouse gas emissions. SINGH & al. (2003) highlighted maize starch's versatility in products such as sweeteners, thickeners, adhesives, and biodegradable plastics. In Nigeria and across Africa, maize serves as a crucial income source. SMALE & MASON (2014) noted that maize farming supports the livelihoods of millions of rural households, contributing to poverty reduction and economic growth. FAO (2020) reported that maize is one of the most globally traded cereals, with exports driven by its use in food, feed, and industrial purposes. REVILLA & al. (2022) discussed maize's cultural significance, emphasizing its role as a symbol of heritage and identity in indigenous cultures.

Despite maize's significant economic importance, several limitations impact its production, particularly in developing countries like Nigeria. One of the main challenges is weed interference in maize fields. Weeds have a significant impact on maize cultivation, affecting crop growth, yield, and overall productivity. These unwanted plants compete with maize for essential resources such as sunlight, water, nutrients, and space, which can severely hinder crop development [SOLTANI & al. 2016]. The extent of weed interference depends on factors such as the type of weed species, their density, and the timing of weed emergence relative to the maize crop. Herbicide application is a widely used method for controlling weeds in maize cultivation. LUKANGILA & al. (2024) demonstrated that selective herbicides, when applied at the appropriate growth stage, can effectively reduce weed competition and improve maize yields. In addition to chemical methods, non-chemical approaches, such as crop rotation and intercropping, are also being explored. [LIEBMAN & ZIMDAHL, 2018] suggested that these practices can substantially reduce weed pressure and enhance maize yields, especially in organic farming systems. Given the critical role that weed pressure plays in maize production, this study aims to evaluate various weed control methods, including herbicides, in a derived savanna ecosystem.

Materials and methods

The experiments were carried out on arable fields of Ogbomoso North Local Government farms in Oyo State, Nigeria between April to August 2023 and 2024 in Ogbomoso North (8°9′N, 4°15′E). The climate of Ogbomoso is mostly influenced by the Northeast trade wind and Southwest trade wind. The annual rainfall of the area is between 1000 mm - 1286 mm. Temperature of the area ranges between 28 °C to 33 °C with a relative humidity of about 78% all year round except in January when the dry harmattan is at its peak. The soil type at the location where the experiment was set up was sandy loam with 14% clay content as described by EWETOLA & OSHUNSANYA (2015).

The experiment consisted of eight treatments (Table 1) laid out in a randomized complete block design with three replicates making a total of 24 experimental plots. Each plot size was 3 m × 2 m (6 m^2). Each plot was separated with 1m space between them and 2 m space in between the replicates. The total land area was 13 m by 23 m. Soil samples were collected before sowing at 0-15 cm depth randomly to determine the physico-chemical properties of the soil.

The result indicates that the soil was slightly acidic, sandy loam with nitrogen level that is well below the critical level of 0.15%. Sites were cleared and ploughed to pulverize the soil manually. Oba Super 6, a pro-vitamin A hybrid maize variety was the maize variety grown. It was planted at a spacing of 0.6 m × 0.5 m. Two seeds were planted per hill and thinned down to one seedling per hill at 14 DAS to give a plant density of 20 plants per plot.

In plots intercropped with cowpeas, the variety IT18 was planted one seed per hill in at 0.10 m from maize planting hills at two weeks after planting of maize. In the plots intercropped with potato, potato vines were planted at two weeks before planting maize. All plots including the control received basal application of Fertilizer N:P:K, (15:15:15) which was applied basally two weeks after planting maize at the rate of 250 kg /ha and Urea (46% N) at the rate of 100 kg/ha at six weeks after planting to meet the nutrient requirement of the maize.

Pre-emergence herbicide (PeEH) plots were planted as previously described and then sprayed with herbicides on the day of sowing. Post-emergence herbicides (PoEH) were applied after three weeks of planting. Herbicides were applied using a hand-pumped Knapsack sprayer which delivers 380 liters/ha of spray liquids. Manual weeding in Manual I plots was done at three weeks intervals, for Manual II at two weeks intervals and weed free plot was weeded weekly. In the maize + cowpea plot, and maize + potato plot weeding was done only once at 3 weeks after planting. This simulated the smallholder farmer practice in Nigeria of planting maize.

Weed species composition, weed density and weed dry weight

Weed species composition and weed density were determined by placing two quadrats size of 50 cm × 50 cm diagonally on each plot and then the weeds within each quadrat were uprooted, and sorted into broadleaf weeds, grasses, and sedges. The weed types were identified to the species level with the aid of weed identification manual of AKOBUNDU & al. (2016). The weeds were counted to calculate the weed density. Weed dry weight was estimated after oven-drying weed samples at 80 °C for 48 hours to constant weight.

Data collection and analysis

Data were subjected to analysis of variance (ANOVA) to test for treatment effects and interactions using the statistical analysis system (SAS) computer software package version 9.4 (SAS Institute, 2011). A combined ANOVA was conducted on plot means for all treatments in the two years. Significant differences between varieties were compared using the Fisher's least significant difference (LSD) at 5% probability level. Afterwards, Multiple Linear Regression Model (MLRM) was used to establish the linear relationship of dependent and independent variable [JEFFER, 1967] using PROC REG in SAS. The general linear model for MLRM in which response is related to a set of independent variables (X1) is given:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_k X_k + \varepsilon_i$$

Where Y = dependent variable, β_0 is the intercept, β_1, β_2 … β_k are coefficients of the variables, X_1, X_2 … X_k are k^{th} independent variables and ε_i error term.

Principal Component Analysis (PCA) was performed to determine the parameters that account for most of the variations using R statistical software (Version 4.2.2) and was plotted using the package 'FactoMineR'.

Table 1. Treatments and their description

Treatments	Description
T1 (Weedy)	No weeding was done throughout the experiment
T2 (Weedy free)	Hoe weeding was carried out every week
T3 (Manual I)	Hoe weeding was done at (3weeks interval) 3, 6, and 9 WAP
T4 (Manual II)	Hoe weeding was done at (2weeks interval) 2, 4, 6, and 8 WAP
T5 (PeEH)	Pre emergence herbicide Glyphosate at 1.08 kg a.i ha $^{-1}$
T6 (PoEH)	Post emergence herbicide Nicosulfuron at 0.12 kg a.i .ha $^{-1}$
T7 (Cowpea)	Maize was relayed into cowpea at 2 WAP
T8 (Potato vine)	Maize was relayed into potato at 2 WAP

Results

Weed biodiversity

The species list of weeds encountered during the study is presented in Table 2. Altogether, sixteen weed species were identified during the two years when this experiment was conducted. The overview of various weed species, their families, life cycles, and densities over two years are shown in Table 3. Understanding weed density and relative density is crucial for managing weed populations and ensuring healthy crop growth. The weeds belong to nine different families, with a dominance of species from the Asteraceae, Poaceae, and Euphorbiaceae families. 50% of these weeds belong to broadleaves while the rest 50% are grass family. Seven of these weeds were annual while eight were perennial and only *Tithonia diversifolia* can either be annual or perennial depending on various environmental factors that enhance the survival of this weed species. The relative densities are provided for Year 1 and Year 2, showing significant variations across the years. *Euphorbia heterophylla* exhibited the highest weed density in Year 1, with a relative density of 54.82%, indicating it was the most dominant weed. *Imperata cylindrica* which is a grass weed also showed significant presence with relative densities of 23.35% in Year 1 while *Tithonia diversifolia* dominated the field in Year 2, with a relative density of 37.43%. This broadleaf weed is both an annual and perennial, making it more resilient and harder to control.

Means separation across all the treatments for Weed density, dry weed biomass, weed control effectiveness {Rated (1-10)}, and Phytotoxicity also rated 0-5 were presented in Table 2. The highest weed population (46.778) was observed in the weedy treatment, where no control measures were applied and this shows the natural weed proliferation without intervention. Weed-free treatment had the lowest weed population (17.722); Manual I (27.222) and Manual II (24.389) plots were manually weeded at different interval, and both significantly reduced the weed population compared to the weedy treatment, although they did not perform as well as the weed-free treatment. All other treatments showed relatively weed control efficiencies. Cowpea (24.333) and Potato vine (25.389) treatment plots had moderate weed populations, similar to the manual weeding methods, showing that they provided reasonable control of weeds. The overall mean for weed population was 28.59, with significant variation between treatments as indicated by the LSD (Least Significant Difference) value of 6.45. This suggests that differences greater than 6.45 between treatment means are statistically significant. Similar inferences was drawn from weed biomass production from all the treatment plots. The average dry weed biomass across all treatments was 0.04 kg/ha, with a significant difference between treatments at the LSD of 0.01 kg/ha. The average weed control rating was 7.28, indicating generally good control across treatments, with an LSD of 1.38, meaning differences in weed control ratings greater than 1.38 are statistically significant.

The overall analysis suggests that both manual and organic treatments (cowpea and potato vine) offer effective weed control with no phytotoxicity, while PoEH provides good control but with some crop damage. Weed-free and manual methods remain the most reliable in terms of reducing weed populations and biomass.

Table 2. Weed species list at the experimental site during study periods

Weed Species	Family	Class	Life Cycle	Weed Density (m^2)		Relative Density %	
				Year 1	Year 2	Year 1	Year 2
Acanthrospermum hispidum DC.	Asteraceae	Broadleaf	A	7		3.55	
Tithonia diversifolia (Hemsl.) A.Gray	Asteraceae	Broadleaf	A/P		64		37.43
Tridax procumbens L.	Asteraceae	Broadleaf	A	1		0.51	
Euphorbia heterophylla Desf.	Euphorbiaceae	Broadleaf	A	108		54.82	
Cleome rutidosperma DC.	Cleomaceae	Broadleaf	A	11		5.58	
Ipomoea triloba L.	Convolvulaceae	Broadleaf	A		5		2.92
Desmodium scorpiurus (Sw.) Poir.	Fabaceae	Broadleaf	P		12		7.02
Sida acuta Burm.f.	Malvaceae	Broadleaf	P		5		2.92
Mimosa invisa Mart. ex Colla.	Fabaceae	Broadleaf	P		19		11.11
Phyllanthus amarus Schumach. & Thonn.	Phyllanthaceae	Broadleaf	A		11		6.43
Imperata cylindrica (L.) Raeusch.	Poaceae	Grass	P	46		23.35	
Andropogon gayanus Kunth	Poaceae	Grass	P	17		8.63	
Chloris pilosa Schumach.	Poaceae	Grass	P	2		1.02	
Chrysopogon aciculatus (Retz.) Trin.	Poaceae	Grass	P	5		2.54	
Pennisetum violaceum (Lam.) Rich.	Poaceae	Grass	P		22		12.87
Setaria barbata (Lam.) Kunth	Poaceae	Grass	A		33		19.30

Table 3, shows the effect of different treatments caused substantial variation in the number of seeds per cob, grain weight per cob in kg, cob length in m, weight of 100 seeds per plot in kg, grain weight per plot in kg and grain weight per hectare in kg/ha. Weedy free had the highest yield parameters when compared with all the treatment: number of seeds per cob (547.67), grain weight per cob (0.206 kg), cob length (27.00 m), number of seeds per plot (0.033 kg), grain weight per plot

(3.843 kg) and grain weight per hectare (6377.70). Manual I was significantly higher than Manual II only in terms of number of seeds per cob (452.67) and weight of seed per plot (0.029 kg). All other yield parameters in Manual I and Manual II were not significantly different. Treatment PoEH which is a post emergent herbicide had yield parameters that were significantly higher than treatments PeEH across all the yield parameters. This implies that when yield is being considered post emergence herbicide will give higher yield than pre emergence herbicides. However, for treatments Cowpea and Potato, there is no significant difference between the two treatments except in terms of seeds per plot in which, cowpea (0.026 kg) than potato (0.024 kg). This implies cowpea and potato interchangeable for weed control and still have the same yield.

Table 3. Mean value for weed parameters of the evaluated treatments across the two years in kg/ha

Treatments	Weed parameters			
	Weed Population ($0.5m^2$)	**Dry Weed Biomass (kg/ha)**	**Weed Control Rating (1-10)**	**Phytotoxicity Rating (0-5)**
Weedy	46.78a	0.07a	3.44c	0.00b
Weed free	17.72c	0.02c	9.72a	0.00b
Manual I	27.22b	0.04b	7.22b	0.00b
Manual II	24.39b	0.04b	7.94b	0.00b
PeEH	40.61a	0.04b	6.89b	0.00b
PoEH	22.28bc	0.04b	7.89b	1.00a
Cowpea	24.33b	0.04b	7.61b	0.00b
Potato vine	25.39b	0.04b	7.50b	0.00b
Mean	28.59	0.04	7.28	0.13
LSD(0.05)	6.45	0.01	1.38	0.19

Means followed by the same letter in a column are not significantly different at 5% probability level. PeEH – pre emergence herbicide; PoEH – post emergence herbicides; LSD – least significant difference at 5% probability levels.

Multivariate analysis of weed and maize parameters

The correlogram illustrates the strength and direction of the linear relationships between parameters. In Figure 1, the dry weed biomass had a linear positive significant ($p<0.05$) relationships with weed population ($r = 0.81$). The weed population had a strong negative linear significant ($p<0.01$) relationship with the number of seeds per cob ($r = -0.91$). A similar trend was seen in grain weight per cob ($r = -0.87$), Dry weed biomass also had a strong negative linear significant ($p<0.01$) relationship with the number of seeds per cob ($r = -0.91$). A similar trend as that of weed population was seen in cob length ($r = -0.85$). Weed population also had a negative linear significant ($p<0.05$) relationship with cob length ($r = -0.83$) in similar manner as dry weed biomass with grain weight per plot ($r = -0.82$) for weed population and grain weight per plot ($r = -0.83$). For grain weight per hectare $r = -0.83$ and $r = -0.81$ respectively. However, there was very strong negative high correlation relationship ($p<0.001$) of dry weed biomass with weed control rating ($r = -0.98$) and grain weight per cob ($r = -0.93$).

Regression analysis examining the relationship between dry weed biomass and differences in yield parameters of maize (Table 5). It further indicates that dry weed biomass as controlled by the treatments in this experiment affects maize production negatively. This is further indicated by the strong significance of the regression coefficient ($p<0.001$ and $p<0.01$) and coefficient of determination ($R^2>0.9$) in Table 4. Consistent with the important differentiating parameter, a regression analysis examining the relationship between dry weed biomass and yield in maize. This is indicated in the strong significance in number of seed per cob, grain weight per cob, length of cob, weight of seed per cob and grain weight per plot for each treatment are not left out.

Principal component analysis (PCA) was based on the measured weed and maize parameters. The first two principal components (PCs) with eigenvalues >1 accounted for approximately 91% of the total variation among the accessions. The first and second PCs explained 80.7% and 10.3% of the total variation among the accessions, respectively. The proportion of variance explained by the third PC was 4.1% and the fourth PC accounted for 3.2% of the total variation. The PCs loading visualized by the PCA biplot shows the contributions of the measured parameters to PC1 and PC2 (Figure 2). The vectors of phytotoxicity rating, grain weight per hectare, cob length, weed population, dry weed biomass, grain weight per cob and grain weight of seed per plot point in the direction of PC1. The strength of the vectors weed population and dry weed biomass denotes a strong positive influence on PC1. Conversely, the vectors weed control rating, phytotoxicity, number of seed per cob, grain weight per cob, cob length, weight of seed per plot, and grain weight per hectare points to the negative side of PC1, indicating a strong negative influence on PC1. Dry weed biomass and weed population had a strong positive influence on PC1 while only weed population influenced PC2 positively.

Table 4. Mean value of yield parameters on maize for the evaluated treatments in kg/ha

Treatments	Yield Parameters on Maize					
	Number of Seeds per Cob	**Grain Weight per Cob (kg)**	**Cob Length (m)**	**Weight of Seed Per plot (kg)**	**Grain Weight Per Plot (kg)**	**Grain Weight per hectare (kg/ha)**
Weedy	177.00c	0.05d	13.33c	0.01d	0.24d	399.30d
Weedy free	547.67a	0.21a	27.00a	0.03a	3.84a	6377.70a
Manual I	452.67bc	0.15b	24.67a	0.03abc	2.90b	4750.50b
Manual II	493.83ab	0.15b	24.50a	0.03bc	2.99b	4970.00b
PeEH	346.17d	0.12c	20.33b	0.03bc	1.52c	2140.70c
PoEH	449.67bc	0.15b	26.00a	0.03ab	2.86b	4761.80b
Cowpea	400.67cd	0.12c	19.67b	0.03bc	1.56c	2593.30c
Potato	382.33cd	0.12c	20.33b	0.02c	1.55c	2473.70c
Mean	406.25	0.13	21.98	0.03	2.18	3558.37
LSD (0.05)	22.94	0.02	3.28	0.01	0.50	750.07

Means followed by the same letter are not significantly different at 5% probability.

Table 5. Contributions of Dry Weed Biomass (DWB) to differences in yield parameters of maize based on stepwise regression

Agronomic trait	Mean ± SE	Coefficient of determination (R^2)	Regression coefficient (β)	Intercept (α)	Significant F level	Regression equation y = βx + α
Number of seeds per cob	406.25±28.95	0.40	-7082.25***	696.18	15.09	y =-7082.25x + 696.18
Grain weight per cob (kg)	0.13±0.01	0.87	-2.78***	0.25	37.60	y = -2.784x + 0.25
Cob length (cm)	21.979±1.144	0.769	-261.62**	32.689	15.33	y = -261.62x + 32.689
Weight of seed per cob (kg)	0.026±0.002	0.847	-0.354**	0.040	8.45	y = -0.354x + 0.040
Grain weight per plot (kg)	2.182±0.173	0.727	-65.765**	4.874	44.91	y = -65.765x + 4.874

*,**,*** = significant at 0.05, 0.01 and 0.001 probability levels, respectively.

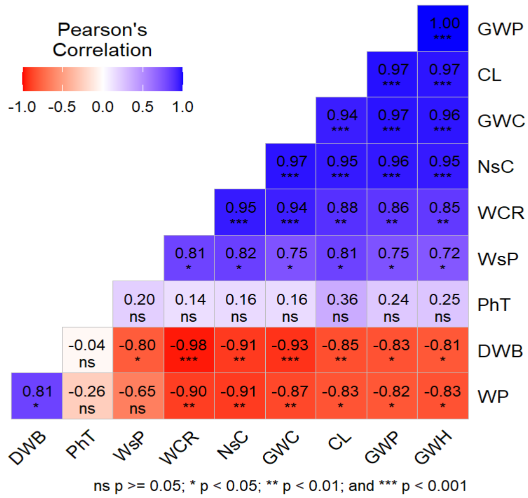

Figure 1. Correlogram showing the relationship between average values of weed and maize parameters. Dark blue denotes a high positive correlation, whereas dark red represents a high negative correlation. The cell value denotes correlation coefficient (r) values. WP = Weed population; DWB = dry weed biomass; PhT = phytotoxicity rating; WsP = weight of 100s seed per plot (kg); WCR = weed control rating (1-10); NsC = number of seed per cob; GWC = grain weight per cob; CL = cob length (cm); GWP = grain weight per plot (kg); GWH = grain weight per hectare (kg/ha); *,**,*** = significant at 0.05, 0.01 and 0.001 probability levels, respectively; ns = nonsignificant.

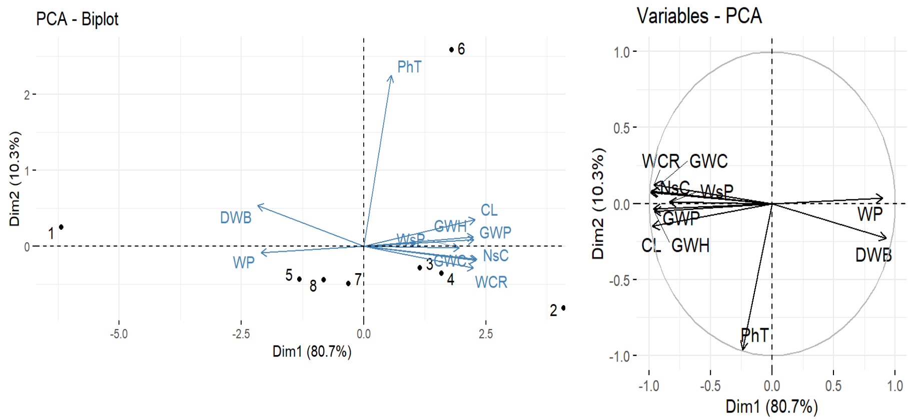

Figure 2. A two-dimensional principal component analysis (PCA) showing the relationships weed and maize parameters and checks evaluated. The first two components, PC1 (80.7%) and PC2 (10.3%) explaining the highest variance were plotted on the x-axis and y-axis, respectively. The arrows indicate weed and maize parameters contributing to the respective PCs and the correlation between parameters can be determined by the close arrow proximity. WP = weed population; DWB = dry weed biomass; PhT = phytotoxicity rating; WsP = weight of seed per plot (kg); WCR = weed control rating (1-10); NsC = number of seed per cob; GWC = grain weight per cob; CL = cob length (cm); GWP = grain weight per plot (kg); GWH = grain weight per hectare (kg/ha).

Discussions

The variation in weed density and species dominance between the two years indicates the dynamic nature of weed populations, likely influenced by environmental factors, crop rotations, or herbicide applications. The dominance of broadleaf species like *Euphorbia heterophylla* in Year 1 and *Tithonia diversifolia* in Year 2, as well as the emergence of grass weeds like *Imperata cylindrica* and *Setaria barbata*, suggests that integrated weed management strategies are required to target both broadleaf and grassy species.

The result shows that Manual I, Manual II, PeEH, PoEH, Cowpea, and Potato vine are all effective methods of weed control when compared to weedy plots as supported by IMOLOAME & OSUNLOLA (2017) and NGONADI & al. (2023). The weed control rating of this experiment also followed the same trend as they are not significantly different at 5% probability level. The effects of treatments on yield and yield components of maize shows that the use of post emergence herbicide (PoEH) method of weed control works effectively as Manual I and Manual II methods of weed control since there is no significant difference among them for all yield and yield components of maize. This finding is in accordance with the work of UGBE & al. (2016) and TIZHE & al. (2023). The yield in post emergence herbicide-PoEH was also significantly higher as a method of weed control when compared to that in Cowpea and Potato vine. This aligns with the findings of IMOLOAME (2017) and FALADE & al. (2023), who documented that the use of herbicides supports yield in maize. However, cowpea and potato vine treatments (cover crops) there was no significant difference in all the yield and yield components in maize production which implies they can be used interchangeably. This agrees with the works of NAYAN & al. (2020) and MAS-UD & al. (2021).

Regression analysis shows a significant effect between dry weed biomass and the yield and yield components of maize. It highlights the impact of the linear trends of the response of yield and yield components in maize. This signifies that a unit increase in dry weed biomass will likely lead to a decrease in yield and yield components in maize which is following the work of KOLAWOLE & OLAYINKA (2023) whose result on regression analysis shows that a unit increase in an independent variable can lead to an increase in the dependent variable (yield). The two-year combined data (2023-2024) in the correlogram shows that a positive highly significant correlation was revealed in the weight of seed per plot and weed control rating which is in accordance with the findings of VERMA & al. (2023). However, dry weed biomass, and weed population were highly negatively correlated with yield. This result supports the findings of VERMA & al. (2023) and DANIYA & al. (2013) who reported negative correlations between weed components and yield in cowpea and sesame respectively.

The PC analysis identifies two PCs accounting for 91% of the variations observed in which dry weed biomass and weed populations are the major parameters responsible as descriptors of yield and yield components in maize. This finding aligns with that of OLAYINKA & al. (2024) whose work identified four PCs to be collectively responsible for 73% of total variations in the research.

Conclusion

The different weed control efficacy assessment varied for all treatments-weed control methods. The weed-free plot stood out regarding maize yield and yield components. Post-emergence weed control PoEH gave a yield that had no significant difference from that of Manual I and Manual II which may be laborious and expensive in areas where availability of manpower is a limiting factor. This experiment affirms the reason why the use of herbicide is preferred over other control methods. Also, the findings from this experiment from the regression, correlation, and PC analysis show that weeds generally are principal factors determining yields in maize the derived savanna agroecology of Nigeria.

References

ABAH D., ESHEYA S. & OCHOCHE C. O. 2021. Effect of maize production on agricultural output in Nigeria (1981-2019): Implication for sustainable development. *International Journal of Agricultural Economics, Management and Development* (IJAEMD). **9**(1): 42-54.

AKOBUNDU I. O., EKELEME F., AYAKWA C. W. & OGAZIE C. A. 2016. *A handbook of West African weeds*. International Institute of Tropical Agriculture, Ibadan: p. 380-382.

BOUIS H. E., HOTZ C., MCCLAFFERTY B., MEENAKSHI J. V. & PFEIFFER W. H. 2011. Biofortification: a new tool to reduce micronutrient malnutrition. *Food and Nutrition Bulletin.* **32**(suppl.1): S31-S40. https://doi.org/10.1177/15648265110321s105

DANIYA E., DADARI S. A., NDAHI W. B., KUCHINDA N. C. & BABAJI B. A. 2013. Correlation and path analysis between seed yield and some weed and quantitative components in two sesame (*Sesamum indicum* L.) varieties as influenced by seed rate and nitrogen fertilizer. *Journal of Biology, Agriculture and Healthcare* **3**(15): 12-16.

ERENSTEIN O., JALETA M., SONDER K., MOTTALEB K. & PRASANNA B. M. 2022. Global maize production, consumption and trade: trends and R&D implications. *Food Security.* **14**(5): 1295-1319. https://doi.org/10.1007/s12571-022-01288-7

EWETOLA E. A. & OSHUNSANYA S. O. 2015. Artificial topsoil removal effect on some arable crops performance in Ogbomoso, Nigeria. *Journal of Agriculture and Veterinary Science.* **8**(5): 90-98. https://doi.org/10.9790/2380-08519098

FALADE A. A., LAGOKE S. T. O., ADIGUN J. A., PITAN O. R. & OSUNLETI O. S. 2023. Growth and yield of maize (*Zea mays* L.) as influenced by cropping pattern and weed control treatments in the forest – savanna agro-ecological zone of southwest Nigeria. *Acta Fytotechnica et Zootechnica.* **26**(2): 155-162. https://doi.org/10.15414/afz.2023.26.02.155-162

FAO. 2020. *The State of Food and Agriculture 2020. Overcoming water challenges in agriculture*. Rome. https://doi.org/10.4060/cb1447en

HARUNA L. Z., SENNUGA S. O., BAMIDELE J., BANKOLE O. L., ALABUJA F. O., PREYOR T. J. & BARNABAS T. M. 2023. Factors influencing farmers' adoption of improved technologies in Maize Production in Kuje Area Council of FCT-Abuja, Nigeria. *GPH-International Journal of Agriculture and Research.* **6**(4): 25-41. https://doi.org/10.5281/zenodo.7924557

IMOLOAME E. O. 2017. Evaluation of herbicide mixtures and manual weed control method in maize (*Zea mays* L.) production in the Southern Guinea agro-ecology of Nigeria. *Cogent Food & Agriculture.* **3**: 1375378. https://doi.org/10.1080/23311932.2017.1375378

IMOLOAME E. O. & OSUNLOLA O. S. 2017. Effect of method of weed control and insecticide (*Lambda cyhalothrin*) rates on the productivity of cowpea (*Vigna unguiculata* (L.) Walp.) in a southern Guinea savanna of Nigeria. *Revista Brasileira de Herbicidas.* **16**(3): 216-229. https://doi.org/10.7824/rbh.v16i3.531

JEFFERS J. N. R. 1967. Two case studies in the application of principal component analysis. *Journal of the Royal Statistical Society. Series C (Applied Statistics)*. **16**: 225-236.

KOLAWOLE A. O. & OLAYINKA A. F. 2023. Evaluation of the relationship between nitrogen fertilization and agronomic performance of maize (*Zea mays* L.) varieties. *Open access journal of Agricultural Research 8*(4): 000322. https://doi.org/10.23880/oajar-16000322

LIEBMAN M. & ZIMDAHL R. L. 2018. *Cultural techniques to manage weeds. Integrated weed management for sustainable agriculture*. London: Burleigh Dodds Science Publishing, p. 203-226.

LU Y. & MOSIER N. S. 2008. Current technologies for fuel ethanol production from lignocellulosic plant biomass. In: VERMERRIS W. (ed.) *Genetic improvement of bioenergy crops*. Springer, New York: p. 161-182. https://doi.org/10.1007/978-0-387-70805-8_6

LUKANGILA M. A. B., TABU H. I., MUGISHO D. B., LUBOBO A. K. & MBOMBO A. K. M. W. 2024. Evaluating the effects of manual hoeing and selective herbicides on maize (*Zea mays* L.) productivity and profitability. *Heliyon.* **10**(13): e33294. https://doi.org/10.1016/j.heliyon.2024.e33294

MAKAMA S. A., UMAR S. M., ISAH M. A., SADIQ M. S. & MAGAJI B. D. 2022. Socioeconomic factors influencing maize production in Giwa Local Government area of Kaduna state, Nigeria. *Journal of Agriculture and Environment.* **18**(2): 135-139.

MAS-UD M., DOKURUGU F. & KABA J. S. 2021. Effectiveness of cowpea (*Vigna unguiculata* L.) living mulch on weed suppression and yield of maize (*Zea mays* L.). *Open Agriculture*. **6**(1): 489-497. https://doi.org/10.1515/opag-2021-0031

NAYAN G. S., TAKIM F. O., AREMU C. O. & OKUNOLA A. A. 2020. Effect of maize sweet potato intercrop over sole cropping system on weed infestation. *IOP Conference Series*: *Earth and Environmental Science*. **445**: 012007. https://doi.org/10.1088/1755-1315/445/1/012007

NGONADI E. N., UKO I. & OKONKWO N. J. 2023. Profitability of selected weed control methods in maize (*Zea mays* L. Moench) production at Igbariam in three successive months. *International Journal of Agriculture, Food and Biodiversity*. **2**(1): 37-42.

NUSS E. T. & TANUMIHARDJO S. A. 2010. Maize: a paramount staple crop in the context of global nutrition. *Comprehensive Reviews in Food Science and Food Safety*. **9**(4): 417-436. https://doi.org/10.1111/j.1541-4337.2010.00117.x

OLANIYAN A. B. 2015. Maize: Panacea for hunger in Nigeria. *African Journal of Plant Science*. **9**(3): 155-174. https://doi.org/10.5897/AJPS2014.1203

OLAYINKA A. O., IBITOYE D. O. & ADERIBIGBE O. R. 2024. Unveiling phenotypic diversity among tomato (*Solanum lycopersicum* L.) accessions: a comprehensive analysis of agronomic and physicochemical traits. *Technology in Horticulture*. **4**: e021. https://doi.org/10.48130/tihort-0024-0018

POOLE N., DONOVAN J. & ERENSTEIN O. 2021. Agri-nutrition research: revisiting the contribution of maize and wheat to human nutrition and health. *Food Policy*. **100**: 101976. https://doi.org/10.1016/j.foodpol.2020.101976

REVILLA P., ALVES M. L., ANDELKOVIĆ V., BALCONI C., DINIS I., MENDES-MOREIRA P., REDAELLI R., RUIZ De GALARRETA J. I., VAZ PATTO M. C., ŽILIĆ S. & MALVAR R. A. 2022. Traditional foods from maize (*Zea mays* L.) in Europe. *Frontiers in Nutrition*. **8**: 683399. https://doi.org/10.3389/fnut.2021.683399

SAS. 2011. Statistical Analysis System for windows. Release 9.4. SAS Institute Inc. Cary, North Carolina, USA.

SINGH N., SINGH J., KAUR L., SODHI N. S. & GILL B. S. 2003. Morphological, thermal and rheological properties of starches from different botanical sources. *Food Chemistry*. **81**(2): 219-231. https://doi.org/10.1016/S0308-8146(02)00416-8

SMALE M. & MASON N. 2014. Hybrid seed and the economic well-being of smallholder maize farmers in Zambia. *Journal of Development Studies*. **50**(5): 680-695. https://doi.org/10.1080/00220388.2014.887690

SOLTANI N., DILLE J. A., BURKE I. C., EVERMAN W. J., VANGESSEL M. J., DAVIS V. M. & SIKKEMA P. H. 2016. Potential corn yield losses from weeds in North America. *Weed Technology*. **30**(4): 979-984. https://doi.org/10.1614/WT-D-16-00046.1

TIZHE T. D., ALONGE S. O., ADEKPE D. I. & IOORTSUUN D. N. 2023. Evaluation of the effect of nicosulfuron and bentazone herbicides on growth and yield performance of two maize varieties in Mubi, Nigeria. *Asian Journal of Agriculture*. **7**(2): 122-130. https://doi.org/10.13057/asianjagric/g070208

UGBE L. A., NDAEYO N. U. & ENYONG J. F. 2016. Efficacy of selected herbicides on weed control, cowpea (*Vigna uniguiculata* L. Walp) performance and economic returns in Akamkpa, Southeastern Nigeria. *International Journal of Research in Agriculture and Forestry*. **3**(5): 19-27.

VERMA K. C., SINGH H., MEENA R., KHAN M., ATTAR S. K., KHATIK C. L., MAHALA S. C. & DHAKA S. R. 2023. Correlation coefficient and path analysis between grain yield and growth parameters, weed and yield attributes of cowpea (*Vigna unguiculata* L.) as influenced by weed management practices under rainfed condition. *The Pharma Innovation Journal*. **12**(6): 2142-2146.

WOSSEN T., MENKIR A., ALENE A., ABDOULAYE T., AJALA S., BADU-APRAKU B., GEDIL M., MENGESHA W. & MESEKA S. 2023. Drivers of transformation of the maize sector in Nigeria. *Global Food Security*. **38**: 100713. https://doi.org/10.1016/j.gfs.2023.100713

How to cite this article:

AFON O. P., AJAYI O. O., OLAYINKA A. O., OLAGUNJU E. A. & ADESINA G. O. 2024. Assessing different strategies for controlling weeds in maize cultivation within the derived savanna agro-ecology in Nigeria. *J. Plant Develop*. **31**: 105-115. https://doi.org/10.47743/jpd.2024.31.1.960