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Effect of Weed Control Techniques on Bambara Groundnut (*Vigna Subterranea* (L.) Verdc) Varieties in Semi-Arid Environment of Nigeria

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ABSTRACT

Multi-locational field trials were conducted during the 2021 growing season at Teaching and Research Farm Faculty of Agriculture of BUK and FUDMA to study the herbicidal potentials of *Tithonia diversifolia (hemsley)* a. gray on weed component of bambara groundnut (*Vigna subterrenea (l.) verdc*) genotypes in Semi-arid zone of Nigeria. The experiment consisted of three (3) Bambara groundnut genotype (Hawayen Zaki, Idon Bazawara and Red) and nine (9) (w1, w2, w3, w4, w5, w6, w7, w8, w9) weed control methods which were factorially combined in three replications, and were laid out in a split plot design with genotypes at the main plot while weed control methods at the sub-plot. The gross plot size consisted of 6 ridges, 0.75 m apart and 3 m long (11.25m2). The net plot contained four (4) inner ridges of 3m long (9 m2), and the last two border rows served as discard. Data on weed parameters were collected and subjected to analysis of variance for Split Plot Design (SPD). F-test was used to test for the level of significance, mean comparison was done using Student Newmans' Keul (SNK) at $P < 0.05$, Statistical analysis Software (SAS) version 9.1 was used to analyze the generated data. The findings indicated that the Weed Specie Composition shows *Digitaria nuda Schumach* was present in the DTM but not in the BUK while *Eragrostis tremula Hochst*. Ex Steud was present at BUK with a high occurrence level, but was not found at DTM.

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Keywords: *Vigna Subterranea,* Herbicidal Potentials, *Digitaria nuda Schumach*

INTRODUCTION

Bambara groundnut (*Vigna subterranea* (L.) Verdc) is a legume indigenous to Africa and is cultivated across the semi-arid sub-Saharan Africa region (Hillocks *et al.,* 2012). It is a hardy crop and has been recognized as an important nutritious food source when food is scarce (Mbosso *et al.,* 2020). Bambara groundnut is thought to have its center of origin somewhere between West and Central Africa (Temegne *et al.,* 2018). It is grown widely in sub-Saharan Africa and is also present at low levels in Thailand, Malaysia, and Indonesia (Mayes *et a.l,* 2019). Higher preference for Bambara groundnut has been observed in dry regions prone to drought (Mubaiwa *et al.,* 2018). This is possibly linked to its ability to produce reasonable yields under such conditions, hence acting as a safety net for farmers. This could be attributed to its climate-smart features, including its ability to fix nitrogen, and to grow under adverse environmental conditions such as poor soils and drought (Mayes *et al.,* 2019; Paliwal *et al.,* 2020). Bambara groundnut is nutrient-dense legume which is sometimes termed a "complete food" due to its balanced macronutrient composition. It contains about 64.4% carbohydrate, 23.6% protein, 6.5% fat, and 5.5% fiber and is rich in minerals (Azman *et al.,* 2019). It is relatively underutilized compared with major cash crops and has often been associated with small-scale, subsistence farming, with women being the major producers and processors (Mbosso *et al.,* 2020; Mubaiwa *et al.,* 2018). Bambara groundnut production is very low due to biotic and abiotic constraints. Some of the biotic constraints to bambara groundnut production are; pest, diseases and weed infestation. Weed compete with bambara groundnut for limited environmental resource and habour disease and pest that are harmful to the crop plants bambara groundnut yield lobes due to weed reported local research (Mubiat, 2009). Ohiambo and Stomph, 2005 reported about 90% yield loss of Bambaranut due to weed infestation. Similarly, 40-60% yield loss due to weed in bambaranut has been recorded. (Kumar and Yadav 2005).

MATERIALS AND METHODS

Experimental Sites

Field trials were conducted at Teaching and Research Farm of Faculty of Agriculture, Bayero University Kano (latitude 11^0 58'N, longitude 8^{0}25'E and 475m above sea level) and Teaching and Research farm of Faculty of Agriculture Federal University Dutsin-Ma (FUDMA) (latitude 12^0 08'N, longitude 8^0 32'E, 500 m above sea level) during the 2021 and 2022 rainy season.

Meteorological Data

During the experimental period, records of rainfall, temperature, sunshine hour and relative humidity in the experimental sites (BUK and FUDMA research farms) were collected from the meteorological station of BUK and FUDMA respectively.

Determination of Soil Nutrient Status

Soil samples were collected randomly from the experimental sites at a depth of 0-30 cm the samples collected was bulked, sieved; oven dried and was subjected to physicochemical analysis. Soil samples were collected randomly from the experimental sites at a depth of 0-30 cm using soil auger. Routine soil analysis was carried out to determine particle size distribution by hydrometer method (Bouyocous, 1951). Soil pH, using pH meter as described by Walkley and Black (1934), total N was determined using Kjeldhal method as described by Bremner and Mulvaney (1982). Available P was determined by Bray 1 test (Bray and Kurtz, 1945). Exchangeable bases (Ca, Mg, k and Na) were extracted with IN Ammonium (NH_4OAC) (Anderson and Ingram, 1993) Ca and Mg were determined using absorption spectrophotometer while K and Na was determined using flame photometer. Soil samples taken after the experiment from each plot and was subjected to pesticide residue analysis.

Treatments and Experimental Designs

The experiment consisted of three (3) Bambara groundnut genotypes (hawayen zaki, idon bazawara, and jar gujjiya) which were sourced from Dawanau seed market Kano and nine (9) weed control methods;

i. Pre-emergence application of *Tithonia*,
ii. Pre-emergence application of *Tithonia* followed by (*fb*) Supplementary hoe weeding (*SHW*) at 6 weeks after sowing (WAS),
iii. Pre-emergence application of *Tithonia* followed by (*fb*) post-emergence application of *Tithonia* at 6 WAS,
iv. Pre-emergence application of *Tithonia* followed by (*fb*) imazethapyr 0.5kg ai/ha at 6 AWAS,
v. Pre-emergence application of pendimenthaline 2.0 kg ai/ha followed by (*fb*) post-emergence application of *Tithonia* at 6 WAS,
vi. Pre-emergence application of pendimenthaline 2.0 kg ai/ha followed by (*fb*) imazethapyr 0.5kg ai/ha at 6 WAS,
vii. Pre-emergence application of pendimenthaline 2.0 kg ai/ha followed by (*fb*) supplementary hoe weeding (*SHW*) at 6 WAS,
viii. Supplementary hoe weeding (*SHW*) at 3and 6 WAS,
ix. Weedy check.

These were factorially combined with three replications, and was laid out in a split plot design with genotypes at the main plot while weed control methods at the sub-plot.

Plot Sizes

The gross plot size consisted of 6 ridges, 0.75 m apart and 3 m long (11.25m^2). The net plot contained four (4) inner ridges of 3m long (9 m^2), and the last two border rows served as discard for destructive sampling.

Preparation of the *Tithonia* Extract

Aqueous extract was prepared according to Hua *et al*., (2005) with little modification. Fresh *Tithonia diversifolia* plants were collected, cleanse and separate into leaves and shoots. The leaves were chopped into about 3-5cm and air dried at room temperature to constant weight. The dried leaves were milled into fine powder with A2 grinder and sieved through 10 mm sieve. 1000g of the powder of various parts was placed into 20 litre plastic bucket and was soaked in 20 litre of distilled water for 24 hours at room temperature to obtain the solution that was used as herbicide during the trial.

Description of the Genotype

i. Stripped cream: This is a medium maturing (60-90 days) genotype with a potential of almost 4 tons per hectare
ii. Ja: This is a variety that is red in color it is also medium maturing ((60-90 days) with a potential yield of 3.5 tons per hectare
iii. Idon bazawara: this is also a medium maturing genotype with potential yield of 3.5 ton per ha.

Cultural Practices

Land Preparation

The land was harrowed and ridged 75cm apart using tractor after which the plots were demarcated. A space of 1 m between the plots and 2 m between replicates was used as borders.

Sowing

Three seeds were sown per stand and later thinned to two seedlings per stand at 2 weeks after sowing (WAS). An intra-row spacing of 15cm was maintained.

Weed Control

This was carried out as per treatment basis.

Fertilizer Application

Fertilizer was applied to each plot at the rate of 30 Kg N: 500 kgha^{-1} P_2O_5 and 40kg k per hectare at sowing. All of N, K and half of P were applied basally a week after emergence using NPK 15:15:15 the remaining half of P was applied at 4 WAS Using SSP 18%.

Pest Control

Insect pest observed during the trial were controlled using cypermethrin 50 EC at the rate of 1 liter/ha using knapsack sprayer.

Harvesting

Harvesting was done manually at physiological maturity stage. This was done by digging up the whole plant using a hoe and hand picking of the pods from the soil.

Data Collection

Data on the following weed component were collected per plot and per hectare

Weed Species Composition

Weeds were harvested from 1 m^2 quadrant which was randomly placed in each of the net plots at physiological maturity of the crop. The harvested weeds were identified by species, and separated in to grasses, sedges and broadleaves.

Weeds Cover Score

Weed cover score was taken at physiological maturity by visual observation using a scale of 1-5, where 1 represents low weed cover while 5 represents complete cover according to the scale used by Komboik *et al.* (2003).

Weed Dry Weight (g)

The weed sampled obtained from the above were cleaned, washed and oven dried at 65 ^{0}C to a constant weight. The dried weeds were measured using a mettler weighing balance (model number PB3002-SRS) and extrapolated to kgha^{-1}.

Weed Density

The weeds samples identified were counted to obtain the density of the individual weed species. The sums of all species recorded at harvest were taken as the total weed density for each plot.

Weed Index (WI)

This was estimated using the equation below;

Weed index (%) =

$$\frac{\text{Yield from weed free plot - Yield from treated plots}}{\text{Yield from weed free plot}} x100$$

This helped in accessing each weed control methods the lesser the weed index the better efficiency of the herbicide and vice versa.

Weed control efficiency (WCE) (%)
This was determined at maturity using the formula deduced by Das (2011).

$$\text{WCE (\%)} = \frac{\text{Dry weight of weed in an unweeded area - dry weight of weed in weeded control}}{\text{dry weight of weed in weeded control}} x100$$

RESULTS AND DISCUSSION

Table 1: Weed Species Compositions In and Their Level of Occurrence at BUK and DTM during the 2021 Rainy Season

Weeds species	Level of Occurrence BUK	Dutsin-Ma
Narrow leaves		
Achyranthes aspera L.	***	*
Aerva javanica (Burm.f.) Schult.	**	**
Cynodon dactylon	***	*
Eleusine indica	**	***
Eragrostis tremula Hochst. Ex Steud.	-	
Broad leaves weeds		
Amaranthus spinosus	*	**
Abelmoschus moschatus Medik.	*	**
Celosia loxa	-	***
Cassia mimosoides L.		*
Hyptis spicigera	*	-
Senna occidentalis	-	*
Ageratum conyzoides	***	**
Ludwiga octovalvis (Jacq) P. Raven	*	-
Aspilia africana	**	*
Chromoleana odorata	***	**
Tridax procumbens	***	**
Calopogonium mucunoidess Desv.	-	-
Commelina benghalensis	***	**
Euphorbia heterophyila	**	*
Phyllantus amarus	**	***
Conmelina diffusa	***	-
Sedges		
Cyperus rotundus	**	*
Cyperus tuberosus	*	**

- =no infestation: * low infestation (30% frequency of occurrence): ** moderate infestation (30-60% frequency of occurrence); *** heavy infestation (>60% frequency of occurrence), BUK Bayero University Kano, DTM Dutsin-Ma.

Table 2: Weed Density and Weed Dry Weigh As Influenced By Weed Control Methods and Bambara Groundnut Genotypes during the 2022 Wet Season at BUK and DTM

Treatments	Weed Density BUK	Weed Density DTM	Weed dry weight BUK	Weed dry weight DTM
Genotypes(G)				
Hawayen zaki	101.67	73.11	188.09^{a}	37.17^{b}
Ja	105.26	77.11	132.85^{b}	47.78^{a}
Idon bazawara	91.78	79.96	164.13^{ab}	50.45^{a}
p-value	0.837	0.798	0.005	<.0001
SE±	16.51	7.23	11.53	2.06
Weed control(W)				
Pre emergence application of tithonia	135.78	56.67^{bc}	159.21^{b}	45.63^{b}
Pre-emergence application of *Tithonia* fb Supplementary hoe weeding at 6 WAS,	121.67	70.00^{bc}	149.88^{b}	38.78^{b}
Pre-emergence application of *Tithonia* fb post-emergence application of *Tithonia* at 6 WAS	75.56	76.11^{b}	138.00^{b}	42.74^{b}
Pre-emergence application of *Tithonia fb* imazethapyr 0.5kg ai/ha at 6 AWAS	110.33	91.56^{b}	126.39^{b}	48.15^{b}
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* post-emergence application of *Tithonia* at 6 WAS	85.22	69.00^{bc}	136.15^{b}	43.63^{b}
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* imazethapyr 0.5kg ai/ha at 6 WAS,	65.22	65.22^{bc}	176.21^{b}	45.74^{b}
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* supplementary hoe weeding at 6 WAS,	72.89	64.78^{bc}	209.89^{b}	39.22^{b}

Treatments	Weed Density		Weed dry weight	
	BUK	DTM	BUK	DTM
Supplementary hoe weeding at 3and 6 WAS,	107.33	20.44[c]	52.57[c]	36.80[b]
Weedy check	122.11	176.78[a]	306.91[a]	65.50[a]
p-value	0.615	<.0001	<.0001	<.0001
SE±	28.60	12.53	19.97	3.57
Interaction				
G*W	0.442	0.7737	0.471	0.8862

Means followed by unlike letter(s) are statistically significant at 5 % level of probability.

Table 3: Weed Control Efficiency and Weed Index as Influenced By Weed Control Methods and Bambara Groundnut Genotypes during the 2022 Wet Season at BUK and DTM

Treatments	Weed control efficiency		Weed index	
	BUK	DTM	BUK	DTM
Genotypes(G)				
Hawayen zaki	38.62[b]	45.46	50.35	38.74
Ja	52.22[a]	46.66	45.38	36.33
Idon bazawara	45.31[ab]	49.28	39.31	45.47
p-value	0.045	0.7117	0.064	0.296
SE±	3.75	3.33	3.25	4.24
Weed control(W)				
Pre emergence application of tithonia	43.28[b]	58.84[ab]	46.54[b]	37.32[a]
Pre-emergence application of *Tithonia* fb Supplementary hoe weeding at 6 WAS,	51.70[b]	52.84[ab]	42.35[b]	36.18[a]
Pre-emergence application of *Tithonia* fb post-emergence application of *Tithonia* at 6 WAS	49.02[b]	54.40[ab]	53.17[b]	44.39[a]
Pre-emergence application of *Tithonia fb* imazethapyr 0.5kg ai/ha at 6 AWAS	55.51[b]	51.98[ab]	49.24[b]	48.45[a]
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* post-emergence application of *Tithonia* at 6 WAS	54.03[b]	48.05[ab]	50.57[b]	43.27[a]
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* imazethapyr 0.5kg ai/ha at 6 WAS,	37.31[b]	43.17[b]	46.97[b]	40.05[a]
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* supplementary hoe weeding at 6 WAS,	34.93[b]	45.68[ab]	45.81[b]	52.73[a]
Supplementary hoe weeding at 3and 6 WAS,	82.68[a]	69.24[a]	0.00[c]	0.00[b]
Weedy check	0.00[c]	0.00[c]	70.49[a]	59.22[a]
p-value	<.0001	<.0001	5.63	7.35
SE±	6.50	5.78	<.0001	<.0001
Interaction				
G*W	0.530	0.6327	0.973	0.5518

Means followed by unlike letter(s) are statistically significant at 5 % level of probability.

Table 4: Weed Cover Score and Weed Control Index as Influenced by Weed Control Methods and Bambara Groundnut Genotypes during the 2022 Wet Season at BUK and DTM

Treatments	Weed cover score		Weed control index	
	BUK	DTM	BUK	DTM
Genotypes(G)				
Hawayen zaki	1.78	1.96		
Ja	2.04	2.41		
Idon bazawara	2.59	2.11		
p-value	0.071	0.354		
SE±	0.25	0.22		
Weed control(W)				
Pre emergence application of tithonia	1.89	2.44[b]		
Pre-emergence application of *Tithonia* fb Supplementary hoe weeding at 6 WAS,	1.67	1.44[b]		
Pre-emergence application of *Tithonia* fb post-emergence application of *Tithonia* at 6 WAS	2.55	1.55[b]		
Pre-emergence application of *Tithonia fb* imazethapyr 0.5kg ai/ha at 6 AWAS	2.78	1.89[b]		
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* post-emergence application of *Tithonia* at 6 WAS	2.22	2.11[b]		

Treatments	Weed cover score		Weed control index	
	BUK	**DTM**	**BUK**	**DTM**
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* imazethapyr 0.5kg ai/ha at 6 WAS,	2.67	1.78[b]		
Pre-emergence application of pendimenthaline 2.0 kg ai/ha *fb* supplementary hoe weeding at 6 WAS,	2.11	2.33[b]		
Supplementary hoe weeding at 3and 6 WAS,	1.67	2.00[b]		
Weedy check	1.67	2.89[a]		
p-value	0.398	0.002		
SE±	0.43	0.38		
Interaction				
G*W	0.795	0.3600		

Means followed by unlike letter(s) are statistically significant at 5 % level of probability.

CONCLUSION

The results show that *Tithonia diversifolia*, when used as a pre-emergence or post-emergence bioherbicide, significantly inhibited weed growth while delivering additional nutrients, increasing crop performance. Manual hoe weeding, albeit labor-intensive, resulted in considerable weed reduction and robust crop growth. Among the three Bambara groundnut landraces tested, "hawayen zaki" regularly outperformed the other two in terms of weed suppression due to its taller stature and larger leaf area, making it a promising choice for integrated weed control. The "Ja" and "Idon Bazawara" landraces showed moderate weed resistance but were limited by slower growth and reduced competitiveness. The cost-benefit analysis revealed that introducing *Tithonia diversifolia* into weed control strategies is both economically viable and environmentally sustainable. Based on the findings of this research, the following recommendations are made. Hawayen Zaki landrace is recommended for optimizing the production of Bambra groundnut in both the study area. Pre-emergence application of pendimethalin 2.0 kg ha^{-1}followed by post-emergence application of tithonia at 6 WAS is recommended as a weed control strategy in the study area.

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