JOURNAL OF AGRIPRENEURSHIP AND SUSTAINABLE DEVELOPMENT (JASD)
Volume 7, Number 1, March, 2024
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365 Website:http://www.jasd.daee.atbu.edu.ng

EFFECTS OF INTEGRATED NUTRIENT AND WEED MANAGEMENT ON WEED DYNAMICS AND MAIZE PERFORMANCE IN MINNA, SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT
A field trial was conducted during the rainy season of 2023 at Minna, southern guinea savanna of Nigeria to determine the effects of inorganic NPK fertilizer and poultry manure as nutrient sources, and control of weeds using manual (hoe) weeding and chemical methods on weed dynamics and performance of maize. The treatments consisted of four nutrient sources (control, NPK fertilizer at the rate of 90-30-30 kg ha^{-1}; poultry manure (PM) at 10 Mg ha^{-1}; NPK fertilizer at the rate of 45-15-15 kg ha^{-1} combined with PM at 5 Mg ha^{-1}) and four weed management (control; pre-emergence herbicide at planting and post-emergence herbicide at 5 weeks after sowing (WAS); two hoe-weeding at 2 and 5 WAS; pre-emergence herbicide at planting and one hoe-weeding at 5 WAS). These were factorially combined and laid out in a randomized complete block design (RCBD) with three replications. Data collected were subjected to analysis of variance and means were separated using Student Newman Keuls (SNK). The results showed that integration of inorganic NPK fertilizer with manure and control of weeds using pre-emergence herbicide and one hoe-weeding at 5 WAS gave significant reduction in weed density and significantly higher weed control efficiency compared to control. The integration of inorganic NPK fertilizer with manure, and control of weeds using pre-emergence herbicide and one hoe-weeding at 5 WAS had significantly higher yield and yield attributes than control. The integration of inorganic fertilizer with manure and control of weeds using pre-emergence herbicide combined with one hoe-weeding at 5 WAS seems to enhance maize production and is recommended for farmers in the study area.
Key words: Dynamics, Maize, Management, Nutrient and Performance.

INTRODUCTION
Maize (*Zea mays* L.), also known as corn, is the third-largest widely consumed cereal crop in the world after rice and wheat (Rakesh *et al.,* 2022). Ajayo *et al.* (2021), reported that out of the 1.15 billion tonnes of maize produced worldwide in 2018, 78.9 million tonnes were produced in Africa and 10.2 million tonnes were produced in Nigeria. In addition to being used as human food and animal feed, maize has a wide variety of industrial applications (Atehnkeng *et al.,* 2016). Chemical fertilizers increase crop output and provide the nutrients that crops need, but under continuous cropping system, its application alone as source of nutrient cannot sustain agricultural production. Organic manures applied in a sequence have been found to improve the use efficiency of inorganic fertilizers. The use of organic manure provides these benefits, including increased sequestration of soil carbon, improved nitrogen fixation, and reduced harmful greenhouse gas (GHG) emission (Wang *et al.,* 2021). Integrated nutrient management (INM), a modified farming

method, has the potential to utilize organic and inorganic resources, to improve the SOC and crops, and making farming more economically viable and sustainable (Padbhushan *et al.,* 2021).

Weed infestation on maize field causes significant reduction in crops yield. Competition of weeds for nutrients, water and sunlight, resulting in low yields according to Scavo and Mauromicale (2020), can be reduced effectively by manual weeding operations but increasing labour cost, its availability for agricultural purposes is very scarce, time consuming and not feasible for larger area. Herbicides are effective against many weed species, but most of them are specific and are effective against narrow range of weed species and raises serious concerns about environmental pollution, herbicide residues in the food chain, the development of herbicide-resistant weeds, and the deterioration of soil biological health (Hasanuzzaman *et al.,* 2020). In order to maintain the weed population below the economic threshold level an integrated weed management method is required. Therefore, it is necessary to use a suitable herbicide in combination with manual weeding to increase weed control efficiency and harness the yield potential of crops.

In Nigeria, maize yield per unit area is still low, at estimate 2 Mg ha^{-1}, which is significantly lower than yields obtained in well-managed field tests, where yields obtained were greater than 7 Mg ha^{-1} (Shehu *et al.,* 2018). The wide gap between potential productivity and actual yield harvested, may be bridged by adopting proper nutrient management in conjunction with weed management. Therefore, the objectives were to determine the effect of integrated nutrient and weed management practices on (i) weed population dynamics and (ii) the yield and yield attributes of maize.

MATERIALS AND METHODS

The study Area

The field experiment was conducted at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology (SAAT) of Federal University of Technology, Minna, Niger State (Latitude 9^{0}31'54.731"N and Longitude 6^{0}27'19.781"E; 235 m above sea level) located in southern guinea savanna region of Nigeria during 2023 cropping season. Minna has distinct dry and rainy seasons, with mean annual rainfall of 1200 mm. Rainfall often starts in March, peak in September and last through October. The mean monthly rainfall during the period of this study was presented in Fig. 1 as provided by FAO Climate Info Tool (2024). The relative humidity is between 60 and 80 %, while the temperature is between 22 and 40 °C (Weather Spark, 2022). The vegetation of the area is mainly short grasses and shrubs with scattered trees. Minna is underlain by basement complex rocks weathered to form dominant soil of order alfisol and subgroups such as Typic Plinthustalf, Plinthic Paleustalf and Typic Plinthaqualf (Lawal, 2017). Prior to the study over the years, the field had been cultivated with maize, yam and cowpea in sole or mixed cropping continuously with little or no fertilization program.

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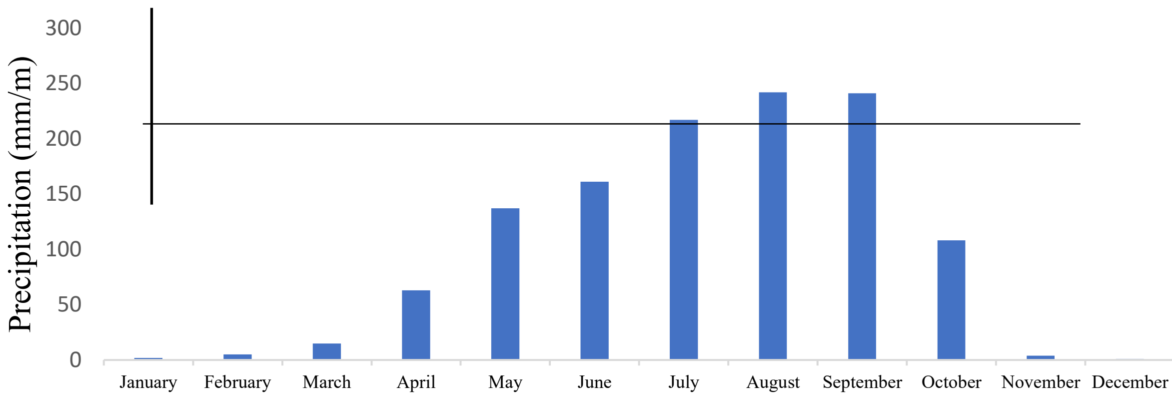

Figure 1: *The mean monthly precipitation pattern at Minna in 2023*
Source: FAO Climate Information Tool

Treatments and Experimental Design

The treatments consisted of four nutrient sources (control (N_0); NPK fertilizer at the rate of 90-30-30 kg ha^{-1} (N_1); poultry manure at 10 Mg ha^{-1} (N_2); NPK fertilizer at the rate of 45-15-15 kg ha^{-1} combined with poultry manure at 5 Mg ha^{-1} (N_3)) and four levels of weed management (control (W_0); Atrazine 800 g kg^{-1} wettable powder (WP) at 3.0 kg active ingredient per hectare (a. i. ha^{-1}), being the pre- emergence herbicide and Nicosulfuron 40 g l^{-1} oil dispersion (OD) at 60 g a. i. ha^{-1}, being the post-emergence herbicide (W_1); manual weeding using hoe at 2 and 5 WAS (W_2); and Atrazine 800 g kg^{-1} WP at 3.0 kg a. i. ha^{-1} combined with one hoe-weeding at 5 WAS (W_3)) The treatments were factorially combined to give 16 treatments, laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The experimental plot size was 6 m x 5 m (30 m^2) with an alley of 0.5 m and 1 m between the plots and replicates, respectively.

Agronomic practices

The field was manually cleared and ridged at 75cm apart using hoe. The maize variety, SC-719 was sown (2 plants per stand) at 25 cm within the ridge and latter thinned to one plant stand at 2 WAS to give a total plant population of about 53,333 plants per hectare. All the plots that required poultry manure, had it incorporated into the top soils on the ridges at two weeks before sowing to allow for mineralization of the organic material (OM) at rates of 10 Mg ha^{-1} and 5 Mg ha^{-1} for manure alone and integrated nutrient management (INM), respectively. All the plots that required inorganic fertilizer, had basal application at rates of 30 and 15 kg ha^{-1} N, P and K for inorganic fertilizer alone and INM, respectively using NPK 15-15-15 at 2 WAS. The remaining 60 and 30 kg ha^{-1} N were top dressed to complete the recommended rates for inorganic fertilizer alone and INM, respectively using urea 46 % N at 6 WAS. The inorganic fertilizers were applied by band placement about 5 cm deep and 5 cm away from the plant stand and covered. For weed control, pre-emergence herbicide (Atrazine 800 g kg^{-1} WP at 3.0 kg a. i. ha^{-1}) was applied at 1 day after sowing (DAS) while the post-emergence herbicide (Nicosulfuron 40 g l^{-1} OD at 60 g a. i. ha^{-1}) was applied at 6 WAS for all the plots that required the treatment. These herbicides were applied using calibrated Jacto 20 litre sprayer. For manual weeding, the first manual weeding was clearing of weeds at 2 WAS while second weeding was remoulding at 5 WAS and were done using hoe for all plots that required the treatment. The integrated weed management involved use of pre-emergence herbicide at 1 DAS and remoulding at 5 WAS for all plots that required the treatment.

Soil sampling and analysis

Surface soil (0-20 cm) samples were collected along three diagonal transects at regular intervals of 10 m using auger. The samples from each transect were bulked together to give three composite samples, which were used to characterize the field before land preparation. The soil samples collected were taken to the laboratory, as soon as possible and were air-dried, crushed gently, passed through 2 mm mesh. The sieved samples were analyzed according to standard laboratory procedures (IITA, 2015). Briefly, soil particle size distribution was determined by Bouyoucus hydrometer method with sodium hexametaphosphate as dispersing agent. Soil pH was determined in 1:2.5 soil to water ratio using a glass electrode attached to a digital pH meter. Soil organic carbon was determined by Walkley and Black wet oxidation method with oxidation of organic matter using potassium dichromate ($K_2Cr_2O_7$) and Sulphuric acid (H_2SO_4). Total nitrogen was determined by Kjeldahl method. Available phosphorus was extracted by 1 N ammonium fluoride (NH_4F) and 0.5 N hydrochloric acid (HCl) in aqueous solution using Bray P1 procedure and determined by molybdenum blue method and concentration read on spectrophotometer. Exchangeable acidity (Al^{3+} + H^+) was extracted using 1 N unbuffered neutral salt of potassium chloride (KCl) and determined by titration method. Soil cation exchange bases (Ca^{2+}, Mg^{2+}, K^+, and Na^+) were extracted using 1 N ammonium acetate (NH_4OAC) solution. The Mg^{2+} extracted in the solution was determined using atomic absorption spectrophotometer while Ca^{2+}, K^+ and Na^+ were determined using flame photometer. The Effective cation exchange capacity (ECEC) was the summation of exchangeable bases and the exchangeable acidity.

Chemical Analysis of Poultry Manure

A teaspoon of poultry manure were collected from the top, middle, and bottom of each bag of the poultry manure and bulked together to form a representative samples into three places and taken to the laboratory as soon as possible for analysis to minimize deterioration due to enzymatic reaction. The representative samples of the manure were dried in an oven at 65°C until a constant weight was achieved. The dried samples were grinded into fine powder using porcelain mortar and pestle and passed through 40 mesh screen. After the handling and preparation of the manure samples, the following parameters were analyzed; nitrogen (N), phosphorus (P), and potassium (K) according to the standard laboratory procedures (IITA, 2015). Briefly, N was determined by the micro-Kjeldahl method. P was extracted by perchloric acid digestion (wet-oxidation) of the sample and concentration of P was calorimetrically read using atomic absorption spectrophotometer and extracted K was determined using flame emission spectrophotometer.

Weed Parameters Analysis

Weed flora was identified and classified into three categories *viz*: grasses, broadleaf weeds (BLW) and sedges. Weed density was taken at 4, 7, 10 and 13 WAS by counting the number of weeds found within the 1 m^2 quadrant randomly placed in each plot. This was expressed as

$$\text{Weed density} = \frac{\text{Total number of weeds (no.)}}{\text{Total survey area } (m^2)} \quad \text{(Maszura } et\ al.,\ 2018) \qquad \dots (1)$$

Weed control efficiency was taken at 4, 7, 10 and 13 WAS and used to evaluate the effectiveness of weed control methods used in each plot and expressed in percentage (%). The formular used:

$$WCE\ (\%) = \frac{W_0 - W_1}{W_0} \times 100 \quad \text{(Hossain et al., 2020)} \qquad \ldots(2)$$

W_0 = Dry weight of weed in non-weeding plot; W_1 = Dry weight of weed in the treatment plot.

Crop Yield Parameters Analysis

From five selected plants at random after harvest from each plot, the yield and yield attributes were determined. The ear length of the corn cobs were measured using meter rule. The average cob length was then determined and expressed in centimeter (cm). The ear diameter of the corn cobs after shelling were measured using vernier caliper. The average ear diameter was then determined and expressed in centimeter (cm). Stover yield was determined from above ground growth of the cut plants without their cobs and were oven dried to a constant weight and then the dry matter was recorded using weighing balance and was extrapolated and expressed in mega grams per hectare (Mg ha^{-1}). The weight of 100 dry seeds from harvested cobs were manually counted and weight was taken using Mettler Toledo weighing balance and recorded. This was expressed in grams (g). Grain yield was taken from the harvested cobs and were sundried to a moisture content of 12.5 % read by Delmhorst G.7 moisture meter and the dry matter of grains were weighed using Mettler Toledo weighing balance and was extrapolated and expressed in Mg ha^{-1}.

Data Analysis

All data collected were subjected to analysis of variance techniques using Statistical Tool for Agricultural Research (STAR) version 2.0.1. The significantly different treatment means were separated using Student Newman Keuls (SNK) at 5 % level of probability unless otherwise stated.

RESULTS AND DISCUSSION

The Study Area

The physical and chemical properties of the experimental site before planting are shown in Table 1. The soil textural class was sandy loam with sand having highest value of 678 g kg^{-1}, slightly acidic soil reaction with pH value of 6.4 in water and organic carbon with value of 3.60 g kg^{-1}, total N with value of 0.2 g kg^{-1} were found to be low (Chude *et al.,* 2011). The coarse nature of the soil indicates poor water holding capacity and nutrient availability. The slight acidity indicate plants can grow well there and pH of 6.5 is most appropriate for optimum nutrient absorption (Gondal *et al.,* 2021). The low SOC and total N could be from farm practices such as bush burning, no return of crop residues, organic manures and deep tillage which facilitates aeration and decomposition of organic materials by microbes. Organic matter is the main source of N in the soil (Brady and Weil, 2010). The available P was moderately low with value of 16 mg kg^{-1} (Chude *et al.,* 2011). The moderately low P could be due to high affinity for P from crops cultivated in the area and phosphate groups formed in the acidic soil. The exchangeable Ca^{2+} and K^{+} ions were medium (2.47 and 0.21 cmol kg^{-1}) while Mg^{2+} and Na^{+} ions were high with value of 1.68 and 0.44 cmol kg^{-1}, respectively (Esu, 1991). The medium Ca^{2+} and K^{+} ions could be attributed to nutrient mining by soil exhaustive crops (yam and maize) continuously cultivated in the area (Udom *et al.,* 2019) with little or no fertilizer added while high Mg^{2+} and Na^{+} could be from the parent materials which the soils are formed. The exchangeable acidity ($Al^{3+} + H^{+}$) was low with value of 0.12 cmol kg^{-1} (Esu, 1991). The soil is thus low in potential acidity and will not add to the active acidity of the soil which may not constitute toxicity to crops with adverse effect on root development (Adeboye *et al.,* 2020). High amount of Al^{3+} is toxic to roots and cause swelling of the roots impeding the plants ability to actively adsorb water and nutrients from the soil (Brady and Weil, 2010). The effective cation exchange capacity (ECEC) was found to be low with value of 4. 92 cmol kg^{-1} (Esu, 1991). The low ECEC could be attributed to little soil organic matter (SOM) and inactivity of the clay fraction (kaolinite > 80 %) in the tropical soils (Costa *et al.,* 2020). Similarly, Gloria and Katan (2016), showed most soils in the savanna region are sandy, contains little organic matter, have poor water holding capacity and low nutrients as a result of wind and water erosion.

Nutrient Composition of Poultry Manure

The properties of the poultry manure used in the experiment are shown in Table 2. The poultry manure contained 0.73 % N, 0.20 % P and 0.52 % K. As expected, N had the highest concentration compared to the others. Nahm (2003), showed that most of the N (approximately 60 – 70 %) excreted in poultry manure is in the form of uric acid and urea. The P is found to be low. Ashworth *et al.* (2020), showed that P is generally imported into poultry systems by mineral-P supplements in feed, including enzymes integrated into diets to improve nutrient adsorption by poultry, as well as the use of crops that contain lower levels of indigestible phytate-P.

Weed flora

The weed species recorded at the experimental site were mainly comprised with grasses, sedges and BLW. The impact of high rainfall resulted to quick re-emergence of weeds in that year. The dominant weed species infested in the experimental field were Grasses–*Digitaria horizontalis* (Crabgrass), *Cynodon dactylon* (Bermuda grass), and *Rottboelia cochinchinesis* (Itch grass). Sedges were *Cyperus rotundus and Cyperus esculentus* (Purple nutsedge and Yellow nutsedge), respectively. BLW were *Portulaca oleraceae* (Common Purslane).

Table 1: Physical and chemical properties of soil of the experimental site before land preparation

Soil properties	Values
Sand (g kg^{-1})	678
Silt (g kg^{-1})	167
Clay (g kg^{-1})	155
Textural class	Sandy loam
pH in H_2O (1:2.5)	6.4
Organic Carbon (g kg^{-1})	3.60
Total Nitrogen (g kg^{-1})	0.20
Available P (mg kg^{-1})	16.0
Exchangeable Bases (cmol kg^{-1})	
Ca^{2+}	2.47
Mg^{2+}	1.68
K^{+}	0.21
Na^{+}	0.44
Exchangeable Acidity (cmol kg^{-1})	0.12
Effective cation exchange capacity (cmol kg^{-1})	4.92

Table 2: Nutrient composition of poultry manure

Poultry manure	Values (%)	Values (g kg^{-1})
Nitrogen (N)	0.73	7.3
Phosphorus (P)	0.20	2.0
Potassium (K)	0.52	5.2

Tridax procumbens (Coat buttons), *Euphorbia hirta* (Asthma herb), *Commelina bonghalensis* (Tropical spiderwort), and *Ageratum conyzoides* (Goat weed).

Effects of Nutrient and Weed Management on Weed Density

The effects of nutrient and weed management on weed density are shown in Table 3. Nutrient management had significant effect on weed density at different sampling periods. The inorganic NPK fertilizer combined with manure recorded highest weed density on average (39 – 40 %) over control at 4 and 7 WAS, respectively while control recorded highest weed density at 10 and 13 WAS, respectively and were significantly different from each other.

Table 3: Effects of nutrient and weed management on weed density and weed control efficiency

Treatments	**Weed density (no.m^{-2})**				**Weed Control Efficiency (%)**			
	4 WAS	**7 WAS**	**10 WAS**	**13 WAS**	**4 WAS**	**7 WAS**	**10 WAS**	**13 WAS**
Nutrient Management (N)								
Control	19.33b	22.42b	48.67a	67.33a	61.42a	70.52b	59.49b	62.49b
Inorganic NPK fertilizer at rate of 90-30-30 kg ha^{-1}	26.08a	31.00a	32.08b	36.25b	59.18a	69.53b	51.48c	68.27a
Poultry manure at 10 Mg ha^{-1}	30.83a	36.67a	38.83b	43.00b	61.09a	72.37a	65.90a	65.65ab
Inorganic NPK fertilizer at rate of 45-15-15 kg ha^{-1} and poultry manure at 5 Mg ha^{-1}	31.50a	37.58a	39.75b	49.75b	63.01a	70.26b	64.54a	69.34a
SE±	1.63	2.09	2.41	4.81	1.19	0.56	1.09	1.11
Weed management (W)								
Control	74.58a	110.58a	117.58a	135.42a	0.00c	0.00c	0.00d	0.00d
Atrazine WP (3.0 kg a. i. ha^{-1}) at 1 DAS and Nicosulforun OD (60 g a. i. ha^{-1}) at 6 WAS	12.42b	5.83b	6.25c	6.08c	79.22b	93.64b	87.86a	96.41a
Two hoe-weeding at 2 and 5 WAS	8.17b	7.08b	19.50b	31.67b	85.89a	92.47b	70.03c	79.33c
Atrazine WP (3.0 kg a. i. ha^{-1}) at 1 DAS and one hoe-weeding at 5 WAS	12.58b	4.17b	16.00b	23.17b	79.58b	96.57a	83.52b	90.03b
SE±	1.63	2.09	2.41	4.81	1.19	0.56	1.09	1.11
Interaction								
N x W	**	**	**	**	NS	*	**	**

All means within a column of each factor followed by the same letter(s) are not significantly different at $p < 0.05$
*= Significant; ** = highly significant; NS = Not significant; WAS = Week after sowing; DAS = Day(s) after sowing

The significant increase in weed density from the integration of inorganic NPK fertilizer with manure, could be attributed to gradual release of nutrients from manure and high Nitrogen use efficiency (NUE) from split application of inorganic NPK fertilizer to the soil may have supported weeds uptake, and increased weed density at early growth stage of maize. Nitrogen is an essential plant nutrient that is known to impact plant community, assembly, and previous research has documented that certain weed species (*Amaranthus retroflexus*, *Persicaria lapathifolia, Echinochloa crus-galli*) are more responsive to N than other species (Moreau *et al.,* 2014). Similarly, Chipomho *et al.* (2020), revealed that cattle manure (CM) and NPK with CM amended treatments increased weed density compared to control. The environmental factors such as high rainfall, high relative humidity and light intensity and internal factors such as hardy and reproductive nature of weeds in control may have contributed to weeds quick re-emergence at late growth stage of maize.

Similarly, weed management had significant effect on weed density at different sampling periods. The control recorded highest weed density and was significantly different from other treatments. This could be attributed to weedy environment that may have resulted to increase in weed population and abundance. The control of weeds using pre-emergence and post emergence herbicides recorded lowest weed density and was significantly different from other treatments at 10 and 13 WAS, respectively. The inhibitory effect of the pre-emergence and post-emergence herbicides on weed seeds, root and shoots growth may have resulted to significant reduction in weed density. These herbicides are selective and systemic in action for control of annual and perennial grasses, broad leaved weeds (BLW) and sedges in maize field. Similarly, Shiv *et al.* (2023), showed significant reduction in total weed density (4.40 m^{-2}) under application of pendimethalin at 500 g ha^{-1} and imazethapyr at 450 g ha^{-1}.

The interaction effects of nutrient and weed management on weed density were highly significant ($p < 0.01$) at different sampling periods as presented in Table 4. The treatment combination of inorganic NPK fertilizer with manure and weedy check (control) gave the highest weed density at 4 and 7 WAS, respectively while the absolute control (No fertilizer and weedy check) produced highest weed density at 10 and 13 WAS, respectively. The uncontrolled weed condition at critical period of weed control (CPWC) may have provided environment for weeds resistance, persistence, and abundance. The gradual release of N and other nutrients from manure and the high NUE from split application of inorganic NPK fertilizer in weedy environment may have supported weeds uptake at early growth stage of maize while impact of high rainfall, high relative humidity and light intensity as external factors and the hardy and reproductive nature of weeds as internal factors may have resulted to weed seeds dispersal, weed flush and abundance at late growth stage of maize.

Effects of Nutrient and Weed Management on Weed Control Efficiency

The effects of nutrient and weed management on weed control efficiency at different sampling periods are shown in Table 3. Nutrient management had no significant effect on weed control efficiency only at 4 WAS. The manure alone gave highest weed control efficiency at different sampling periods while the integration of inorganic NPK fertilizer with manure gave highest weed control efficiency (10 %) compared to control at 13 WAS. It has been reported that use of chicken manure can be an effective weed management practice for weed control (Haidar and Sidahmed, 2006). Liebman and Davis (2000), showed that the split application or controlled release of nitrogen may be a useful practice for managing weeds in sweet maize. Early-season soil N levels are kept intentionally low because sweet maize demand for N at this time is minimal.

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ISSN (Print): 2651-6144; ISSN (Online): 2651-6365 Website:http://www.jasd.daee.atbu.edu.ng

Table 4: Interaction effects of nutrient and weed management on weed density and weed control efficiency

Nutrient management (N)	Weed management (W)	Weed density (no. m^{-2})				Weed control efficiency (%)		
		4 WAS	7 WAS	10 WAS	13 WAS	7 WAS	10 WAS	13 WAS
N_0	W_0	46.00c	72.67c	152.33a	193.00a	0.00c	0.00d	0.00e
N_0	W_1	12.00d	6.00d	5.00d	5.67d	93.42b	86.72ab	96.40ab
N_0	W_2	8.00d	6.33d	20.33d	44.67d	91.18b	70.27b	66.33d
N_0	W_3	11.33d	4.00d	17.00d	26.00d	97.47ab	80.97b	87.25b
N_1	W_0	72.00b	107.67b	90.33c	87.33c	0.00c	0.00d	0.00e
N_1	W_1	12.00d	4.33d	5.00d	6.00d	93.59b	88.60ab	96.14ab
N_1	W_2	8.00d	6.67d	16.67d	20.00d	92.70b	39.63c	87.00b
N_1	W_3	12.33d	5.33d	15.33d	31.67d	91.85b	77.68b	89.95ab
N_2	W_0	87.00a	129.00a	116.00b	120.67b	0.00c	0.00d	0.00e
N_2	W_1	13.00d	7.00d	6.67d	6.67d	95.69ab	91.39a	95.09ab
N_2	W_2	9.33d	7.00d	21.33d	28.00d	94.84b	85.40ab	76.49c
N_2	W_3	14.00d	3.67d	15.00d	16.67d	98.94a	86.81ab	91.04ab
N_3	W_0	93.33a	133.00a	111.67b	140.67b	0.00c	0.00d	0.00e
N_3	W_1	12.67d	6.00d	8.33d	6.00d	91.86b	84.74ab	98.01a
N_3	W_2	7.33d	8.33d	18.67d	34.00d	91.16b	84.84ab	87.50b
N_3	W_3	12.67d	3.00d	16.67d	18.33d	98.02ab	88.60ab	91.87ab
SE $\pm$		3.26	4.18	4.82	9.62	1.12	2.18	2.22

All means within a column followed by the same letter(s) are not significantly different at $p < 0.05$; N_0 = Unfertilized (control); N_1 = Application of Inorganic NPK fertilizer at rate of 90-30-30 kg ha^{-1}; N_2 = Application of poultry manure (PM) at 10 Mg ha^{-1}; N_3 = Integration of inorganic NPK fertilizer at rate of 45-15-15 kg ha^{-1} and PM at 5 Mg ha^{-1}; W_0 = Weedy check (control); W_1= Application of Pre-and-post emergence herbicide; W_2 =Application of two hoe-weeding at 2 and 5 WAS; W_3 = Application of Pre-emergence herbicide and one hoe-weeding at 5 WAS; WAS = Weeks after sowing

Weed management had significant effect on weed control efficiency at different sampling periods. The application of two hoe-weeding at 2 and 5 WAS recorded highest weed control efficiency and was significantly different from other treatments at 4 WAS, while the application of pre-emergence herbicide at 1 DAS and one hoe-weeding at 5 WAS recorded the highest weed control efficiency and was significantly different from other treatments at 7 WAS, and lastly, the application of pre-emergence herbicide at 1 DAS and post emergence herbicide at 6 WAS gave the highest weed control efficiency and was significantly different from other treatments at 10 and 13 WAS, respectively. Amare *et al.* (2015), discovered that hand weeding dramatically reduced weed density, efficient weed control in maize fields when compared to weedy check areas. Mustari *et al*. (2014), showed that Carfentrazone-ethyl performed the best in terms of weed control efficiency (79.68 %), while Pendimethalin performed the worst (52.74 %) on a wheat field. The weed controlled condition provided by manual or chemical control methods or combination of both methods at CPWC seem effective in reducing weed density and efficient in controlling weeds.

The interaction effects of nutrient and weed management on weed control efficiency were not significant only at 4 WAS. The interaction effects of nutrient and weed management were significant ($p<0.05$) at 7 WAS and were highly significant ($p<0.01$) at 10 and 13 WAS, respectively as presented in Table 4. The treatment combination of manure alone and control of weeds using pre-emergence and one hoe-weeding at 5 WAS produced highest weed control efficiency at 7 WAS, while manure alone and control of weeds using pre-emergence and post-emergence herbicides produced highest weed control efficiency at 10 WAS, while integration of inorganic NPK fertilizer with manure and control of weeds using pre-emergence and post-emergence herbicides produced highest weed control efficiency at 13 WAS. This could be attributed to the efficacy of the pre-emergence and post-emergence herbicides in controlling grasses, BLW, and sedges and the impact of hoe-weeding in reducing weed density at CPWC. The gradual release of N and other nutrients from manure and the high NUE from split application of inorganic NPK fertilizer in a weed controlled environment may have benefitted the crop uptake.

Effects of Nutrient and Weed Management on Yield and Yield Attributes

The effects of nutrient and weed management on yield and yield attributes of maize are presented in Table 5. Nutrient management had significant effect on yield and yield attributes of maize. The integration of inorganic NPK fertilizer with manure significantly increased the ear diameter (15 %), ear length (21 %), stover yield (44 %), 100 grain weight (47 %), and grain yield (74 %), compared to control and was statistically at par to manure alone. This may be because organic fertilizers are known to contain plant nutrients, growth promoting substances and beneficial microflora which in combination with inorganic fertilizers provide favourable soil conditions to enhance nutrient use efficiency. Similarly, Tarafder *et al.* (2020), revealed that the combination of 3 t ha^{-1} poultry manure (PM) and 70 % soil test based (STB) inorganic fertilizers was superior to other treatments for pods $plant^{-1}$, seeds pod^{-1} , 100 seed weight, seed yield , stover yield and biological yield of Mungbean (*Vigna radiata* L.).

Weed management had significant effect on yield and yield attributes. The control of weeds using pre-emergence and post-emergence herbicides gave superior ear diameter (9 %), ear length (12 %), stover yield (50 %), 100 grain weight (20 %), and grain yield (40 %) compared to control. This could be attributed to the efficient control of weeds by the pre-emergence and post-emergence herbicides in reducing weed density. The result is in conformity that weedy environment in maize results in significant yield reduction.

JOURNAL OF AGRIPRENEURSHIP AND SUSTAINABLE DEVELOPMENT
(JASD)
Volume 7, Number 1, March, 2024
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365 Website:http://www.jasd.daee.atbu.edu.ng

Table 5: Effects of nutrient and weed management on yield and yield attributes of maize

Treatments	**Yield and yield attributes**				
	Ear diameter (cm)	**Ear Length (cm)**	**Stover Yield (Mg ha^{-1})**	**100 Grain weight (g)**	**Grain Yield (Mg ha^{-1})**
Nutrient Management (N)					
Control	2.67b	11.87b	5.39b	11.92c	1.36c
Inorganic NPK fertilizer rate of 90-30-30 kg ha^{-1}	3.12a	15.20a	9.16a	19.21b	3.98b
Poultry manure at 10 Mg ha^{-1}	3.16a	15.07a	9.91a	22.02a	4.72a
Inorganic NPK fertilizer at rate of 45-15-15 kg ha^{-1} and poultry manure at 5 Mg ha^{-1}	3.13a	15.08a	10.06a	22.56a	5.28a
SE$\pm$	0.055	0.33	0.63	0.68	0.20
Weed management (W)					
Control	2.85b	13.31b	5.42c	16.27b	2.66b
Atrazine WP (3.0 kg a. i. ha^{-1}) at 1 DAS and Nicosulforun OD (60 g a. i. ha^{-1}) at 6 WAS	3.13a	15.17a	10.87a	20.39a	4.42a
Two hoe-weeding at 2 and 5 WAS	3.08a	14.31ab	9.19ab	19.93a	4.02a
Atrazine WP (3.0 kg a.i. ha^{-1}) at 1 DAS and one hoe-weeding at 5 WAS	3.01a	14.43ab	9.03b	19.11a	4.23a
SE$\pm$	0.055	0.33	0.63	0.68	0.20
Interaction					
N x W	NS	NS	NS	NS	NS

All means within a column of each factor followed by the same letter(s) are not significantly different at $p < 0.05$;
NS = Not significant; WAS = Week(s) after sowing; DAS = Day(s) after sowing.

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Similarly, Acharya *et al.* (2022), showed that Atrazine as pre-emergence followed by (fb) Tembotrione as post-emergence produced the highest yield (3.575 Mt ha^{-1}) for maize season whereas 4.8 Mt ha^{-1} was obtained in Metribuzin treated plot as post emergence herbicide in wheat growing season. The yield increments by Tembotrione as post emergence was 71.51 % and Metribuzin was 63.09 % over weedy check. The interaction effects of nutrient and weed management on yield and yield attributes of maize were not significant.

CONCLUSION AND RECOMMENDATIONS

There was response to application of both poultry manure and inorganic NPK fertilizer when applied sole or when they are combined. All the yield and yield indices of maize were enhanced by their application. Maize grain yield for example, was increased by over 74 % by their combined application with control of weeds using pre-emergence herbicide with one hoe weeding at 5 WAS. Weed infestation was drastically reduced by the application of pre-emergence herbicide followed by one hoe-weeding at 5 weeks after sowing (WAS) and enhanced the growth and development of the maize. Weed control efficiency was increased by more than 92 % over the control by controlling the weeds in the maize field by the combination of pre-emergence herbicide and one hoe-weeding at 5 WAS. Pre-emergence herbicide combined with one hoe-weeding at 5 WAS is recommended for weed control in the study site. Application of 5 Mg ha^{-1} of PM combined with half of the recommended rate of the inorganic NPK fertilizer; 45 N, 15 P, 15 K ha^{-1}, for maize is recommended for soil fertility improvement and optimum maize grain yield.

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