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COMBATING TROPICAL SOIL DEGRADATION: THE ROLE OF NITROGEN FERTILIZER AS A CLIMATE-SMART STRATEGY TOWARDS MAIZE (ZEA MAYS L.) PRODUCTIVE CULTIVATION

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Abstract. *Challenges facing humanity over the years include food insecurity, loss of soil and water resources and associated ecosystem disturbance. The rate of hungry people in developing world keeps on increasing and causing death and malnutrition. Food shortages, food insecurity or undernourishment has assumed a global dimension especially as climate change hits the globe with its negative impacts, with more severe cases recorded in the poor-resource African countries. Soil is the natural capital which drives the agricultural sector, being a strong-hole for crop/animal farming, apart-from being a medium for production of raw materials which powers industrial and domestic production. The inherent quality of soil is impaired by various factors including climate variability like excessive rainfall, which ends-up leaching nutrients downstream, thereby resulting in contamination of water bodies with fertilizer/agro-chemical residues. Like most tropical humid soils, the inherent quality of Nigerian soils is generally low, causing rapid degradation of applied nutrients and total crop failure in extreme cases. This has most often been exacerbated by most prevalent land use/agricultural systems, coupled with the problem of over-grazing and indiscriminate deforestation, alongside rapid population expansion with consequent urbanization and industrialization. For effective soil management, especially in the face of climate change, the need for Climate-Smart Strategy (CSS) towards agricultural production becomes imperative, inother to find a Sustainable Approach (SA) to man's drive towards food production for effective survival. For efficient maize (Zea mays L.) production, application of mineral fertilizer becomes an important aspect for human/animal food production. Field experimentation was conducted at the Teaching and Research Farm of the Cross River University of Technology (Latitude 6° 06' N and Longitude 8° 18' E), to evaluate the potential of Nitrogen fertilizer as a Climate-Smart Approach (CSA) for sustainable maize production in the humid tropics. Maize seed variety: Ikom Local White were treated to one level of Nitrogen fertilizer at 0.078 kg ha-1. The treatment was laid out in a Randomized Complete Block Design (RCBD). The treatment were replicated four time to give a total of sixteen (16) field plots. Data collection on plant growth parameters (number of leaves and height of maize) were subjected to Analysis of Variance (ANOVA), while significant means among treatments were separated using Least Significant Difference (LSD) at 5% probability level. Result obtained showed that plots treated with 0.078 kg ha-1 of Nitrogen fertilizer (N-Fertilizer) significantly ($p<0.05$) increase growth parameter of maize over the control. Outcome of the study concluded that 0.078 kg ha^{-1} of N-Fertilizer applied to Maize planted at 1m spacing between plants on bed increase crop growth, and acts as a CSA to remedy the rapid degradation of humid tropical soil productivity, and for environmental sustainability.*

Key words: *Climate-Smart Strategy; Tropical Soils; Nitrogenous Fertilizer; Zea Mays; Combat*

1. INTRODUCTION

1.1. Background of the Study

Over the years tropical soil degradation has been a point of concern for agricultural including environmental sustainability. This situation has been worsen especially in the humid tropics of the globe, with African low-income humid tropics been the most disadvantageous (FAO, 2000), and almost failing in her ability to feed the ever growing human population found in countries like Nigeria. Soil degradation has been referred to as an hindrance to global sustainability, reducing the per capital income of tropical regions, acting like a barrier to improved standard of living of urban and mostly rural people (Adiaha, 2016; World Bank, 2013).

The devastating impact of climate change on soil degradation word-wide has been disastrous (Obigbesan, 2014), dragging Scientists, academicians, policy makers, business tycoons including Agricultural practitioners to come together, seeking lasting solutions to resolving the problem, kicking into action different forms of conferences, symposia, workshop including seminars, all with the aim of developing mitigative or adaptive approaches towards lasting solution to tackle the problem.

Changes caused by climate variability, resulting in increased cases of annual flooding; causing massive urban and rural destruction of lives and properties has been reported by many researchers including Obigbesan (2014) and Oku (2011), presenting the phenomena as agents driving soil erosion, that reduces per capital income of a nation (Oku *et al.*, 2014). Results of landslides, longer dry periods, shrinking water supplies, desertification, unpredictable and changing in seasonal weather pattern has been reported by many climate change scientists including Oku (2015) and Obigbesan (2014). This changes has resulted in low crop yield, including increased in human/animal hunger, leading to disease outbreak, malnutrition including global food shortages.

Nitrogen (N) is an essential and often a limited nutrient to plant growth. Nitrogen is an important plant nutrient, N determine plants vegetative and reproductive phase (Adiaha, 2016). Nitrogen has been reported by Amonymous (2000) to make up 1-4% of maize dry matter. N plays a key function in chlorophyll and enzymes activities in the plant system, with visible sign of reduce growth (Adiaha, 2016) when the nutrient is deficient. Maize responds effectively to supplemental N, which leads to annual application of about 10 million metric tons of N fertilizer (FAO, 2004; Stephen and Below, 2009). All cultivated maize crop in most developing countries receives some form of N fertilizer for maximum growth and yield, The extensive use of N fertilizer has been found not only to increase crop production output, but also act as a remedy to the loses of N from cultivated soils/landuse systems to the atmosphere (FAO, 2004). The use of N fertilizer has been reported by Tilman *et al*. (2002) to have an impact in the ecosystem.

Nitrogen Use Efficiency (NUE) can be defined in a variety of ways that emphasize different components of the soil and plant system (Good *et al*., 2004; Stephen and Below, 2009). In most cereal crops like maize, agronomic NUE is most simply expressed as the ratio of grain yield to N fertilizer supplied. Comparisons of maize grain yields and N fertilizer usage on a global scale have been accessed to have led to NUE ranging from 25-50% (Raun and Johnson, 1999; Tilman *et al*., 2002), presenting a view that half of the N fertilizer in maize production is lost to the environment, especially due water run-off or flooding of farm lands.

Maize is a cereal crop, and belongs to the grass family *Poaceae*. Maize is also known as corn, with its origin from Central American tropics and Mexico (Brewbaker, 2003; Adiaha, 2016). Corn has been found useful in human/animal nutrition, medical, pharmaceutical, industrial, economic and herbal value (Adiaha, 2016). Corn is widely produced in the United States, with an annual production of 310 million metric tons and a world production at 177.3 million tons and yield of 3.6tons per acre. Presenting USA as the largest corn producer in the world. Nigeria produces 8 million tons of maize (IITA, 2014), giving Nigeria a leading step in corn production within the Sub-Saharan Africa.

A climate-smart Agricultural System looks carefully into mechanism for adapting into the trend of climate change. Oku (2015) presented a view that inability of traditional farmers to key into the trend of the changing climate is one hindering factors towards global sustainability. A Climate-Smart Agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural practitioner/systems to effectively support development and ensure food security in a changing climate (FAO, 2006). CSA aims to tackle three main objectives: sustainability increasing agricultural productivity and incomes; adapting and building resilience to climate change, and reducing and/or removing greenhouse gas emission, where possible (FAO, 2006).

CSA tends to develop agricultural strategies to secure sustainable food security under climate change. CSA has been reported by several research literature including reports of FAO (2006) as a means of providing a strategy to help stakeholders at local and international level, to identify best agricultural practices/systems suitable to their local area/conditions.

Against the rapid degradation of tropical soils, and as a means to adapt to the changing climate, the need for this research becomes imperative with the following objectives:

1. Present the influence of Nitrogen fertilizer on maize growth parameters
2. Present a view that N-fertilizer is a climate-smart approach for sustainable maize production in the humid tropics.

2. MATERIALS AND METHOD

2.1. The Study Area

The study was conducted at the Teaching and Research Farms of Cross River University of Technology, Obubra, Cross River State, south-south Nigeria. The area lies between Latitude 6° 06' N and Longitude 8° 18' E in the rainforest zone of Nigeria. The area has an average annual rainfall range of 2250-2500mm per annum (CRADP, 1992) and annual temperature range of 25 °C to 27 °C. The geological material of soil in the study area is an Ultisol, derived from coastal plain sands, characterized by low organic matter, low cation exchange capacity and are highly leached (Kekong *et al*., 2014; Onweremadu *et al*., 2011).

Tropical rainforest is the dominant vegetation of the area, through with remarkable ecological diversity caused anthropogenic activities, especially farming and deforestation, resulting to depleted vegetation as a responds to demographic pressure. Subsistent farming is a major socio-economic activities of the local. Soil fertility restoration in the area is done by semi-bush fallowing and through application of limited/scares organic materials. The location map of the study area is shown in Figure A and B and the actual position on earth was determine using Google Earth software 3.0 as presented in Figure C.

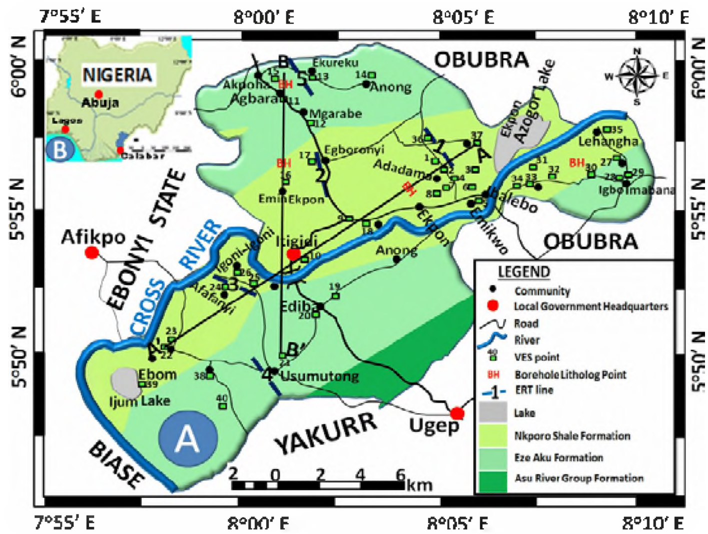

Fig. A: Map of Cross River State of southern Nigeria

Source: *https://www.researchgate.net/profile/Chimezie_Emeka/publication/273151557/figure/fig1/AS:294851414380548@1447309463634/Geological-map-of-Abi-LGA-a-showing-locations-of-VES-stations-and-ERT-profiles.png*

Fig. B: Map showing the different localities in the study area

Source: *https://www.researchgate.net/profile/Chimezie_Emeka/publication/273151557/figure/fig1/AS:294851414380548@1447309463634/Geological-map-of-Abi-LGA-a-showing-locations-of-VES-stations-and-ERT-profiles.png*

Fig. C: Aerial map of the position of the study area was developed using Google Earth software 3.0

2.2. Land Preparation:

The study area which was under two years fallow, dominated by shrubs and grasses was mapped out manually, cleared using cutlass and hoe and mapped out into experimental plots. Composite soil samples were randomly collected for pre-planting soil sample analysis and to determine if fertilizer should be applied to the soil or not. Sampling was done using soil auger at 0-30 cm depth. The samples were air dried for a period of one week and sieved using 2mm mesh sieve and then subjected to routine laboratory analysis.

2.3. Field Layout and Experimental Design:

The study site was mapped into sixteen (16) field plots. Each plot measured 4 × 4m with inter plot and inter replicate distance of 1m each.

The experimental plots were manually tilled to form bed. The treatments were laid out in a Randomized Complete Block Design (RCBD) with four replications.

Planting and cultural practices

Maize seed (Ikom Local White), an early maturing maize cultivar widely cultivated in the area were sown on August 1st, 2016 and 2017 respectively. Healthy seed were collected from Agricultural Extension Office, Ikom, Cross River State, Nigeria and treated with Apron plus (seed dressing chemical). Seedlings were sprayed with an insecticide- Sniper (Vinyl dimethyl phosphate DDVP, 1000EC) to control insect attack.

2.4. Treatments:

In both 2016 and 2017 studies, the treatments consisted of one level of Nitrogen fertilizer (Urea) at 0.078 kg ha^{-1} applied to the sixteen field plots.

2.5. Application of N-Fertilizer to the Test Crop

The treatment was carefully applied by ring application method as described by (Adiaha, 2016) to each stand of the planted maize (*Zea mays* L.) at all the various replication.

2.6. Routine Agronomic Practices

a. ***Thinning***: Maize seedlings were thinned to two seedlings per stand.

b. ***Replacement of missing stand***: missing stands were replaced for uniform field/crop establishment

c. ***Weeding***: First weeding was done at one (1) week after planting of the test crop.

Fertilizer application (Experimental procedures)

N-fertilizer was applied five (5) Weeks after Planting (WAP) in a ring method according to procedures described by Adiaha (2016) at an application rate of 0.078 kg ha^{-1} of urea containing (46%N), applied at a ring distance of 10 cm from the plant root and at a depth of 5 cm. After which the ring was covered with soil

2.6. Measurement of Growth Parameter

Net plot plants were selected and labeled/tagged specifically for data collection. An in-situ measurement of plant height and leaf was measured on a weekly interval. Plant height was measured using a metre rule from the surface of the soil to the tip of the tallest leaf (Nwafor, et al., 2010).

2.7. Laboratory analysis

Particle size distribution was determine by hydrometer method according to the procedure established by Gee and Bauder (1986). *Bulk density* was determine by core method according to Grossman and Reinsch (2002). *Total porosity* was calculated from the result of bulk density using the formular:

$$\text{Total Porosity } (TP) = [1 - (BD/Pd \times 100)] \quad (1)$$

Where: Pd = particle density (2.65g/cm^3)
Bd = Bulk density

Moisture Content was determine using the formular:

% soil moisture content =
= (weight of the moisture contained in the soil sample/weight of soil sample) × 100 (2)

Silt/Clay ratio was calculated by dividing the value of the silt fractions by the clay fractions. Soil p^H was determine in water and in KCl using metre in soil/liquid suspension of 1:2.5 according to Hendershot *et al*., (1993).

- *Organic Carbon* was determine using chromic wet oxidation method according to Nelson and Somers, (1982).
- *Organic Matter:* It was determined by the dichromate wet-oxidation method as described by Nelson and Sommers (1996). The value was multiplied by 1.732 to obtain organic matter content.
- *Total nitrogen* was determined by the kjeldahl digestion and distillation method using concentrated H_2SO_4 and sodium copper sulphate catalyst mixture as described by Bremmer and Yeomans (1988).
- *Avilable Phosphorus:* It was determined by the Bray-1 method as described by Kuo (1996).
- *Cation Exchange Capcity:* Cation exchange capacity was determine by method described by Summer and Miller (1996).
- *Exchangeable Cations:* The bases were extracted with neutral NH_4OA_c. Calcium and magnesium were determine in the extract by EDTA titration, and potassium and sodium by the use of flame photometer (Udo *et al*., 2009).

3. RESULT AND DISCUSSION

3.1. Routine Soil Physical and Chemical Laboratory Analysis Result

Results obtain from the composite sample at the study area before cropping, and application of N mineral fertilizer is presented in Table 1.

1. Soil Physical and Chemical Status of the study Site before Experimentation (Cropping)

Soil Property	2016	2017
Sand (g/kg)	850	832
Silt (g/kg)	76	70
Clay (g/kg)	74	98
Textural class	Sandy loam	Sandy Loam
Silt/Clay Ratio	0.52	0.43
Bulk Density (g/cm^3)	1.44	1.40
Total Porosity (%)	44.0	44.5
Moisture Content (g/kg)	139	129.2
Organic matter (%)	1.80	1.90
pH H2O (1:2.5)	5.49	5.46
PH KCl (1:2.5)	4.29	4.27
Total Nitrogen (g/kg)	0.9	0.9
Avail. Phosphorus (mg/kg)	3.5	3.3
Exchangeable Ca (cmol/kg)	2.45	2.52
Exchangeable Mg (cmol/kg)	0.21	0.23
Exchangeable K (cmol/kg)	0.13	0.10
Exchangeable Na (cmol/kg)	0.18	0.19
Exchangeable Acidity (cmol/kg)	2.72	2.80
CEC (cmol/kg)	1.9	1.10

3.2. Statistical analysis

Field data (raw data) were processed and analyzed, and presented in tables and graphs/ figures in this experiment.

All the data were analyzed using the procedure for analysis of variance (ANOVA) for Randomized Complete Block Design (RCBD). Separation of means was done using Fishers Least Significant Difference (f-LSD) at 0.05% probability level.

3.3. Plant Data Collection

Data was collected on the following growth parameters; plant height and number of leaves across all the tag plants in all the replicates.

Plant height were measured first at 6 Weeks after planting (one Week after fertilizer application (WAFA)) according to method presented by Adiaha (2016). Subsequent measurements of plant height were taken at one Week interval (WI) in all the net plots. Number of leaves were counted and recorded for each treatment throughout all the replications. This was done at 6WAP (1WAFA) and at 1WI interval.

Result obtained in plant height at one Week after fertilizer application (1WAFA) showed that plant height increase across the treatments at all stages of growth using ring application method with highest plant height of (70.70 cm) at 1WAFA been

2. Influence of N-Fertilizer on maize (Zea mays L.) height: as a Climate-Smart Strategy for Tropical Agriculture. 2016 Experiment

Treatment Code	Planting Distance	Treatment	Maize mean height at 1WAFA (cm)	Maize mean height at 5WAFA (cm)
Treatment 1 (T_1)	30cm×30cm	0.078kg ha1 Urea by Ring Application method	60.71	74.44
Treatment 2 (T_2)	1m×1m	0.078kg ha1 Urea by Ring Application method	70.70	84.30
Treatment 3 (T_3)	70cm×70cm	0.078kg ha1 Urea by Ring Application method	61.61	75.67
Treatment 4 (T_4)	30cm×25cm	0.078kg ha1 Urea by Ring Application method	61.75	75.30
Treatment 5 (T_5)	Random planting	Control	51.66	60.66
LSD ($P < 0.05$)			8.80	9.00

Mean was separated using Fishers separation (f -LSD). The least mean produced minimum plant height observed for corn planted at 1m×1m. Application of 0.078 kg ha^{-1} N-fertilizer (urea) recorded a height of 61.75cm which was closely followed by 61.61cm at a planting distance of 70cm×70cm. Application of 0.078kg ha^{-1} of N-fertilizer applied to maize sowed at 30 ×30cm recorded a mean value of 60.71 cm. Plant heights differed significantly ($P < 0.05$) across all treatments. The least (minimum) plant height was obtained in the control plot (Random planting) with a mean value of (51.66 cm).

Plant height at 5WAFA indicated an increase in height of the plants over the control. Application of 0.078 kg ha^{-1} N-fertilizer by Ring application at 1 ×1m gave the highest ($P = 0.05$) plant height of 84.30 cm. This was followed by treatment application to 70×70cm which recorded a mean value of (75.67 cm). 30×25cm planting distance recorded a mean value of 75.30 cm indicating that 70×70 and 30×25 influenced the plant height almost at the same frequency by recording a mean value almost at the same mean separation grade. Application of 0.078 kg ha^{-1} N-fertilizer by ring method influenced the plant height to 74.44 cm at 5WAFA, indicating a significant difference in maize height over the control. The control mean height was recorded at (60.66 cm) 5WAFA, presenting the control as the least in maize height recorded at five (5) weeks after fertilizer application. The increase in plant height at 1WAFA and at 5WAFA indicated that application of 0.078 kg ha^{-1} N-fertilizer by Ring application, to all the different planting distance significantly ($P < 0.05$) influenced the plant height, thereby resulting in a height which stands over the control.

The result obtained in plant height in this experiment agrees with the findings of Omotoso and Shittu (2007) who reported increase in *Abelmoschus esculentus* (L.) growth parameters when NPK fertilizer was applied by ring method of application. Also findings of this study agrees with the experiment of Adiaha (2016), where the Scientist reported significant increase in *Zea mays* L. growth parameter due to application of mineral fertilizer.

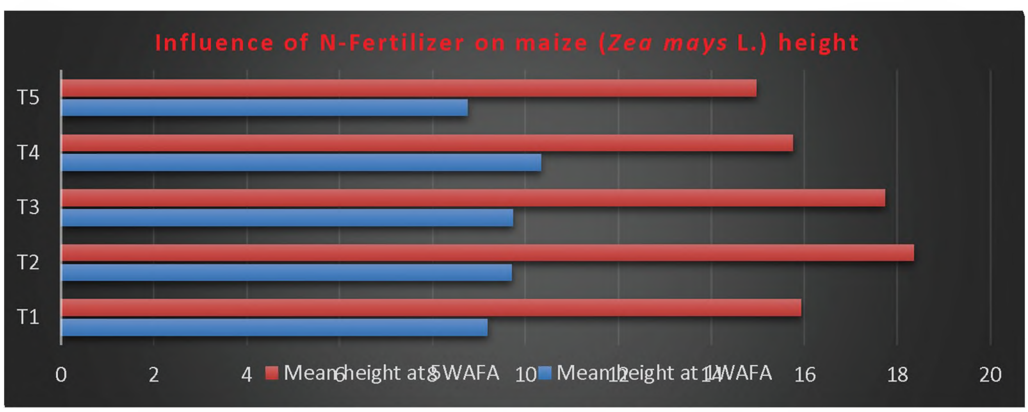

Figure 1. 2016, Influence of N-Fertilizer on Zea mays L height in rain prone area in southern Nigeria (plant height at 5WAFA and 1WAFA)

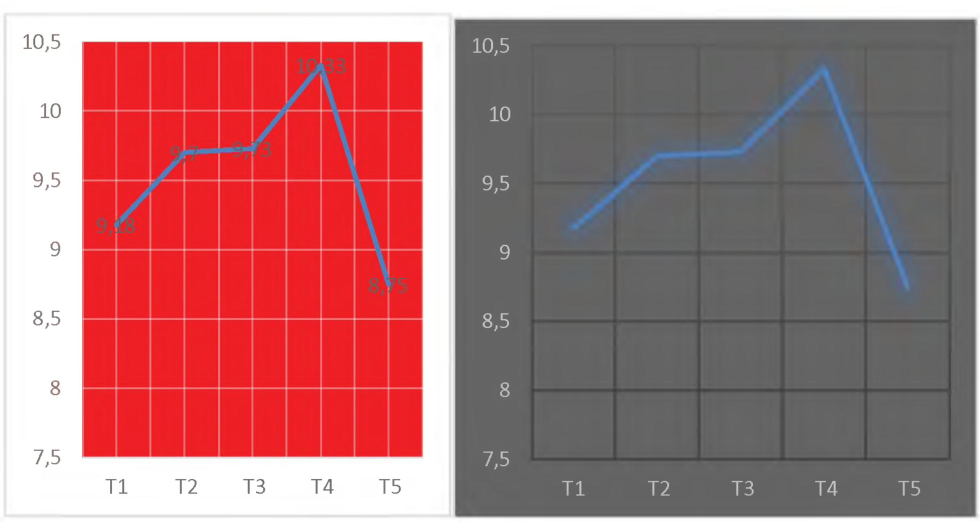

Fig. 2: 2016, Zea Mays L. height as influence by N-fertilizer: An approach for Climate-Smart Agriculture

3. Influence of N-Fertilizer on maize (Zea mays L.) height: as a Climate-Smart Strategy for Tropical Agriculture (cm). 2017 Experiment

Treatment Code	Planting Distance	Treatment	Maize Mean height at 1WAFA	Maize mean height at 5WAFA
Treatment 1 (T_1)	30cm×30cm	0.078kg ha1 Urea by Ring Application method	59.51	75.23
Treatment 2 (T_2)	1m×1m	0.078kg ha1 Urea by Ring Application method	72.73	85.78
Treatment 3 (T_3)	70cm×70cm	0.078kg ha1 Urea by Ring Application method	61.87	75.69
Treatment 4 (T_4)	30cm×25cm	0.078kg ha1 Urea by Ring Application method	60.88	77.09
Treatment 5 (T_5)	Random planting	Control	52.18	60.15
LSD ($P < 0.05$)			5.69	8.66

Mean was separated using Fishers separation (f-LSD). The least mean produced minimum plant height

Analysis of variance for plant height at 1WAFA indicates a significant ($P < 0.05$) difference with Ring application at 1×1 m producing (72.73 cm) maximum plant ($P = 0.05$) height over the all other treatments. 70×70cm planting distance produced a mean value of 61.87 cm, followed by 60.88 cm in 30×25cm spacing distance, presenting these treatments as effective compared to the control. 30×30 cm planting distance recorded a figure at 59.51 cm, indicating the effect of this treatment over the (52.18 cm) observed at the control. At 5 Weeks after fertilizer application, treatment two ((T_2) 1 m×1 m) produced plants with a mean height of 85.78 cm, reflecting the influence of this treatment to consistently increase the height of the plants. Result obtained for 70×70 cm spacing shows significant ($P = 0.05$) increase in the height of maize plant over the control. Treatment one ((T_1)30 cm×30 cm) and treatment three ((T_4)30×25 cm) produced a mean height of 75.23 cm and 77.09 cm) respectively. The least plant height was recorded in the control plot with a mean value of (60.15 cm) in this experiment. Data obtained in the 2016 experiment is similar with 2017 experiment and agrees with the experiment of Omotoso and Shittu (2007) which recorded increased growth characteristics in *Abelmoschus esculentus* (L.) when NPK fertilizer was applied by ring method. Olufolaji *et al*. (2002) reports also agrees with this findings, where they recorded an increase growth parameters using ring application method. Research of Adiaha (2016) is also in line with this finding, where the experimenter reported increase in *Zea mays* L. growth parameters over the control using mineral fertilizer.

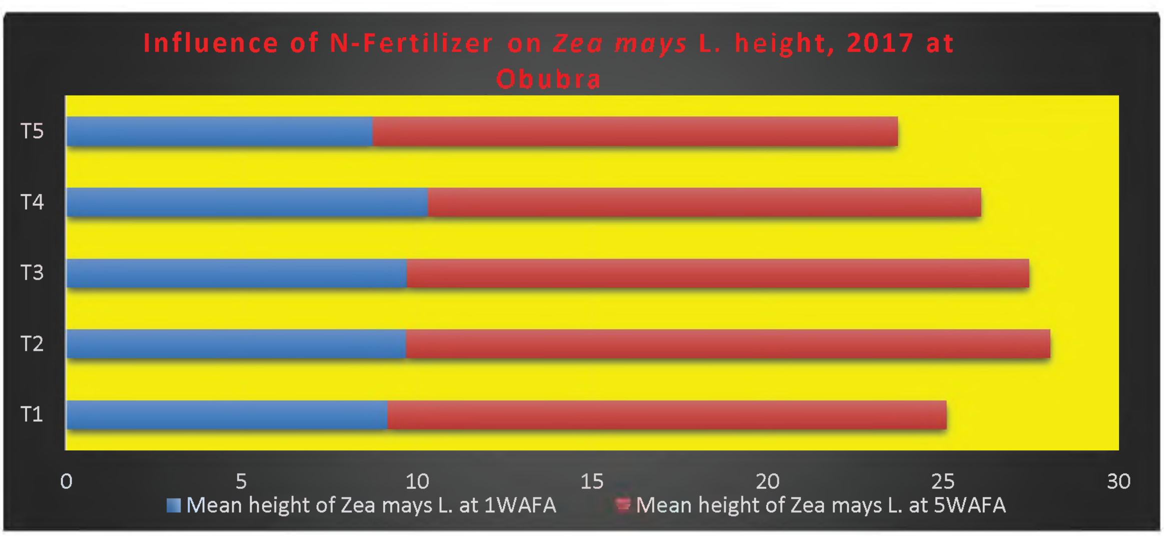

Fig. 3: 2017, Influence of N-Fertilizer on Zea mays L height in rain prone area in southern Nigeria (plant height at 5WAFA and 1WAFA)

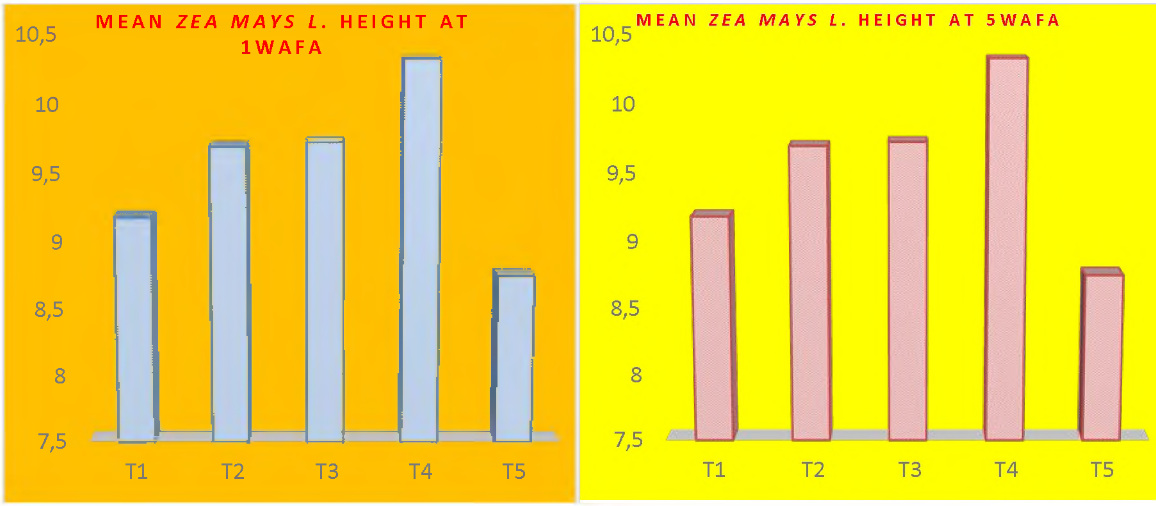

Fig. 4: 2017, Zea Mays L. height as influence by N-fertilizer: An approach for Climate-Smart Agriculture

3.4. Number of leaves

Table 4 presents the trend observed and recorded in the number of leaves as influence by application N-fertilizer.

The data recorded in Table 4, showed the trend observed in the number of leaves produced by the plant at different stages of growth. At 1WAFA there was no significant ($P > 0.05$) difference in the number of leaves per plant among the various treatments. At one Week after fertilizer application to planting distance at 30×25cm produce the highest number of leaves (10.33), giving it an edge over the control. Planting distance of 70×70 cm recorded a mean value of 9.73, which was closely followed by 1×1m distance which recorded a mean value of (9.70). 30×30 cm distance method produced a mean number of leaves at 9.18, indicting an increase over the control which recorded a mean value of 8.75. At five (5) weeks after fertilizer application, 1×1m planting distance produced 17.73 mean number of leaves, which was significantly ($P < 0.05$) different, producing the maximum ($P = 0.05$) number of leaves over all other treatments. 70×70 cm planting distance recorded a mean value of (17.73), placing T_2 and T_3 over T_1 and T_4, BC and the control (Random planting). 30×30 cm and 30 ×25 cm produced (15.93 and 15.75) mean value respectively, presenting these treatments as preferred over the control which recorded a value of 14.96 mean number of leaves.

Results obtained by ANOVA analysis indicates maximum ($P = 0.05$) number of leaves in Ring application method at plant spacing of 1 m ×1 m, with a mean value of (11.51). 10.93 mean value was recorded in 30×25 cm spacing which shows

4. Influence of N-Fertilizer on maize (*Zea mays* L.) number of leaves, as a Climate Strategy for Climate Change Resilience (cm). 2016 Experiment

Treatment Code	Planting Distance	Treatment	Maize Mean height at 1WAFA	Maize Mean height at 5WAFA
Treatment 1 (T_1)	30cm×30cm	0.078kg ha1 Urea by Ring Application method	9.18	15.93
Treatment 2 (T_2)	1m×1m	0.078kg ha1 Urea by Ring Application method	9.70	18.36
Treatment 3 (T_3)	70cm×70cm	0.078kg ha1 Urea by Ring Application method	9.73	17.73
Treatment 4 (T_4)	30cm×25cm	0.078kg ha1 Urea by Ring Application method	10.33	15.75
Treatment 5 (T_5)	Random planting	Control	8.75	14.96
LSD ($P < 0.05$)			NS	1.76

Mean was separated using Fishers separation (f-LSD). The least mean produced minimum number of leaves

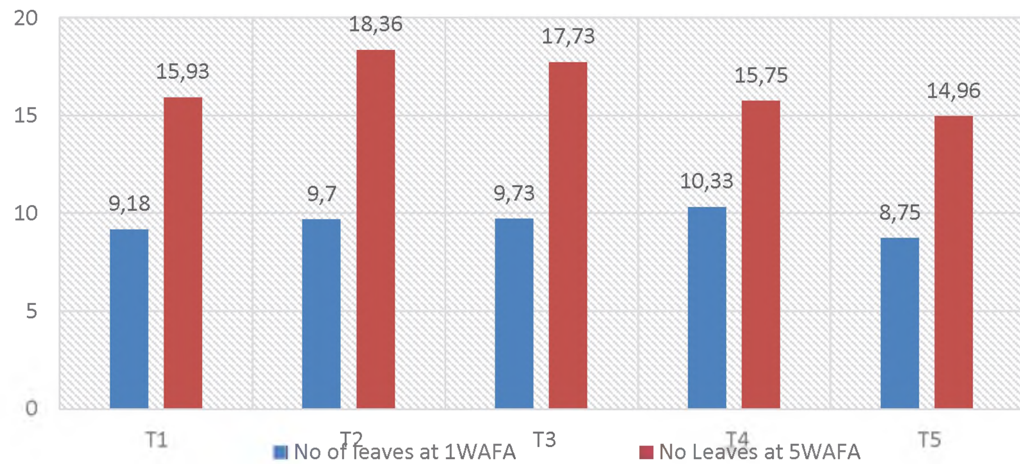

Fig. 5. Zea Mays L. No. of Leaves as influence by N-fertilizer for Climate Smart Agriculture

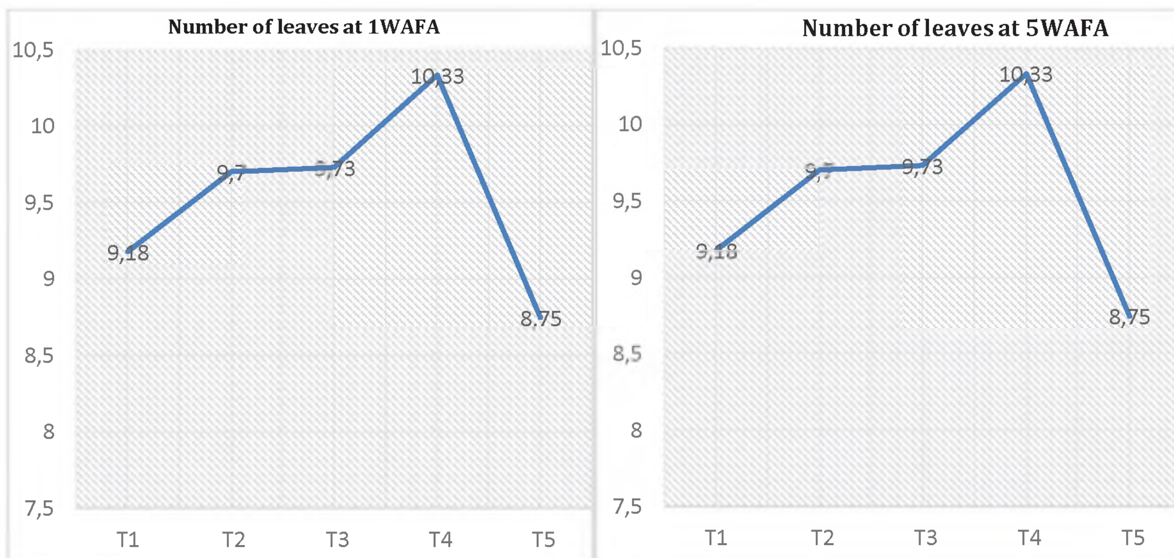

Fig.6. Behavior of growth number of leaves of Zea Mays L.
under the influence of N-fertilizer in humid tropical soils of Sothern Nigeria

5. Influence of N-Fertilizer on maize (*Zea mays* L.) number of leaves, as a Climate Strategy for Climate Change Resilience. 2017 Experiment

Treatment Code	Planting Distance	Treatment	Maize Mean height at 1WAFA	Maize Mean height at 5WAFA
Treatment 1 (T_1)	30cm×30cm	0.078kg ha1 Urea by Ring Application method	10.30	16.54
Treatment 2 (T_2)	1m×1m	0.078kg ha1 Urea by Ring Application method	11.51	19.75
Treatment 3 (T_3)	70cm×70cm	0.078kg ha1 Urea by Ring Application method	10.45	18.68
Treatment 4 (T_4)	30cm×25cm	0.078kg ha1 Urea by Ring Application method	10.93	18.86
Treatment 5 (T_5)	Random planting	Control	9.10	15.21
LSD ($P < 0.05$)			1.60	2.05

Mean was separated using Fishers separation (f -LSD). The least mean produced minimum number of leaves an increase in the number of leaves produced. 70×70 cm distance produced 10.45 mean numbers of leaves. 30×30 cm spacing recorded a mean value of 10.30, indicating an increase over the control. The least number of leaves was produced in the control. At 5 Weeks after fertilizer application, Ring application to 1 m ×1 m still maintained it positive influence on the crop, producing a mean value of (19.75) number of leaves, indicating a significant ($P < 0.05$) difference over the control. 30×25 cm and 70×70 cm recorded a mean value at (18.86 and 18.68) respectively, presenting these treatments as been positively influencing the growth parameters of maize. 30×30 cm spacing method recorded a mean value at (16.54), indicating an increase over the control. All treatments increased the number of leaves of the crop, except the control which produced the least number of leaves (15.21). The result obtained in number of leaves in this experiment is in line with the submission of Olufolaji *et al.* (2002); Omotoso and Shittu (2007), where they recorded an increase in plant growth parameters with the application of mineral fertilizers. Outcome of this finding further confirms the report of Adiaha (2016), where the scientist presented significate ($P < 0.05$) increase in *Zea mays* L. growth parameter after application of mineral fertilizer.

3.5. Climatic and hydrological Data

Climatic and hydrological information about the study area was collected in the weather station at the Cross River University of Technology (CRUTECH). Information presented in Table 6 indicated both extreme and normal trend occurring in the experimental site during the experimental year 2016 and 2017 respectively.

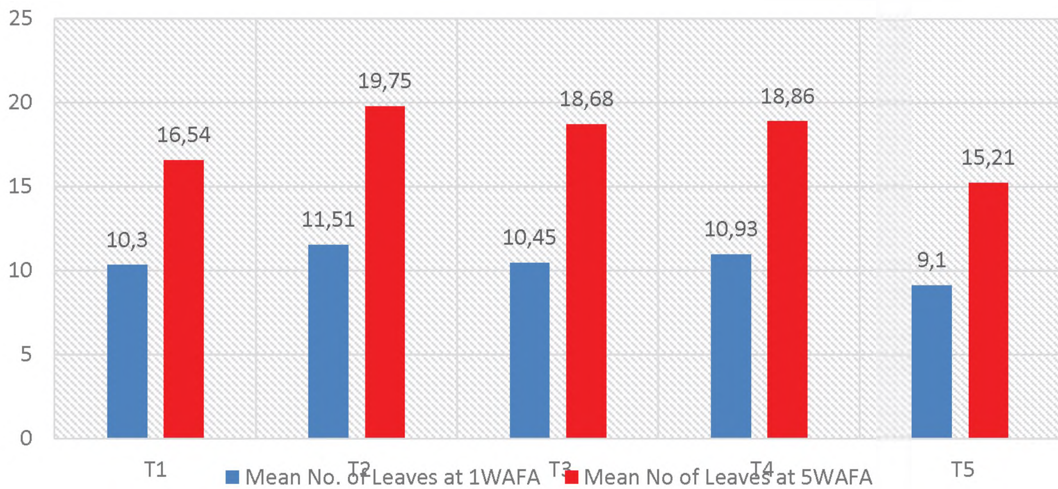

Fig. 7. Zea Mays L. No. of Leaves as influence by N-fertilizer for Climate Smart Agriculture

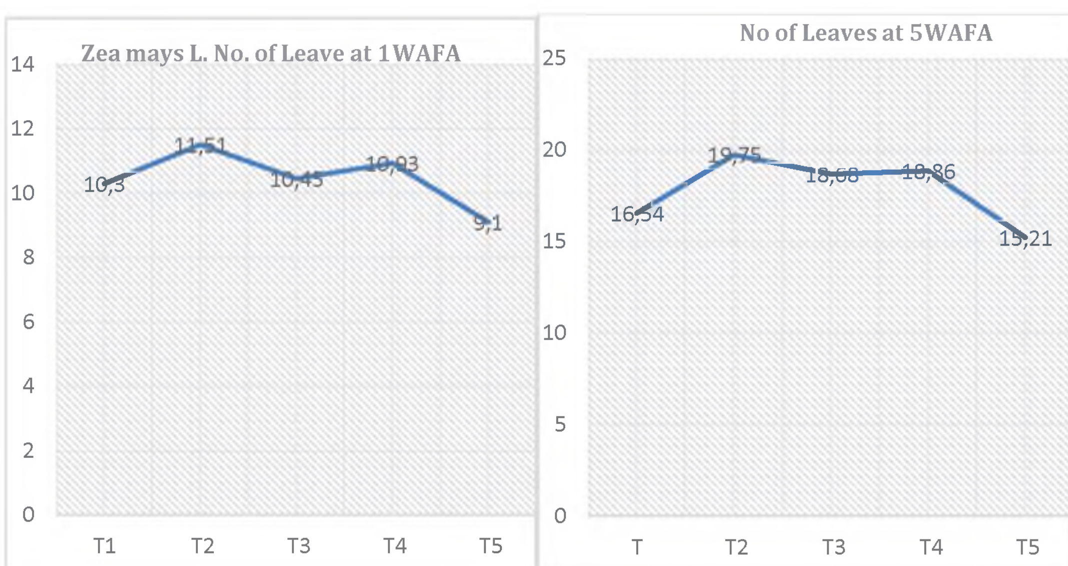

Fig. 8. Behavior of growth number of leaves of Zea Mays L.
under the influence of N-fertilizer in humid tropical soils of Sothern Nigeria, 2017

6. Experimental sites weather data summary of 2016 and 2017 cropping seasons

Months	Rainfall	Temperature (0C)		Relative Humidity (%)
		Maximum	Minimum	
2016 Cropping Season				
March	58.3	34.1	27.2	72.2
April	163.2	34.5	25.8	81.1
May	263.1	31.3	22.1	83.1
June	537.1	30.1	23.1	87.7
July	637.5	32.3	24.3	90.8
August	389.8	29.2	25.1	85.3
September	421.5	28.1	26.4	87.2
October	301.2	30.4	20.1	75.5
November	187.1	29.5	20.1	84.1
December	15.3	29.5	20.1	65.7
Total	2974.1	308	239.5	812.7
Mean	297.41	30.80	23.95	81.27
2017 Cropping Season				
March	38.3	34.2	28.1	70.3
April	229.5	33.5	26.4	78.6
May	321.4	32.4	24.5	80.7
June	446.87	34.5	22.7	85.4
July	701.24	31.3	22.9	88.6
August	343.89	30.2	26.3	80.9
September	402.5	29.5	25.7	84.3
October	301.7	28.7	25.3	84.2
November	107.5	28.5	23.4	78.6
December	13.8	28.1	22.3	76.4
Total	2906.6	310.9	247.6	719.1
Mean	290.66	31.09	24.76	71.91

Fig. 9: Test crop at physiological harvesting

4. CONCLUSION

The result obtained showed that 0.078 kg ha^{-1} of N-fertilizer applied by ring method significantly ($p<0.05$) influenced the overall growth performance of maize over the control, and contribute to environmental sustainability, while in turn been a smart approach to crop production in the face of the changing climate. Application of N-fertilizer at the right point of application: two weeks after planting (2WAP) had significant influence on the growth of maize. Studying the application of N-fertilizer as a climate smart approach for improvement of soil fertility/ productivity and for sustainable crop production, it is concluded that application of N-fertilizer at the right time, and at the required quantity is efficient and responsive as a climate smart approach to combat the change due to variabilities in the climate, and maize has been observed to responds well to the application of 0.078 kg ha^{-1} of N when planted at 1 m× 1m spacing on bed.

Key Contribution of the Study to Knowledge

1. Timely and application of N containing fertilizer at 0.078kg ha^{-1} has been found to be productive for maize production in southern Nigeria under rain-fed cultivation.

2. N deficiency in humid tropical soils has always been a problem, and exacerbated by the impact of climate change. To combat this, this study have proof that the application of N-Fertilizer (Urea) at five (5) Weeks After Planting will boost the growth stage of *Zea mays* L. (corn), and make nutrients available in the soil for exchange between crop and soil, as it is a climate smart approach to crop production under the current trend in the impact of climate change on Agriculture.

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М.С. Адиаха

Борьба с деградацией тропических почв: роль азотных удобрений как составляющей климатически разумной стратегии в сфере эффективного производства кукурузы

Аннотация. *Проблемы, стоящие перед человечеством на протяжении многих лет, включают отсутствие продовольственной безопасности, потерю почвенных и водных ресурсов и связанные с этим нарушения экосистемы. Число голодающих людей в развивающихся странах продолжает увеличиваться, вызывая недоедание и смерть. Нехватка продовольствия, отсутствие продовольственной безопасности или недоедание приобрели глобальный характер, особенно в связи с тем, что изменение климата поражает весь мир своими негативными последствиями, причем более серьезной эта ситуация отмечается в африканских странах с ограниченными ресурсами. Почва является природным капиталом, который движет сельскохозяйственным сектором, являясь сильной основой для растениеводства/животноводства, помимо того, что является средой для производства сырья, которое обеспечивает промышленное и внутреннее производство. На качество почвы влияют различные факторы, в том числе изменчивость климата, например чрезмерное количество осадков, что приводит к вымыванию питательных веществ вниз по течению, что в свою очередь провоцирует загрязнение водоемов удобрениями/остатками агрохимикатов.*

Присущие нигерийским, как и большинству тропических влажных почв, свойства, как правило, низкие, что приводит к быстрой деградации вносимых питательных веществ и полному *неурожаю в экстремальных случаях. Чаще всего это усугубляется применением наиболее распространенных систем землепользования/ведения сельского хозяйства в сочетании с проблемой чрезмерного выпаса скота и беспорядочной вырубкой лесов наряду с быстрым ростом населения с последующей урбанизацией и индустриализацией. Для эффективного управления почвенными ресурсами, особенно в условиях изменения климата, очень остро встает вопрос о необходимости принятия климатически разумной стратегии (CSS) в сфере сельскохозяйственного производства с целью найти устойчивый подход (SA) к производству продовольствия для выживания человечества. Для эффективного производства кукурузы (Zea mays L.) применение минеральных удобрений становится важным аспектом производства продуктов питания для человека/животных. Полевые эксперименты проводили в учебно-исследовательском фермерском хозяйстве Технологического университета Кросс-Ривер (широта 6° 06' северной широты и 8° 18° восточной долготы), с целью оценки потенциала азотных удобрений в качестве климатически разумного подхода (CSA) для устойчивого производства кукурузы во влажных тропиках. Семена кукурузы сорта Ikot Local White обрабатывали азотными удобрениями в дозе 0,078 кг/ га. Обработка проводилась в рандомизированном полном блочном дизайне (RCBD). Обработку повторяли четыре раза, чтобы получить в общей сложности шестнадцать (16) полевых участков. Собранные данные о параметрах роста растений (количество листьев и высота кукурузы) подвергались дисперсионному анализу (ANOVA), в то время как значительные средние значения в ходе обработки были выделены с использованием наименьшего значимого различия (LSD) при уровне вероятности 5%. Полученный результат показал, что участки, обработанные 0,078 кг/га азотного удобрения (N-удобрение), значительно (p = 0,05) увеличивают параметр роста кукурузы по сравнению с контролем. В результате исследования был сделан вывод о том, что 0,078 кг/га N-удобрения, вносимого под кукурузу, посаженную на расстоянии 1 м между растениями, увеличивает рост урожая и выступает в качестве CSA с целью предотвращения быстрого ухудшения продуктивности влажных тропических почв и обеспечения экологической их устойчивости.*

Ключевые слова: *климатически разумная стратегия, тропические почвы, азотное удобрение, кукуруза, борьба*

М.С. Адіаха

Боротьба з деградацією тропічних ґрунтів: роль азотних добрив як кліматично розумної стратегії у сфері ефективного виробництва кукурудзи

Анотація. *Проблеми, які стоять перед людством протягом багатьох років, включають відсутність продовольчої безпеки, втрату ґрунтових і водних ресурсів і пов'язані з цим порушення екосистеми. Число голодуючих людей в країнах, що розвиваються, продовжує збільшуватися, викликаючи смерть і недоїдання. Нестача продовольства, відсутність продовольчої безпеки або недоїдання набули глобального характеру, особливо у зв'язку з тим, що зміна клімату вражає весь світ своїми негативними наслідками, причому більш серйозна ситуація складається в африканських країнах з обмеженими ресурсами. Грунт – це природний капітал, який є рушійною силою сільськогосподарського сектору а, будучи основною базою для рослинництва/тваринництва, крім того що він є середовищем для виробництва сировини, що забезпечує промислове виробництво. На якість ґрунту впливають різні чинники, в тому числі мінливість клімату, наприклад надмірна кількість опадів, що призводить до вимивання поживних речовин униз за течією, і, як наслідок, до забруднення водойм добривами/залишками агрохімікатів.*

Властивості нігерійських ґрунтів, як і більшості тропічних вологих ґрунтів, як правило, низькі, що призводить до швидкої деградації внесених поживних речовин і повного неврожаю в екстремальних випадках. Часто це поглиблюється із-за через використання найбільш поширених систем землекористування/сільського господарства в поєднанні з проблемою надмірного випасу худоби і безладної вирубки лісів поряд із швидким зростанням населення з подальшою урбанізацією і індустріалізацією. Для ефективного управління грунтовими ресурсами, особливо в умовах зміни клімату, виникає гостра потреба в кліматично продуманій стратегії (CSS) щодо сільськогосподарського виробництва, для того щоб знайти стійкий підхід (SA) до виробництва продовольства з метою виживання людства. Для ефективного виробництва кукурудзи (Zea mays L.) застосування мінеральних добрив стає важливим аспектом виробництва продуктів харчування для людини/тварин. Польові експерименти проводили на навчально-дослідному фермерському господарстві Технологічного університету Крос-Рівер (широта 6 ° 06' північної широти та 8 ° 18 ° східної довготи), з метою оцінювання потенціалу азотних добрив як складової якісного кліматично розумного підходу (CSA) для стійкого виробництва кукурудзи у вологих тропіках. Різновид насіння кукурудзи Ikot Local White обробляли азотними добривами в дозі 0,078 кг/га. Обробіток проводили в рандомізованому повному блоковому дизайні (RCBD) з чотириразовою повторюваністю і було отримано в цілому шістнадцять (16) *польових ділянок. Зібрані дані про параметри росту рослин (кількість листків і висота кукурудзи) піддавалися дисперсійному аналізу (ANOVA), в той час як значні середні значення, отримані під час обробок, були виділені з використанням найменшої значущої відмінності (LSD) за рівня ймовірності 5%. Отримані результати показали, що на ділянках, де вносили 0,078 кг/га азотного добрива (N-добриво), значно (р = 0,05) підвищувався параметр росту кукурудзи в порівнянні з контролем. У результаті дослідження було зроблено висновок про те, що 0,078 кг/га N-добрива, внесеного під кукурудзу, посаджену на відстані 1 м між рослинами, сприяє зростанню врожаю і виступає як CSA для запобігання швидкого погіршення продуктивності вологих тропічних ґрунтів і забезпечення їхньої екологічної стійкості.*

Ключові слова: *кліматично розумна стратегія, тропічні ґрунти, азотне добриво, кукурудза, подолання*