

Original Research Article

Influence of N:K Ratios in Soils on Growth, Nutrient Availability and Yield of Maize (*Zea mays L.*) in Southern Nigeria.

ABSTRACT

This study was undertaken ~~in two distinct ecological zones of Edo state of Nigeria~~ to determine the influence of N:K ratios applied to soils and the availability of N, K on yield of maize in two distinct ecological zones of Edo state of Nigeria during the... (specify the year/s/). The sites used were Rubber Research Institute of Nigeria (RRIN) Iyanomo (Forest) and the Teaching and Research Farm of Ambrose Alli University, Emaudo, Ekpoma (Derived Savanna). The soils of the two experimental sites were analyzed for both physical and chemical properties before the commencement of the experiments. The experiments were carried out as ~~p~~Pot experiments in the screen house and ~~f~~Field experiments. Each of the experiments had ten treatments (adjusted ratios) that were fitted into randomized complete block design and replicated three times. Maize was used as the test crop. Results from the screen house revealed that N/K ratio 4:1 had the highest dry matter yield for both locations, (RRIN; 2.60 g/pot and Emaudo; 2.75 g/pot) but these values were not significantly different ($P < 0.05$) from what were obtained from N/K ratio 3:1 and 2:1, respectively. The N:K ratio in soil had influence on the availability of N and K. Under field conditions, N/K ratio 4:1 had the highest grain yield for both locations (RRIN; 3.46 ton/ha and Emaudo; 3.33 ton/ha), and the highest cob field weight (RRIN; 9.92 ton/ha and Emaudo; 9.33 ton/ha), hence its recommendation.

Key-words: N:K ratios, Nutrient availability, Growth, Maize, yield, Soils.

Comment [WU1]: Unncessary sentence
Please removed

Formatted: Font: Not Bold

Comment [WU2]: Connect two words

Formatted: Font: Bold

Introduction

Chemical fertilizers are essential components of any system in which the aim is to maintain good yield in the absence of organic manure [1]. However the rate of application and dosage has a greater influence on both crop yield and its environment [2]. Excessive application of fertilizer as opined by [3] does not really enhance sustainability, crop nutrient uptake nor significantly increase yields but tends to encourage economic waste and damage to the environment. Inadequate application, on the other hand, can retard growth and lower yield in short term and in the long run jeopardizes sustainability through soil mining and erosion. This precarious tilt between “excessive” and “inadequate” is the major challenge of fertilizer recommendation efforts and can only be effectively bridged when nutrients are applied at the right ratios.

Soil nutrient leaching and low level of soil organic matter has made nitrogen a limiting nutrient to maize production in Nigeria [4;5]. However, high supply of N is frequently associated with acidification and accumulation of ammonia in the rhizosphere [6]. Increases in N availability may also lead to strong P and K shortage which might exclude some plant species through vitality [7].

Potassium is known to play a major role in osmoregulation, enzyme activation and carbohydrate translocation [8]. The release and fixation of K is as a function of fertilizer application rate and soil parent material [9]. Furthermore, K supply might affect N uptake in leaves, photosynthetic activity and water use efficiency [10].

Majority of tropical soils are fragile and low in plant nutrients [11; 12] and with climate that is characterised by high rainfall and insolation which are however not evenly distributed in the various ecological zones. Hence, variation in the performance of crops, the soil condition and nutrient status are expected among the ecological zones.

The study was however performed in a screenhouse house and field to determine the vVariation of N:K Ratio in sSoils, growth, nutrient availability and mYield of mMaize (*Zea mays L.*). To better understand the variations in N:K ratios, an examination of the growth responses, nutrient concentrations in earleaf at silk and crop yield for the best combination of N:K ratios in soils were carried out in the locations.

Comment [WU3]: State your research objectives

Materials and Methods

The experiment was performed in two locations, viz; Rubber Research Institute of Nigeria (RRIN) Iyanomo (rain forest). The soils are derived from the coastal plain sand parent material and the second location was the Teaching and Research Farm of Ambrose Alli University, Emaudo annex, Ekpoma (derive savanna), the soils are from the transition zone between the coastal plain and basement complex, both in Edo state, Nigeria. Soils from RRIN used for the study are Inceptisols, classified as Typic Dystrudept and specifically located at latitude $6^{\circ} 09'$ and $6^{\circ} 85'$ N and longitude $5^{\circ} 35'$ and $5^{\circ} 58'$ E [13], while soils from Emaudo are Ultisols, classified as Rhodic paleudults and located at latitude $6^{\circ} 18'$ and $6^{\circ} 46'$ E and longitude of $6^{\circ} 00'$ and $6^{\circ} 40''$ N [14]. The experiment was carried out in two stages: Pot experiment in the screen house (screen house ionic experiment) and field experiment (field ionic experiment).

Comment [WU4]: Include subheading
2.1 Description of study areas
2.2. Experimental design and procedures
2.3 soil/plant tissue analysis
2.4 Data analysiss

Surface sSoil samples taken from each of the experimental sites, were air dried, sieved and analyzed for both physical and chemical properties, 1500g each were weighed and placed in 2 liter plastic cups, based on the soil test values, using the following adjusted ratios: 0:0, (Control) 1:1, 2:1, 3:1, 4:1, 5:1, 1:2, 1:3, 1:4 and 1:5 N:K treatments (Table 1). The experiments were fitted into a randomized complete block design (RCBD) and replicated three times. Nitrogen was applied as urea, and potassium as muriate of potash. Maize was used as the test crop, distilled water was used for irrigation. The above ground portions of maize plant were harvested six weeks after planting (WAP). The experiment was repeated in the field as a follow up of the screen house work. The field ionic studies were conducted in two locations, RRIN and Emaudo,

Comment [WU5]: Plsease use symbol of degree

respectively. The experiment was a randomized complete block design. N:P:K ratio trials were laid out consisting of 10 treatments, based on the soil test values, using the following adjusted ratios: 0:0, (Control) 1:1, 2:1, 3:1, 4:1, 5:1, 1:2, 1:3,

Table 1: Adjusted N:K ratios in the soil before planting in the screen house

Ecological Zone	Location	Trt No	NK Ratio in Soil	Soil adjusted Nutrients (g/pot)	
				N	K
Derived Savanna	Emuado	1	0 : 0	-	-
		2	1 : 1	0.12	0.12
		3	1 : 2	0.12	0.24
		4	1 : 3	0.12	0.36
		5	1 : 4	0.12	0.48
		6	1 : 5	0.12	0.60
		7	2 : 1	0.24	0.12
		8	3 : 1	0.36	0.12
		9	4 : 1	0.48	0.12
		10	5 : 1	0.60	0.12
Forest	RRIN	1	0 : 0	-	-
		2	1 : 1	0.12	0.12
		3	1 : 2	0.12	0.24
		4	1 : 3	0.12	0.36
		5	1 : 4	0.12	0.48
		6	1 : 5	0.12	0.60
		7	2 : 1	0.24	0.12
		8	3 : 1	0.36	0.12
		9	4 : 1	0.48	0.12
		10	5 : 1	0.60	0.12

Formatted: Font: Not Bold

1:4 and 1:5 for N:K (Table 2) randomized among the plots within the block. Each plot size was 2.5m x 2.0m and the planting distance adopted was 75 x 25cm with a space of 50 cm between plots and 80 cm between blocks. N:K treatments were applied 2 weeks after planting (WAP). Agronomic growth traits were measured at 4 and 8 WAP. Two ear leaf samples were randomly selected from the centre row of each plot at silking stage and were analyzed for their nutrient contents of N and K. Three plants in each plot (middle row) were harvested from 15 plants in each plot to eliminate the effect of cross feeding. The harvested maize cobs were dried and dehusked, the dry weight (yield) noted. All data obtained from laboratory, screen house and field studies were subjected to statistical analysis (SARS).

Comment [WU6]: Write the way of analysis in subheading

Soils/plant tissue analysis

Soil pH was measured in 1:1 soil water suspension [15]. Exchange acidity (Al^{3+} , H^+) was extracted with INKCl [16]. Organic Carbon was determined by wet dichromate acid oxidation method [17]. Available phosphorus was extracted with Bray P1 solution and measured by the molybdenum blue method on a technicon auto analyzer as modified BY [18]. Exchangeable cations (Ca, Mg, K and Na) were extracted with 1N NH_4OAC at pH 7.0. Potassium and Na were determined with a flame emission photometer while Ca and Mg were determined with absorption

Table 2. Adjusted N:K ratios in the soil before planting in the field atomic

Formatted: Font: Not Bold

Ecological Zone	Location	Trt No	NK Ratio in Soil	Soil adjusted nutrients (kg/ha)	
				N	K
Derived Savanna	Emuado	1	0 : 0	-	-
		2	1 : 1	56.16	56.16
		3	1 : 2	56.16	56.16
		4	1 : 3	56.16	56.16
		5	1 : 4	56.16	56.16
		6	1 : 5	56.16	56.16
		7	2 : 1	112.36	112.36
		8	3 : 1	168.48	168.48
		9	4 : 1	224.64	224.64
		10	5 : 1	280.80	280.80
Forest	RRIN	1	0 : 0	-	-
		2	1 : 1	56.16	56.16
		3	1 : 2	56.16	112.36
		4	1 : 3	56.16	168.48
		5	1 : 4	56.16	224.64
		6	1 : 5	56.16	280.80
		7	2 : 1	112.36	56.16
		8	3 : 1	168.48	56.16
		9	4 : 1	224.64	56.16
		10	5 : 1	280.80	56.16

spectrophotometer [19]. Effective cation exchange capacity (ECEC) was calculated by the summation of exchangeable bases and exchange acidity [19]. Particle size distribution was determined by the hydrometer method according to [20]. Plant samples were oven dried at 70 °C for 72 hours, milled and sieved through 0.5 mm mesh sieve. Nitrogen was determined using the macro-kjedahl method [19], Potassium was determined by flame photometer; and

pPhosphorus was determined using Bray P I method and measured by the molybdenum blue method [18].

[Data analysis \(state how the data analyzed?\)](#)

Results and Discussion

The physical and chemical properties of the soils used for the experiments are presented on Table 3. The Soils from the two sites were acidic in nature and had low electrical conductivity, total nitrogen, organic carbon, exchangeable potassium and sodium and are below the critical

Table 3. Physical and chemical properties of experimental sites.

Formatted: Font: Not Bold

Parameters	RRIN	Emaudo
pH	5.30	5.36
Organic Carbon (g/kg)	8.0	7.7
Organic matter (g/kg)	13.8	13.3
Available P (mg/kg)	4.37	4.78
Total Nitrogen (N) (g/kg)	0.72	0.58
Exchangeable Ca (Cmol/kg)	2.48	1.60
Exchangeable Na (Cmol/kg)	0.63	0.15
Exchangeable k (Cmol/kg)	0.16	0.18
Hydrogen (H ⁺) Cmol/kg	0.50	0.80
Aluminum (Al ³⁺) Cmol/kg	0.10	0.20
ECEC Cmol/kg	3.72	3.33
Clay (g/kg)	149.70	40.40
Silt (g/kg)	89.50	59.50
Sand (g/kg)	760.80	900.10
Textural class	Sandy Loam	Sand

nutrient element levels given for most crops of this region [21; 22; 23; 24]. The textural classes were sandy loam and sand.

Variations in N:K ratios on plant nutrient concentrations, uptake and dry matter yield in the screen house for both soils of RRIN and Emaudo are presented on Table 4, the concentration of N increased with increase in N application. N:K ratio experiment in the screen house work showed significant effect of applied ratios on DMY with N:K ratio 4:1 having the highest DMY in both soils. There was a positive and significant correlation between and uptake of N and K ($r < 0.977^{**}$) in soils of RRIN (Table 5) as a result of the applied N/K ratios while in the soils of

Emaudo, there was a positive correlation between the uptake of N and K ($r < 0.512$) although not significant. This was a probably indication of synergistic relationship, and is in agreement with the findings of [25].

Higher application of nitrogen significantly affected the maize plant growth rate with N:K applied ratios 4:1 having the highest growth rate in terms of maize plant height, stem girth, leaf area and number of leaves at 4 and 8 weeks after planting (WAP) for both Experimental sites.

Table 4: Variations in N:K ratios on plant nutrient concentrations, uptake and D.M.Y. of maize in the screen house at RRIN and Emaudo

Location	Adjusted N:K ratios in soils	D.M.Y (g/pot)	Conc of nutrients in plant (%)		uptake of nutrients (mg/kg)	
			N (conc)	K (conc)	N (uptak)	K (uptak)
RRIN	0 : 0	0.54	1.71	1.61	9.21	9.74
	1 : 1	1.17	1.72	1.65	20.11	21.69
	1 : 2	1.09	1.782	1.91	21.92	23.47
	1 : 3	0.95	1.84	1.94	22.82	24.04
	1 : 4	0.70	1.99	2.05	26.45	27.20
	1 : 5	0.53	1.92	2.17	49.72	56.32
	2 : 1	1.24	1.92	1.95	20.93	20.13
	3 : 1	1.33	2.87	1.81	21.54	16.05
	4 : 1	2.60	2.93	1.72	16.10	11.00
	5 : 1	1.23	3.54	1.31	13.46	6.94
		SE (P < 0.05)	ns	ns	ns	ns
Emaudo	0 : 0	1.13	1.49	1.65	17.88	22.20
	1 : 1	1.57	1.50	1.87	23.55	29.36
	1 : 2	1.52	1.54	2.10	16.94	23.10
	1 : 3	1.29	1.69	2.14	46.14	28.42
	1 : 4	1.28	1.74	2.29	22.62	29.77
	1 : 5	1.20	1.77	28.85	28.85	39.61
	2 : 1	1.76	2.13	1.61	24.07	18.19
	3 : 1	1.80	3.15	1.51	38.70	27.18
	4 : 1	2.75	3.18	1.24	33.35	18.97
	5 : 1	1.20	3.32	1.17	37.12	18.72
		SE (P < 0.05)	ns	ns	ns	ns

SE: Standard Error, ns: not significant, D. M. Y. : Dry matter yield

Comment [WU7]: Write the full name

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Table 5: Correlation coefficient matrix showing the effect of applied N:K ratios in soils on the relationship between nutrient concentrations, uptake and DMY of maize in the screen house

Formatted: Font: Not Bold

Location	D.M.Y	N conc (%)	N Uptake	K conc (%)	K conc (%)
RRIN	D. M. Y.	1			
	N conc (%)	-0.340	1		
	N Uptake	0.983**	-0.172	1	
	K conc (%)	0.789**	-0.755*	0.701*	1
	K Uptake	0.998**	-0.368	0.977**	0.810**
Emaudo	D. M. Y.	1			
	N conc (%)	0.048	1		
	N Uptake	0.870**	0.528	1	
	K conc (%)	0.088	-0.749*	-0.303	1
	K Uptake	0.835**	-0.376	0.512	0.618

D. M. Y. : Dry matter yield; *, ** - significant at 5 and 1 respectively

The higher the application rate, the higher the vegetative growth rate and agreed with the findings of [5] that high application of N in maize triggers complex array of morphophysiological responses. In the N:K ratio experiment, there was an effect of applied ratio on earleaf DMY in both soils of RRIN and Emaudo. DMY and concentrations of N and K were highest at N/K ratio 4:1 in both soils. [26] observed that fertilizer fortified with Nitrogen increases the concentrations of nitrogen and phosphorus as well as potassium concentration in plant tissue. This could be the probable reason while K concentration in the plant tissue was high

Table 6: Variations in N:K ratio on maize mean plant height, stem girth, leaf area and number of leaves at 4 week after planting WAP at (Emaudo).

Adjusted NK ratios in soil	Plant hHeight (cm)	Stem gGirth (cm)	Leaf aArea (cm ²)	Number of lLeaves
0 : 0	17.10 ^b	0.83 ^{ab}	72.80	7.67
1 : 1	22.77 ^{ab}	1.20 ^{ab}	106.38	8.67
1 : 2	19.03 ^{ab}	0.97 ^{ab}	79.59	8.00
1 : 3	17.60 ^b	0.77 ^b	68.85	7.67
1 : 4	17.97 ^b	0.93 ^{ab}	78.18	7.67
1 : 5	15.97 ^b	0.77 ^b	67.25	7.33
2 : 1	21.13 ^{ab}	1.10 ^{ab}	87.33	8.33
3 : 1	21.13 ^{ab}	1.20 ^a	106.38	8.67
4 : 1	22.77 ^a	1.20 ^a	108.27	8.67
5 : 1	25.77 ^{ab}	0.80 ^{ab}	73.59	7.33
SE. (P<0.05)	2.29	0.13	ns	ns

Means within the same column having the same letter(s) are not significantly different from each other, SE: Standard Error, ns: not significant difference

Table 7: Variations in N:K ratios on maize mean plant height, stem girth, leaf area and number of leaves at 8 weeks after planting WAP at (Emaudo).

Adjusted NK ratios in soils	Plant Height (cm)	Stem Girth (cm)	Leaf Area (cm ²)	Number of Leaves
0 : 0	46.67 ^c	1.20 ^c	188.89 ^b	13.67
1 : 1	83.25 ^{ab}	1.73 ^{ab}	380.46 ^a	14.33
1 : 2	73.77 ^{bc}	1.67 ^{ab}	395.67 ^a	15.00
1 : 3	73.60 ^{bc}	1.73 ^{ab}	429.05 ^a	14.33
1 : 4	72.30 ^{bc}	1.73 ^{ab}	362.05 ^a	13.67
1 : 5	57.37 ^{ab}	1.67 ^{ab}	391.26 ^a	15.00
2 : 1	83.27 ^{ab}	1.67 ^{ab}	391.26 ^a	15.00
3 : 1	90.13 ^{ab}	1.67 ^{ab}	424.15 ^a	15.00
4 : 1	107.13 ^a	1.77 ^a	466.70 ^a	15.00
5 : 1	64.27 ^{cd}	1.43 ^{bc}	301.31 ^{ab}	15.00
SE. (P<0.05)	11.14	0.10	56.2	ns

Means within the same column having the same letter(s) are not significantly different from each other, SE: Standard Error, ns: non significant difference not significant

with higher N application (Table 10). Nitrogen/pPotassium application of varying ratios affected maize vegetative growth significantly in some stages of growth. However, [27] found at carimagua that the crop did not respond to N unless K was applied in the right proportion. In both soils, the concentration of N in the ear leaf increased with increase in N application. The highest N concentration was obtained from applied N:K ratio 4:1, this was

Table 8: variations in N:K ratios on maize mean plant height, stem girth, leaf area and number of leaves at 4 W week after planting at RRIN. AP (RRIN)

Adjusted NK ratios in Soils	Plant <u>h</u> Height (cm)	Stem <u>g</u> Girth (cm)	Leaf <u>a</u> Area (cm ²)	Number of <u>L</u> eaves
0 : 0	24.00 ^b	0.73 ^c	170.4 ^c	6.33
1 : 1	27.33 ^{ab}	0.87 ^{abc}	207.4 ^{bc}	7.67
1 : 2	27.00 ^{ab}	0.82 ^{abc}	203.6 ^{bc}	7.00
1 : 3	27.00 ^{ab}	0.79 ^{bc}	198.0 ^{bc}	7.67
1 : 4	24.67 ^b	0.79 ^{bc}	194.3 ^c	7.67
1 : 5	24.67 ^b	0.79 ^{bc}	174.7 ^c	6.67
2 : 1	29.67 ^{ab}	0.90 ^{ab}	222.8 ^{bc}	7.67
3 : 1	30.00 ^{ab}	0.92 ^{ab}	259.4 ^{ab}	7.67
4 : 1	32.33 ^a	0.96 ^a	282.7 ^a	8.00
5 : 1	28.00 ^{ab}	0.80 ^{ab}	218.2 ^{bc}	7.33
SE. (P<0.05)	2.22	0.13	19.17	Ns

Means within the same column having the same letter(s) are not significantly different from each other, SE: Standard Error, ns: non significant difference not significant

Table 9: Variations in N:K ratios on maize mean plant height, stem girth, leaf area and number of leaves at 8 W week after planting at WAP (RRIN).

Adjusted NK	Plant <u>h</u> Height	Stem <u>g</u> Girth	Leaf <u>a</u> Area	Number of
-------------	-----------------------	---------------------	--------------------	-----------

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

ratios in soil	(cm)	(cm)	(cm ²)	Leaves
0 : 0	102.0 ^c	1.03	385.4 ^b	11.00 ^c
1 : 1	159.0 ^{bcd}	1.40	525.9 ^{ab}	12.33 ^{abc}
1 : 2	159.0 ^{bcd}	1.40	486.3 ^{ab}	12.33 ^{abc}
1 : 3	151.0 ^{cd}	1.37	481.0 ^{ab}	12.00 ^{abc}
1 : 4	146.3 ^{cd}	1.27	470.2 ^{ab}	12.00 ^{abc}
1 : 5	138.7 ^d	1.03	456.8 ^{ab}	11.33 ^{bc}
2 : 1	169.0 ^{abc}	1.47	560.8 ^{ab}	12.67 ^{ab}
3 : 1	178.3 ^{ab}	1.53	575.3 ^{ab}	13.00 ^a
4 : 1	184.7 ^a	1.60	587.0 ^a	13.33 ^a
5 : 1	160.7 ^{abcd}	1.43	537.7 ^{ab}	12.67 ^{ab}
SE. (P<0.05)	7.66	Ns	58.3	0.49

Means within the same column having the same letter(s) are not significantly different from each other. SE: Standard Error, ns: ~~non significant difference~~ not significant.

closely followed by 3:1 and 2:1, respectively. The highest K concentration was obtained from applied N: K ratio 1:5. The highest N uptake was from applied N: K ratio 1:5. The highest K uptake was also obtained from applied N: K 1:5. [26] observed that fertilizer fortified with Nitrogen increases the concentrations of nitrogen and phosphorus as well as potassium concentration in plant tissue. This could be the probable reason while K concentration in the plant tissue was high with higher N application.

Table 10. Variations in N:K ratios on plant nutrient concentrations, uptake and d.m.y. of maize at silking at RRIN and Emaudo.

Comment [WU8]: Write the full name

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Location	Adjusted N:K ratios in soils	D.M.Y (g/pot)	Conc of nutrients in plant (%)		uptake of nutrients (mg/kg)	
			N (conc)	K (conc)	N (uptak)	K (uptak)
RRIN	0 : 0	162.38	1.59	1.03	2.58	0.40
	1 : 1	179.46	1.64	1.61	2.90	0.54
	1 : 2	178.32	1.57	1.91	3.27	0.77
	1 : 3	175.05	1.55	1.99	4.03	1.44
	1 : 4	166.78	1.53	2.08	4.23	1.75
	1 : 5	210.82	1.51	2.12	4.65	2.02
	2 : 1	263.37	1.74	1.75	3.12	0.54
	3 : 1	280.45	2.98	2.15	3.71	0.47
	4 : 1	283.65	3.22	2.36	3.89	0.47
	5 : 1	184.95	2.51	1.31	4.19	0.42
	SE (P<0.05)	ns	Ns	ns	ns	ns
	0 : 0	143.75	1.32	1.65	3.41	2.43
	1 : 1	207.32	1.73	1.67	3.83	3.76
	1 : 2	204.11	1.64	1.73	3.76	3.74
	1 : 3	188.00	1.55	1.89	3.65	4.45

Emaudo	1 : 4	159.29	1.02	2.03	2.68	5.33
	1 : 5	151.36	2.44	2.18	5.56	4.42
	2 : 1	224.86	2.83	2.38	5.44	2.66
	3 : 1	234.26	3.11	2.37	5.79	2.56
	4 : 1	275.91	3.59	2.31	6.41	2.33
	1 : 5	175.29	3.72	2.12	6.27	1.89
SE (P<.05)		ns	ns	ns	ns	ns

Means within the same column having the same letter(s) are not significantly different from each other. DMY = --- SE: Standard Error, ns: non significant difference or significant.

Nitrogen/potassium application of varying ratios affected maize vegetative growth significantly in some stages. Nitrogen and pPotassium concentrations in the earleaf at silk at this particular N/K ratio application level were within the sufficiency ranges based on values given by Jones and [27]. The positive and significant correlation between the uptake of N and K in both soils is indication of synergistic relationship (Table 11), with 'r' values of 0.676* for RRIN soils and 'r' values of 0.662* for Emaudo, respectively.

Table 11: Correlation coefficient matrix showing the effect of applied N:K ratios in soils on the relationship between nutrient concentrations, uptake and earleaf dmy of maize in soils of Emaudo

Formatted: Font: Not Bold

Location		D.M.Y	N conc (%)	N Uptake	K conc (%)	K conc (%)
RRIN	D. M. Y.	1				
	N conc (%)	-0.547	1			
	N Uptake	0.648*	0.281	1		
	K conc (%)	0.726*	-0.881**	0.0290	1	
	K Uptake	0.986**	-0.505	0.676*	0.720*	1
Emaudo	D. M. Y.	1				
	N conc (%)	-0.792**	1			
	N Uptake	-0.581	0.948**	1		
	K conc (%)	0.611	-0.706*	-0.611	1	
	K Uptake	0.890**	-0.824**	0.662*	0.901**	1

D. M. Y. : Dry matter yield; *, ** = significant at 5% and 1% respectively

With grain yield (Table 12), applied N/K ratio 4:1 recorded the highest in both soils of RRIN and Emaudo for both locations (RRIN; 3.46 ton/ha and Emaudo; 3.33 ton/ha) although not significant, and the highest cob field weight (RRIN; 9.92 ton/ha and Emaudo; 9.33 ton/ha). The highest cob yield was also obtained from the same applied ratio 4:1 in both soils.

Since majority of tropical soils are fragile and low in plant nutrients [Carsky and Iwuofor, 1995; Juo and Wilding, 1996] and with climate that is characterised by high rainfall and insolation which are however not evenly distributed in the various ecological zones, these applications seems not to have any variation in the two distinct soils (Ultisols and Inseptisols).

Comment [WU9]: Make consistency

Gething (1993) of the international potash institute stated that in Asia the N: K ratio usage approaches 10: 1 compared with around 2: 1 in Europe and North America and some other parts of the world. This implies that with soils of RRIN and Emaudo, N:K ratios 4:1 could probably be the best ratio suggested for maize production in these locality.

Table 12.-Effect of soil N:K ratios on the mean yield of maize (cobs and grains) in soils of RRIN and Emaudo

Formatted: Font: Not Bold

Adjusted N:K Ratios in Soil	RRIN		Emaudo	
	C _{eob} field weight (ton/ha)	G _{rain} yield (ton/ha)	C _{eob} field weight (ton/ha)	G _{rain} yield (ton/ha)
0 : 0	6.11 ^d	2.16	5.12 ^c	2.07
1 : 1	7.46 ^b	3.06	7.62 ^b	3.01
1 : 2	7.46 ^b	2.60	7.61 ^b	2.71
1 : 3	7.32 ^c	2.45	6.81 ^c	2.62
1 : 4	6.47 ^c	2.34	6.35 ^c	2.33
1 : 5	6.14 ^d	2.28	6.11 ^c	2.21
2 : 1	8.22 ^a	3.12	7.71 ^b	3.07
3 : 1	8.63 ^a	3.37	8.71 ^a	3.11
4 : 1	9.92 ^a	3.46	9.33 ^a	3.33
5 : 1	6.79 ^c	2.36	6.52 ^c	2.46
SE. (P < 0.05)	0.011	ns	0.049	ns

SE: Standard Error, Means within the same column having the same letter ~~(s)~~ are not significantly different from each other.

Conclusion

In the field N:K ratio experiment, there was a significant effect of applied ratio on ear_{leaf} DMY in both soils of RRIN and Emaudo. The DMY and concentration of N and K where highest at N:K ratio 1:4 in both soils. With grain yield, applied N:K ratio 4:1 recorded the highest in both soils of RRIN and Emaudo although not significant. The highest cob yield was also obtained

from the same applied ratio in both soils. This implies that with soils of RRIN and Emaudo, N:K ratios 4:1 could probably be the best ratio suggested for maize production.

References:

1. Bakare, A. O.; Omueti, J. A. I.; Osemwota I. O. and Orimoloye J. R. (2012) Evaluation of the efficacy of organomineral fertilizers as soil amendment in an ultisols of Edo-State, Nigeria. *Chemtech Journal* ~~2012~~, 8, 106-113.
2. Gruhn, P., Goletti, F., and Yudelman, M. (2000). Integrated nutrient management, soil fertility, and sustainable agriculture: Current Issues and future challenges. In: "Food, Agriculture and the Environment Discussion", Vol. 32, pp. pp1-31. International Food Policy Research Institute, Washington, USA.
3. Smaling, E. M. A., and Braun, A. R. (1996). Soil fertility research in Sub-Saharan Africa: New dimensions, new challenges. *Communications in Soil Science and Plant Analysis* 27 (Nos. 3 and 4).
4. Adetunji, M. T. (-1991). An evaluation of soil nutrient status for maize production in southwestern Nigeria. *Samaru Journal. Agr. Res.* 8: 101-113.
5. Azeez, J. O. (2009). Effect of nitrogen application and weed interference on performance of maize genotypes in Nigeria. *Pedosphere*, 19(5): 654- 662.
6. Roem, W. J., Klees, H. and Berendse, F. (-2002). Effects of nutrient addition and acidification on plant species diversity and seed germination in healthland. *Jour. Of applied ecology*. 39,937-948.
7. Lawniczak, A. E., Güsewell, S., and Verhoeven, J. T. A. (2009). Effect of N:K supply ratios on the performance of three grass species from herbaceous wetlands. *Basic and Applied Ecology* 10, 715-725.
8. Zhi-Yong, Z., Quing-Lian, W., Zhao-Hu, L., Liu-Sheng, D. and Xiao-Li, T.(2009). Effect of Potassium deficiency on root growth of cotton and its physiological mechanisms. *ACTA Agronomica Sinica*. 35 (4) 718-723.
9. Simonsson, M., Andersson, S., Andrist-Rangel, Y., Hillier, S., Mattsson, L., and Öborn, I. (2007). Potassium release and fixation as a function of fertilizer application rate and soil parent material. *Geoderma* 140, 188-198.
10. Egilla, J. N., Davies, F. T. Boutton, T. W. (2005). Drought stress influences leaf water content, photosynthesis and water use efficiency of *Hibiscus rosa-senensis* at three potassium concentrations. *Photosynthetical*. 43: 135-140.

Formatted: Font: Not Bold

Formatted: Font: Not Bold

11. Carsky, R. K. and Iwuafor, E.N.O. (1995). Contribution of soil fertility research and maintenance of improve maize production and productivity in sub Saharan Africa. *In The international institute of tropical agriculture (IITA) ed.* Proceeding of regional workshop, 29 May-2 June, 1995. IITA, Cotonon, Benin Republic, pp35-52.
12. Juo, A.S.R. and Wilding, L. P. (1996). Soils of the lowland forest of west and central Africa, in proceedings of royal society of Edinburgh. Vol 104B, pp 15-29.
13. Orimoloye, J. R. (2011). Characterisation and evaluations of selected soils of southern Nigeria for rubber (*Hevea brasiliensis* Muel. Arg) cultivation., Ph.D thesis, Dept of Agronomy, University of Ibadan, Ibadan, Oyo State 217 pp.
14. Obazuaye, E. (2009). Mapping and classification of some soils in Ambrose Alli University teaching and research farm, Emuado, Ekpoma, M.Sc thesis, Dept of Soil Science, Ambrose Alli University, Ekpoma, Edo State, Nigeria pp 39.
15. Macleans, E. O. (1982). Aluminium, P. pp 927. In: C. A. Black (ed). Methods of soil analysis Part 11. Agron 9: American Soc of Agron. Madison, Wisconsin, USA.
16. Thomas, G. W. (1982). "Exchangeable cations. pp 159-165. In: A.L. Page et al., (ed.) Methods of soil analysis: Part 2. Chemical and microbiological properties. *Agronomy Monograph* Number 9, 3rd edition of ASA and SSSA, Madison Wisconsin.
17. Nelson, D. W. and Sommers, L. E. (1982). Total Carbon, Organic Carbon and Organic matter. In page, A. L. et al (eds) methods of soil analysis Part 2. Agron. Monogra – 9. Second edition ASA and SSSA. Madison Wisc. pp 539-579.
18. Olsen, S. R., and Sommers, L. E. (1982). "Phosphorus. A. L. Page, R. H. Miller, and D. R. Keeney [eds.] Methods of soil analysis, part 2 - No 9 Part 2.," American Society of Agronomy, Soil Science Society America, Madison, WI., pp 403-430.
19. Anderson, J. M., and Ingram, J. S. I. (1993). "Tropical soil biology and fertility: A handbook of methods" 2/Ed. C.A.B. International, Michigan, 221pp.
20. Okalebo, J. R., Gathua, K. W., and Woomer, P. L. (2002). "Laboratory methods of soils and plant analysis. A working manual," 2/Ed. Sacred Africa, Nairobi, Kenya.
21. Sobulo, R. A. and Osiname, A. O. (1981). Soils and Fertilizer use in Western Nigeria. University of Ife institute of Agriculture and training Research bulletin II, pp 8-9.
22. Adeoye, G. O. and Agboola, A. A. (1985). Critical levels for Soil pH, available P, K, Zn, Mn and maize earleaf content of P, Cu, and Mn in sedimentary soils of south western Nigeria. *Fertilizer research* 6 (1): 65-71.
23. Agboola, A. A., and Corey (1973). The relationships between Soil pH, organic matter, available phosphorus, exchangeble potassium, cassium, magnessium and nine other elements in the maize tissue. *Soil Science*. 115:367-375.

24. Agboola, A. A., and Obigbesan G. O. (1974). The response of some improve crop varieties to different fertilizers in forest zones of western Nigeria. Report FAO/NORAD/FDA. Serminar on Fertilizer use Development in Nigeria.
25. Heathcote, R. G. (1972). Potassium fertilization in the savanna zone of Nigeria. *Potash Review*.
26. Eghball, B., and Power, J. F. (1999). Phosphorus- and Nitrogen-Based Manure and Compost Applications Corn Production and Soil Phosphorus. *Soil Science Society of American Journal*. 63: 895-901.
27. Howeler, R. H., and Spain, J. M. (1980). The effects of potassium manuring of some crops on the tropical climate. Potash Review. Subj. 16. Suite 83. In: "The effects of potassium manuring of some crops on the tropical climate. Potash Review. Subj. 16. Suite 83".
28. Jones, J. B. J. and Eck, H. V. (1973). Plant analysis as an aid in fertilizing Corn and grain Sorghum. In : L. M. Walsh and J. O. Beaton (ed), Soil testing and plant analysis, revised edition. Soil Sci. Soc Am. Madison Wisconsin.
29. Gething, P. A. (1993). Improving Returns from Nitrogen Fertilizer Henley-on-Tharnes / United Kingdom. In: "The Potassium-Nitrogen Partnership", IPI Research Topic, No 13, 2nd Revised edition, pp. 1-53. International Potash Institute Basel, Switzerland.

Formatted: Font: Not Bold

UNDER PEER REVIEW