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

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Authors' contributions

This work was carried out in collaboration between both authors. Author IOO designed the study; author AOB performed the experiment, the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Managed the analyses of the study, the literature searches. Author IOO read and approved the final manuscript.

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ABSTRACT

This study was undertaken in two distinct ecological zones of Edo state of Nigeria to determine the effects of N:P:K ratios applied to the soils on the availability of N, P, K and on yield of maize. The sites used were Rubber Research Institute of Nigeria (RRIN) Iyanomo (Rain forest) and the Teaching and Research Farms of Ambrose Alli University, Emaudo, Ekpoma (derived savanna). Soils from both sites were analyzed for both physical and chemical properties before the commencement of the experiments. The experiments were carried out as: Pot and Field experiments. Each of the experiments had ten treatments (adjusted ratios) that were fitted into randomized complete block design and replicated three times, with maize as the test crop. Results from pot experiment in the screen house revealed that N:P:K ratio 4:1:1 had the highest dry matter yield for both locations, (RRIN; 7.10 g/pot and Emaudo; 6.33 g/pot) but these values were not significantly different ($P < 0.05$) from what were obtained from N:P:K ratio 3:1:1 and 2:1:1, respectively. The N:P:K ratio in soil had influence on the availability of N,P and K. Under field conditions, N:P:K ratio 3:1:1 had the highest grain yield for both locations (RRIN; 5.54 ton/ha and Emaudo; 5.25 ton/ha). The N:P:K ratio 3:1:1 was the best ratio with the highest yield for both locations and is therefore suggested for these soils.

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Keywords: N:P:K; ratios; nutrient availability; maize; yield; soils; growth.

1. INTRODUCTION

Inorganic 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 [2-4]. In soils, balance nutrient ratio is necessary for sustainability of crop yield. However the rate of application and dosage has a greater influence on both crop yield and its environment. Excessive application of fertilizer, as opined by [5], 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 jeopardize 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. In attempting to develop viable fertilizer recommendation programmes, some workers have used single element approaches such as N, P or K alone or in combinations [6]. The consequences of applying fertilizer recommendations without the right ratios will have effect on growth and yield. For example, the application of N does not increase yield in the long run but may result in accelerated deficiency of other nutrients. Excessive usage of Phosphorus is known to depress soil –Zn availability, reduces absorption by roots and subsequently retards Zn translocation from roots to shoots. Proper fertilizer recommendation takes into practise regional growing conditions of crops, i.e. Soil type, climate, rainfall, irrigation, crop variations etc. Hence the need for optimum mineral fertilizer adaptable to the local region combine in the right nutrient ratios and not blanket fertilizer recommendation adopted from another region being managed. Therefore the specific aim of this study was to evaluate the effect of N, P and K nutrient ratios applied to the soils on their availability and maize (Zea mays L.) performance.

2. MATERIALS AND METHODS

The experiment was carried out in two sites. The first location was 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 6^0 09' and 6^0 85' N and longitude 5^o 35' and 5^o 58' E [7], while soils from Emaudo are Ultisols, classified as Rhodic paleudults and located at latitude 6^0 18' and $6^0$46' E and longitude of 6^0 00' and 6^0 40' N [8].

The experiment was carried out in two stages: Pot experiment in the screen house (screen house ionic experiment). Field experiment (field ionic experiment). Surface Soil samples taken with the aid of an auger at a dept of 0-20 cm, buiked together to form composite soil sampled from each of the experimental sites. The soils were further air dried, sieved, mixed thoroughly and 500g was carefully packaged for laboratory analysis of 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: 0:0:0, (control) 1:1:1, 1:2:1, 1:3:1, 1:4:1, 2:1:1, 3:1:1, 4:1:1, 1:1:2 and 1:1:3 for N:P:K treatments Table 1. The experiments were fitted into randomized complete block design and replicated three times. Nitrogen was applied as urea, phosphorus as single super phosphate (SSP) 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 plants, were harvested six weeks after planting (WAP). The experiment was repeated in the field as a follow up of the screen house work. The screen house recommendation were also carried out in the field. The field ionic studies were conducted in two locations, RRIN and Emaudo 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: 0:0:0, (control) 1:1:1, 1:2:1, 1:3:1, 1:4:1, 2:1:1, 3:1:1, 4:1:1, 1:1:2 and 1:1:3 for N:P:K treatments Table 2 randomized among the plots within the blocks. Each plot size was 2.5 x 2.0 m and the planting distance adopted was 75 X 25 cm with a space of 50 cm between plots and 80 cm between blocks. N:P: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, P 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 and the dry weight (yield) noted. All data obtained from laboratory, screen house and field studies were subjected to statistical analysis (SARS).

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

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

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

Ecological Zone	Location	Trt No	NPK Ratio in Soil	Soil adjusted Nutrients (Kg/ha)		
				N	P	K
		1	0 : 0 : 0	-	-	-
		2	1 : 1 : 1	56.16	56.16	56.16
		3	1 : 2 : 1	56.16	112.36	56.16
Derived		4	1 : 3 : 1	56.16	168.48	56.16
Savanna	Emuado	5	1 : 4 : 1	56.16	224.64	56.16
		6	2 : 1 : 1	112.36	56.16	56.16
		7	3 : 1 : 1	168.48	56.16	56.16
		8	4 : 1 : 1	224.64	56.16	56.16
		9	1 : 1 : 2	56.16	56.16	112.36
		10	1 : 1 : 3	56.16	56.16	164.48
		1	0 : 0 : 0	-	-	-
		2	1 : 1 : 1	56.16	56.16	56.16
		3	1 : 2 : 1	56.16	112.36	56.16
Forest	RRIN	4	1 : 3 : 1	56.16	168.48	56.16
		5	1 : 4 : 1	56.16	224.64	56.16
		6	2 : 1 : 1	112.36	56.16	56.16
		7	3 : 1 : 1	168.48	56.16	56.16
		8	4 : 1 : 1	224.64	56.16	56.16
		9	1 : 1 : 2	56.16	56.16	112.36
		10	1 : 1 : 3	56.16	56.16	164.48

2.1 Soils/Plant Tissue Analysis

Soil pH was measured in 1:1 soil water suspension [9]. Exchange acidity (Al^{3+}, H^+) was extracted with 1NKCl [10]. Organic Carbon was determined by wet dichromate acid oxidation method [11]. Available phosphorus was extracted with Bray P1 solution and measured by the molybdenum blue method on a technicon auto analyzer as modified by [12]. 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 atomic absorption spectrophotometer [13]. Effective cation exchange capacity (ECEC) was calculated by the summation of exchangeable bases and exchange acidity [13]. Particle size distribution was determined by the hydrometer method according to [14]. Plant samples were oven dried at 70 ^{0}C for 72 hours, milled and sieved through 0.5mm mesh sieve. Nitrogen was determined using the macro-kjedahl method [13], Potassium was determined by flame photometer; and Phosphorus was determined using Bray P I method and measured by the molybdenum blue method [12].

3. 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 nutrient element levels given for most crops of this region [15-18]. The textural classes were sandy loam and sand.

Plates 1, 2, 3 and 4 show the effect of variations in nutrient ratios on the growth of maize in the screen house. Nitrogen encourages above ground vegetative growth and imparts deep green colour [19] to the leaves as observed in plate 1, 2 and 4 when compared with plates 2 and 3 where nitrogen was missing. There is a clear indication of slow or poor growth rate in plates 2 and 3 where phosphorus was missing. This actually showed that P supports roots elongation. Functions of phosphorus include cell division and multiplication and root development particularly fibrous and lateral roots [20]. This could be the probable reason for poor growth in pots where P was missing. A combination of the three nutrient elements (NPK) gave the best growth rate as observed in plates 1and 4 when compared to others.

Higher application of nitrogen significantly affected the maize plant growth rate with N:P:K applied ratios 4:1:1 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 (Tables 4,5,6 and 7). These indicated that the higher the nitrogen level applied, the higher the vegetative growth rate and agreed with the findings of [21-22] that high application of N in maize triggers complex array of morphophysiological responses.

Table 3. Physical and chemical properties of experimental sites

Parameters	RRIN	EMUADO
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 Mg (cmol/kg)	0.48	0.40
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	SL	S

SL = Sandy Loam S = Sand

N:P:K ratio 3:1:1. The highest K uptake was also obtained from applied N: P: K ratio 4:1:1, it was also closely followed by applied N:P:K ratio 3:1:1.. Nitrogen concentration in the earleaf was positively and significantly correlated with N and P uptake with 'r' values of 0.925** and 0.745*, respectively. Nitrogen uptake in the earleaf was positively and significantly correlated with P and K uptake with 'r' values of 0.837** and 780** respectively. Phosphorus uptake was positively correlated with K uptake but not significant. The earleaf DMY correlated positively and significantly with N concentration and uptake with 'r' values of 0.760* and 0.926**. While in RRIN soils, the concentration of N in the ear leaf increased with increase in N application. The highest N concentration was obtained from applied ratio N:P:K 4:1:1, this was closely followed by applied ratio N:P:K 3:1:1. [22] reported that application of N in Maize triggers complex array of morphophysiological responses, this could suggest even while the highest DMY was from N:P:K ratio 4:1:1. The highest K uptake was obtained from applied

Plate 1. Effect of variations in N:P and N:P:K ratios on the growth of maize in the screen house (Soil of Emaudo)

Plate 2. Effect of variations in P:K and N:K ratios on the growth of maize in the screen house (Soil of Emaudo)

N:P:K ratio 4:1:1. [23] 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. Nitrogen concentration in the earleaf was positively and significantly correlated with N, P and K uptake with 'r' values of 0.819**, 0.670*, and 0.686*, respectively. Nitrogen uptake was positively and significantly correlated with K uptake with 'r' value of 0.933**. It was positively correlated with P uptake although not significant. Phosphorus uptake was positively correlated with K uptake but also not significant. [24] reported that crop does not respond to N unless K was applied in the right proportion.

The highest grain and cob yield were obtained at N/P/K ratio 3:1:1 Table 12). Nitrogen, Phosphorus and Potassium concentrations in the earleaf at silk in both N/P/K levels were within the sufficiency range [25]

Plate 3. Effect of variations of P:K and N:K ratios on the growth of maize in the screen house (Soil of RRIN)

Plate 4. Effect of variations in N.P and N:P:K ratios on the growth of maize in the screen house (Soil of RRIN)

Table 4. Effect of N:P:K ratios on maize mean plant height, stem girth, leaf area and number of leaves at 4 W.A.P. (RRIN)

Adjusted NPK ratios in soil	Plant Height (cm)	Stem Girth(cm)	Leaf Area (cm^2)	Number of Leaves
0 : 0 : 0	19.70^{c}	0.68^{c}	116.70^{c}	7.33^{d}
1 : 1 : 1	26.00^{abc}	0.78^{abc}	174.34^{ab}	9.33^{abc}
1 : 2 : 1	25.30^{abc}	0.78^{abc}	163.43^{ab}	9.00^{abc}
1 : 3 : 1	23.70^{abc}	0.73^{bc}	151.18^{bc}	8.33^{bcd}
1 : 4 : 1	20.97^{bc}	0.73^{bc}	145.58^{bc}	8.00^{cd}
2 : 1 : 1	26.00^{abc}	0.83^{ab}	178.08^{ab}	9.67^{ab}
3 : 1 : 1	27.00^{ab}	0.83^{ab}	179.55^{ab}	9.67^{ab}
4 : 1 : 1	28.00^{a}	0.88^{a}	198.66^{a}	10.00^{a}
1 : 1 : 2	25.00^{abc}	0.75^{bc}	152.03^{bc}	8.67^{abcd}
1 : 1 : 3	25.00^{abc}	0.75^{bc}	156.18^{bc}	8.67^{abcd}
SE. (P<0.05)	1.92	0.12	12.43	0.44

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

Table 5. The effect of N:P:K ratios on maize mean plant height, stem girth, leaf area and number of leaves at 8 W.A.P. (RRIN)

Adjusted NPK ratios in soil	Plant Height (cm)	Stem Girth (cm)	Leaf Area (cm^2)	Number of Leaves
0 : 0 : 0	127.00^{c}	1.17^{c}	408.8^{b}	10.33^{c}
1 : 1 : 1	165.67^{ab}	1.70^{ab}	595.3^{ab}	12.67^{abc}
1 : 2 : 1	162.67^{abc}	1.57^{abc}	592.3^{ab}	12.33^{ab}
1 : 3 : 1	160.33^{abc}	1.47^{abc}	553.5^{ab}	11.33^{bc}
1 : 4 : 1	139.67^{bc}	1.23^{bc}	436.8^{b}	11.33^{bc}
2 : 1 : 1	171.00^{ab}	1.70^{ab}	607.5^{ab}	12.33^{ab}
3 : 1 : 1	174.67^{ab}	1.70^{ab}	677.5^{ab}	13.33^{a}
4 : 1 : 1	193.00^{a}	1.83^{a}	694.8^{a}	13.33^{a}
1 : 1 : 2	149.00^{bc}	1.30^{bc}	587.9^{ab}	12.00^{ab}
1 : 1 : 3	159.00^{abc}	1.37^{abc}	581.8^{ab}	12.33^{ab}
SE. (P<0.05)	11.42	0.15	80.69	0.53

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

Table 6. Effect of N:P:K ratios on maize mean plant height, stem girth, leaf area and number of leaves at 4 WAP (Emaudo)

Adjusted NPK ratios in soil	Plant Height (cm)	Stem Girth (cm)	Leaf Area (cm^2)	Number of Leaves
0 : 0 : 0	127.00^{c}	0.83^{ab}	83.07^{b}	7.33^{d}
1 : 1 : 1	165.67^{ab}	1.13^{ab}	140.63^{ab}	9.33^{abc}
1 : 2 : 1	$24.03b^{cd}$	1.13^{ab}	131.58^{ab}	131.58^{ab}
1 : 3 : 1	19.77^{cde}	0.90^{ab}	103.76^{ab}	8.33^{bc}
1 : 4 : 1	17.37^{de}	0.87^{ab}	88.85^{b}	8.00^{cd}
2 : 1 : 1	26.10^{bc}	1.23^{ab}	141.29^{ab}	9.67^{ab}
3 : 1 : 1	29.77^{ab}	1.23^{ab}	155.03^{a}	9.67^{ab}
4 : 1 : 1	34.83^{a}	1.27^{a}	155.65^{a}	10.00^{a}
1 : 1 : 2	20.10^{cde}	1.00^{bc}	587.9^{ab}	8.67^{abcd}
1 : 1 : 3	22.97^{bcd}.	1.00^{ab}	115.61^{ab}	8.67^{abcd}
SE. (P<0.05)	2.22	0.12	17.73	0.44

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

Table 7. Effect of N:P:K ratios on maize mean plant height, stem girth, leaf area and number of leaves at 8 WAP (Emaudo)

Adjusted NPK ratios in soil	Plant Height (cm)	Stem Girth (cm)	Leaf Area (cm^2)	Number of Leaves
0 : 0 : 0	83.27^{b}	1.40^{c}	352.85^{b}	14.00^{b}
1 : 1 : 1	111.60^{ab}	1.87^{ab}	579.76^{a}	15.33^{ab}
1 : 2 : 1	110.93^{ab}	1.83^{ab}	575.06^{a}	15.00^{ab}
1 : 3 : 1	95.10^{b}	1.73^{abc}	478.98^{ab}	14.33^{b}
1 : 4 : 1	91.03^{b}	1.60^{bc}	360.45^{b}	14.33^{b}
2 : 1 : 1	120.70^{ab}	1.93^{ab}	589.69^{a}	15.67^{ab}
3 : 1 : 1	124.43^{ab}	2.00^{a}	609.53^{a}	15.67^{ab}
4 : 1 : 1	143.77^{a}	2.07^{a}	645.85^{a}	16.33^{a}
1 : 1 : 2	98.80^{b}	1.77_{ab}	504.18^{ab}	14.67^{ab}
1 : 1 : 3	103.00^{ab}	1.77_{ab}	515.29^{ab}	14.67^{ab}
SE. (P<0.05)	12.93	0.11	60.92	0.58

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

Table 8. Effect of N:P:K ratios on nutrient concentrations, uptake and earleaf dry matter yield of maize at silking stage in soils of RRIN

Adjusted NPK ratios in soil	D.M.Y (g/pot)	conc of nutrients in plant (%)			uptake of nutrients (mg/kg)		
		N	P	K	N	P	K
0 : 0 : 0	162.38	1.31	0.15	1.42	2.13	0.24	2.31
1 : 1 : 1	252.88	1.35	0.22	1.34	3.41	1.06	3.39
1 : 2 : 1	238.51	1.54	0.28	1.32	3.67	1.14	3.15
1 : 3 : 1	221.27	1.89	0.37	1.32	4.18	1.26	2.92
1 : 4 : 1	219.33	2.07	0.39	1.21	4.54	1.38	2.66
2 : 1 : 1	339.79	2.13	0.25	2.25	7.02	1.15	4.12
3 : 1 : 1	333.64	2.22	0.38	2.35	7.41	0.83	4.50
4 : 1 : 1	371.85	2.37	0.40	2.00	8.81	1.48	5.03
1 : 1 : 2	216.73	1.39	0.17	2.33	3.01	0.58	2.88
1 : 1 : 3	227.56	2.08	0.18	2.39	4.73	1.32	3.16
SE. (P<0.05)	ns	Ns	ns	ns	ns	ns	ns

SE: Standard Error, ns: not significant

Table 9. Effect of N:P:K ratios on nutrient concentrations, uptake and earleaf dry matter yield of maize at silking stage in soils of Emaudo

Adjusted	Earleaf	conc of nutrients in earleaf			uptake of nutrients in earleaf		
N:P:K ratios in soils	D.M.Y.	N	P	K	N	P	K
in soils	(g/pot)	---------------(%)-----------------			-----------------------mg/kg---------------------------		
0 : 0 :0	157.60	1.25	0.18	1.57	1.96	0.44	3.10
1 : 1 :1	268.10	2.79	0.26	1.49	4.81	0.97	4.00
1 : 2 :1	247.20	2.52	0.26	1.29	6.25	1.25	3.20
1 : 3 :1	240.50	2.54	0.34	1.29	6.11	1.24	3.10
1 : 4 :1	221.30	2.52	0.41	1.01	5.70	1.15	2.23
2 : 1 :1	302.40	2.68	0.31	2.11	8.09	1.24	3.35
3 : 1 :1	339.30	2.75	0.35	2.79	9.26	1.48	6.10
4 : 1 :1	352.50	3.55	0.35	2.94	12.66	1.66	6.83
1 : 1 :2	202.70	2.08	0.15	2.45	4.20	0.33	2.93
1 : 1 :3	219.30	2.55	0.24	2.97	5.68	0.53	4.33
SE (.05)	ns	ns	ns	ns	ns	ns	ns

SE: Standard Error, ns: not significant

Table 10. Correlation coefficient matrix showing the effect of applied N:P:K ratios in soils on the relationship between nutrient concentrations, uptake and earleaf DMY of maize in soils of Emaudo

	D.M.Y	N conc (%)	N Uptake	P conc (%)	P Uptake	K conc (%)	K conc (%)
D. M. Y.	1						
N conc (%)	0.760*	1					
N Uptake	0.926**	0.925**	1				
P conc (%)	0.480	0.519	0.505	1			
P Uptake	0.847**	0.745**	0.836**	0.867**	1		
K conc (%)	0.0523	-0.036	0.108	-0.443	-0.198	1	
K Uptake	0.780*	0.583	*0.779**	0.105	0.525	0.654*	1

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

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

	D.M.Y	N conc (%)	N Uptake	P conc (%)	P Uptake	K conc (%)	K conc (%)
D. M. Y.	1						
N conc (%)	0.717*	1					
N Uptake	0.948**	0.891**	1				
P conc (%)	-0.084	0.336	0.030	1			
P Uptake	0.465	0.670*	0.539	0.867**	1		
K conc (%)	-0.194	-0.300	-0.203	-0.469	-0.481	1	
K Uptake	0.985**	0.686*	0.9328**	-0.145	0.4083	-0.032	1

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

Table 12. Effect of soil nitrogen/ phosphorus/potassium ratios on the mean yield of maize (cob and grains) in soils of RRIN and Emaudo

Adjusted N:P:K Ratios in Soil	RRIN		EMAUDO	
	COB FIELD WEIGHT (ton/ha)	GRAIN YIELD (ton/ha)	COB FIELD WEIGHT (ton/ha)	GRAIN YIELD (ton/ha)
0 : 0 : 0	6.02^{h}	2.31^{e}	5.71^{e}	2.09^{d}
1 : 1 : 1	10.83b^{c}	4.70b^{c}	10.52^{b}	4.64^{b}
1 : 2 : 1	7.91^{ef}	3.63^{d}	7.87^{c}	3.35^{c}
1 : 3 : 1	7.54f^{g}	3.48^{d}	7.54^{d}	3.30^{c}
1 : 4 : 1	7.13^{g}	2.95^{e}	7.41^{d}	2.27^{d}
2 : 1 : 1	11.16^{b}	4.92^{b}	10.95^{a}	4.73^{b}
3 : 1 : 1	11.92^{a}	5.54^{a}	11.75^{a}	5.25^{a}
4 : 1 : 1	10.46^{c}	4.42^{c}	10.37^{b}	4.42^{b}
1 : 1 : 2	8.38d^{e}	3.64^{d}	8.01^{d}	4.64^{c}
1 : 1 : 3	8.66^{d}	3.71^{d}	8.43^{c}	3.58^{c}
SE. (P<0.05)	0.16	0.11	0.11	0.17

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

4. CONCLUSION

The green house highest DMY was from N:P:K ratio 4:1:1, the highest N and K uptake were obtained from applied N:P:K ratio 4:1:1 indicating that the higher the N content in soils the higher the DMY. The field N:P:K ratio in soils showed significant effect on maize grain yield, N:P:K ratio 3:1:1 had the highest grain yield for both locations in the experiments. N:P:K 3:1:1 was the overall best ratio for grain yield and is therefore suggested for these soils.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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