Applied Tropical Agriculture

Influence of Combined Application of Agrolyser[r] and NPK Fertilizer Using Foliar and Soil Application Methods on Soil Properties and Yield of Maize (Zea mays L.)

Iren, O. B.

Department of Soil Science, Faculty of Agriculture, Forestry and Wildlife Resources Management, University of Calabar, Cross River State, Nigeria. e-mail: myirenlady@gmail.com

ABSTRACT

Balanced fertilization involves the application of both macro- and micro-nutrients in the right amount and proportions for optimum crop yield. The experiment was conducted to compare the effectiveness of sole and combined application of agrolyser[R] (micronutrient) and NPK fertilizer using foliar and soil application methods on soil properties and yield of maize in the humid forest zone of south-eastern Nigeria. The experiment was laid out in a randomized complete block design with three replications comprising of 10 treatments. The treatments were three levels of agrolyser[R] (0.2, 0.3 and 0.4 kg ha^{-1}) using two methods of application (foliar spray and soil placement). Equal basal rate of NPK fertilizer (150 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 90 kg K_2O ha^{-1}) was applied to all the treatments, except the controls. The control plots had only agrolyser[R] applied at 0.3 kg ha^{-1} as foliar spray and soil placement, and plots without amendment (absolute control). There was also a check plot where only NPK fertilizer was applied. The experimental soil was loamy sand in texture, strongly acidic and low in fertility. The result shows a significant ($P \leqslant 0.05$) increase in soil pH amongst treatments when compared with the absolute control. The combination of agrolyser[R] and NPK fertilizer significantly improved the availability of total nitrogen, available phosphorus, and exchangeable Ca and Mg in the soil. Application of NPK fertilizer alone or in combination with agrolyser[R] significantly ($P \leqslant 0.05$) increased maize grain yield. The method and rate of agrolyser[R] application did not significantly ($P > 0.05$) increase maize grain yield. Minor differences existed between plots that received only NPK fertilizer (82 % increase over absolute control) and those that received NPK fertilizer and agrolyser[R] (84 % increase). Plots that received only agrolyser[R] using foliar and soil placement had only 18 % (399.63 kg ha^{-1}) and 17 % (392.92 kg ha^{-1}) increase, respectively over the absolute control (327.87 kg ha^{-1}). It was therefore concluded that agrolyser[R] cannot be substituted for NPK fertilizer but that it could be used as a supplementary treatment to supply micronutrients. Agrolyser[R] could be applied either as a foliar spray or mixed with NPK fertilizer and applied directly to the soil.

Keywords: Agrolyser[R], micronutrient, application method, soil properties, maize grain yield

INTRODUCTION

Soil plays a major role in determining the sustainable productivity of an agro-ecosystem. The sustainable productivity of soil mainly depends upon its ability to supply essential nutrients, both macro- and micro-nutrients, to the growing plants. The tendency for micronutrient deficiencies to occur in soils where only macronutrient fertilizers are applied as soil amendments strongly indicates the need for balanced fertilization. This will involve the application of both macro- and micro-nutrients in the right amount and proportion. The deficiency of micronutrients has become a major constraint to the productivity, stability and sustainability of soils (Bell and Dell, 2008). Also, the continuous use of only inorganic fertilizers leads to depletion of micronutrients which may influence plant, animal and human health (Iren *et al.*, 2012).

Agrolyser[R] is a biochemical plant nutrient highly useful for increasing the yield of crops, consisting mostly of inert and naturally-occurring nutrients, and classified as a plant growth regulator. Agrolyser[R] contains 10 cations (copper, manganese, magnesium, iron, sodium, calcium, sulphur, boron, zinc, molybdenum) three of which are secondary nutrients (Ca, Mg, S). It provides essential micronutrient elements during the growth of various plants, including cassava and maize (Davies *et al.*, 2006).

Over the years, Agrolyser[R] has been extensively tested on several major crops in many ecological zones of Nigeria. Yield increases of 30 – 50 % have been reported, while the shelf-life of harvested perishable crops has been increased three to four times (Cybernetics Nig. Ltd., 1991). This study therefore, investigates the effectiveness of sole and combined application of agrolyser[R] (micronutrient) with NPK fertilizer using foliar and soil application methods on soil properties and yield of maize in a degraded rainforest vegetation zone of Nigeria.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Teaching and Research Farm of the University of Calabar, Calabar (latitude 5° 32' and 4° 27' N and longitude 7° 15' and 9° 28' E). The site has secondary rainforest vegetation. The town is characterized by a bimodal rainfall pattern with a long rainy season (March- July) and a short rainy season (September - early November) with a very short dry spell in late August (Table 1). The total rainfall ranges from 2000-3500 mm annually while the mean temperature ranges from 23 - 33°C. The mean relative humidity is 60- 90%.

Table 1: Meteorological records of Calabar in 2010 and 2011

Month	Rainfall (mm)		Air Temperature (^{0}C)		Relative Humidity (%)		Solar Radiation (hr)	
	2010	2011	2010	2011	2010	2011	2010	2011
Jan.	31.8	40.0	33.8	27.0	82.0	85.0	5.6	5.4
Feb.	88.2	113.3	33.1	27.9	85.0	80.0	5.4	6.0
Mar.	36.7	63.6	33.0	27.6	83.0	86.0	3.7	5.8
Apr.	130.4	152.1	33.1	28.1	83.0	83.0	5.2	3.7
May	306.5	495.1	31.5	27.1	85.0	82.0	4.4	5.6
Jun.	421.2	611.3	29.8	25.9	88.0	86.9	3.2	3.7
Jul.	384.0	601.8	28.8	24.5	90.0	91.0	1.8	1.8
Aug.	291.2	325.8	28.2	24.1	91.0	76.2	1.8	6.2
Sep.	406.7	351.3	28.9	24.4	89.0	74.5	2.4	6.8
Oct.	269.6	273.8	31.0	24.1	86.0	82.0	3.8	3.9
Nov.	272.1	274.8	30.7	25.6	85.0	75.6	3.7	6.5
Dec.	56.2	43.30	31.7	26.9	83.0	81.7	5.9	5.8
Total	2694.6	3346.2	374.3	313.2	1030.0	983.9	47.1	61.2
Mean	224.6	278.9	31.2	26.1	85.8	82.0	4.0	5.1

Source: Nigeria Meteorological Unit (NIMET), Margaret Ekpo International Airport, Calabar

Experimental Design and Treatments

The experimental site was manually cleared, tilled and plots measuring 4.5 m x 3 m marked out. An alley of 1.5 m was left between blocks and 0.75 m between plots. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 10 treatments consisting three levels of Agrolyser^R (0.2, 0.3 and 0.4 kg ha^{-1}) applied using two methods, viz. foliar spray and soil placement. Equal basal rate of NPK fertilizer (150 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}, 90 kg K_2O ha^{-1}) was applied to all the treatments except the two controls. The first control treatment had only Agrolyser^R applied at 0.3 kg ha^{-1} applied using foliar spray and soil placement, while the second control treatment had no soil amendment (absolute control). There was also a check plot where only NPK fertilizer was applied. The NPK fertilizer sources used were urea, single superphosphate and muriate of potash at the rates of 150 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 90 kg K_2O ha^{-1}, respectively. The single fertilizer materials were mixed together after measuring the required quantity of each fertilizer nutrient.

Planting and field maintenance

Lime ($CaCO_3$) was applied to the experimental field at the recommended rate of 500 kg/ha three days before planting by broadcasting. Two seeds of maize were sown per hole at a spacing of 0.75 m x 0.25 m and later thinned down to one plant per stand at 10 days after planting, giving a plant population of 53,333 plants/ha. A pre-emergence herbicide, Primextra 500^R, was applied at the rate of 6.36 litres/ha one day after planting in the morning when the soil was still moist using 20 litres capacity of CP_3 Knapsack sprayer. A total amount of 700 ml of Primextra 500^R to 40 litres of water was applied on the experimental field. Supplementary weeding was done at six weeks after planting (WAP). At 2 WAP, NPK fertilizer and Agrolyser^R were applied to specified plots, with the latter applied as described above. For foliar application, Agrolyser^R was dissolved in water and sprayed on the leaves of the young maize seedlings using a hand pump. For soil placement, Agrolyser^R was mixed with NPK fertilizer and incorporated to the soil using band placement. Agrolyser^R was applied directly to the soil in plots without NPK treatment.

Soil sampling and processing

Soil samples were collected from the experimental site before commencement of experiment at 0-15 cm depth with soil auger, about 8-10 sample points were taken from each block, mixed thoroughly to represent a composite sample. One composite soil sample was taken per plot after the experiment for laboratory analysis. The soil samples were air-dried, pulverised and sieved through a 2 mm sieve. Soil samples were analyzed following the procedures outlined by Udo *et al.* (2009). Soil pH was determined in 1:2.5 soil: water ratio with a pH meter. Organic carbon was determined by Walkley Black Dichromate Method; total N by micro-Kjeldahl method: available P was extracted with Bray – 1 method (Bray and Kurtz, 1945). Exchangeable bases (K, Ca, Na, Mg) were extracted with 0.1N ammonium acetate, K and Na were read with a flame photometer while Ca and Mg were determined through the EDTA titration method. Exchangeable acidity (H^+, Al^{3+}) was determined by leaching the soils with 1N KCl and titrating aliquots with 0.01 NaOH. Effective cation exchange capacity (ECEC) was calculated as the sum of Ca, Mg, K and Na and exchangeable acidity (Al^{3+} and H^+). Base saturation was calculated by dividing the sum of exchangeable bases by ECEC and multiplying by 100.

Maize Yield and Data Analysis

At maturity (14 WAP), 10 maize plants were sampled per plot for the determination of grain yield. The maize cobs were weighed after harvesting, sun-dried and the change in weight noted. The cobs were then shelled and the grains weighed. The shelling percentage for the maize yield was 73 %, while the average percentage moisture loss after oven-drying was 34.51 %. The oven-dried weight was obtained by oven-drying 100 grains at 60 ^{0}C for 24 hours. The maize grain yield data were subjected to analysis of variance and means compared using the New Duncan's Multiple Range Test (DMRT) at 5% probability level.

RESULTS AND DISCUSSION

Table 2 shows the initial status of the soil used for the experiment. The experimental soil was strongly acidic (pH 4.85), and this occasioned the application of lime prior to maize planting. Jones (1987) gave approximate soil pH range of 5.8 – 6.2 as suitable for maize cultivation in humid regions. The soil organic carbon and total nitrogen contents were low compared to the benchmark set by Aduayi *et al.* (2011) for Nigerian soils. Exchangeable K and Na contents of the soil were very low; other exchangeable cations were moderate in the soil while available P was high. The soil was loamy sand with a very high base saturation of more than 50%.

Table 2: Pre-cropping soil properties in the experimental site

Soil Property	Values
pH (H_2O)	4.85
Total N (g/kg)	0.8
Organic C (g/kg)	8.9
Available Phosphorus (mg/kg)	79.99
Exchangeable Calcium (cmol/kg)	3.20
Exchangeable Magnesium (cmol/kg)	2.80
Exchangeable Sodium (cmol/kg)	0.26
Exchangeable Potassium (cmol/kg)	0.12
Exchange Acidity (cmol/kg)	1.20
ECEC (cmol/kg)	9.78
Base Saturation (%)	87.70
Sand (g/kg)	859
Silt (g/kg)	74
Clay (g/kg)	67
Texture	Loamy Sand

Table 3 shows the properties of the soil after experiment. The result shows a significant ($P \leqslant 0.05$) increase in soil pH amongst treatments, with the highest pH value of 5.96 obtained from the plots in which NPK + 0.4 kg ha^{-1} agrolyser^R was applied by soil placement. However, this value was not significantly higher than those obtained from plots treated with NPK + 0.4 kg ha^{-1} agrolyser^R (foliar), NPK + 0.2 kg ha^{-1} agrolyser^R (soil) and NPK + 0.3 kg ha^{-1} agrolyser^R (soil). Other treated plots gave significantly lower pH than in plots treated NPK + 0.4 kg ha^{-1} agrolyser^R. This suggests that apart from the effect of the lime applied before experiment, the cations present in the agrolyser^R also enhanced the soil pH contrasting the lower soil pH before experiment and from the absolute control (no amendment).

Application of micronutrient agrolyser^R in combination with NPK fertilizer either by soil placement or foliar spray generally improved soil nitrogen content than where either agrolyser^R or NPK fertilizer was applied alone. This indicates availability of soil N for plant uptake (Agbede and Otonko, 2004). The authors obtained higher N uptake from plants that received agrolyser^R in combination with N, P, or K than from the control or N applied alone. The high residual N obtained in this study from the combination of agrolyser^R with NPK fertilizer is also in conformity with the findings of Qurashi and Cornfield (1971) that Cu application stimulated N mineralization and nitrification.

A significant ($P \leqslant 0.05$) increase in soil available P was recorded across treatments, with the highest value in plots that received NPK fertilizer alone. Adediran and Banjoko (2003) reported accumulation of P due to annual application of NPK fertilizer and therefore, attributed the phenomenon to lower mobility of P in comparison with N. All the plots treated with NPK fertilizer had significant increases in soil available P when compared with the controls (agrolyser^R alone, absolute control).

Table 3: Effects of combined application of agrolyser[R] and NPK fertilizer using foliar and soil application methods on soil properties

Treatments	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Texture	pH (H_2O)	Total N (g/kg)	Org. C (g/kg)	Av. P (mg/kg)	Exchangeable cations (cmol/kg)				EA (cmol/kg)	ECEC (cmol/kg)	BS (%)
									Ca	Mg	Na	K			
Control (no amendment)	864a	48a	88a	LS	4.93d	0.70d	12.6a	89.99c	3.20f	3.60cd	0.21a	0.11a	1.08a	8.20a	86.83a
Agrolyser alone (0.3 kg/ha) (foliar)	864a	58a	78a	LS	5.26c	0.64e	12.8a	93.32c	4.00e	4.40b	0.19a	0.10a	1.92a	10,61a	81.90a
Agrolyser alone (0.3 kg/ha)(soil)	852a	74a	74a	LS	5.35c	0.70d	11.5a	79.99c	3.60ef	2.00g	0.20a	0.10a	1.74a	7.64a	77.23a
NPK alone (150: 40:90 kg/ha)	884a	48a	68a	LS	5.15c	1.10b	7.6a	156.65a	3.20f	0.80h	0.22a	0.20a	1.92a	6.34a	69.72a
NPK + 0.2 kg/ha agrolyser (foliar)	854a	58a	88a	LS	5.70b	1.00c	7.6a	125.15b	4.80d	2.80ef	0.19a	0.21a	0.66a	8.66a	92.38a
NPK + 0.3 kg/ha agrolyser (foliar)	864a	58a	78a	LS	5.71b	1.00c	6.5a	129.99b	5.60c	3.20de	0.23a	0.17a	1.14a	10.34a	88.97a
NPK + 0.4 kg/ha agrolyser (foliar)	874a	48a	78a	LS	5.92a	1.09b	11.1a	113.32b	7.60b	2.00g	0.18a	0.16a	1.08a	11.02a	90.20a
NPK + 0.2 kg/ha agrolyser (soil)	872a	74a	54a	LS	5.80ab	1.11b	13.2a	113.26b	4.80d	2.40fg	0.24a	0.18a	0.84a	8.46a	90.07a
NPK + 0.3 kg/ha agrolyser (soil)	874a	54a	72a	LS	5.91a	1.20a	12.3a	123.32b	2.40g	7.20a	0.18a	0.17a	1.86a	11.81a	84.25a
NPK + 0.4 kg/ha agrolyser (soil)	894a	34a	72a	LS	5.96a	1.24a	13.6a	123.32b	8.40a	4.00bc	0.20a	0.20a	0.96a	13.76a	93.02a

Means having the same letter within a column are not significantly different by DMRT at P<0.05

There were significant ($P \leq 0.05$) differences in the exchangeable Mg and Ca contents of the soil contrasting the non –significant differences obtained for soil organic carbon, exchangeable K, Na, exchange acidity, ECEC and base saturation. The non-significant increase in soil organic carbon content could be attributed to lack of incorporation of organic matter and continuous cultivation of the study site. The effect of agrolyser^R on maize grain yield is presented in Table 4. The yield obtained in the 2011 cropping season was generally higher than that obtained in 2010 cropping season. The higher maize grain yield in the second year (2011) could be attributed to the residual effects of the previous year's treatment, coupled with the additional fertility improvements in the second year. The positive influence of increased water supply for vigorous plant growth and dry matter production, arising from the higher rainfall status in the 2011 cropping season is also strongly indicated (Table 1). However, in both cropping seasons, the highest grain yield was obtained from plots treated with NPK + 0.3 kg ha^{-1} agrolyser^R using foliar spray method, although this was not significantly ($P > 0.05$) higher than in the plots where NPK fertilizer was applied alone or in combination with agrolyser^R regardless of the rate and method of application. The positive yield responses obtained from the fertilizer additions were due to the low initial nutrient status of the soil.

Table 4: Effects of combined application of agrolyser with NPK fertilizer using foliar and soil application methods on maize grain yield

Treatments	Maize grain yield (kg/ha)		Mean	Yield increase
	2010	2011		(%)
Control (no amendment)	324.71b	331.03b	327.87b	-
Agrolyser alone (0.3 kg/ha) (foliar)	404.86b	394.40b	399.63b	18
Agrolyser alone (0.3 kg/ha)(soil)	387.97b	397.87b	392.92b	17
NPK alone (150: 40:90 kg/ha)	1589.07a	2088.39a	1838.73a	82
NPK + 0.2 kg/ha agrolyser (foliar)	1593.79a	2112.99a	1853.39a	82
NPK + 0.3 kg/ha agrolyser (foliar)	1997.56a	2232.32a	2114.94a	84
NPK + 0.4 kg/ha agrolyser (foliar)	1724.53a	2267.69a	1996.11a	84
NPK + 0.2 kg/ha agrolyser (soil)	1561.67a	2167.55a	1864.61a	82
NPK + 0.3 kg/ha agrolyser (soil)	1819.45a	2160.19a	1989.82a	84
NPK + 0.4 kg/ha agrolyser (soil)	1920.16a	2214.94a	2067.55a	84

Plots that received only agrolyser^R using foliar spray and soil placement had only 18 % and 17 % increases, respectively over the absolute control. These increases could be attributed to the agrolyser^R applied but the results revealed that plots that received agrolyser^R only and absolute control had low yields compared to plots that were treated with only NPK fertilizer or NPK + agrolyser^R, which had 82 % and 84 % increases, respectively, over the absolute control. Minor differences existed between plots that received only NPK fertilizer and those in combination with agrolyser^R. Similar results were also obtained by Chigbundu and Ibeawuch (2006) who reported non-significant effect of agrolyser^R on the yield of cowpea in Zuru, Sahel savannah of Nigeria. Thus, agrolyser^R cannot be substituted for NPK fertilizer but it could be used as a supplementary treatment for the supply of micro-nutrients. Abdullahi *et al.* (2011) stressed the need for micro-nutrient inclusion in fertilizer package as supplements of macro-nutrients for higher yield, especially in soils with micro-nutrients below critical levels. Adepoju *et al.* (1991) reported significant increases in maize yield due to the application of 200 g agrolyser^R with NPK (120-60-60 kg/ha) at Samaru (22.4%) and Saminaka (50.4%). Agbede and Otonko (2004) reported increases in the grain yield of maize where NPK was applied either singly or in combination with agrolyser^R at Okuku in Cross River State.

CONCLUSION

It was concluded that agrolyser^R cannot be substituted for NPK fertilizer but that it could be used as a supplementary treatment for the supply of micronutrients. In addition, there was no significant difference in the effects of either the methods or the rates of application of agrolyser^R on maize grain yield. Agrolyser^R could be applied either as a foliar spray or mixed with NPK fertilizer and applied directly by placement to the soil. Since the effect of rates of agrolyser^R on maize grain yield was not significant, the critical level for applying agrolyser^R to maize in Calabar and its environs could not be determined from the present study. There is also the need to carry out further studies to determine the critical level for applying agrolyser^R to maize in the humid rain forest agro climatic zone of Nigeria.

REFERENCES

Abdullahi, A. A.; E. O. Uyovbisere; I. Y. Amapu; K. O. Oluwasemire and N. Abdu (2011). Effects of some micronutrients application on NERICA rice varieties in the Savanna. *Nigerian Journal of Soil and Environment Research,* 9: 36- 43.

Adepoju, A. Y.; E. O. Ajayi and K. A. Ayotade (1991). Effect of agrolyser on combined rice production. Proceedings of the 1st National Workshop on Agrolyser Micronutrient

Fertilizer. Minna, 37 – 42.

Adediran, J. A. and V. A. Banjoko (2003). Comparative effectiveness of some compound fertilizer formulations for maize production in Nigeria. *Nigerian Journal of Soil Science*, 13: 42-49.

Aduayi, E. A.; V. O. Chude; B. O. Adebusuyi; S. O. Olayiwola (eds) (2011). Fertilizer use and management practices for crops in Nigeria (4th ed.). Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development, Abuja, 229 pp.

Agbede, O. O. and E. A. Otonko (2004). Effect of Agrolyser micronutrients on N-P-K nutrition and yield of maize. *Nigerian journal of Soil Science*, 14: 64-67.

Bell, R. W. and B. Dell (2008). Micronutrients for sustainable food, feed, fibre and bioenergy production. First edition, IFA, Paris, France (*www.fertilizer.org*).

Bray, R. A. and L. T. Kurtz (1945). Determination of total and available forms of phosphorus in soils. *Soil Science,* 53: 39–45.

Chigbundu, I. N. and I. I. Ibeawuchi (2006). Effect of agrolyser on the yield of cowpea in Zuru, Kebbi State, Northwestern Nigeria. *International Journal of Agricultural Development*, 7(2): 56- 61.

Cybernetics Nig. Ltd. (1991). Information booklet on agrolyser micronutrient fertilizer (A.M.F.) for increased agricultural productivity, 62 p.

Davies, O. A.; J. F. Alfred-Ockiya and A. Asele (2006). Induced growth of phytoplankton using two fertilizers (NPK and agrolyser) under laboratory conditions. *African Journal of Biotechnology*, 5(4): 373-377.

Federal Ministry of Agriculture and Rural Development (FMA&RD) (2011). Fertilizer use and management practices for crops in Nigeria. Federal Fertilizer Department. *V.O. Chude, S.O. Olayiwola, A.O. Osho, C.K. Daudu (eds.), Abuja, 229 p.*

Iren, O. B., John, N. M. and Imuk, E. A. (2012). Effects of sole and combined applications of organic manures and urea on growth, crude protein and nutrient uptake of fluted pumpkin (T*elfairia occidentalis*, hook f.). J*ournal of Agriculture, Forestry & Environment*, 2(1): 78-84.

Nigeria Meteorological Unit (NIMET). Margaret Ekpo International Airport, Calabar.

Quraishi, M. S. I. and A. H. Cornfield (1971). Effect of an addition of varying levels of copper as oxide or phosphate on nitrogen mineralization and nitrification during incubation of slightly calcareous soil receiving dried blood. *Plant and Soils*, 5: 51- 55.

Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O. and Esu, I. E. (2009). Manual of soil, plant and water analyses.