

Effect of Combination of Soil Granular NPK and Foliar Liquid Fertilizer on Nutrients Uptake and Maize Yield

Adeniyon ON, Aluko AO, Olanipekun SO and Ogunniyan DJ and Oduwaye OF

Institute of Agricultural Research and Training, Obafemi Awolowo University (OAU)
P. M. B. 5029 Ibadan.

ABSTRACT

Investigation to compare the effect of soil basal granular NPK fertilization to its combination with liquid foliar fertilization on maize nutrients uptake and yield was conducted on experimental station of the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Moor Plantation Ibadan located at Ikenne, Ogun state Nigeria; high rain forest agro-ecology (6.87° N, 3.72° E) and experimental farm of the Nigeria Institute For Oil Palm Research (NIFOR) at Ikoga, Badagry, Lagos state; coastal rain forest agro-ecology (6.42° N, 2.88° E) in 2009 cropping season. The experimental design was a randomized complete block design (RCBD) with three replications. The treatments were composed of different levels of soil applied NPK (20-10-10) fertilizer in combination with liquid foliar applied fertilizer from Vioryl products, sole 100kg/ha NPK and sole liquid foliar fertilizer products. Application of 100kg/ha granular NPK fertilizer combined with foliar fertilizer application resulted in highest concentrations of N, P, K, Mg and Zn in maize tissue in both locations. Soil application of NPK mineral fertilizer at different levels combined with foliar fertilizer application resulted in higher maize cob weight, maize grain weight and maize dry matter yield than either NPK fertilizer alone or foliar fertilizer alone. The increase due to the soil application of NPK fertilizer at different levels (100, 80, 60 and 40kg/ha) combined with foliar fertilizer compared to the sole application of 100 kg/ha NPK fertilizer varied from 60, 52, 44, 16% at Ikenne and 47.8, 43.5, 47.8, 17.4% at Badagry for maize grain weight, and 25.9, 21.7, 20.1, 6.2% at Ikenne and 29.7, 23.5, 20.5, 5.8% at Badagry for maize dry matter yield. Based on the results of this study, farmers are advised to use the foliar liquid fertilizer as a nutrient complement rather than as the basic fertilizer as is envisaged. Research needs to be conducted to ascertain the influence of seasons on various applications on maize production.

Keywords: Cropping season, Dry matter yield, Investigation, Maize production, Nutrient complement, Organic matter.

1. INTRODUCTION

Crop productivity in tropical regions is hindered by low soil fertility largely due to low organic matter, cation exchange capacity (CEC), nitrogen and phosphorus deficiencies prevalent in most soils [1, 2]. The traditional method of maintaining soil fertility and crop productivity in

the tropics and sub-tropics has been the bush-fallow system whereby arable land is allowed to revert after 3-4 years of continuous cultivation [3]. However, according to FAO [4], the traditional bush-fallow system does not sustain much crop productivity because of low nutrient availability, shortened fallow periods and shortage of land due to increased population. Thus, the bush-fallow system has been rendered unsustainable [4]. The bush fallow system was therefore replaced with the use of organic manures [5, 6], mineral fertilizers [7] and combination of both organic manure and mineral fertilizer [8, 9]. The application of foliar fertilizers started a few years back and is known to produce good results [10]. According to Rumbidzi and Justin [10] the high costs and environmental hazards caused by the use of mineral fertilizers resulted in the use of foliar fertilizers. They stated further that, the use of alternative fertilizer application strategies to achieve maximum yields and to enhance nutrient use efficiency which has been proposed for decades. Randall et al. [11] have reported that foliar fertilizers act similar as mineral fertilizers. A previous work [12] showed that direct application of P and K to soybeans can have a significant impact on soybean yield. It has also been indicated that in maize, fluid fertilizer placed in a band near the seed at planting has frequently shown positive effects on yield [13]. Even, Hag and Mallarino [14] suggested that a combination of broadcast and band applications coupled with folia applications could provide optimum nutrient uptake in low soil fertility conditions. Foliar nutrients are mobilized directly into a plant leaf, which is the goal of fertilization to begin with, increasing the rate of photosynthesis in the leaves, and by doing so stimulate nutrient absorption by plant roots [15]. From their studies, Barel and Black [16] suggested that foliar fertilization is by far the most effective way to apply micro nutrients or trace elements, and supplement the major elements. According to them, the readily available nutrients in the foliar application are more easily utilized by the plants, because they need not dissolve in water or enter into the soil solution. In addition, foliar fertilization can correct nutrient deficiencies, strengthen weak or damaged crops, speed growth and grow better plants, which are of course, the bottom line [16]. Therefore the objective of the investigation was to compare the effect of soil basal granular NPK fertilization to combination of soil basal granular NPK and liquid foliar fertilization on nutrients up-take and maize yield in two locations.

2. MATERIALS AND METHODS

The study was conducted in 2009 cropping season in two locations lie within the tropical rainforest agro-ecological zone of south-western Nigeria. The first location was on experimental station of the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Moor Plantation Ibadan located at Ikenne, Ogun state Nigeria; high rain forest agro-ecology (6.87 ° N, 3.72 ° E). Precipitation varies from 1500 to 1750mm annually, with nearly all falling as rain in the wet season (April-October). The mean annual temperature is about 27°C with high relative humidity (80%). The second location was on experimental farm of the Nigeria Institute For Oil Palm Research (NIFOR) at Ikoga in the Badagry Local Government Area of Lagos State, Nigeria. The study area (6.42 ° N, 2.88 ° E), is situated in a low-lying coastal region with a general elevation of less than 20m. Mean daily temperatures remain about 26° -28°C. Mean annual rainfall is about 2000mm with rainfall in all the months of the year. The experimental plots were arranged in a randomized complete block design (RCBD) with three replications. The treatments were composed of the followings:

T1: 100 kgN/ha, 50 kgP/ha, 50 kgK/ha (NPK 20-10-10) + 3.5 L/ha Auxenol (5-5-9) + 2.5 L/ha Oligo-8Zn (12-0-0+8Zn) + 2.5 L/ha Oligo-8Mn (14-0-0+8Mn) applied at 1st leaves stage + 3.5 L/ha Operon (29-0-0) applied at tasselling stage.

T2: 80 kgN/ha, 40 kgP/ha, 40 kgK/ha (NPK 20-10-10) + 3.5 L/ha Auxenol (5-5-9) + 2.5 L/ha Oligo-8Zn (12-0-0+8Zn) + 2.5 L/ha Oligo-8Mn (14-0-0+8Mn) applied at 1st leaves stage + 3.5 L/ha Operon (29-0-0) applied at tasselling stage.

T3: 60 kgN/ha, 30 kgP/ha, 30 kgK/ha (NPK 20-10-10) + 3.5 L/ha Auxenol (5-5-9) + 2.5 L/ha Oligo-8Zn (12-0-0+8Zn) + 2.5 L/ha Oligo-8Mn (14-0-0+8Mn) applied at 1st leaves stage + 3.5 L/ha Operon (29-0-0) applied at tasselling stage.

T4: 40 kgN/ha, 20 kgP/ha, 20 kgK/ha (NPK 20-10-10) + 3.5 L/ha Auxenol (5-5-9) + 2.5 L/ha Oligo-8Zn (12-0-0+8Zn) + 2.5 L/ha Oligo-8Mn (14-0-0+8Mn) applied at 1st leaves stage + 3.5 L/ha Operon (29-0-0) applied at tasselling stage.

T5: Sole liquid fertilizers at 3.5 L/ha Auxenol (5-5-9) +2.5 L/ha Oligo-8Zn (12-0-0+8Zn) + 2.5 L/ha Oligo-8Mn (14-0-0+8Mn) applied at 1st leaves stage + 3.5 L Operon (29-0-0) applied at tasselling stage.

T6: Without fertilization (Control)

T7: Sole 100 kgN/ha, 50 kgP/ha, 50 kgK/ha (NPK 20-10-10) applied at 1st leaves stage + 46 kgN/ha (Urea 46% N) applied at tasselling stage.

Before planting, surface (0-15cm) soil samples were collected using auger and bulked for analysis. The soil sample was air-dried and allowed to pass through 2mm sieve. Analyses were carried out according to Juo [17]. The land was disc ploughed and harrowed to a fine tilt. Plots were marked just before planting in April, 2009. The plot size was 30m² (5 x 6m) with rows of maize spaced at 0.75m inter-row and 0.30m intra-row at two plants per stand. Crop management practices included weed control with pre-emergence application of herbicide (Atrazine of 80% wettable powder). The herbicide was applied at the rate of 100 ml to 20 liters of water and was supplemented by one manual hoe weeding. The foliar application of the liquid fertilizers were carried out at 1st leaves (two weeks after planting), while the soil basal dressing of granular NPK 20-10-10 mineral fertilizer was carried out after the first weeding operation (four weeks after planting). At tasselling, liquid fertilizer (Operon (29-0-0) was applied to the necessary plots and granular Urea (46%) was applied to the necessary plots, both were applied as top dressing to boost the availability of nitrogen. For the control, no fertilizers were applied to the plots. At harvest, 10 plants per plot were randomly selected to determine maize cob weight and grain yield (12% moisture content). For tissue analysis, 4 out of ten tagged plants per plot were uprooted and severed, then bagged in brown envelopes and dried in oven at 75°C to constant weight. The dry plant samples were ground with a Willey mill to pass through 0.5mm sieve and used for analysis. Total N was determined by kjeldahl procedure [18]. The P and K contents were determined by ash method. P concentration was determined by vanado-molybdate yellow colorimetric method [19]. Digested samples were diluted and used to determine the concentration of K using flame photometry method [18]. Concentrations of nutrients were expressed on the basis of percentage dry plant material. The nutrient uptake was computed by multiplying the respective grain/straw yield with nutrient contents and expressed as kg/ha. The nutrient uptake was calculated by using the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (kg ha}^{-1}\text{)} \times \text{Yield (kg ha}^{-1}\text{)}}{100}$$

The data collected were statistically analyzed using analysis of variance procedure [20]. Means were compared using Duncan Multiple Range Test at 5% level of probability.

3. RESULTS AND DISCUSSION

The texture of the soils at both Ikenne and Badagry was sandy loamy with high sand fraction (Table 1). The Ikenne soil pH was 5.1 while the Badagry soil pH was 4.9, the Ikenne and Badagry soils reaction was acid. Such higher soil pH condition at Badagry could be attributed to the high rainfall peculiarity of the coastal areas, which could leach out basic cations from the soil.

Table 1: Pre-planting physio-chemical characteristics of the top soil (0-15cm) at the experimental sites.

	Ikenne	Badagry
Sand (%)	76.6	80.6
Silt (%)	10.9	8.9
Clay (%)	12.4	10.4
Organic C (%)	0.8	0.2
Total N (%)	0.08	0.02
Available P (ppm)	7.1	5.8
Exchangeable K (me/100g)	0.1	0.1
Exchangeable Ca (me/100g)	1.3	1.2
Exchangeable Mg (me/100g)	0.6	0.6
Exchangeable Na (me/100g)	0.6	0.6
Exchangeable H ⁺ (me/100g)	0.6	0.7
Exchangeable Cation Exchange Capacity (ECEC) (me/100g)	5.0	3.1
Available Zn (ppm)	4.9	5.5
Available Fe (ppm)	11.2	12.1
Available Cu (ppm)	1.8	1.9
p ^H (H ₂ O)	5.9	4.1

Fertilization of maize with soil basal application of granular NPK 20-10-10 mineral fertilizer in combination with foliar application of liquid fertilizer in Ikenne and Badagry respectively significantly ($P = 0.05$) enhanced the tissue concentration of N, P, K, Mn and Zn of the crop (Tables 2 and 3). Soil basal application of different levels of granular NPK 20-10-10 fertilizer combined with folia application of liquid fertilizer gave higher plant tissue nutrient concentrations than either granular NPK 20-10-10 fertilizer alone or liquid fertilizer alone. Treatment that contained soil basal application of 100kg/ha granular NPK 20-10-10 fertilizer combined with foliar application of liquid fertilizer gave highest N, P, K, Mg and Zn concentration in maize tissue from both soils. There were increases in micronutrients (Mn and Zn) concentrations in all the treatments that contained foliar applied liquid fertilizer compared to soil applied sole granular NPK 20-10-10 fertilizer in Ikenne and Badagry (Tables 2 and 3). This might be related to the Mn and Zn percentage content as prescribed by the formulation of the foliar liquid fertilizer, therefore, it is ascertained that applied foliar liquid fertilizer released both the macro and micro nutrients for maize growth and development.

Table 2: Effect of different fertilizer types and levels on nutrient concentration in maize from Ikenne experimental site

Treatment	N	P	K	Mn	Zn
	<-----	--%--	----->	< ----- mgkg ⁻¹ ----- >	

T1 - 100kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	1.78a	0.66a	1.76a	17.7a	57.9a
T2 - 80kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	1.64a	0.59a	1.65a	16.6a	50.3a
T3 - 60kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	1.56a	0.47a	1.59a	14.4a	48.9a
T4 - 40kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	1.29b	0.28c	1.30d	10.4c	35.7b
T5 - Sole *Liquid folia fertilizer products	0.64c	0.22d	0.96c	12.5c	32.5b
T6 – Sole100kg/ha N, P, K (20-10-10)	1.21b	0.35b	1.42b	08.3d	22.8c
Means in a column followed by the same letter(s) are not significantly different according to DMRT (P = 0.05)					
* Auxenol (5-5-9) + Oligo-8Mn (14-0-0-8Mn) + Oligo 8Zn (12-0-0-8Zn) + Operon (29-0-0)					
Table 3: Effect of different fertilizer types and levels on nutrient concentration in maize from Badagry experimental site.					

Treatment	N <-----	P --%--	K ----->	Mn < ---- mgkg ⁻¹ ---- >	Zn ----->
T1 - 100kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	1.72a	0.68a	1.74a	18.7a	55.5a
T2 - 80kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	1.65a	0.66a	1.61a	16.9a	52.1a
T3 - 60kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	1.53a	0.57a	1.57a	15.4a	42.5a
T4 - 40kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	1.26b	0.30c	1.32d	11.8c	33.2b
T5 - Sole *Liquid folia fertilizer products	0.78c	0.22d	0.99c	12.1c	31.6b
T6 – Sole100kg/ha N, P, K (20-10-10)	1.23b	0.37b	1.46b	08.7d	20.3c
Means in a column followed by the same letter(s) are not significantly different according to DMRT (P = 0.05)					
* Auxenol (5-5-9) + Oligo-8Mn (14-0-0-8Mn) + Oligo 8Zn (12-0-0-8Zn) + Operon (29-0-0)					
The N, P and K uptake by maize was significantly influenced by soil basal application of granular NPK 20-10-10 fertilizer combined with foliar application of liquid fertilizer in both Ikenne and Badagry (Tables 4 and 5). There were increases in N, P, and K uptake by maize plants fertilized with 100, 80 and 60 kg/ha of granular NPK 20-10-10 mineral fertilizer combined with folia application of liquid fertilizer compared to the application of sole liquid					

fertilizer and sole granular 100kg/ha NPK 20-10-10 fertilizer in both non-acid and acid soils. Therefore, it has been ascertained that a combination of broadcast and band applications coupled with folia applications could provide optimum nutrients uptake in low soil fertility conditions [14]. Foliar nutrients are mobilized directly into a plant leaf, which is the goal of fertilization to begin with, increasing the rate of photosynthesis in the leaves, and by doing so stimulate nutrients absorption by plant roots [15].

Table 4: Effect of different fertilizer types and levels on nutrient uptake (kg ha⁻¹) in maize from Ikenne experimental site

Treatment	N <----- kg ha ⁻¹ ----->	P <----- kg ha ⁻¹ ----->	K
T1 - 100kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	144.2a	53.5a	142.6a
T2 - 80kg/ha N, P, K (20-10-10) *Liquid folia fertilizer products	121.4a	47.7a	122.1a
T3 - 60kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	109.2a	32.9b	111.3a
T4 - 40kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	79.9b	17.4c	80.6b
T5 - Sole *Liquid folia fertilizer products	32.6c	11.2d	48.9c
T6 – Sole 100kg/ha N, P, K (20-10-10)	66.6b	19.3c	78.1b

Means in a column followed by the same letter(s) are not significantly different according to DMRT ($P = 0.05$)

* Auxenol (5-5-9) + Oligo-8Mn (14-0-0-8Mn) + Oligo 8Zn (12-0-0-8Zn) + Operon (29-0-0)

Table 5: Effect of different fertilizer types and levels on nutrient uptake (kg ha⁻¹) in maize from Badagry experimental site.

Treatment	N <----- kg ha ⁻¹ ----->	P <----- kg ha ⁻¹ ----->	K
T1 - 100kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	118.7a	46.9a	120.1a
T2 - 80kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	99.0a	39.6a	96.6a
T3 - 60kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	87.2a	32.5a	89.5a
T4 - 40kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	60.5b	14.4b	63.4b
T5 – Sole *Liquid folia fertilizer products	31.2c	8.8c	39.6c

T6 – Sole100kg/ha N, P, K (20-10-10) 51.7b 15.5b 61.3b

Means in a column followed by the same letter(s) are not significantly different according to DMRT ($P = 0.05$)

* Auxenol (5-5-9) + Oligo-8Mn (14-0-0-8Mn) + Oligo 8Zn (12-0-0-8Zn) + Operon (29-0-0)

Application of granular NPK mineral fertilizer at different levels combined with folia fertilizer gave higher maize cob weight significantly ($P = 0.05$) than either NPK 20-10-10 granular fertilizer alone or foliar fertilizer alone in both locations (Table 6). At Ikenne, the increases due to the soil application of granular NPK fertilizer at different levels (100, 80, 60 and 40kg/ha) combined with folia fertilizer compared to the sole application of 100 kg/ha NPK 20-10-10 granular fertilizer varied from 47.3, 34.6, 27.3, and 12.7%. While at Badagry, the increases due to the application of granular NPK fertilizer at different levels (100, 80, 60 and 40kg/ha) combined with foliar fertilizer compared to the sole application of 100 kg/ha NPK 20-10-10 granular fertilizer varied from 64.3, 42.9, 35.7, and 14.3%.

Table 6: Effect of different fertilizer types and levels on maize cob weight at Ikenne and Badagry experimental sites.

TREATMENTS	Maize cob weight at Ikenne (t/ha)	Difference as compared with sole NPK at Ikenne (%)	Maize cob weight at Badagry (t/ha)	Difference as compared with sole NPK at Badagry (%)
T1 - 100kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	8.1a	+47.3	6.9a	+64.3
T2 - 80kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	7.4ab	+34.6	6.0abc	+42.9
T3 - 60kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	7.0abc	+27.3	5.7abc	+35.7
T4 - 40kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	6.2cd	+12.7	4.8bc	+14.3
T5 – Sole *Liquid folia fertilizer products	5.1e	-7.3	4.0b	-4.8
T6 – No treatments	3.9f	-29.1	2.9d	-30.9
T7 – Sole100 kg/ha N, P, K (20-10-10)	5.5e	-	4.2bc	-

Means in a column followed by the same letter(s) are not significantly different according to DMRT ($P = 0.05$)

* Auxenol (5-5-9) + Oligo-8Mn (14-0-0-8Mn) + Oligo 8Zn (12-0-0-8Zn) + Operon (29-0-0)

Soil basal application of NPK 20-10-10 granular fertilizer at different levels combined with folia application of liquid fertilizer gave significantly ($P = 0.05$) higher maize grain weight than either basal application of sole NPK 20-10-10 granular fertilizer or foliar application of sole liquid fertilizer in both locations (Table 7). At Ikenne, the increases due to the soil application of granular NPK fertilizer at different levels (100, 80, 60 and 40kg/ha) combined with folia fertilizer compared to the sole application of 100 kg/ha NPK 20-10-10 granular fertilizer varied from 60, 52, 44 and 16%. While at Badagry, the increases due to the application of granular NPK fertilizer at different levels (100, 80, 60 and 40kg/ha) combined with folia fertilizer compared to the sole application of 100 kg/ha NPK 20-10-10 granular fertilizer varied from 47.8, 43.5, 47.8 and 17.4%. Hag and Mallarino [14] indicated that, a combination of broadcast and band applications coupled with foliar applications can provide optimum nutrient uptake in low soil fertility conditions. However, under current reduced tillage systems that is currently being advocated for so as to increase crop yield, broadcasted nutrients can remain on the compacted soil surface through wheel traffic due to limiting root contact the soil surface [21]. This means that alternative strategies must be considered [22]. Rumbidzai and Justin [10] suggested that this may be corrected through some combination of starter and foliar fertilizer application, fertilizer rate adjustment of both macro and micronutrients.

Table 7: Effect of different fertilizer types and levels on maize grain weight at Ikenne and Badagry experimental sites.

TREATMENTS	Maize grain weight at Ikenne (t/ha)	Difference as compared with sole NPK at Ikenne (%)	Maize grain weight at Badagry (t/ha)	Difference as compared with sole NPK at Badagry (%)
T1 - 100kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	4.0a	+60	3.4a	+47.8
T2 - 80kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	3.8ab	+52	3.3a	+43.5
T3 - 60kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	3.6ab	+44	3.4a	+47.8
T4 - 40kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	2.9c	+16	2.7ab	+17.4
T5 – Sole *Liquid folia fertilizer products	2.5cd	0	2.3b	0
T6 – No treatments	1.0e	-60	1.4c	-39.1
T7 – Sole 100 kg/ha N, P, K (20-10-10)	2.5cd	-	2.3b	-

Means in a column followed by the same letter(s) are not significantly different according to DMRT ($P = 0.05$)

* Auxenol (5-5-9) + Oligo-8Mn (14-0-0-8Mn) + Oligo 8Zn (12-0-0-8Zn) + Operon (29-0-0)

Soil application of granular NPK fertilizer at different levels combined with foliar fertilizer resulted in a significantly ($P = 0.05$) higher maize dry matter yield than either NPK 20-10-10 mineral granular fertilizer alone or foliar fertilizer alone in both locations (Table 8). At Ikenne, the increases due to the soil application of granular NPK fertilizer at different levels (100, 80, 60 and 40kg/ha) combined with foliar fertilizer compared to the sole application of 100 kg/ha NPK 20-10-10 granular fertilizer varied from 25.9, 21.7, 20.1 and 6.23%. While at Badagry, the increases due to the application of granular NPK fertilizer at different levels (100, 80, 60 and 40kg/ha) combined with folia fertilizer compared to the sole application of 100 kg/ha NPK 20-10-10 granular fertilizer varied from 29.7, 23.5, 20.5 and 5.8%. A previous work showed that direct application of P and K to soybeans can have a significant impact on soybean yield [12]. On the other hand, in maize, fluid fertilizer placed in a band near the seed at planting has frequently shown positive effects on yield [13]. The readily available nutrients in foliar application are more easily utilized, because they do not have to be dissolved by soil moisture and go into the soil solution. In addition, foliar fertilization can correct deficiencies, strengthen weak or damaged crops, speed growth and grow better plants, which are of course, the bottom line [15].

Table 8: Effect of different fertilizer types and levels on maize dry matter yield (g/plant) at Ikenne and Badagry experimental sites.

TREATMENTS	Maize dry matter yield at Ikenne (g/plant)	Difference as compared with sole NPK at Ikenne (%)	Maize dry matter yield at Badagry (g/plant)	Difference as compared with sole NPK at Badagry (%)
T1 - 100kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	3.64a	+25.9	3.53a	+29.7
T2 - 80kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	3.52a	+21.7	3.36a	+23.5
T3 - 60kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	3.47ab	+20.1	3.28ab	+20.5
T4 - 40kg/ha N, P, K (20-10-10) + *Liquid folia fertilizer products	3.07b	+6.2	2.88b	+5.8
T5 – Sole *Liquid folia fertilizer products	2.24c	-22.4	2.37c	-12.8
T6 – No treatments	1.95d	-32.5	1.53d	-43.7
T7 – Sole 100 kg/ha N, P, K (20-10-10)	2.89c	-	2.72b	-

270 Means in a column followed by the same letter(s) are not significantly different according to
271 DMRT ($P = 0.05$)

272 * Auxenol (5-5-9) + Oligo-8Mn (14-0-0-8Mn) + Oligo 8Zn (12-0-0-8Zn) + Operon (29-0-0)

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276 The effect of combination of basal application of granular NPK and folia application of liquid
277 fertilizers on maize yield is shown in Table 9. Response of maize grain yield to the
278 combined basal application of NPK 20-10-10 granular fertilizer and folia application of liquid
279 fertilizer was site specific; this was not surprising though, because maize yield is directly
280 dependent on a number of factors, such as soil pH. Soil pH has an important role in the loss
281 of N and or fixation of most nutrients and therefore different nutrient management practices
282 are required for crop production in calcareous and non-calcareous soils [23].

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285 **Table 9: Combined effect of different fertilizer types and levels on maize grain yield**
286 **from the two locations.**

LOCATIONS	Maize grain weight (t/ha)
Ikenne (High rainforest non-acid soil)	3.0a
Badagry (High rainforest acid soil)	2.6b

287 Means in a column followed by the same letter(s) are not significantly different according to
288 DMRT ($P = 0.05$)

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291 4. CONCLUSION

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293 The results of the study have shown that the foliar application of the liquid fertilizer cannot
294 compete equally with the basal applied granular mineral fertilizer since the yields obtained
295 were far less than those of the soil applied mineral fertilizer. From the results of this study
296 farmers can be recommended to use the foliar liquid fertilizer as a nutrient supplement rather
297 than as the basic fertilizer as envisaged. More research needs to be carried out with various
298 application periods (early and late maize) of the foliar fertilizer than the application to the
299 early maize production.

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303 5. REFERENCES

304

- 305 1. Sanguinga N, Okongun JA, Vanlauwe B, Diels J, Carsky RJ, Dashiell K. Nitrogen
306 contribution of promiscuous soybeans in maize-based cropping systems. Pp. 157-
307 177; In Sustaining soil fertility in West Africa. SSSA Special Publication 58 SSSA
308 Madison W.I. 2001.
- 309 2. Pal UR, Shehu Y. Direct and residual contributions of symbiotic nitrogen fixation by
310 legumes to the yield and nitrogen uptake of maize (*Zea mays* L.) in the Nigerian
311 savannah. J. Agron. Crop Sci. 2001; 187 (1): 53-58.
- 312 3. Chude VO, Olayiwola SO, Osho, AO, Dauda CK. Fertilizer use and management
313 practices for crops in Nigeria. 4th Edition produced by Federal Fertilizer Department,
314 Federal Ministry of Agriculture and Rural Development 2011; Abuja. Pp. 1-231.
- 315 4. FAO. Production year book. An Agricultural Organization of the United Nations
316 Rome 1989; 490pp.

- 317 5. Martins JH, Warren L, Stamps DL. Principles of field crop production. 3rd ed.
318 Macmillan Publication Company Inc. N. York 1976.
- 319 6. Olayinka A, Adebayo A. Effect of incubation temperatures and different sources of
320 N and P on decomposition of sawdust in soil. *Agricultural Wastes* 1984; 11: 293-
321 306.
- 322 7. Chude VO. Perspective of fertilizer use in the 21st century. Proceedings of the 25th
323 Annual Conference held at Precious Palm Royal Hotel Benin City from 21st-25th
324 November 1999. Pp 255-263.
- 325 8. Adeniyi ON, Ojeniyi SO. Comparative effectiveness of residual effects of different
326 levels of poultry manure with mineral fertilizer on soil fertility, nutrient uptake and
327 yield of maize. *Moor J. Agric. Res.* 2003; 4(2): 191-197.
- 328 9. Adeniyi ON, Ojeniyi SO. Effect of poultry manure, N.P.K. fertilizer and combination
329 of their reduced levels on maize growth and soil chemical properties. *Nigerian*
330 *Journal of Soil Science* 2005; 15: 34-41.
- 331 10. Rumbidzai DK, Justin G. Evaluating the Effectiveness of Organic Foliar Fertilizer on
332 Bean (*Phaseolus Vulgaris L*) Production in Makonde District of Zimbabwe. *IJSBAR*
333 2014; 16 (1): 484-495
- 334 11. Randall GW, Schulte EE Corey RB. Effect of soil and folia-applied Manganese on
335 the micronutrient content and yield of soybeans. *Agron. J* 1975; 502-507.
- 336 12. Gordon B. Maximizing irrigated soybean yields in the Great Plains, *Better Crops*
337 2008; 92 (2): 6-7.
- 338 13. Rehm GW, Lamb J A. Corn response to fluid fertilizers placed near the seed at
339 planting. *Soil Sci. Soc. Am. J.* 2009; 73: 1427-1434.
- 340 14. Haq MU, Mallarino AP. "Soybean yield and nutrient composition as affected by early
341 season foliar fertilization". *Agron. J.* 2000; 93: 1220–1226.
- 342 15. Barel D. Black CA. Folia application of P. I. Screening of various inorganic and
343 organic P compounds. *Journal of Agricultural and Biological Science* 1979a; 1: 15-
344 21.
- 345 16. Barel D, Black CA. Folia application of P. II. Yield responses of corn and soybeans
346 sprayed with various condensed phosphate and P-N compounds in greenhouse and
347 field experiment. *Agron. J.* 1979b; 7: 21-24.
- 348 17. Juo ASR. Selected methods for soil and plant analysis. IITA Manual Series No. 1,
349 International Institute of Tropical Agriculture Ibadan Nigeria 1975; 70.
- 350 18. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi.
351 1973
- 352 19. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in
353 soils by extraction with sodium Bicarbonate. USDA Circ. No. 939, Washington. 1954
- 354 20. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2nd ed.)
355 John Willey & Sons, New York 1993; 680.
- 356 21. Giller KE, Witter E, Corbeels M, Tittonell P. "Conservation agriculture and
357 smallholder farming in Africa: The heretics' view". *Field Crops Res* 2009; 114: 23-34.
- 358 22. Kovar JL, Mallarino AP. "Starter fertilizer formulations and placement for reduced
359 tillage corn". *Fluid Forum Proceedings* 2001; 18:188–194.
- 360 23. Rahman MM, Soaud AA, Fareed H. AL Darwish AL, Faruq Golam F, Sofian-Aziru
361 M. Growth and nutrient uptake of maize plants as affected by elemental sulfur and
362 nitrogen fertilizer in sandy calcareous soil. *Afr J of Biotechnol* 2011; 10 (60): 12882-
363 12889.

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