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Effect of Mineral and Organo-Mineral fertilizer under different methods of application on Maize *(Zea mays L.)* production

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Abstract
Soil fertility problems are normally combated with the use of mixtures of organic and inorganic fertilizers. A field experiment was conducted during the 2005 and 2006 rainy season (May –September) at the Teaching and Research Farm of the University of Ibadan, Southwestern Nigeria, to evaluate the effect of Mineral and Organo-Mineral fertilizers on growth and yield of Maize using different methods of application. ACR.91 SWAN1 maize variety was used as the test crop. A randomized complete block design was used with 11 treatments namely: control (no fertilizer), 2 and 1 t/ha-urea amended compost (buried and surface of Grade A and B), 6.7 and3.4t/ha (buried and surface of Grade A and B), N.P.K (300kg/ha-l, buried and surface) and replicated three times. Data were analysed using ANOVA and the means were separated using Duncan multiple range test. Result showed that NPK (buried) gave the best performance in all characters observed with grain yield of 6.32tha-l followed by urea amended compost (buried) with 5.53tha-l. The buried methods of N.P.K., urea amended compost and 6.7t/ha compost gave 6.32tha-l, 5.53t/ha and 3.08t/ha when compared with surface method with 5.83t/ha, 5.0t/ha and 2.83t/ha grain yield respectively. Organo-mineral fertilizer grade A at full dose and buried methods of application performed better than the grade B at full dose (6.7t/ha) that whichproduced yields of 2.83t/ha and 3.08t/ha for surface and buried methods of application respectively. Half dose followed the same trend as shown in the full doses of grade A and B. The use of Organic amended fertilizer gave a better result in maize growth and yield parameters considered than that of control with grain yield 2.13t/ha. Upgrading the fortification of manures with mineral fertilizer, should be seen as a better option for improving nutrient use efficiency and amelioration of soil for optimum maize production.

Keywords: *N.P.K, Organo-mineral, buried, surface and Maize*

Introduction

Maize is one of the most important food crops worldwide. It is grown virtually throughout sub-Saharan Africa in a range of agro-ecological and economic environment. The crop is an important crop within the tropics and it is one of the top three grains grown in West and Central Africa in recent years (I.I.T.A, 1992). The crop responds well to high soil fertility and maximum yield potentials is possible with high fertility. Hence, adequate soil fertility therefore is one of the requirements for profitable maize production (Davis and Westfall, 2009). Most options for yield increases or continuous productions are becoming limited since marginal lands conversion into productive arable land is diminishing (Crosson and

Anderson, 1992).The challenge of producing large quantities of biomass required to support the timid population, while maintaining adequate level offoodproduction,andalso conservingnatural resources and preserving environmental quality, should not be understated. The introduction of high yielding, fertilizer response varieties gave boost to fertilizer consumption in maize crop. Hence, long term high input agriculture has a strong positive effect in improving agronomic properties of soil (Buol andStokes, 1997). However, the reduction in inorganic matter with continuous use of mineral fertilizer at times gives rise to erosion and loss of top soil. Also, farmers cannot afford due to their high cost and scarcity (Adediran *et al*., 2009).

Pacesetter's Grade A and B (PGA &PGB) are major wastes generated in the commercial market (Bodija Ibadan) and in the processed municipal wastes respectively. An attempt to waste management strategies and adoption of organo-mineral fertilizer development was accepted in principle as viable options. Farmers are aware of the availability of these wastes but there is need to intensify effort on its acceptable form for Maize production and easy adoption. Most times, these wastes are dumped pollutant and incinerated at market. Recycling wastes for farm inputs is a viable option for efficient management and optimum production (Adeoye *et al*., 2005). Seifritz (1982) work also, stated that the Improvements of environmental conditions as well as public health are also important reasons for advocating increased use of organic materials this assertion was similar to the result of Ayoola and Makinde, 2008. Organic materials are thus, suitable substitute for inorganic fertilizers to maintain sustainable crop production and environmental quality (Pawar *et al*.,2003). Reports on the positive responses of crops to Pacesetter organo-mineral fertilizers (PGB) cut across some agricultural crops like Mushrooms (Adeoye, *et al.*, 1998); *Amaranthus* (Makinde, *et al*., 2010); Maize and Cassava (Omueti *et al*., 1996).

The use of organic manure alone, to sustain cropping has been inadequate due to unavailability in the required quantities and their relatively low nutrient content (Palm *et al.*, 1997). Hence, organic and inorganic fertilizers amendment had been suggested (Palm *et al*., 1997) and thus confirmed (Ibeawuchi *et al*.,2006) work that the application of inorganic and/or organic fertilizers have increased plant growth because they contain considerable quantities of plant nutrients. This study was therefore, conducted to evaluate the effects of mineral and organo-mineral fertilizers under different methods of application on the performance and yield of maize production.

Materials and Method

The experiment was conducted at Teaching and research farm of Agronomy Department University of Ibadan, South Western Nigeria, during the 2005 and 2006 rainy season (May to September). Ibadan is situated on latitude $3^{0}405^{1}$N and longitude $7^{0}4\ 30^{1}$N and has a bimodal rainfall regime, with an annual mean of 1278mm, and a mean annual temperature of 26^{0}C. The rainy season begins in March and ends in November and usually with a short dry spell in August interrupting this rainy season.

The treatments consist of (i) four levels of organo-mineral fertilizer comprising: (2.0 tha^{-1} OMFA (A1) full dose, 1.0tha^{1} OMFA,(A2) half dose, 6.7tha^{-1}OMFB(B1) full dose and 3.4ha^{-1}OMFB(B2), where (OMFA = Urea amended compost and OMFB = un-amended compost).

(ii) One level of mineral fertilizer (Kgha-[1]): 300N15 P15K15(C) = complete (iii) No fertilizer (F0); Methods of application include (A) Buried method (M1) and (B) Surface method (M2). Treatment combinations of the Organo-mineral and Mineral Fertilizer applied to the maize plants are; A1M1= Full dose of OMFA by buried method, A1M2= Full dose of OMFA by surface method, A2M1= Half dose of OMFA by buried method, A2M2= Half dose of OMFA by surface method, B1M1= Full dose of OMFB by buried method, B1M2= Full dose of OMFB by surface method, B2M1= Half doseof OMFB by surface method, B2M2= Half dose of OMFB by surface method, CM1= NPK 15-15-15 by buried method, CM2= NPK 15-15-15 by surface method and F0 = No fertilizer.

It was laid out in a randomized complete block design with three replicates. The blocks were 1m apart and 0.5m between plots. Each plot measured 3m x3m with the total field size of 24m x24m. The inter-row and intra-row spacing were 75cm x25cm. Prior to field experimentation bulked soil samples were randomly taken from 18 different locations on the experimental site for assessment of soil physical and chemical properties from top soil (0-15cm depth). The site was ploughed and harrowed. Both Grades A brand (OMFA) and Grade brand B were commercially produced by Pacesetters organo-mineral plant at Bodija in Ibadan, Oyo state in Nigeria. ACR.91 SWAN1.SCRI maize variety was used and the seeds were treated with Furandan (G) against stem borers before planting. Three maize seeds were planted per hole and latter thinned to one per stand after two weeks. Weeding was done twice before harvesting in June and July respectively.

Parameters were measured weekly, starting from 3weeks after planting (WAP). This includes plant height, leaf length, leaf area, stem girth that were measured with measuring tape and the number of leaves were counted. The circumference measurements were taken at the base (5cm) from soil surface. At seven WAP, the length of the ear-leaves and number of nodes were taken. The ear-leaves were oven dried at 65^0C for 24hrs and grounded for laboratory analysis to analyse for N, P, K, Ca and Mg. Harvesting was done 13WAP and yield parameters determined were weight of grain, length of Cob, length of grain filled, percentage grain filled diameter of the Cob, number of seeds per row, maize root weight and Maize root length.

The analysis of variance (ANOVA) procedure was used to determine the treatments effect using statistical analysis system SAS (1999). All mean values were separated with the least significant difference (LSD) at 0.5 level of probability using Duncan multiple range test.

Results

Table 1: Proximate analysis of organo-mineral fertilizer grades

Nutrient Element (%)	Grade (A)	Grade (B)
N	4.42	1.68
P	1.10	1.03
K	0.68	0.60
Na	0.08	0.o8
Ca	0.68	0.48
Zn (mgKg-^{1})	712.7	57.20
Mn (mgKg-^{1})	558.3	30.60
Fe (mgKg-^{1})	8153.40	355.30
Cu(mgKg-^{1})	257.40	9.60

Source: Pacesetter Fertilizer Company, Bodija Ibadan

Key: OMFA = N& P sources amended compost
OMFA= Un-amended compost

Characteristics of Soil used

The results of the physical and chemical analysis of the soil used prior to the commencement of the experiment are shown in Table 2. The soil is sandy loam with slightly acidic pH. The organic matter, organic carbon and total nitrogen were relatively low. The exchangeable bases and CEC were very low (FPDD, 1989) with the exception of available phosphorus that is high. The result shows that the soil is low in fertility and hence, the need for its restoration for optimum production.

Effect of treatment on agronomic parameters

The effects of treatments on plant height, leaf area, number of leaves, number of leaves and plant girth are presented on Table 4. Significant ($P<0.05$) treatments effects were observed on all agronomic characters considered. There was significant increase in the mean plant height throughout the growing period and with significant difference among the treatments. At 3,4,5 and 6 weeks after planting the greatest mean height was observed in plots with NPK (15-15-15) fertilizer 300kg/ha(183.83cm) and OMFA (2t\ha)(177.33cm) buried. However, OMFB (97.63cm) surface gave the lowest mean height exclusive of the control (83.27cm).

Also, the result of the mean leaf area shows significant difference among treatments throughout the growing period. Although, NPK buried, gave the highest mean leaf area (572cm-^{2}) followed by full dose of OMFA (buried)(555.33cm-^{2})m) > OMFB (buried &surface)(350cm-^{2}& 321.67cm-^{2}) > control(310.33cm-^{2}) at 3, 4, 5 and 6 WAP.

From Table 4, the number of leaves at 4,5 and 6 weeks after planting shows NPK 15-15-15(11.80) and(11.43) OMFA(buried) with the highest number of leaves per plant and there was significant difference between treatments with full dose of OMFB (buried) and full dose of OMFB (surface) throughout the period of investigation. The control (8.87) gave the lowest mean number of leaves in all the treatments.

Table 2: Chemical analysis of experimental soil

Sample	pH (H20) (%)	OrgC (%)	KJEL N%	C/N ratio	P (mgKg-1)	Exchangeable cations Ca	Mg	K	Na (CmolKg-1)	acidity	Mn	ECEC	Particle size analysis (Sandy loam) Sand(%)	Silt(%)	Clay
1	5.5	1.16	0.209	5.6	6.5	2.1	1.0	0.1	0.21	0.3	0.1	3.71	69	18	13
2	5.7	1.09	0.199	5.5	31.4	2.4	1.1	0.1	0.18	0.4	0.1	4.18	71	16	13
3	5.5	1.13	0.194	5.8	27.9	2.1	1.1	0.2	0.17	0.4	0.1	3.97	72	17	11
4	5.5	1.16	0.200	5.8	7.9	2.3	1.0	0.2	0.17	0.4	0.1	4.07	73	12	15
5	5.5	1.13	0.198	5.7	21.9	2.1	0.9	0.3	0.17	0.1	0.1	3.87	69	14	17
6	5.4	0.99	0.171	5.8	9.1	1.8	0.9	0.3	0.18	0.1	0.1	3.68	73	12	15
7	5.5	1.29	0.233	5.5	18.3	2.9	1.1	0.2	0.18	0.5	0.1	4.88	69	16	15
8	5.5	1.21	0.211	5.7	28.1	2.3	1.1	0.1	0.20	0.3	0.1	4.00	71	12	17
9	5.7	1.29	0.218	5.9	57.8	2.5	1.2	0.2	0.16	0.3	0.1	4.36	74	11	15
10	5.7	1.15	0.209	5.5	21.4	2.5	1.1	0.2	0.16	0.4	0.1	4.36	71	14	15
11	5.4	0.97	0.161	6.0	17.4	1.7	1.8	0.1	0.16	0.3	0.1	4.06	71	14	15
12	5.3	1.11	0.193	5.8	22.3	1.7	1.0	0.3	0.16	0.3	0.1	3.46	73	14	13
13	5.7	1.15	0.214	5.4	6.4	2.5	1.3	0.2	0.15	0.4	0.1	4.56	64	15	21
14	5.4	1.34	0.246	5.4	23.5	2.3	1.4	0.2	0.15	0.4	0.1	4.55	69	14	21
15	5.7	1.58	0.275	5.7	39.7	3.0	1.5	0.3	0.17	0.3	0.1	5.27	69	18	13
16	5.5	1.07	0.191	5.6	5.0	21	1.0	0.3	0.19	0.3	0.1	3.89	69	18	13
17	5.4	1.27	0.221	5.7	11.3	2.7	1.5	0.3	0.18	0.3	0.1	4.98	71	16	17
18	5.5	1.29	0.210	6.1	22.8	2.4	1.3	0.3	0.17	0.5	0.1	4.47	63	20	17

Table 3: Effect of organo-mineral fertilizer and NPK on Maize yield

Fertilizer type	Rate	Placement	Husk with Wt.cob(kg)	Weight of cob(Kg)	Number of cob	Cob dry weight	Cob length (cm)	Length of grain filled cob(cm)	Percentage grain filled (%)	Cob diameter (cm)	Number of seed per cob	Seed per row (number	Wt. of 10 cobs	Cob yield (t/ha)	Grain yield
Pacesetter (A)	2t/ha	Surface	5.33c	2.10c	10.33a	0.99c	14.77cd	13.23c	83.01b	4.60b	489.00cd	288.33bc	1.87c	5.25c	5.00c
	2t/ha	Buried	5.83b	2.43b	10.00a	1.10b	15.53bc	14.40b	92.70a	4.87a	514.00bc	30.33b	2.07b	6.08b	5.53
	1t/ha	Surface	4.50c	1.43c	10.67e	0.62de	13.10e	11.90d	90.81ab	4.07cde	430.00e	25.67cd	1.17de	3.58e	3.33e
	1t/ha	Buried	4.77d	1.60d	10.00a	0.66d	14.33d	12.90c	92.35ab	4.27c	466.00d	28.66bc	1.30d	4.00d	3.75d
Pacesetter (B)	6.7t/ha	Surface	4.00fg	1.23fg	10.33a	0.59e	11.90f	10.93de	91.89ab	3.93def	362.00f	24.33de	1.10e	3.08fg	2.83f
	6.7t/ha	Buried	4.17f	1.37ef	1q.33a	0.62de	12.07f	10.93de	90.62ab	4.13cd	402.00e	24.67de	1.17de	3.43ef	3.08ef
	3.4t/ha	Surface	3.40	1.13gh	10.67a	0.53ef	11.07f	10.23e	92.45a	3.93def	315.00g	22.33f	1.00f	2.83gh	2.28gh
	3.4t/ha	Buried	3.83g	1.20gh	10.00a	0.53ef	11.83f	10.83e	91.49ab	4.87a	327.31fg	23.33def	1.00f	300gh	2.75fg
NPK 15-15-15	300kg/ha	Surface	6.07b	2.53b	10.00a	1.19ab	16.30b	15.27b	92.13ab	5.00a	535.30b	29.33b	2.23a	6.38b	5.83b
	300kg/ha	Buried	6.33a	2.70a	10.63a	1.24a	18.53a	17.50a	94.41a	3.80f	626.00a	37.67a	2.10ab	6.88a	6.32a
Control	___	_____	3.07i	1.07h	10.67a	0.46f	11.63f	10.70e	92.13ab		256.30h	21.00f	0.87f	2.68h	2.13h

Means with the same letters in the column are not significantly different at 5%

Table 4: Effect of organo-mineral fertilizer and NPK on Maize performance

Fertilizer type	Rate	Placement	Plant height (cm) in WAP				Leaf area (cm^2) in WAP				Number of leaves in WAP			Stem girth (cm) WAP		
			3	4	5	6	3	4	5	6	4	5	6	4	5	6
Pacesetter (A)	2t/ha	Surface	72.17c	74.93c	118.73b	149.30b	308.6c	379.17c	505.17c	523.80c	8.93b	9.87c	10.93c	7.87c	8.53b	8.80c
	2t/ha	Buried	75.13b	80.13b	124.20a	177.33a	332.00b	413.77b	523.13a	555.33b	9.13ab	10.53b	11.43b	8.20b	8.80a	9.07b
	1t/ha	Surface	60.57e	64.93e	103.03d	131.63c	273.83e	306.23e	418.50e	461.33e	7.93cd	9.03ed	10.00e	7.13e	8.07c	8.27e
	1t/ha	Buried	63.00d	70.00d	107.80c	134.40c	285.93d	32.13d	433.57d	480.33e	8.23c	9.27d	10.43d	7.53d	8.13c	8.543d
Pacesetter (B)	6.7t/ha	Surface	53.90a	60.07f	94.63f	115.57d	260.07f	275.50g	372.90g	402.50gd	7.67de	8.76ef	9.53f	6.80f	7.60d	8.07fg
	6.7t/ha	Buried	57.53f	61.30f	97.63e	93.23e	263.90ef	287.90f	380.33f	421.50f	7.83de	8.93ef	9.60f	6.93f	7.70d	8.20ef
	3.4t/ha	Surface	50.47	53.00h	88.43g	97.63e	241.83g	263.50h	306.87i	321.67i	7.56de	8.40g	9.00gh	6.50g	7.00fe	7.93g
	3.4t/ha	Buried	51.50h	55.87g	90.57g	153.50b	246.93g	270.97gh	324.30h	350.17h	7.67de	8.70f	9.13g	6.53g	7.13e	8.00g
NPK 15-15-15	300kg/ha	Surface	77.2a	76.50c	120.33a	153.50b	334.33b	413.57b	515.50b	541.83b	9.33a	10.53b	11.47a	8.13b	8.86a	9.27a
	300kg/ha	Buried	77.80a	84.85a	125.33a	183.83a	371.17a	425.33a	527.07a	572.00a	9.40a	11.00a	11.80	8.37a	8.93a	9.37a
Control	______	_____	41.80i	47.93i	73.47i	83.27f	202.07h	263.50h	276.67j	310.33i	7.00f	8.27h	8.87h	6.27h	6.87f	7.20h

Means with the same letters in the column are not significantly different at 5%

The result of stem girth at 4, 5 and 6WAP shows that buried NPK 15-15-15 has the highest mean (9.7cm) stem girth, followed by OMFA (9.07cm) while the OMFB (8.20cm) had the least stem girth exclusive of the control. In all parameters considered the trend NPK>full dose OMFA> full dose OMFB>half dose OMFA >half dose>control with buried application better than the surface method.

Effect of treatment on yield parameters

From (Table 3), Significant (P>0.05) treatments effect were obtained on weight of husk with cob, weight of cob, cob dry weight, cob length, length of grain filled cob, cob diameter, number of seed per row and weight of 10cobs. Although, there was no significant difference in mean number of cobs consider and this may be attributed to the effect of genetic factor. Also, there was no significant difference between OMFB half dose (surface) and OMFB half dose (buried) and same between the OMFB either buried or surface, full dose and the control in the case of cob length value. With the length of grain filled, there was no significant difference between the OMFB either buried or surface, half dose and control. However, over 90% of the treatments have the same percentage grain filled. The result followed similar trend when compared with observation from agronomic parameter result in Table 4. In terms of Total grain yield and cob yield (t/ha), the highest value was obtained in plant treated with buried NPK (6.32 & 6.88t/ha) and followed by buried full dose of OMFA with5.25 & 5.00t/ha of grain and cob yield respectively. The lowest value (2.13t/ha) was from control. The result, clearly indicate that buried method performed remarkably better than surface.

Discussion

The low value recorded from pre soil analysis (Table 1) implies very low cation retention capacity and high ability to leach nutrients. Result of plant height, leaf area and stem girth among all the treatments were significantly different from that of the control. This assertion is similar to the findings of (Adeoye *et al*., 1993). The best performance of NPK 15-15-15 at 300kgha-^{1} in almost all characters considered for growth and yield of maize followed by Organo-mineral fertilizer grade A (OMFA) at 2tonha-^{1} could be attributed to readily availability and easy absorption of fertilizer by maize. The effectiveness of the organo-mineral fertilizer (OMF) to supply plant nutrients in slowly available form was probablydue to initial delay in the rate of decomposition and mineralization (Sharma and Mitra, 1991).

The organo-mineral fertilizer grade A full dose (2tonha-^{1}) effect was significantly equal to NPK 15-15-15 in most of the parameters considered. Comparable yields, as from inorganic fertilization was therefore realized with N-enriched cow-dung. This is because organo-mineral fertilizer is complete and contains all the essential elements in moderate proportion (Table1). The response of organo-mineral fertilizer grade A, organo-mineral fertilizer grade B and NPK 15-15-15 with buried method of application irrespective of the rate in maize growth and yield parameters were better than surface method of application either at full dose or half dose. This might be suggestive that buriedmethod minimizes soil erosion and leaching of nutrients.

The experiment also revealed that organo-mineral fertilizer grade A (OMFA) performed better in most of the characters considered than the grade B fertilizer (OMFB) either at full dose or half dose. The urea added to OMFA, made it an N and P rich sources amended compost, thus make the Nitrogen and Phosphorus content of OMFA higher than that of OMFB (Table 1). The result also shows that organo-mineral fertilizer at full dose performed better than organo-mineral fertilizer at half dose in all the growth and yield parameters of maize observed. Therefore, the higher the rate of organo-mineral fertilizer application the better the economic response and this corroborate the findings of (Adediran *et al.*; 1999).

Results also shows that organo-mineral fertilizer gives a better result when compared with the control. This confirms the decline of crop yield under continuous cultivation with acidification, soil compaction and loss of soil organic matter (Juo *et al.*, 1995a). Maize growth was observed to be more favoured by the enriched amended compost than sole compost application. This indicated that the combined use of Organic and inorganic nutrient management strategy is certainly a good substitute for enhancing soil fertility, and crop productivity (Bello and Haftom, 2008). Similar responses were also reported by Ayoola and Makinde, (2009) and Adediran *et al.* (2005) respectively.

Conclusion

Recognition of the absolute necessity to maintain sufficient reserves of soil organic matter , preserve physical conditions and biotic health in complement to ensuring sufficient inputs of nutrients from organic and inorganic sources to balance losses from crop harvesting, leaching, erosion, and volatilization is one key to a future successful agricultural industry. Hence, a combination of both organic and inorganic fertilizer may be a more cost effective approach.

From the results grains indicated a highly significant yield of (6.32tha-^{1} and 5.83tha-^{1}) when NPK 15-15-15 was applied at the rate of 300kgh-$^{1.}$ Followed by organo-mineral fertilizer grade A (OMFA) at 2tha-^{1} with grain yield (5.53tha-^{1} and5.00tha-^{1})organo- mineral fertilizer grade A (OMFA) at the rate of 1tha-^{1} with grain yield (3.75tha-^{1} an32tha-^{1} and 3.33tha-^{1}). Organo-mineral fertilizer grade B at the rate of 6.7tha-^{1} (3.08tha-^{1} and 2.82tha-^{1}). Organo-mineral fertilizer grade B at the rate of 3.4tha-^{1} (2.75tha-^{1} and2.28tha-^{1}) and control had the least grain yield of 2.13tha-^{1}.

Organo-mineral fertilizer grade A (OMFA) serves as a better substitute potential for mineral fertilizers in maize production. The findings also showed that effect of organo-mineral fertilizer grade A (OMFA) on growth and yield of maize crop is significantly different from that of organo-mineral fertilizer grade B (OMFA). Organo-mineral fertilizer grade A (OMFA) should be fortified with more Nitrogen and Phosphorus sources in order to meet up with N and P nutrients requirement of maize as NPK 15-15-15 doses. The use of organo-mineral fertilizer has been proved to be best soil fertility management strategy in many countries of the world. Hence, the combined use of inorganic and organic fertilizer should be promoted for sustainable maize production for poor resource farmers.

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