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Comparative Assessment of the Growth and Yield of Two Drought-Tolerant Maize Varieties to Cowdung and Poultry Composts as Soil Amendments

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Abstract
A field experiment was conducted in the early (wet) and late (dry) maize planting seasons of 2014 to assess the effect of cowdung and poultry composts application on the growth and yield of two drought-tolerant maize varieties in rain forest ecology of Nigeria. Cow dung and poultry droppings were separately composted aerobically for three months. Maize varieties DT-SR-WC$_2$ and DT-SYN-8W were planted with seventreatments, namely; 100% cow dung (CD), 100% poultry (PLT) and 50% CD + 50% PLT; each at three and six tonnes per hectare and zero compost application that served as control. The experiment was a randomized complete block design and each plot (3.0 m x 2.5 m) was replicated three times to give a total of 21 plots per maize variety. At full maturity, maize ears were harvested, dried, manually shelled and grains were weighed. The growth and yield components of maize variety DT-SR-WC$_2$ were higher thanDT-SYN-8W in the wet and dry seasons. Also, highest maize grain yield (2.41 t ha^{-1}) obtained with equal proportion of cow dung and poultry composts at 6 t ha^{-1} was only significantly ($p < 0.01$) different from the yields obtained with cow dung compost alone at 3 t ha^{-1} and the control plots in the wet season. Therefore, we concluded that 3 t ha^{-1} of poultry compost was the best option for enhanced and optimal maize grain yield.

Évaluation comparative de la croissance et du rendement de deux variétés de maïs résistantes à la sécheresse à la bouse de vache et au compost de volaille en tant que modifications du sol

Mots-clés:
Compost, bouse de vache,
maïs tolérant à la sécheresse,
écologie forestière,
rendement en maïs,
fientes de volaille

Résumé
Une expérimentation sur le terrain a été réalisée en 2014 pour évaluer l'effet de la bouse de vache et des composts de volaille sur la croissance et le rendement de deux variétés de maïs résistantes à la sécheresse dans l'écologie des forêts tropicales du Nigeria. . La bouse de vache et les excréments de volaille ont été compostés séparément en aérobiose pendant trois mois. Les variétés de maïs DT-SR-WC2 et DT-SYN-8W ont été plantées avec sept traitements, à savoir; 100% de bouse de vache (CD), 100% de volaille (PLT) et 50% de CD + 50% de PLT;

chacun à trois et six tonnes par hectare et aucune application de compost qui a servi de contrôle. L'expérience consistait en un plan de sondage complet randomisé et chaque parcelle (3,0 mx 2,5 m) a été répétée trois fois pour donner un total de 21 parcelles par variété de maïs. À pleine maturité, les épis de maïs ont été récoltés, séchés, égrenés manuellement et pesés. Les composantes de croissance et de rendement de la variété de maïs DT-SR-WC2 étaient plus élevées que celles de DT-SYN-8W pendant les saisons sèches et humides. En outre, le rendement grainier le plus élevé (2,41 t ha-1) obtenu avec une proportion égale de bouse de vache et de compost de volaille à 6 t ha-1 était significativement différent (p <0,01) des rendements obtenus avec le compost de bouse de vache seul à 3 t ha-1 et les parcelles témoins en saison des pluies. Par conséquent, nous avons conclu que 3 t ha-1 de compost de volaille était la meilleure option pour un rendement amélioré et optimal du grain de maïs.

Introduction

Climate change is one of the most serious global environmental threats. As the climate change phenomenon is global, so also are its impacts. But, the most adverse effects are felt majorly by developing countries, especially those in Africa, due to their low level of coping capabilities (Thornton *et al*., 2008).The issues of climate change have become very threatening, not only to the sustainable development of socio-economic and agricultural activities of a nation(Odjugo, 2010); but also to the totality of human existence (Bello *et al*., 2012).

As the planet warms, rainfall patterns shift, and extreme events such as droughts, floods, forest fires were more frequent. In addition, access to food becomes severely compromised by climate variability and change, thereby making African farmers more vulnerable (UNFCCC, 2007). The importance of soil quality to food security cannot be overemphasized (Pimental, 2006; Blum and Nortcliff, 2013) and climate change has the potential to threaten food security through its effects on soil properties and processes (Brevik, 2013). Soil organic matter and many other soil properties such as structure formation, water holding capacity, cation exchange capacity, and soil N have direct relationship. Soils with adequate amount of organic matter tend to be more productive than soils that are depleted in organic matter (Ewulo, 2005).

Drought, particularly in the humid tropics of Africa, cripples the means of livelihood of a large number of people. It is a major economic and social burden that slows economic growth and makes escape from poverty enormously difficult. As such, improved technologies such as drought-tolerant maize varieties are important for reducing the grinding economic burden of drought in Africa. Hence, the promotion of drought-tolerant maize for African project can be viewed as a welcome additional solution to the long standing problem of low crop productivity caused by frequent droughts. The cultivation of drought-tolerant crops in drought-prone ecologies was the cheapest and safest insurance against crop failure in such environments (Aina, 2015). Also, organic amendments are good sources of plant nutrients and have positive effects on improvement of the soil physical (Silva *et al*., 2006; Zelalem, 2013) and chemical (Wakene *et al*., 2005; Khaliq *et al*., 2009) properties. In this study, we choose two different animal manures that are inadvertently left to waste in the open in many of the cities and towns in Nigeria and separately compost before use as a simple and environment-friendly clean-up technology to enhance soil properties and crop yields. Therefore, we assessed the effects of cowdung and poultry composts on the growth and yield of two drought-tolerant maize varieties in a forest agro-ecology.

Materials and Methods

The field experiment was carried out at the Teaching and Research Farm (T&RF) [latitude 07º32' N and longitude 004º32' E], Obafemi Awolowo University (OAU), Ile-Ife, Nigeria, during the early (April-July) and late (September-December) maize cropping seasons of year 2014. Cowdung and poultry droppings were collected from the Beef and Poultry Unit of the T&RF, OAU, Ile-Ife. The two animal wastes were heaped separately under a shed and allowed to compost aerobically for three months. The heaps were mixed once in two weeks to enhance aeration and composting. The fully cured manures were air-dried, ground and bagged. Viable seeds of maize varieties DT-SR-WC2 and DT-SYN-8W were obtained from the Institute of Agricultural Research and Training (IAR &T), Ibadan.

The experimental plots were cleared manually twice. The experiment was carried out in two sites each consisted of three 27.0 m x 2.5 m blocks; each block was in turn divided into four plots of 3.0 m x 2.5 m with an alley of 1.0 m between blocks and 1.0 m within plots. Each of the treatment plots was replicated three times to give a total of 21 plots in each experimental site. The test crop was sown at three seeds per stand using 75 cm x 50 cm planting distance. Each variety of maize was laid out in a randomized complete block design with seven treatments: 100% cow dung (CD), 100% poultry (PLT), 50% CD + 50% PLT and each at the rate of three and six tons per hectare and zero compost application served as control. Composts were applied at sowing. The maize seedlings were later thinned to two seeds per stand at two weeks after sowing (WAS) to give a total of 53,333 maize stand population per hectare. Manual weeding was carried out at 2 and 5 weeks after sowing. Collection of data on growth parameter such as plant height, number of leaves, stem girth of maize commenced at 2 WAS and continued fortnightly till maturity. At full maturity, maize ears were harvested per plot, dried, manually shelled and grains were weighed. The treatment plots used in the early season were maintained for a repeat experiment in the subsequentmaize planting season, but without new treatments addition.

The pre- and post-cropping soil and compost samples were analyzed using standard methods (Page *et al*., 1982). The soil pH was determined in 1:1 soil-water suspension using a glass electrode pH meter. Total nitrogen of the soil and compost were determined by the macro-Kjeldahl method. Available phosphorus in the soil and compost were extracted using Bray P1 method and P in the extractants was determined by colorimeter. The organic carbon in soil and compost were determined using Walkley-Black wet oxidation method. Calcium ion and Mg^{2+} concentrations in the soil and compost were extracted using 1 M ammonium acetate buffered at pH 7.0 and their concentrations in the extracts were measured using Buck Scientific Model 200 (East Norwalk, Connecticut, USA) Atomic Absorption Spectrophotometer, while Na^{+} and K^{+} were determined using Genway flame photometer.

Data obtained were subjected to analysis of variance and their treatment means were separated at 95% confidence limit using GraphPad 5.0 statistical software. Monthly mean weather data (soil temperature, rainfall and relative humidity) were collected from the meteorological station at the T&RF, OAU, Ile-Ife, during the cropping periods in 2014 as shown in Table 1.

Table 1: Monthly mean weather parameters in the year 2014

Month	Soil temperature (ºC)	Rainfall (mm)	Relative humidity (%)
January	38.90	26.10	80.78
February	39.40	27.00	73.45
March	38.60	148.00	81.80
April	36.40	132.80	87.31
May	35.80	224.70	89.76
June	34.00	94.60	92.46
July	34.30	208.60	94.78
August	32.60	198.60	95.95
September	35.70	104.80	94.14
October	35.40	0.00	92.49
November	33.00	0.00	92.49
December	33.00	0.00	93.32

Source: Meteorological Station, Teaching and Research Farm, OAU, Ile-Ife.

Results and Discussion

Physical and chemical properties of soil of the experimental site

The physical and chemical characteristics of the experimental field are presented in Table 2. The soil texture was sandy loam. This may be attributed to the parent material from which the soil was formed. The soil might have been formed from sandstones and quartz parent materials as Brady and Weil (1999) and Enujeke *et al*. (2013) earlier reported, that high sand content of a soil could be attributed to high content of quartz in the parent material. The soil pH in 1:1 soil to water suspension was 7.86, indicating a slight alkaline soil condition. The relatively high soil organic carbon (22.51 g kg^{-1}) could be attributed to the absence of agricultural activity on the experimental site for six years based on the information obtained from Field Assistants of the T&RF, OAU, Ile-Ife. The relatively high level of total nitrogen (2.12 g kg^{-1})obtained could be attributable to the direct relationship existing between organic-N and soil organic carbon(SOC) of a typical tropical soil (Agboola and Omueti, 1982).

The low concentration of phosphorus (1.63 mg kg^{-1}) could possibly be due to the slight alkaline and high calcium ions content. Muqarrab *et al*. (2012) had observed that alkaline soils and mostly

Table 2: Physical and chemical properties of the soil before sowing

Property	Value
pH (1:1 soil-water)	7.86
Organic carbon (g kg^{-1})	22.51
Total nitrogen (g kg^{-1})	2.12
Available phosphorus (mg kg^{-1})	1.63
Cation exchangeable capacity (cmol kg^{-1})	21.01
Exchangeable acidity (cmol kg^{-1})	0.40
Exchangeable micronutrients (mg kg^{-1})	
As	3.00
B	1.00
Zn	1.39
Soil texture	Sandy loam

calcareous soils are well known for phosphorus fixation. The soil cation exchangeable capacity (Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}) value was high, possibly because of high SOC as these two properties have direct relationship (Wild, 1995). Other nutrients such as Zn, As and B were however low in values. Nigerian soils are generally low in micronutrients, particularly Zn (Adeoye and Agboola, 1985).

Chemical properties of the composts used in the study

Chemical properties of the composts used in the study are presented in Table 3. The compost C/N ratio measures the ease with which it decomposes and mineralizes when applied as soil and crop enhancer (Olayinka, 2009). Adesodun *et al*. (2005) and Ewulo (2005) observed that low C/N value of poultry compost enhanced the decomposition and nutrients' releasing ability of poultry than cow dung composts. Several workers such as Marzouk and Kassem (2011), and Adeniyan *etal.* (2011) obtained C/N ratios of 9.92 and 21.20, and 6.83 and 10.38 for poultry and cow dung composts, respectively. In this study, we obtained C/N ratio values for poultry (10.61) and cow dung (11.67) composts. Other chemical properties such as P, Ca, Mg and Zn in these composts differed. Variation in these values could be due to the differences in the animal feed-stocks and composting methods used. Soils into which cow dung had been incorporated contained potash and lime (Pal *et al*., 2001).

Effects of cowdung and poultry composts on the growth components of two maize varieties

Soil amendments are used to provide essential nutrients such as N, P and K to rebuild the soil fertility status for enhanced crop performance. The growth performance of the two varieties of maize during dry and wet seasons is presented in Figures 1 to 3. Growth parameters for both varieties were positively influenced by the application of cowdung and poultry composts. Results obtained with cowdung and poultry compost applications were similar to what Silva*et al*. (2006) and Adeniyan *et al*. (2011) using *Zea mays*, and also Abdelhamid *et al*. (2004) using *Vicia faba* as test crops obtained. Although, maize variety DT-SR-WC2 had higher mean plant height, number of leaves and stem girth than variety DT-SYN-8W,but with no significant ($p > 0.05$) differences in their values. The variations in the values obtained could be as a result ofvarietal differences in the test crop. Values obtained during the wet season were generally higher than and the dry season, an indication that soil moisture played important role on the growth performance of the crop, drought-tolerant trait notwithstanding.

Table 3: Nutrient composition of cowdung and poultry composts used

Property	A	B
Organic Carbon (g kg^{-1})	135.37	160.21
Total Nitrogen (g kg^{-1})	11.60	15.10
Carbon/Nitrogen ratio	11.67	10.61
Total Phosphorus (mg kg^{-1})	3500.00	4500.00
Calcium (g kg^{-1})	1.11	1.10
Potassium (g kg^{-1})	1.45	1.35
Magnesium (g kg^{-1})	0.58	0.50
Zinc (mg kg^{-1})	500.00	700.00
Arsenic (mg kg^{-1})	1.30	1.00
Boron (mg kg^{-1})	0.80	0.60

Legend: A = Cow dung compost, B = Poultry compost

Effects of cowdung and poultry composts on mean grain yield of two maize varieties

The effects of cow dung and poultry composts on mean grain yield of the two drought-tolerant maize varieties used are presented in Table 4. Six tons per hectare of the two composts in equal proportiongavethe mean grain yield of 2.41 t ha^{-1} for DT-SR-WC2 and 2.09 t $ha^{-1}$for DT-SYN-8W varieties of maize in the wet season.Lower but comparable values were obtained in the dry season. The control plots had the least yield in both seasons. Zeidan *et al*. (2006) reported that poultry and cow dung composts promote the root growth and increased grain yieldof maize. Our results agreed with the findings of Ayoola and Makinde (2009) that the degree of crop response to compost was dependent on the type and amount of compost applied.

Similarly, the overall increase in grain yield of the two maize varieties during the wet season compared to the dry season was a pointer to the importance of soil water to crops performance, irrespective of their moisture requirements. There were significant ($p < 0.01$) differences in the mean grain yields of maize among the treatments in the wet season. However, the highest maize grain yield of 2.41 t ha^{-1} obtained with equal proportion of cow dung and poultry composts at 6 t ha^{-1} was only significantly ($p < 0.01$) different from the grain yields obtained with cow dung compost alone at 3 t ha^{-1} and the control plots in the wet season. No significant ($p > 0.01$) difference was obtained in the mean maize grain yields during the dry season, though plots with initial compost additions recorded higher values than plots with zero compost addition. This agreed with the works of some researchers including Boateng *et al*. (2006) and Khaliq *et al*., (2009) who reported significant differences in the maize yield components with the addition of organic fertilizers.

The amount of rainfall during the wet season (April- July) that was six times greater than the dry season (September-December) (Table 1) could only double the maize grain yield. Another climatic factor such as temperature had been considered very significant by Barlow *et al*. (2015) that at different physiological stages of grain crops, extreme temperature could significantly reduce crop yield. In this study therefore, the high rainfall experienced during the wet season was inversely affected by high temperature as reflected in the marginal increase of maize grain obtained in the wet and dry seasons.

Table 4: Mean Grain Yield of the Two Maize Varieties Used

Treatment	Maize grain weight (t ha^{-1}) DT-SR-WC2DT-SYN-8W			
	Wet season	**Wet season**	**Wet season**	**Wet season**
1	1.92b	0.85ns	1.69b	0.79ns
2	2.01ab	0.92ns	2.04a	0.89ns
3	2.21ab	0.97ns	1.82ab	0.76ns
4	2.36a	1.07ns	2.05a	0.92ns
5	1.98ab	1.03ns	1.96ab	0.88ns
6	2.41a	1.11ns	2.09a	0.97ns
7	1.69c	0.83ns	1.39c	0.73ns

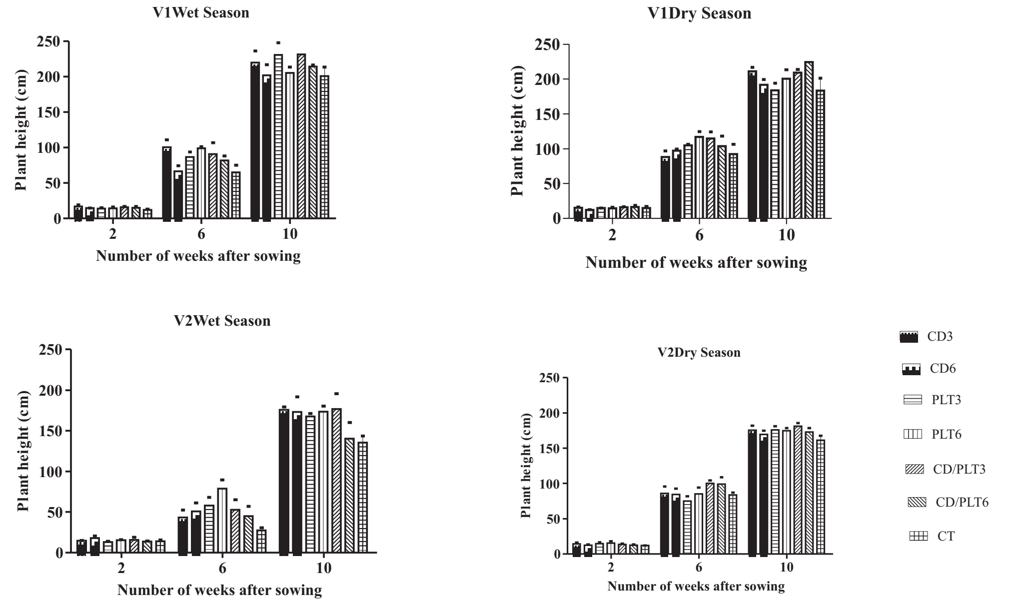

Figure 1: Mean plant height with composted cowdung and poultry manure application for both varieties in wet and dry seasons. Vertical bars represent SE.

Legend:CD3 = 100% cowdung compost at 3 t ha^{-1}, CD6 = 100% cowdung compost at 6 t ha^{-1}, PLT3 = 100% poultry compost at 3 t ha^{-1}, PLT6 = 100% poultry compost at 6 t ha^{-1}, CD3/PLT3 = 50% cowdung compost + 50% poultry compostat 3 t ha^{-1}, CD6/PLT6 = 50% cowdung compost + 50% poultry compostat 6 t ha^{-1}, CT = Control (Zero compost application), V1 = Maize variety DT-SR-WC_2 and V2 = Maize variety DT-SYN-8W

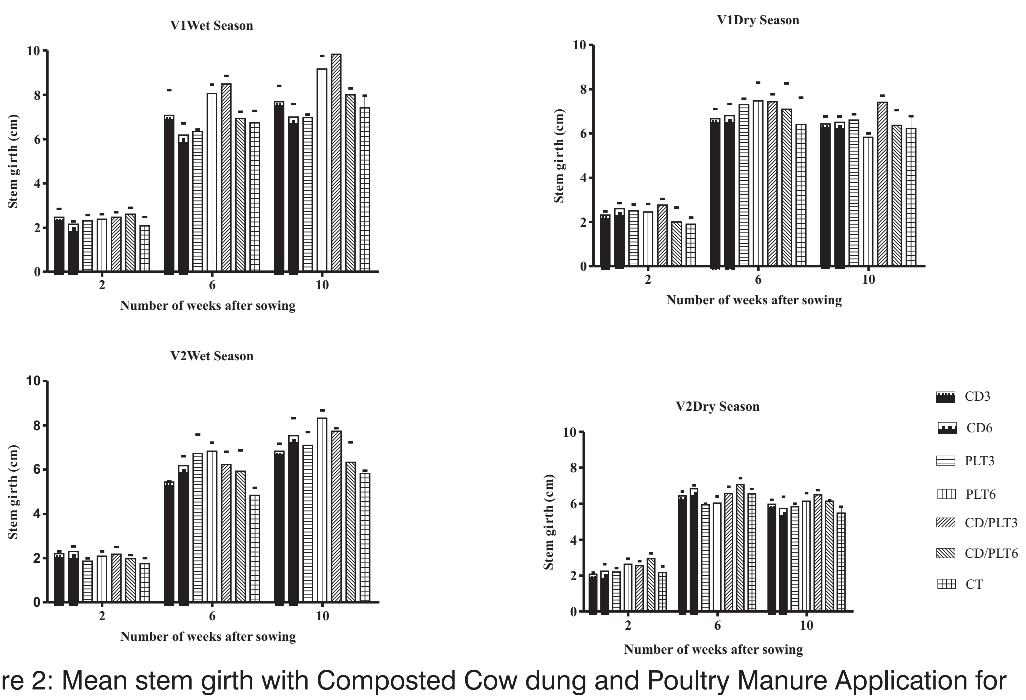

Figure 2: Mean stem girth with Composted Cow dung and Poultry Manure Application for both Varieties in Wet and Dry Seasons. Vertical bars represent SE.

Legend:CD3 = 100% cowdung compost at 3 t ha-1, CD6 = 100% cowdung compost at 6 t ha-1, PLT3 = 100% poultry compost at 3 t ha-1, PLT6 = 100% poultry compost at 6 t ha-1, CD3/PLT3 = 50% cowdung compost + 50% poultry compostat 3 t ha-1, CD6/PLT6 = 50% cowdung compost + 50% poultry compostat 6 t ha-1, CT = Control (Zero compost application), V1 = Maize variety DT-SR-WC2 and V2 = Maize variety DT-SYN-8W

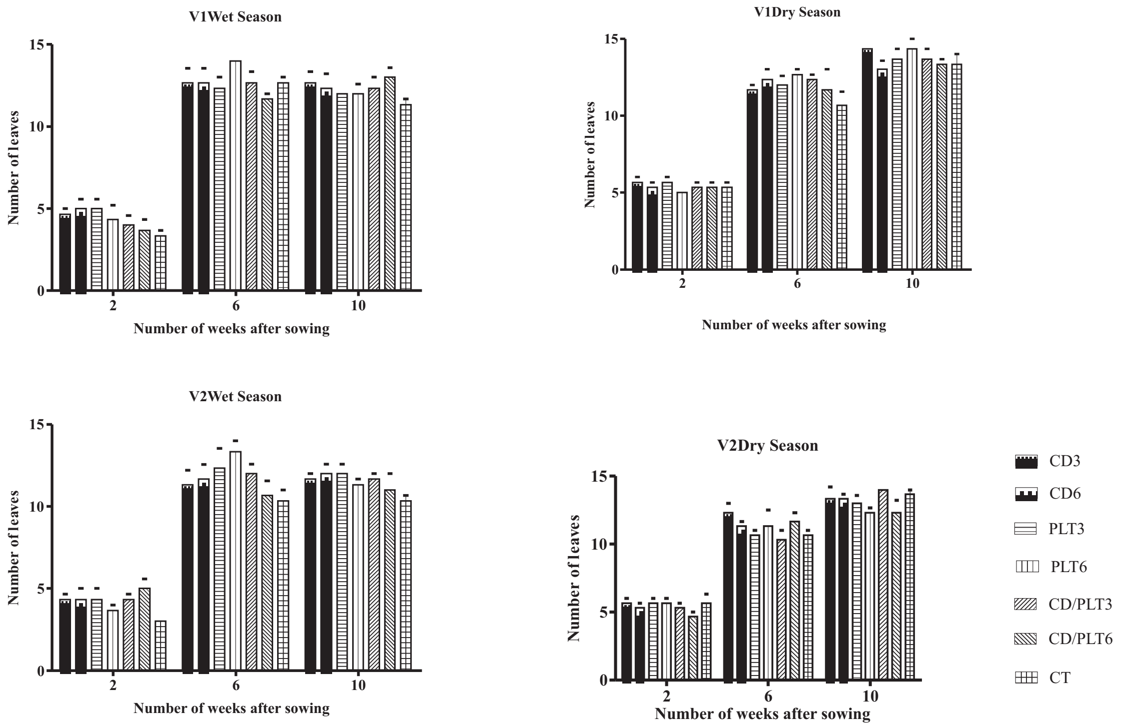

Figure 3: Mean number of leaves with composted cow dung and poultry manure application for both varieties in wet and dry seasons. Vertical bars represent SE.

Legend:CD3 = 100% cowdung compost at 3 t ha-1, CD6 = 100% cowdung compost at 6 t ha-1, PLT3 = 100% poultry compost at 3 t ha-1, PLT6 = 100% poultry compost at 6 t ha-1, CD3/PLT3 = 50% cowdung compost + 50% poultry compostat 3 t ha-1, CD6/PLT6 = 50% cowdung compost + 50% poultry compostat 6 t ha-1, CT = Control (Zero compost application), V1 = Maize variety DT-SR-WC2 and V2 = Maize variety DT-SYN-8W

Conclusion

We concluded that 3 t ha^{-1} of poultry compost was the best option for enhanced and optimal maize grain yield. During the repeat experiment, the residual effects of composts application to a typical sandy loam humid tropical soil of forest ecology for drought-tolerant maize cultivation were insignificant. Also, from this study, the significant differences in the mean grain yields of maize between the two drought tolerant varieties (DT-SR-WC2 and DT-SYN-8W) in the wet season could be due to differences in their traits and moisture abundance, their drought-tolerance notwithstanding.

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Bukola M. Aina and Moses B. Adewole*

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