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Response of different maize (*Zea mays* L.) cultivars grown on a continuously cropped land to nitrogen fertilization at varying times of application in a rainforest agro-ecology

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Abstract
Farmers often apply N fertilizer to the soil for high productivity in maize but different maize cultivars may respond differently to time of fertilizer application on a continuously cropped land which is usually characterized with low organic matter and low plant nutrients. A field trial was conducted during 2014, 2015 and 2016 growing seasons at Benin City in Nigeria Rainforest to determine the response of early maturing, late maturing and local maize cultivars to split-applied N at 1 week before sowing (WBS) and 2 weeks after sowing (WAS), 0 and 3 WAS, 1 and 4 WAS, 2 and 5 WAS, and 3 and 6 WAS and Control (without N) on a continuously cropped land. The trial was laid out in a split-plot design with cultivar assigned to main plots and time of N fertilization assigned to the subplots, having three replications. Over three years, grain yield was high when early maize cultivar was fertilized 1 and 4 WAS (av. 3500 kg ha^{-1}) and at 2 and 5 WAS (av. 3700 kg ha^{-1}). For late maize cultivar, high grain yield was obtained when N was applied 1 and 4 WAS (av. 4300 kg ha^{-1}), 2 and 5 WAS (av. 3900 kg ha^{-1}) and 1 WBS and 2 WAS (av. 3800 kg ha^{-1}). For local maize cultivar, grain yield was high when fertilized 1 WBS and 2 WAS (av. 2700 kg ha^{-1}), 2 and 5 WAS (av. 2600 kg ha^{-1}) and 1 and 4 WAS (av. 2500 kg ha^{-1}). Therefore, different maize cultivars have their appropriate time for fertilizer application to achieve maximum yield on a continuously cropped land.

Keywords: Continuously Cropped Land; Maize Cultivar; Time of N Fertilization; Grain Yield; Rainforest

Introduction
Maize (*Zea mays* L.) is the most important cereal in sub-Saharan Africa and it is mainly used for human consumption and in livestock feed with a small percentage used in agro-allied industries (IITA, 2006). It is one of the major staple food crop grown in Nigeria and across West Africa. Despite an increase in the area of land grown to maize since the mid-2000s, production per hectare is still low (1.3 ha^{-1}) compared to the 8.6 ha^{-1} in developed countries (IITA, 2006). Kamara *et al*. (2013) reported that maize yields in farmers' fields averaged from 1-2 t ha^{-1} in contrast to the higher yields of about 5-7 ha^{-1} obtained in breeding stations in West African moist savannas. Maize yields are higher in the moist savannas especially in Southern Guinea savanna with higher radiation levels, lower night temperatures and a reduced incidence of diseases and insect pests compared to Rainforest agro-ecologies characterized by high rainfall, high cloud cover, lower radiation levels and high pest and disease loads. High rainfall is a major cause of

leaching of soil nutrients especially nitrogen.

While maize is grown on continuously cropped land by some farmers, others grow it on land recently taken out of fallow of varying lengths depending on how population-dense the farming community is (Ewansiha *et al.*, 2017). However, most farmers usually engage in continuous cropping due to high cost of purchasing land, high population pressure and unavailability of fallow lands for crop production. The system of growing maize after a fallow period is unsustainable due to high population pressure and other human activities which have resulted in reduced fallow period (Steiner, 1991). Okigbo (1982) reported that intensive cropping was becoming more common and the primary function of soil productivity and fertility restoration through fallow has become less effective. Poor organic matter and available nutrients are the major feature of most soils in the humid tropics as they are often being subjected to continuous cropping, bringing about great reduction in its productivity and sustainability (Zingore *et al.*, 2003). Even though many biotic and abiotic factors can contribute to big yield gaps, soil fertility depletion and poor nutrient management are among the major factors contributing to low productivity of maize (Mourice *et al.,* 2015).

Nitrogen (N) management in maize production system is one of the main concerns since it is the most important and primary nutrient for growth and development of the crop (Blumenthal *et al.,* 2008). The high demand of maize for nitrogen and other major nutrients such as phosphorus and potassium makes it impossible to achieve high maize yield without fertilizer application (Havlin *et al.*, 2013). The need for high fertilizer use particularly N for higher maize yield is even more serious in a continuously cropped soil because of the unavailability of adequate nutrients and low levels of soil organic matter.

Nevertheless, time of fertilizer application is a factor that affects the efficiency of fertilizer use by plants (Fashina *et al.*, 2002) and maize genotypes differ in the rate of nitrogen absorption and utilization (Oikeh *et al.*, 1997). Nitrogen is the most vulnerable of all the plant nutrients in the soil; it is highly volatile and readily leached. But the most logical approach to increasing N fertilizer use efficiency is to supply N as it is needed by the crop plant in order to reduce the opportunity for N loss (Darren *et al.,* 2000). Mariga *et al* (2000) reported that yield of maize considerably increased when N was applied up to the tassel initiation stage. Similar study was also carried out by Alley *et al.* (2009) who reported that the maximum N uptake by maize occurs during the month prior to tasseling and silking. However, an optimum and efficient time of N application can increase the recovery of applied N up to 58–70% and hence increase yield and grain quality of the crop (Jamal *et al.,* 2006; Haile *et al.,* 2012).

Split application of N during the growing season is considered an important agronomic practice to enhance crop utilization (Boman *et al.*, 1995). Ewansiha *et al.* (2017) reported that fertilizing maize shortly before sowing or any time from 1 week after sowing with top dressing three weeks after basal application would ensure high and relatively stable grain yield on lands following bush fallow. Split application of nitrogen has been reported to improve nitrogen use by crops while reducing the nutrient loss through leaching and volatilization (Sitthaphanit *et al.*, 2010). However, there is a need to determine the best time for basal and top-dressing application of fertilizer to maize cultivars of differing maturities grown on a continuously cropped land. Therefore, this paper reports the response of early and late maturing maize cultivars grown on a continuously cropped land to different times of fertilizer application.

Materials and methods

Experimental Site

The experiment was conducted in the early cropping seasons (March-July) of 2014, 2015 and 2016, at the Teaching and Research Farm of the Faculty of Agriculture, University of Benin, Benin City (06° 20 'E, 5° 39'E; 78 m asl) in the Rainforest of Nigeria on soils classified as ultisols (Olatunji *et al.*, 2014). Rainfall is of high intensity and bimodal, beginning in March/April and ending in October/ November with a dry little spell in August usually referred to as "August Break". About 2025 mm of precipitation falls annually in Benin City with an average annual temperature of 26.1 °C (Climate-Data.org, 2016). The zone has a total growing period of 211 to 270 days (Ogeh and Ukodo, 2012). The rainfall and temperature during the years of trial are given in Figure 1 and Figure 2, respectively. Soil properties of the experimental site prior to start of the experiment are presented in Table 1. The site was previously cropped to yam or cassava or corn for a period of about five years. The last crop prior to the establishment of the trial was yam.

Cultivars

Early maize cultivar (2004 TZE-W POP DT STR C4, matures in 90-95 days) and late maize cultivar (TZL COMP.4 C4, matures in 115-120 days) obtained from IITA and a local cultivar (matures in > 120 days), obtained from Olijie village in Edo State were evaluated in the trial.

Experimental Design and Treatments

The experiment was laid out in a randomized complete block design with a split-plot arrangement having three replications. Maize cultivar was assigned to main plot and time of fertilizer application to subplot. Maize cultivar was comprised of the three maize cultivars. Time of fertilizer application had six levels [1 week before sowing (WBS) and 2 weeks after sowing (WAS), 0 and 3 WAS, 1 and 4 WAS, 2 and 5 WAS, 3 and 6 WAS and zero N fertilization as a control]. Each treatment plot measured 3 m x 5 m. Two plots were separated by 0.75 m and two replications by 0.75 m.

Agronomic Practices

At the beginning of each cropping season, the experimental plot was cleared of vegetation by slashing and the debris removed without burning. Maize seeds were sown on 4 April 2014, 07 April 2015 and 06 April 2016. Each year, three seeds were sown 2-4 cm deep at a spacing of 75 cm x 25 cm. Seedlings were thinned to one plant per stand two WAS. Prior to sowing, maize seeds were treated against insect pests and diseases with Unique plus 30 WS (10% 1 ml dacloprid, 10% metalaxyl and 10% carbendazin) at a rate of 10 g to 4 kg of seeds.

Each cropping season, at the appropriate time according to the trial treatment plan, NPK 15:15:15 at a rate of 60 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} respectively, as a basal dose was applied to all fertilizer plots. Urea was applied to supply 60 kg N ha^{-1} at three weeks after first application. Fertilizer was applied as band placement on one side along the row of maize crop before sowing, at sowing or after sowing. At sowing, a mixture of paraquat (1,1-dimenthyl-bipyridylum dichloride 24% W/W paraquat dichloride) and atraforce (atrazine 80% W/W WP) at a rate of 300 ml and 370 ml respectively, per 20 l of water was applied using knapsack sprayer. At six WAS, hand-weeding was done using hoe. In 2016, there was incidence of armyworms (*Pseudaletia unipuncta* Haworth) which damaged the stalks and leaves of affected plants. This was controlled using Karate (Karate 5EC a.i.:50g/L Lamda-cyhalothrin) and Dimeforce (Dimeforce a.i.: Dimethoate 40% EC) at a rate of 40 ml and 100 ml respectively, per 16 l of water using knapsack sprayer at a weekly interval up to the time the plants tasselled.

Soil Chemical Analysis

Before seeds were sown into various plots, soil samples were taken randomly on the experimental site and taken to the Analytical Services Laboratory (ASLAB) of IITA for initial chemical analysis following standard procedures (IITA, 1982).

Data Collection

Data were collected from the two central rows (net plot) leaving the outside rows in a plot. At full tasselling, plant height was determined on five random plants by measuring height from ground level to the first branch of the tassel using a measuring rule in cm. At maturity, plants in a net plot were harvested for number of ear, 1000-seed weight and grain yield determination. Ears were harvested and recorded as number of ears per plant. Cobs were air-dried for one week and threshed. Mean 1000-seed weight was recorded for each plot. Grains were weighed and expressed in kg/ha, adjusted to 15% moisture content using Farmex MT-16 grain moisture tester.

Statistical Analysis

Statistical analysis was performed using SAS for Windows Release 9.2 (SAS Institute, 2011). The SAS procedure used for the ANOVA was mixed model. Replication was treated as a random effect and cultivar and time of nitrogen application as fixed effects in determining expected mean square and appropriate F-tests in the ANOVA. Differences between two treatment means were compared with Student's t-test based on the least significant difference (LSD) at 5% level of probability.

Results

Soil Physical and Chemical Properties

The soil of the experimental site was 800-808.0 g kg^{-1} sand, 36.0-52.0 g kg^{-1} silt, and 140.0-164.0 g kg^{-1} clay with organic C of 10.2-14.5 g kg^{-1}, total N of 0.1-0.9 g kg^{-1}, available P of 5.6-8.6 mg kg^{-1}, exchangeable K of 0.1-0.3 cmol kg^{-1}, and pH (H_2O, 1:1) of 5.1-5.6 (Table 1).

Rainfall and Temperature

Rainfall and temperature for the period of the trial are summarized in Figures 1 and 2. In 2014, during the growing season, total rainfall was 1697.1 mm. Rain increased from April to June and decreased in July during harvest. Mean temperature ranged from a minimum of 25.5°C to maximum of 28.8°C. In 2015, total rainfall of 1704.1 mm was recorded. Rainfall was minimal in April and reached its peak in June with a slight descent in July when the crop was harvested. Mean temperature ranged from a minimum of 26.1°C to a maximum of 29.5°C. In 2016, total rainfall was 1177.4 mm and there was a steady increase in rainfall from April to July. Minimum mean temperature was 25.0°C and maximum 29.0°C.

Table 1. Soil physical and chemical properties of the experimental site

Property	2014	2015	2016
Sand (g/kg)	808.0	800.0	808.0
Silt (g/kg)	40.0	36.0	52.0
Clay (g/kg)	152.0	164.0	140.0
pH(H_2O) 1:1	5.1	5.6	5.6
OC (g/kg)	14.5	10.2	13.7
N (g/kg)	0.8	0.9	0.1
Mehlich P (g/kg)	5.6	8.6	7.2
Ca cmol/kg	1.8	1.7	2.0
Mg cmol/kg	0.7	0.6	0.7
K cmol/kg	0.3	0.3	0.1
Na cmol/kg	0.1	0.1	0.0
Exch. Acidity	-	0.0	0.0
ECEC	-	2.8	2.8
Zn (g/kg)	14.3	6.8	2.3
Cu (g/kg)	4.4	1.1	0.4
Mn (g/kg)	7.3	9.9	26.4
Fe (g/kg)	136.1	92.8	97.8

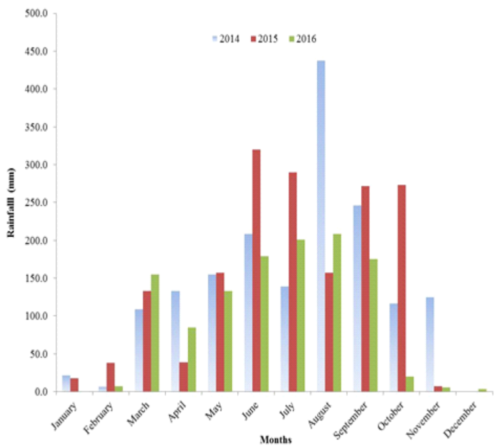

Figure 1. Mean monthly rainfall in Benin City during the trial period

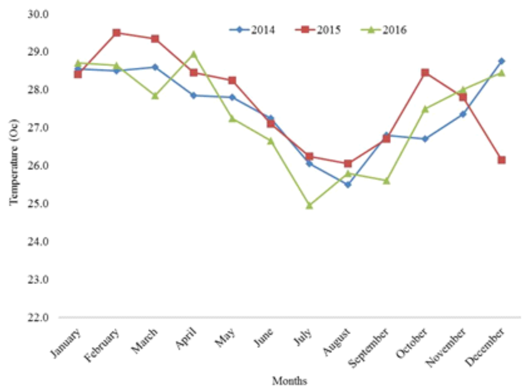

Figure 2. Mean monthly temperature in Benin City during the trial period

Agronomic Parameters

Results of the main effects of year, cultivar and time of fertilizer application for plant height, number of ears per plant, 1000-seed weight, and grain yield are summarized in Table 2. Various significant interactions among year, cultivar and time of fertilizer application were recorded for the attributes studied (Table 2).

Plant height

Year, cultivar and time of fertilizer application influenced plant height. Plant height was comparable in 2014 and 2015 but higher than in 2016. Local maize cultivar had the tallest plants while early maize cultivar had the shortest. Plant height was variable among the different times of fertilizer application but higher than when fertilizer was not applied. Plants fertilized 1 WBS and 2 WAS as well as at 2 and 5 WAS had the tallest plants than other times fertilizer was applied.

Number of ears

Number of ears per plant was influenced by year, cultivar and time of fertilizer application. Number of ears per plant was highest in 2014 and lowest in 2016. Local maize cultivar had significantly lower number of ears than the early and late maize

Table 2. Influence of year, cultivar and time of nitrogen application on performance of maize grown on a continuously cropped land at Benin City in a rainforest agro-ecology

	Plant height	**Number of ear per plant**	**1000-seed weight**	**Grain yield**
Treatment	**cm**		**g**	**kg ha^{-1}**
Year (Y)				
2014	184.2	1.0	262.1	3543.7
2015	186.7	0.8	251.3	3688.9
2016	152.9	0.7	252.2	3340.0
LSD $_{p=0.05}$	6.26	0.04	13.39	187.56
Cultivar (C)				
Early maize	137.6	0.9	256.8	3558.8
Late maize	161.3	0.9	285.3	4261.6
Local maize	224.9	0.8	223.5	2752.1
LSD $_{p=0.05}$	6.26	0.04	13.39	187.56
Time of nitrogen application (T)				
1 WBS, 2 WAS†	185.1	0.9	264.3	3246.2
0, 3 WAS	179.3	0.9	263.0	3042.3
1, 4 WAS	178.1	0.9	264.1	3411.3
2, 5 WAS	186.5	0.9	270.1	3402.3
3, 6 WAS	169.9	0.9	267.6	2939.4
Control	148.7	0.6	202.1	778.7
LSD $_{p=0.05}$	7.20	0.06	14.18	265.26
Significance				
Y	<.0001	<.0001	0.2284	<.0001
C	<.0001	0.0057	<.0001	<.0001
T	<.0001	<.0001	<.0001	<.0001
Y × C	0.0509	<.0001	0.0177	<.0001
Y × T	0.0004	<.0001	0.0118	<.0001
C × T	0.0003	0.0007	<.0001	0.0001
Y × C× T	<.0001	0.0258	0.1235	0.0003

†WBS, week before sowing:, WAS, week after sowing.

cultivars; number of ears did not differ in these cultivars. Number of ears per plant was similar among the different times of fertilizer application but higher than when fertilizer was not applied.

Seed weight

Year had no influence on 1000-seed weight whereas cultivar and time of fertilizer application influenced it. Late maize cultivar had the highest 1000-seed weight while local maize cultivar had the lowest 1000-seed weight. 1000-seed weight was comparable among the different times of fertilizer application but higher than when fertilizer was not applied.

Grain yield

Grain yield was influenced by year, cultivar and time of fertilizer application. Grain yield was highest in 2015 and lowest in 2016. Late maize cultivar had the highest grain yield while the local maize cultivar produced the lowest grain yield. Whereas fertilized maize plants had higher grain yield than those that were not fertilized, those plants fertilized at 1 and 4 WAS as well as at 2 and 5 WAS produced higher grain yield than other times of fertilizer application.

A notable three-way interaction among year, maize cultivar and time of fertilizer application for grain yield showed that in all years and for all cultivars, grain yield was significantly increased by applying nitrogen (Table 3). In 2014, for early maize, grain yield was similar when maize plants were fertilized at 1 WBS and 2 WAS, 0 and 3 WAS, 1 and 4 WAS, as well as 2 and 5 WAS. However, grain yield obtained at these times of nitrogen fertilization were higher than when maize was fertilized at 3 and 6 WAS. For late maize, grain yield was highest when nitrogen was applied at 1 WBS and 2 WAS, 1 and 4 WAS, as well as 2 and 5 WAS. For local maize, similar grain yield was obtained for the different times of fertilizer application with the exception of control.

In 2015, for early maize, grain yield was highest when nitrogen was applied at 2 and 5 WAS. This was followed by grain yield obtained when fertilizer was applied at 1 and 4 WAS. For late maize, nitrogen application at 1 WBS and 2 WAS, 1 and 4

Table 3. Interactive effects of year, cultivar and time of nitrogen application on grain yield of maize grown on a continuously cropped land at Benin City in a rainforest agro-ecology.

Time of nitrogen application	2014				2015				2016			
	Cultivar											
	Early maize	Late maize	Local maize	Mean	Early maize	Late maize	Local maize	Mean	Early maize	Late maize	Local maize	Mean
						(kg/ha)						
1 WBS, 2 WAS†	5408.3	5061.1	3563.3	4677.6	2940.0	3872.5	3063.3	3292.0	1242.2	2446.7	1618.3	1769.1
0, 3 WAS	5641.7	4640.3	2915.6	4399.2	2682.2	3404.4	1995.0	2693.9	1156.7	2723.3	2221.7	2033.9
1, 4 WAS	5014.8	5776.7	3360.0	4717.2	3295.6	4093.3	2693.3	3360.7	2040.0	2885.6	1542.2	2155.9
2, 5 WAS	5487.0	4800.0	3541.1	4609.4	4115.6	4161.1	2534.4	3603.7	1508.9	2697.8	1775.0	1993.9
3, 6 WAS	3404.6	5081.1	3390.0	3958.6	2526.7	3302.2	2790.0	2873.0	1792.2	2681.1	1486.7	1986.7
Control	573.6	1256.7	984.4	938.2	330.2	1205.0	884.4	806.6	285.6	941.1	547.0	591.2
Mean	4255.0	4436.0	2959.1		2648.4	3339.8	2326.8		1337.6	2395.9	1531.8	
LSD $_{p=0.05}$ Y × C	325.3											
LSD $_{p=0.05}$ Y × T	398.3											
LSD $_{p=0.05}$ C × T	398.3											
LSD $_{p=0.05}$ Y × C× T	795.8											

†WBS, week before sowing:; WAS, week after sowing,; Y, year; C, cultivar; T, time of fertilizer application

WAS, as well as 2 and 5 WAS produced similar and highest grain yields. For local maize, similar and highest grain yields were obtained when maize was fertilized at 1 WBS and 2 WAS, 1 and 4 WAS, 2 and 5 WAS as well as 3 and 6 WAS.

In 2016, for early maize, grain yields were higher when nitrogen was applied at 1 and 4 WAS compared to 1 WBS and 2 WAS as well as 0 and 3 WAS. Nitrogen applied at 1 and 4 WAS, 2 and 5 WAS and 3 and 6 WAS gave similar grain yields. For late maize, with the exception of control, similar grain yield was obtained for the different times of fertilizer application. Similar trend was observed for local maize.

Discussion

The study focused on the response of early maturing maize, late maturing maize and local maize which is also late maturing to different times of N fertilization when grown continuously for three years on a piece of land that has been under cultivation of maize or tuber crops for up to five years. Cultivar and time of N fertilization influenced plant height, number of ears, 1000-seed weight and grain yield. This corroborates the cultivar effect of maize in response to fertilizer application reported by Oikeh *et al.* (2003) and Onasanya *et al* (2009).

The significant year × cultivar × time of nitrogen application interaction for plant height, number of ears and grain yield suggests that the maize cultivars responded differently to year and time of fertilizer application for these variables. Environmental factors such as pest infestation, soil fertility level, rainfall and temperature varied among the three years of study. The variation in these factors may have been sufficient to influence each year's performance. For example, the incidence of army worm in the final year most likely had its adverse effect on growth and yield despite the control measures applied. Rainfall might have influenced yield as a result of differences in rainfall intensity, distribution and the interval between the time fertilizers were applied and the time rain fell. For example, a heavy rainfall soon after fertilizer was applied may mean that the amount of fertilizer that would be available to the maize plants would be greatly reduced. Such an occurrence during the trial period was not unlikely. And this is likely to vary with year. Kamara *et al.* (2007) reported that yield losses depend on soil fertility status and agro-climatic conditions amongst others. Jamal *et al.* (2006) indicated that about 50% at higher doses of applied N remains unavailable to a crop due to N loss through leaching in areas receiving heavy rainfall amount and uneven distribution.

Early maize cultivar had higher yields when N was basally applied a week before sowing and 0, 1 and 2 weeks after sowing in one out of three years. Grain yield was higher when basal application was carried out one or two weeks after sowing in two out of the three years. In each time of basal fertilizer application, top-dressing was carried out three weeks after the first. However, over the three years, mean grain yield was higher when N was applied at 1 and 4 as well as 2 and 5 weeks after sowing. This may be due to the fact that at this time plant roots were already present to absorb applied N. Because of the earliness of the cultivar, applying fertilizer beyond this time meant that the crop did not benefit from the later applied N to boost increase in photosynthetic apparatus for greater mobilization of assimilates for higher yields.

For late maize cultivar, response to N application over the tree years followed the following order: 1 and 4 WAS > 2 and 5 WAS > 1 WBS and 2 WAS > 3 and 6 WAS > 0 and 3 WAS > Control. While the higher performance at the first two times of application is clear as given for early cultivar earlier mentioned, what may not be clear in this order is the position of 1 WBS and 2 WAS in affecting yield performance. High yields were still obtained when N was applied at 3 and 6 WAS because of the lateness of the cultivar in reaching maturity. The lack of fertilizer at the first two weeks of growth was compensated for by the prolonged period of growth compared to early cultivars.

Local maize appeared to be adapted to all of the times fertilizer was applied for average yield in all the years with the exception of control. Similar yields were obtained over all times of N application. However, frequency of higher yield occurred when fertilizer was applied a week before sowing and two weeks after sowing, followed by when fertilizer was applied 2 and 5 weeks after sowing and 3 and 6 WAS.

For each cultivar, grain yield was poor in two of the three years when N was applied at 0 and 3 weeks after sowing. This may be so because N applied at the time of sowing is easily lost through leaching or runoff in heavy rainfall areas (Fageria and Baligar, 2005; Randall and Sawyer, 2008; Haile *et al.,* 2012). At this time, the seeds have not germinated and have no roots to make use of the applied N. Damage due to salinity is possible when fertilizers are applied too soon after sowing. The high yields obtained for all cultivars following fertilizer application at 1 WBS and 2 WAS may be due to the fact that pre-plant fertilization can bring the soil to a good nutrient level, before the crop is planted. It ensures that nutrients are available to the maize crop especially the late and local cultivars when they need them, from the very beginning when growth seem to be slow at first. Potassium and phosphorus are not readily mobile in the soil, their availability to the crop along with nitrogen probably increased as a result of the pre-plant applied compound fertilizer.

Nitrogen application at 1 and 4 WAS caused a consistent and higher grain yield in early and late cultivars than the local cultivar which is also late but had taller plants. This finding agrees with earlier report (Sallah and Twumasi-Afriyie, 1999) that improved cultivars produced higher yields and higher nitrogen use efficiencies than local cultivar. The reduction in height in early and late cultivars compared to the local cultivar seems to be the gain in the yield obtained from these improved cultivars (Ewansiha *et al.,* 2017). The taller plants of the local cultivar could not translate to higher yields. The study showed that for control, the local cultivar had a consistent and higher grain yield than early cultivar but not the late cultivar. This may indicate that local cultivars are more adapted to poor soils under continuously cropped soils than early cultivars.

Conclusion

Cultivar and time of N fertilization influenced plant height, number of ears, 1000-seed weight and grain yield of maize. Plant height, number of ears and grain yield depended on year and time of N fertilization. Early maize cultivar had high grain yields when fertilized 2 and 5 WAS and 1 and 4 WAS. Late maize cultivar had high grain yields when fertilized 1 and 4

WAS, 2 and 5 WAS and 1 WBS and 2 WAS. Local maize cultivar which is also late maturing had high grain yields when fertilized 1 WBS and 2 WAS, 1 and 4 WAS and 2 and 5 WAS. It is noted that where a farmer could not fertilize at any of these times, fertilizing late and local cultivars could still give acceptable yields at 3 and 6 WAS.

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