GJAS

Greener Journal of Agricultural Sciences

ISSN: 2276-7770 ICV: 6.15

Submission: 04/10/2015
Accepted: 09/10/2015
Published: 14/12/2015

Subject Area of Article: Agriculture
DOI: http://doi.org/10.15580/GJAS.2015.7.100415139

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Greener Journal of Agricultural Sciences ISSN: 2276-7770 ICV: 6.15 Vol. 5 (7), pp. 265-277, December 2015.

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ABSTRACT

Rain-fed farming systems dominate Ghanaian agriculture, especially regarding the cultivation of major staples, such as maize, yam, cassava and rice. In this environment, farmers depend strongly on seasonal rains and every alteration in precipitation distribution affects their very livelihood. Recent threats of climate change aggravate the already delicate balance of food production and security. This research determined the effects different planting distance on soil moisture and yield of maize in Tolon District. Experimental plots were laid out in randomized complete block design (RCBD), with four replicates and four treatments. The four treatments comprising different planting distance: T1 (20 x 80 cm); T2 (30 x 80 cm); T3 (40 x 80 cm) and T4 (50 x 80 cm), distributed randomly and independently in each plot. The size of each plot was 4 m by 5 m (20 m^2), surrounded by bunds, with bund height of 10 cm, bottom width of 10 cm and top with of 5 cm. The space between plots was 1m. Soil moisture content was monitored using Tensiometers and Time Domain Reflectrometer, while non-weighing lysimeter used to establish the field water balance. Crop parameters monitored were plant height, number of leaves, days to 50 % tasseling and maturity, LAI, grain and biomass yields. The results indicated that there was significant difference for yield and yield-related parameters, but not on soil moisture content when maize was planted at four different planting distances. This suggested that planting distance has effects on maize yield but not soil moisture content. Maximum soil and air temperatures were within the optimum range for rain-fed maize production in the Tolon District during the field experiment. Soil moisture content was at either field capacity or near saturation throughout the various growth stages of maize, with only small amount of water lost to deep percolation. Planting at 20 cm by 80 cm distance had a higher yield, compared to the rest of the treatments. Maize famers should adopt that planting distance to maximise yield. Farmers should also be advised to start planting of maize in July, to escape the effect of early season drought on crop establishment and growth.

Keywords: Maize, Planting distance, Soil moisture content, Rain-fed, Water balance.

1.0 INTRODUCTION

Cropping systems in Ghana are highly diverse, reflecting dynamic adaptations to increasing population pressure, land insecurity, climate variability, and new trading opportunities or markets (USDA, 2011).The amount of rainfall and its distribution over the year (especially during the farming season) greatly affects the productivity of agriculture across the country. It determines the types of crops to be grown, the presence or absence of support activities like irrigation and determines crop yields.

Rainfed farming systems dominate Ghanaian agriculture, especially in the cultivation of major staples, such as maize, yam, cassava and rice. The climate in the country is suitable for this mode of production. In Northern Region of Ghana, rainfall amount ranges from 950-1100mm/annum, while maximum temperatures reach above 42^{o}C in the dry period of the year, which lasts from second half of October, up to April or May every year (Kranjac-Berisavljevic, 1999; Abdul-Ganiyu, 2011 and Kranjac-Berisavljevic*et al.,* 2014).

In this environment, farmers depend strongly on seasonal rains and every alteration in precipitation distribution affects their very livelihood. Recent threats of climate change aggravate the already delicate balance of food production and security.

In developed countries, maize is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing countries, maize is consumed directly and serves as staple diet for some 200 million people (ARSA, 2003). Maize is Ghana's most important cereal crop and is grown by the vast majority of rural households. It is widely consumed throughout the country, and it is the second most important staple food in Ghana, next to cassava. Ghana is one of the major maize producers in Africa south of the Sahara, with maize accounting for about 9 percent of the country's total acreage (Alene and Mwalughali, 2012).

According to ARSA (2003), maize needs 450 to 600 mm of water per season, which is mainly acquired from the soil moisture reserves. About 15.0 kg of grain is produced for each millimetre of water consumed. At maturity, each plant will have consumed about 250 l of water.

The average maize yield in Ghana is estimated to be 1.7 metric tons/hectare (MOFA, 2011), whereas achievable yields based on on-farm trials are between 4 and 6 tons/hectare. Low adoption of inputs, rainfall amount and distribution and improved technologies are often cited as the major reasons for such a gap. In Ghana, maize is produced predominantly by smallholder farmers under rain-fed conditions (SARI, 1996).

1.1 Aims and Objectives of the Study

To develop strategies for enhancing the livelihoods of smallholder farmers affected by drought or flood risks and to improve existing practices and methods in managing these natural phenomena, several initiatives have addressed the issues of resilience in existing farming systems in two regions of Northern Ghana, including the Climate and Ecosystem Change Adaptation and Resilience Research in Africa (CECAR-Africa) Project.

CECAR-Africa Project (2011-2016) is supported by the Japan Science and Technology Agency (JST) / Japan International Cooperation Agency (JICA), the Science and Technology Research Partnership for Sustainable Development (SATREPS), the Government of Japan, and the Government of Ghana (GoG). The special concern of the project was on adaptation strategies to improve on yield of maize, which is the staple crop for the area. This research therefore determined the effects different planting distance on soil moisture and yield of maize in Tolon District.

3.0 MATERIALS AND METHODS

3.1 Study Area

The research was conducted at Fihini, in the Tolon District of Northern Region located at 9^{o} 26' N 1^{o} 4' W. Tolon District (Formerly Tolon/Kumbugu District) was carved out of the then Western Dagomba District in 1998. In the year 2012 the district was divided and separated from Kumbugu. Tolon District is among twenty (26) districts in the Northern Region with **Tolon** as its administrative capital. The district shares borders with North Gonja to the West, Kumbungu District to the North, Central Gonja to the south and to the East with Tamale Metropolitan. Fihini is one of the communities identified to be vulnerable to drought by the CECAR-Africa Project. The site is located about 22 km west of Tamale,in the interior Guinea Savanna agro-ecological zone of Ghana, which has a mean daily temperature of 26 ^{o}C. The area has auni-modal rainfall pattern averaging about 1100 mmannually (Abdul-Ganiyu, 2011). Figure 1 shows the Map of Northern Ghana, depicting Tolon District.

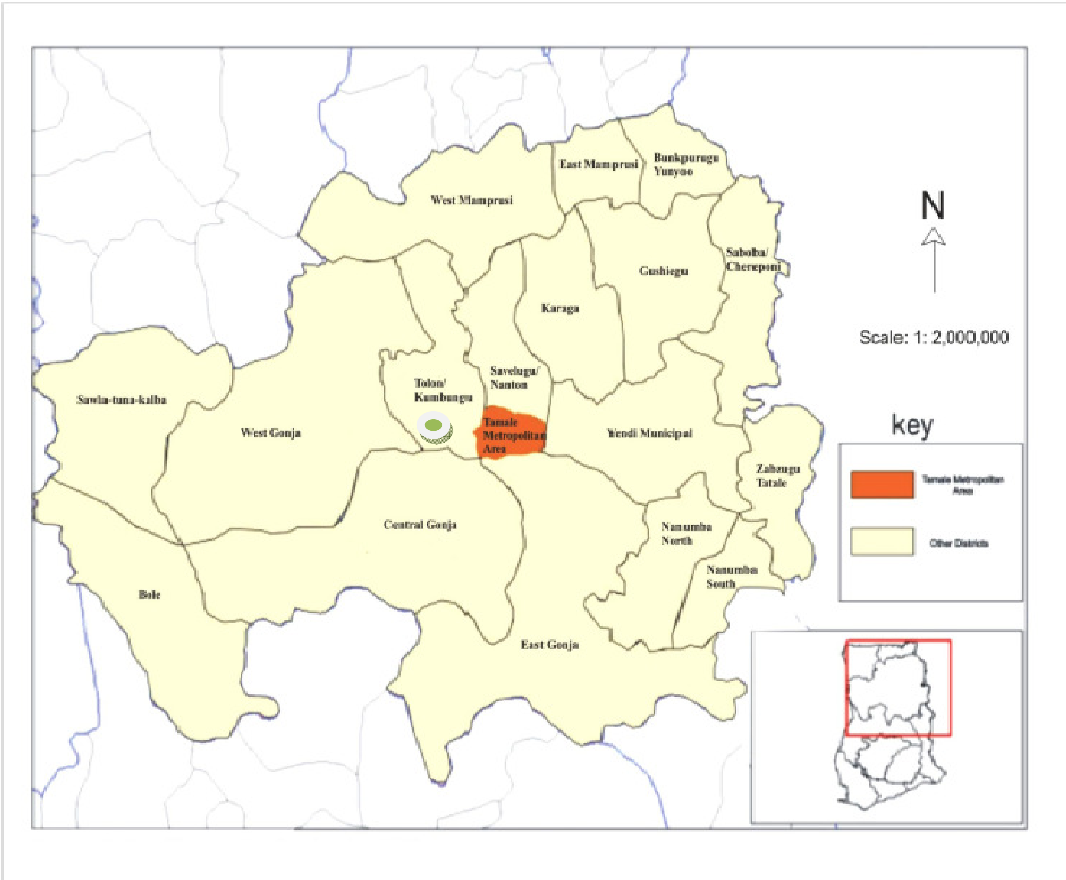


Figure 1: Map of Northern Region Districts showing Tolon/Kumbungu District with green dot (Conrad-J*et a l.*, 2013)

3.2 Experimental Design

An experimental site of 30 m by 30 m (900 m^2) was established using chain link as the fence in the Fihini community, to avoid crops being destroyed by stray animals.

Land preparation was done using hand tools, such as hoes and machetes and by loosening and pulverising the top soil up to the effective rooting depth of 40 cm. The experimental plots were laid out in *randomized complete block design* (RCBD), with four replicates and four treatments. The treatments were distributed randomly and independently in each plot, using draw lots method. The size of each plot was 4 m by 5 m (20 m^2), surrounded by bunds, with bund height of 10 cm, bottom width of 10 cm and top with of 5 cm. The space between plots was 1m. The four treatments, comprising different planting distance are presented in Figure 2.The experimental field had been under fallow since 2008. Before then maize and pepper were planted at the same location.

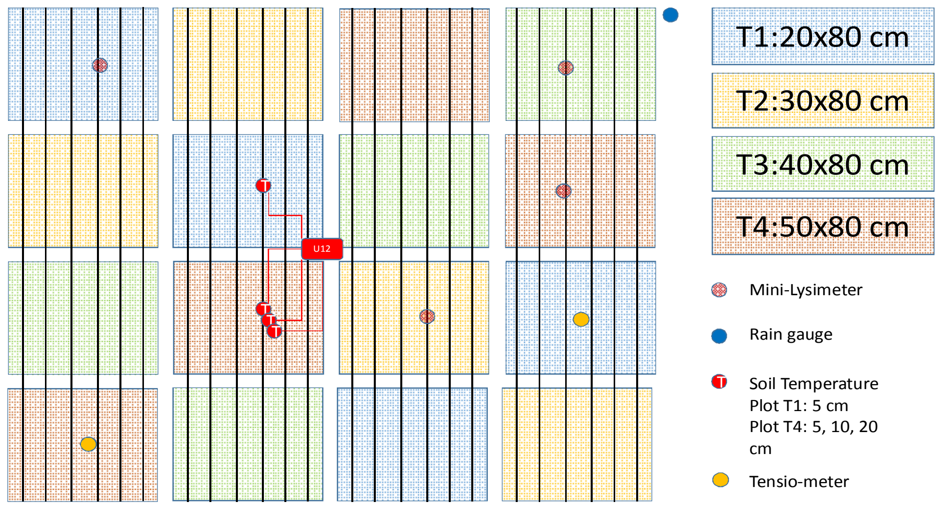


Figure 2: Experimental layout at Fihini (Field study, 2014)

3.3 Instrumentation

1. Four Non-weighing mini-lysimters made of PVC pipe of 30 cm diameter and 1.0 cm thickness, with a length of 50 cm and the bottom sealed with the same PVC plate, but with of 1.5 cm diameter at the middle containing soil of the experimental site. This is mounted on bottom container also with the same diameter and length PVC pipe with the bottom sealed with the same PVC plate to receive the drainage water from the top container; were installed as shown by the legend to help estimation of soil water balance. The following water balance equation (Sajid, 1993) was used to determine the crop water requirement (ETc) from the lysimeters:
$$ETc = R - D + (SMC_f - SMC_i)$$
Where, ETc is crop water requirement (mm); R is rainfall amount (mm), Deep percolation (mm); SMC_f is final soil moisture content (mm) and SMC_i is initial soil moisture content (mm). All the measurements were determined in one month interval.
2. Rain gauge with data logger was calibrated and installed to measure the rainfall within the vicinity of the experiment
3. Soil temperature logger with four probes was also calibrated and installed to measure root zone soil temperature variation, as shown in the layout.
4. Tensiometers were also planted at two different depths (10 and 20 cm) to measure soil water tension of each of the treatments
5. AccuPAR, model LP-80 (PAR/LAI Ceptometer) was used to measure leaf area index (LAI) for the various treatments
6. Time Domain Reflectrometer (TDR) soil moisture meter (HS2 Hydrosense II) was used to measure soil moisture content variation at various stages of the crop growth.
7. Mini-disk Infiltrometer was used to measure the infiltration rate of the soil

3.4 Agronomic Practices

Maize variety, *Obaatanpa* was planted. *Obaatanpa* was selected because it has been widely adopted both by farmers and consumers in Ghana. Presently, it covers more than 50 % of the maize hectare (650 000 ha) in Ghana (Dankyi *et al.,* 2005).It has also been released formally or informally in several other African countries, including Bénin (as *Faaba*), Togo, Mali (as *Debunyuman*), Guinea, Burkina Faso, Côte d'Ivoire, Senegal, Cameroon, Nigeria (as *SAMMAZ 14*), Mozambique (*Susuma*), Uganda, Ethiopia, Zimbabwe, Swaziland, Malawi, and South Africa (Badu-Apraku *et al.,* 2004).

Maize planted at 8th July 2014 was harvested at 15th October 2014 when it matured. Two seeds were planted per hill, producing two plants/ hill. Weeding was done using hand hoe two weeks after sowing before application of fertilizer and also five weeks after sowing.

120-60-60 kg/ha N-P_2O_5-K_2O was applied, using NPK (15-15-15) and Urea. 50% of the nitrogen and all the phosphorus and potassium were applied two weeks after planting. The remaining nitrogen was applied five weeks after planting. The fertilizer was banded on both sides of the plant and buried.
After harvesting, the corn was sun-dried, shelled and weighed at about 15% moisture content.

3.5 Measurement of Soil Physical and Chemical Properties

Composite soil samples (0–15cm and 15-30 cm depth)were collected in all the sixteen (16) experimental plots and analysed for texture and chemical properties at the soil laboratory of Savannah Agricultural Research Institute (SARI) before the commencement of the experiments, while other physical parameters such as bulk density and infiltration capacity were measured *insitu*.

The soils of the major maize growing areas in Ghana are low in organic carbon (<1.5 %), total nitrogen (< 0.2 %), exchangeable potassium (<100 mg/kg) and available phosphorus (< 10 mg/kg) (Adu, 1995, Benneh *et al.,* 1990), and Fihini experimental site was no exception, as can be seen in Table 1. According to FAO (2005) maize thrives in well-drained sandy loam soil, with a pH of 5.7-7.5 and 500-800 mm of rainfall, evenly distributed throughout the growing season for good yield. The pH of the soil at Fihini is slightly below the recommended range, even though the soils are well drained sandy-loam.

Table 1: Soil Chemical properties of Fihini Experimental site

Location	Horizon (cm)	pH(1:2.5 H_2O)	% O.C	% N	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	C.E.C (cmol/kg)
Dow Stream	0-15	4.84	0.20	0.03	2.53	51.81	140.28	37.65	2.03
	15-30	4.89	0.16	0.02	2.49	50.72	240.48	25.10	3.58
Mid Stream	0-15	5.52	0.27	0.02	3.51	58.26	220.44	37.65	1.98
	15-30	5.02	0.20	0.01	2.38	59.11	200.40	25.10	3.71
Up Stream	0-15	5.16	0.23	0.02	2.50	54.83	180.36	20.08	2.85
	15-30	4.91	0.16	0.01	2.44	52.19	100.20	55.22	3.58
Mean		**5.06**	**0.20**	**0.02**	**2.64**	**54.49**	**180.36**	**33.47**	**2.95**

(Soil survey, 2014)

Table 2: Soil Physical properties of Fihini Experimental site

Soil Physical Properties at 0-30 cm Depth	
% Sand	55.7
% Silt	39.8
% Clay	04.5
Texture	Sandy-loam
Bulk Density (g/cm^3)	01.6
Average Infiltration Rate (mm/h)	33.7
Saturation (volumetric %)	39.4
Field capacity (volumetric %)	14.6
Permanent wilting point (volumetric %)	03.4
Saturated hydraulic conductivity (cm/h)	05.0

(Soil survey, 2014)

3.6 Data collection and analysis

During the phenological stages of crop development, soil data were collected as follows: Soil temperature at 5, 15cm and 30 cm from the soil surface; soil moisture content at 12 and 20cm; drainage water and soil tension, using Tensiometers at 10 and 20 cm depth across each of the treatments. Rainfall amount was also collected from rain gauge installed with data logger on the experimental site, along with other agrometeorological data from the meteorological station of the Savannah Agricultural Research Institute, close to the experimental plots.

Data were also collected on some important phenological crop growth parameters (plant height, number of leaves, stem thickness)by sampling eight plats per plot, days to 50 % flowering and days to maturity and leaf area index and yield characters (grain yield, biomass yield and harvest index).

3.7 Data analysis

Data were subjected to analysis of variance (ANOVA) to evaluate the effects of seasonal variations and their interactions on the response variables. The significant difference among the treatment means were determined using least significance difference (LSD) at 5% level of probability (Steel and Torrie, 1988).

4.0 RESULTS AND DISCUSSIONS

4.1 Maize Crop Growth Parameters

Table 3 presents the plant height, number of leaves and stem girth at maturity. From the table, plant height showed significant difference for T4 when the LSD value was compared using T3 as a check. The average plant height was 183.5 cm and ranged from 163.8 cm-194.6 cm. With regards to total number leaves at maturity, there was no any significant difference among the treatment when the LSD value of 1.46 was used to compare the means. However, stem girth showed significant difference for T1 and T2 when the LSD value of 0.54 was used to compare the means using T3 as a check. The stem of T1 and T2 were thinner, compared to T3 and T4

Table 3: Plant Height (cm), Number of leaves and Stock girth at Maturity

Treatment	Plant Height at Maturity (cm)	Number of leaves at maturity	Stem girth at Maturity (cm)
T1 (20 x 80 cm)	188.00a	14.44a	5.44b
T2 (30 x 80 cm)	187.50a	13.84a	5.73b
T3 (40 x 80 cm)	194.60a	13.41a	6.38a
T4 (50 x 80 cm)	163.80b	13.62a	6.26a
MEAN	183.50	13.83	5.95
LSD	030.65	01.46	0.54

Values within each column followed by a common letter are not significantly different (p = 0.05)
(Source: Field study, 2014)

4.2 Days to 50 % tasseling, LAI, CC (%) and Days to Maturity

Table 4 presents the days to 50 % tassel leaf area index (LAI) and days to maturity. From the table, it could be seen that there was no significant difference among the treatments for both days to 50 % tasseling and maturity. The average days to 50 % tassel was 44.6, and varied between 43.75 and 45.75 days. Similarly, the average days to maturity were 92.6, and varied between 91.75 and 93.25 days. With LAI, only T4 showed significant difference when the LSD value of 1.43 was used to compare the treatment means. The highest LAI was recorded by T1 (4.32) due to its highest plant population, while T4 obtained the least LAI (2.62) due to its lowest plant population. The results are comparable with that obtained by Wilhelm *et al.* (2000).

Table 4: Days to 50 % Tassel, LAI, and Days to Maturity

TREATMENT	50% TASSEL (days)	LAI	MATURITY PERIOD (days)
T1 (20 x 80 cm)	43.75a	4.32a	91.75a
T2 (30 x 80 cm)	44.75a	3.27a	92.75a
T3 (40 x 80 cm)	45.25a	3.90a	93.25a
T4 (50 x 80 cm)	44.75a	2.62b	92.75a
MEAN	44.62	3.53	92.62
LSD	01.53	1.43	01.53

Values within each column followed by a common letter are not significantly different (p = 0.05)
(Source: Field study, 2014)

4.3 Maize Crop Yield Parameters

Table 5 presents the grain yield, biomass yield and harvest index of maize crop. As observed from the table, the three parameters showed significant difference when the various treatments means are compared with their LSDs. With regards to grain and biomass yields, even though there was significant difference between T4 and the rest of the treatment, T1 gave the highest grain and biomass yields, while T4 gave the lowest yields. The grain and biomass yields follow a pattern that suggests that the higher the plant population the greater the yield, as expected. The yield obtained is in line with that obtained by Asare *et al.* (2012). From the table, harvest index (HI) also showed significant difference between T4 and the rest of the treatment since it gave the lowest HI of 24.4 %, as compared to the rest of the treatments. In any case, the HI obtained for the maize is lower than the range obtained elsewhere (Echarte and Andrade, 2003).

Table 5: Grain yield, Biomass yield and Harvest index

TREATMENT	GRAIN YEILD (t/ha)	BIOMASS YIELD (t/ha)	HARVEST INDEX (%)
T1 (20 x 80 cm)	4.04a	13.84a	29.20a
T2 (30 x 80 cm)	3.78a	12.86a	28.90a
T3 (40 x 80 cm)	3.56a	12.01a	30.10a
T4 (50 x 80 cm)	2.47b	09.92b	24.40b
MEAN	3.46	12.16	28.20
LSD	1.04	01.37	05.53

Values within each column followed by a common letter are not significantly different (p = 0.05)
(Source: Field study, 2014)

4.4 Weather conditions

Figures 3 and 4 present the weather condition for the 2014 rainy season. From figure 3, a total of 1002.5 mm of rain had fallen across the Tolon district within 80 days, with a total reference evapotranspiration (ETo) of 1746 mm. By considering the balance between the monthly rainfall and evapotranspiration, there was a water deficit from November to May and a positive water balance from July to October, which favoured the rainfed maize production (Figure 3). From figure 4, both average minimum and maximum air temperatures were at their peak around April-May, but began to decrease from June up to September, after which temperatures started to increase again.

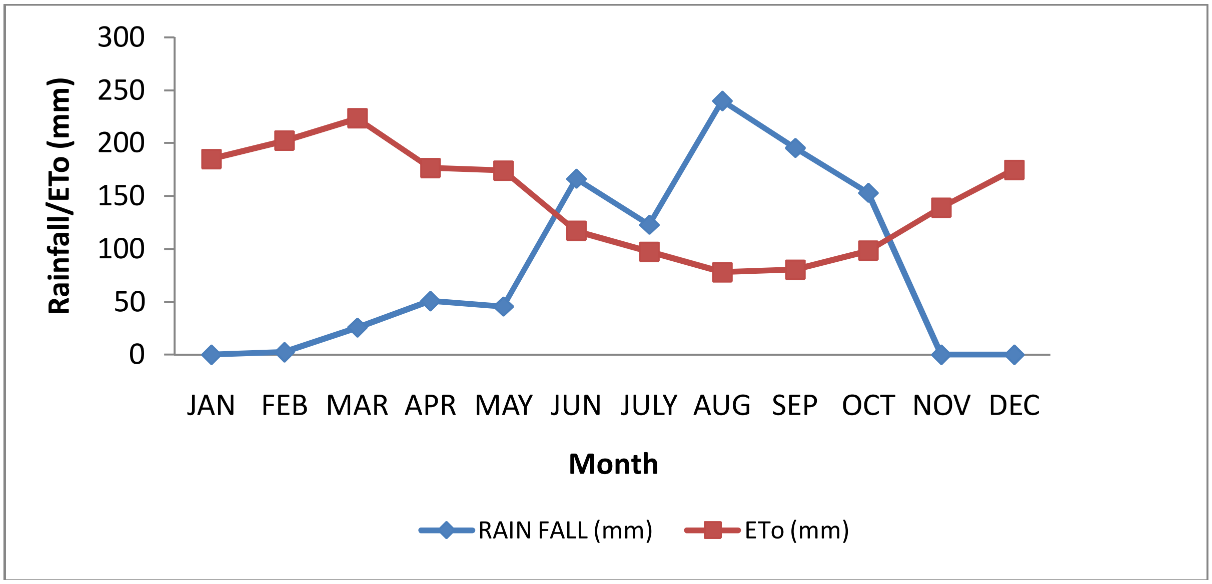


Figure 3: Relationship between rainfall and evapotranspiration for 2014 in Tolon District (SARI, 2014)

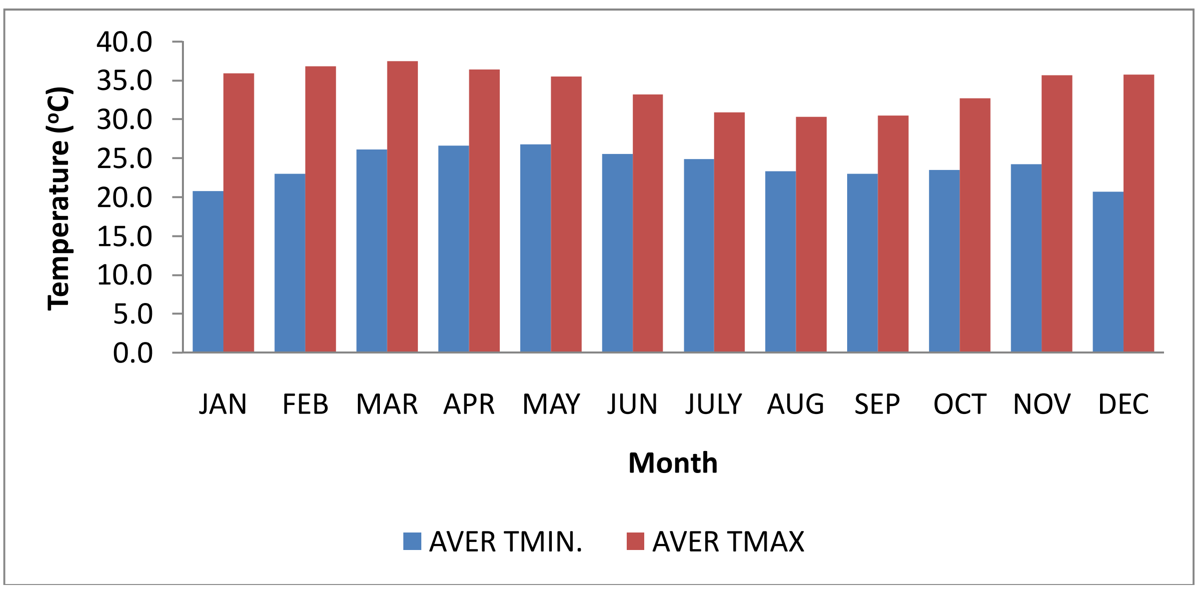


Figure 4: Maximum and Minimum temperatures for 2014 in Tolon District(SARI, 2014)

From Figure 5, the average maximum soil temperature during planting in July was 28.9 ^{o}C, 29.2^{o}C and 29.5 ^{o}C respectively for 5 cm, 15 cm and 30 cm root zone depth. The maximum temperature range was within the optimum temperature range forgermination of maize, which is between 20 and 30 ºC(ARSA, 2003).During the vegetative growth stage of maize, in August, both maximum soil and air temperatures reduced. The reduced soil temperatures at the various root zone depth could be attributed to the increase in soil moisture content, due to increased in rainfall amount (240 mm) in August. These conditions favoured the vegetative growth of the maize crop. Similarly was observed during the reproductive stage (tussling and ear formation) in September. At maturity period in October, both maximum soil and air temperatures increased slightly but were still within the favourable range of temperatures for maize production.

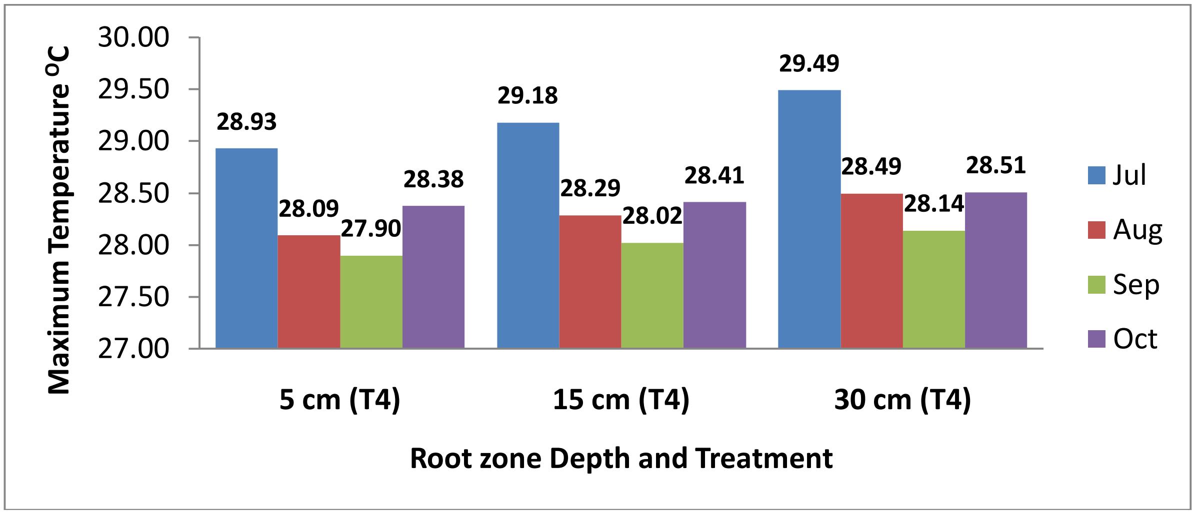
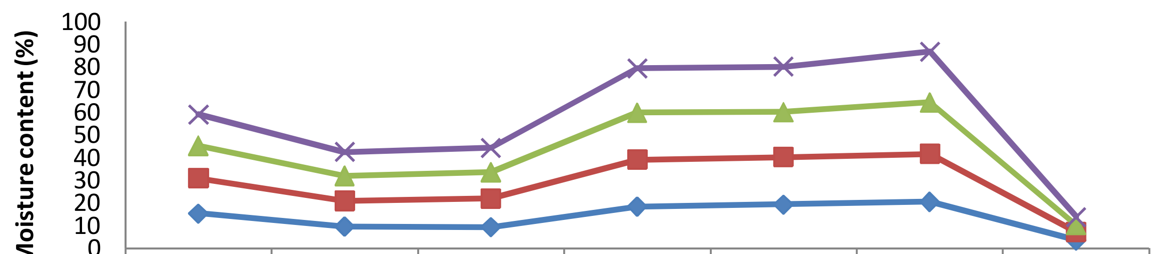


Figure 5: Average Soil Temperature at Root zone Depth (Field Study, 2014)

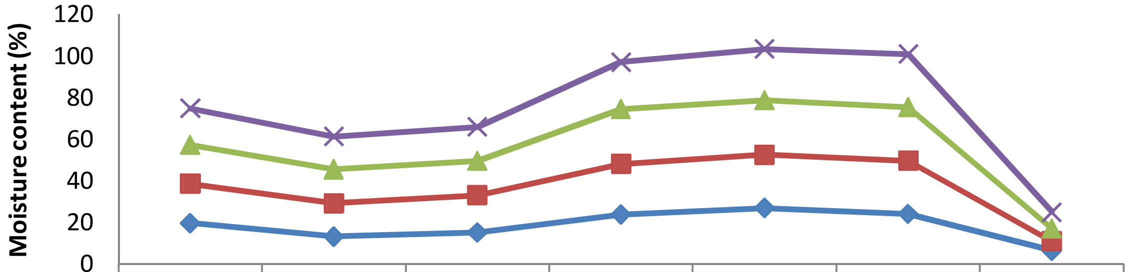
4.5 Soil Moisture Regime at Different Growth stages of the Maize crop

Figures 6 and 7 present the soil moisture regimes at 12 cm and 20 cm depth at the various growth stage of the maize during the 2014 season. The analysis of variance did not indicate any significant difference in soil moisture content among the four treatments. From the graphs, it is observed that the soil moisture content followed closely the amount and distribution of rainfall. Even though the soil moisture increased with increased soil depth, at each growth stage of the crop, moisture content was either at field capacity (14.5 %) or little above it, indicating that the maize crop did not suffer from drought (see tables 6 and 7). This could be due to planting date which was in July, instead of May-June as often practiced by farmers.



	WEEK 1	WEEK 2	WEEK 4	WEEK 6	WEEK 8	WEEK 12	WEEK 14
T4	13.77	10.59	10.68	19.47	19.9	22.32	3.56
T3	14.37	11.04	11.63	20.88	20.03	22.76	3.16
T2	15.54	11.28	12.57	20.56	20.81	21.11	3.54
T1	15.43	9.67	9.46	18.53	19.41	20.62	3.58

Figure 6: Soil Moisture Content (%) at 12 cm Depth (Field Study, 2014)



	WEEK 1	WEEK 2	WEEK 4	WEEK 6	WEEK 8	WEEK 12	WEEK 14
T4	17.55	15.88	16.32	22.69	24.64	25.52	7.84
T3	18.71	16.22	16.6	26.3	26.25	25.82	6.07
T2	18.99	15.94	17.88	24.3	25.62	25.53	4.44
T1	19.65	13.31	15.22	23.83	26.91	24.14	6.59

Figure 7: Soil Moisture Content (%) at 20 cm Depth
(Field Study, 2014)

4.6 Soil Tension (kPa) and Moisture content (%)

Tables 6 and 7 presents the relationship between the soil tension and the soil moisture content as monitored at 12 cm and 20 cm soil depth throughout the growth of maize from (July - October 2014). The soil tension varied, showing inverse relationship with the soil moisture content. Tables 6 and 7 revealed that soil tension were either at field capacity or near saturation.

Table 6: Soil Tension (kPa) and Moisture content (%) at 0-12 cm

Treatment	T1 (20 cm x 80 cm)		T2 (30 cm x 80 cm)		T3 (40 cm x 80 cm)		T4 (50 cm x 80 cm)	
Month	Tension (kPa)	MC (%)	Tension (kPa)	MC (%)	Tension (kPa)	MC (%)	Tension (kPa)	MC (%)
July	11.5	13.55	9	18.74	9	18.29	9.5	17.82
August	9	19	8.5	20	9	19.99	10.5	18.89
Sept	8	20.02	8	20.96	7	21.4	6.5	21.11
Oct	11	12.1	11	12.33	9	18.08	9	17.98
Mean	9.88	14.67	9.63	14.85	9.38	16.19	9.36	15.78
STDEV	1.53	3.66	1.61	4.64	2.78	4.83	3.01	6.16

(Source: Field study, 2014)

Table 7: Soil Tension (kPa) and Moisture content (%) at 0-20 cm

Treatment	T1 (20 cm x 80 cm)		T2 (30 cm x 80 cm)		T3 (40 cm x 80 cm)		T4 (50 cm x 80 cm)	
Month	Tension (kPa)	MC (%)	Tension	MC (%)	Tension (kPa)	MC (%)	Tension (kPa)	MC (%)
July	09.00	16.48	05.50	25.97	06.00	28.72	06.00	25.30
August	07.00	19.52	09.00	19.22	09.00	18.74	09.00	17.89
Sept	06.50	25.53	08.00	19.73	07.00	26.04	06.80	25.08
Oct	10.00	15.37	10.00	14.99	10.50	14.86	11.00	14.07
Mean	08.13	19.23	09.00	19.98	08.13	22.09	08.20	20.59
STDEV	01.90	04.55	01.00	04.52	01.76	05.68	02.26	05.54

(Source: Field study, 2014)

4.7 Water Balance for the 2014 Rainy Season

Table 8 presents the seasonal water balance considering the rainfall as the inflow with deep percolation and crop evapotranspiration as the outflows. Soil moisture content was recorded after every rain and also after every two weeks by four non-weighing lysimeters in each treatment, so as to establish the change in soil moisture content. Soil moisture content was either at field capacity or near saturation throughout the period. There was some amount of water percolated from the four lysimeters in August, due to increase in rainfall with the amount of deep percolation water varying between 0.17-1.13 mm, giving an average of 0.68 mm±0.48 mm. Similarly, September also had some deep percolation records, ranging from 0.49-1.66 mm, with a mean of 1.24 mm±0.54 mm. However, in October, due to reduction in the rainfall, the deep percolation ranged from 0.22-1.1 mm, with a mean of 0.78 mm±0.41 mm. The total rainfall from July to October was 711.6 mm, while the total deep percolation was 2.7 mm, with total seasonal evapotranspiration of 544.5 mm. The total crop evapotranspiration was within the water requirement for maize production (450-600 mm), as indicated by ARSA (2003).

Table 8: Water Balance for 2014 Rainy Season

Lysimeter	Month	R (mm)	D (mm)	MC_i (mm)	MC_f (mm)	∆MC (mm)	ETc (mm)
L1	July	122.90	0	196.50	133.10	63.40	059.50
L2		122.90	0	189.90	159.40	30.50	092.40
L3		122.90	0	187.00	162.20	24.80	098.10
L4		122.90	0	175.50	158.80	16.70	106.20
	Average	122.90	0	187.23	153.38	33.85	089.05
	STDEV			008.77	013.60	20.50	020.50
L1	August	240.00	0.17	238.30	152.20	86.10	153.73
L2		240.00	1.13	243.00	178.80	64.20	174.67
L3		240.00	0.38	262.30	166.00	96.30	143.32
L4		240.00	1.05	226.90	163.20	63.70	175.25
	Average	240.00	0.68	242.63	165.05	77.58	161.74
	STDEV		0.48	014.76	010.93	16.28	015.84
L1	September	195.60	0.49	269.00	241.40	27.60	167.51
L2		195.60	1.62	256.20	255.30	00.90	193.01
L3		195.60	1.66	262.50	258.20	04.30	189.64
L4		195.60	1.21	255.20	246.40	08.80	185.59
	Average	195.60	1.24	260.73	250.33	10.40	183.96
	STDEV		0.54	006.39	007.79	11.92	011.39
L1	October	153.10	1.08	241.40	182.33	59.07	092.95
L2		153.10	0.22	255.30	235.33	19.97	132.91
L3		153.10	1.10	258.20	207.00	51.20	100.80
L4		153.10	0.72	246.40	206.33	40.07	112.31
	Average	153.10	0.78	250.33	207.75	42.58	109.75
	STDEV		0.41	007.79	021.67	16.97	017.37
	Totals	711.6	2.7				544.5

R=Rainfall amount (mm); D=Deep percolation (mm); MCi= Initial soil moisture content (mm); MCf= Final soil moisture content (mm); ∆MC= Change in soil moisture content (mm) and ETc=crop Evapotranspiration (mm) L1= lysimeter 1; L2 = lysimeter 2; L3 = lysimeter 3 and L4 = lysimeter 4

5.0 CONCLUSIONS

There was significant difference among the yields (4.04, 3.78, 3.56, and 2.47 t/ha) and yield-related parameters, however, there was no any significant difference among soil moisture content when maize was planted at four different planting distances. This suggested that planting distance had effect on maize yield but not on soil moisture content under the conditions observed during the 2014 rainy season in the Tolon District. This may be due to the fact that maximum and minimum soil and air temperatures were within the optimum range for rain-fed maize production.

5.0 RECOMMENDATIONS

Since planting at 20 cm by 80 cm can result in higher yield compared to the rest of the treatments, maize famers should be advised to adopt that planting distance.

Farmers should be advised to start planting of maize in July to escape the effect of drought on crop establishment and growth, due to low rainfall amount and high amount of dry-spell in May-June.

6.0 ACKNOWLEDGMENT

This research was carried out by the Enhancing Resilience to Climate and Ecosystem Changes in Semi- arid Africa: An Integrated Approach (CECAR-Africa Project, FY2011-2016) with financial support from the Japan Science Technology Agency (JST) and Japan International Cooperation Agency (JICA) as part of SATREPS (Science and Technology Research Partnership for Sustainable Development).

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Cite this Article: Abdul-Ganiyu S., Osei-Mensah B., Apusiga T.A., Ishikawa H. and Kranjac-Berisavljevic G. (2015). Effects of Different Planting Distance on Soil moisture content and Yield of Maize (*Zea mays* L.) in Tolon District of Northern Region, Ghana. Greener Journal of Agricultural Sciences, 5(7): 265-277, http://doi.org/10.15580/GJAS.2015.7.100415139.