



RESEARCH PAPER

## Growth and Yield of Sweet Pepper (*Capsicum annuum* L.) Varieties as Affected by Nitrogen Fertilizer Rates at Samaru, Zaria, Nigerian Guinea Savanna

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### ABSTRACT

Field research was conducted at the research farm of Institute for Agricultural Research (I.A.R.), Ahmadu Bello University Samaru, Zaria (lat: 11° 11' N and long: 07° 38' E; 686m above sea level) in Guinea Savanna, Nigeria, in 2012 and 2013 rainy seasons to investigate growth and yield of sweet pepper (*Capsicum annuum* L.) varieties (California Wonder and Yolo Wonder) as affected by nitrogen rates (0, 70, 140 and 210 kg N ha<sup>-1</sup>) in form of urea. The treatments were laid out in the field in randomized complete block design (RCBD) in 4 by 2 factorial replicated three times. Observations were made on growth characters like plant height (cm), stem diameter (mm), leaf area index (LAI) and crop growth rate (CGR) per plant (g wk<sup>-1</sup>) at 4, 6, 8 and 10 weeks after transplanting (WAT). Yield and yield components like days to 50% flowering, fruit length (cm), fruit width (cm) and fresh fruit yield per hectare (ton) were recorded on per plot basis. The results obtained showed that application of nitrogen fertilizer up to 210 kg ha<sup>-1</sup> influenced growth of sweet pepper varieties significantly at Samaru, with respect to plant height, stem diameter, leaf area index (LAI) and crop growth rate (CGR) while 70kg N ha<sup>-1</sup> gave greatest fresh fruit weight per plant. Significant variations were observed amongst the varieties where Yolo Wonder had statistically higher values for growth characters of the sweet peppers, while the California Wonder outperformed in terms of yield and yield components in both seasons. Significant interactions of nitrogen rate and variety observed on CGR (at 6-8 WAT in 2012 and at 8-10 WAT in 2013) revealed that in 2013 Yolo Wonder supplied 210kg N ha<sup>-1</sup> had the highest CGR values (46.15g wk<sup>-1</sup>) at Samaru. Thus from the observations made in this research it could be recommended to farmers in Samaru to cultivate California Wonder variety of sweet pepper and application of 70kg ha<sup>-1</sup> urea fertilizer for maximum fresh fruit yield.

**Keywords:** Sweet pepper, Varieties, Nitrogen, Yield, Crop growth rate

### INTRODUCTION

Sweet pepper (*Capsicum annuum* L.), member of the Family Solanaceae, could have originated from Central America because native Americans had domesticated and cultivated peppers between 5,200 and 3,400 BC (Crosby, 2008; Nadeem *et al.*, 2011; Grundberg, 2014). Many wild species of peppers occur in parts of tropical America. Christopher Columbus carried pepper plants and seeds to Europe in 15th century from where they were spread around the world through colonial trade networks (Reddy, 2012; Grundberg, 2014; Anonymous, 2014a; Anonymous, 2014b; Anonymous, 2014c).

All peppers contain varying amounts of active chemical compounds known as capsaicinoids responsible for their spiciness i.e. pungency or the “hot” flavor. Sweet pepper known by many common names like green pepper, paprika,

“tattase”, pimiento, bell pepper and cherry pepper, has relatively lowest contents of the capsaicinoids (Lawal and Fagge, 2011; Grundberg, 2014). They are the second most important fruit vegetable widely eaten in the world, next to tomato. Many people eat the large berry fruits of sweet peppers that are good sources of vitamins A; B1; B2; C and E together with some essential nutrient elements like N; Ca; K; P and Fe (Amans, 2011; Shafeek *et al.*, 2012).

Industrially, the pigments from ripe fruits are used as natural coloring agents for other food products and cosmetics. Oleoresin extracted from the fruits impacts characteristic flavor to

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some food products (Singh and Naik, 1990; Anonymous, 2011a; Shafeek *et al.*, 2012; Hoven, 2013). Green pepper fruits also contain many antioxidants and anti-inflammations good for protection against cardiovascular disorders, cancers and eye diseases (Amans, 2011; Lawal and Fagge, 2011; Nadeem *et al.*, 2011; Aminifard *et al.*, 2013). Sweet pepper is an important export commodity in many African countries since it is grown as cash crop and for consumption. Nigeria was a major African producer and exporter of peppers in the 1950s and 1960s (Ogunlela and Koomen, 2005; Hama *et al.*, 2012). USDA (2011) reported that Nigeria produced 723,000 metric tons (MT) in 2007 which was 7th in the world ranking then followed by Egypt (475,000 MT) and Ghana (270,000 MT) from Africa. The global pepper productions in 2015 were up to 34.6 million MT of fresh fruits. China alone accounted for some 17.65 million MT (51%) followed by Mexico (2.31 million MT), Turkey (2.20 million MT) and Indonesia (1.70 million MT) (Amadala, 2016).

Nitrogen is one of the most important nutrient elements required for normal healthy growth and development of many plants (Havlin *et al.* 2006). Jain (2009) reported that nitrogen universally occurs in all living beings. It is also an essential constituent of protein and enzyme which directly affects several biochemical processes mainly the photosynthetic activity (Marschner, 1993). The Nigeria savannas soils have very low level of nitrogen contents. It has been reported that the improvement in crop yields in the savannas was as a result of application of nitrogen fertilizers to the soils (Ekwu and Okporie, 2000; Zarafi, 2011 and Abdulmalik, *et al.*, 2014). It is therefore important to determine the right amount of nitrogen fertilizer to be used in these savanna soils for sustainable maximum productions of sweet peppers in this country.

In Nigeria peppers productions are mainly by peasant farmers on small farms of less than 0.5 ha. They need improved exotic, high yielding and disease resistant varieties like California Wonder, Yolo Wonder, Aladdin, Red Knight, Marconi, Socrates, etc for increased fruit yields (Trinklein, 2010; Anonymous, 2010; Amans, 2011). The rising economic value of peppers in the markets had created the need to expand and intensify their productions. Therefore, the aim of this research was to enhance the growth and yield of sweet pepper in Guinea Savanna of Nigeria

with the objectives of finding optimum nitrogen rate and which of the varieties could yield greater pepper fruits.

## METHODOLOGY

The research was carried out in Samaru, Zaria (11° 11' N and 07° 38' E; 686m above sea level) in Northern Guinea Savanna of Nigeria at the farm of Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria, in 2012 and 2013 rainy seasons. Soil samples of the sites of the experiment were analyzed to determine the physical and chemical characteristics using standard methods (Black, 1965). The result is shown in Table 1.

The treatments consisted of factorial combinations of nitrogen at 0, 70, 140 and 210 kg N ha<sup>-1</sup> and sweet pepper varieties, California Wonder and Yolo Wonder. The experiment was laid out in 4 x 2 factorial combinations in Randomized Complete Block Design (RCBD) replicated three times. Seeds of the two varieties dressed with Apron Star (20% w/w metalaxyl-M; 20% w/w thiamethoxam and 2% w/w difenoconazole) against soil born pests and diseases were sown on separate nursery beds for each variety in shallow drills 10cm apart and lightly covered with soil. These were mulched with dry grasses straws and watered with watering can. The mulch was removed when the seedlings germinated and these seedlings were cared for five weeks before transplant on to the trial farms. Initially the farms were cleared, harrowed and ridged at 75cm apart mechanically and then marked out into plots. Seedlings of each variety were transplanted on to the ridges in separate plots at 45cm intra-row spacing. Uniform applications of single super phosphate (SSP; 18% P<sub>2</sub>O<sub>5</sub>) at 50 kg ha<sup>-1</sup> and Potassium (60% K<sub>2</sub>O) at 60 kg ha<sup>-1</sup> were done to all plots in each field just before transplanting seedlings. The nitrogen treatments were given to the plot accordingly in form of urea (46% N) by top dressing in two split doses.

Each year of the experiment, the entire experimental fields were sprayed with Grammaxone followed by Butachlor before transplanting the seedlings. Weeds that emerged later were control by manual hoe weeding at three weeks' intervals. Some green aphides were noticed on the shoots of the crops during flowering and Cypermetrin was sprayed all over the fields.

### Assessments of growth and yield characteristics

Five pepper plant stands were tagged randomly with small water proof cardboards in each net plot. Biometric observations on growth characters such as plant height, leaf area index (LAI), stem diameter were carried out on them at 4, 6, 8 and 10 weeks after transplanting (WAT). Numbers of days to 50% flowering were recorded while fruit length, fruit width and total fresh fruit weight per hectare were determined on per plot basis at harvest. The means of observations from these tagged plants stands on growth parameters were recorded for each sampling period. Five fruits were randomly picked from those harvested for each net plot and their fruit lengths and width were measured with Vanier caliper. They were then weighed for each net plot using the Mettler-P1210 electronic balance and the values extrapolated to fresh fruit yield in tons per hectare.

### Analysis of data

All the data collected from the observations were subjected to the statistical analysis of variance (ANOVA) as described by Steel and Torrie (1984). The differences between treatment means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

## RESULTS

### Soil analysis on the physical and chemical properties of soils of experimental sites

Table 1 presents the results of the physical and chemical characteristics of soil of the research locations in 2012 and 2013 at Samaru, Guinea savanna Nigeria. The soil textural classes in both years were loam soils with pH slightly acidic and they were low in organic carbon, total nitrogen and available phosphorus contents. The nutrients and exchangeable bases like  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ , etc of the soils were also of low contents.

### Effect of nitrogen fertilizer rates on plant height of varieties of sweet peppers

Results on effects of nitrogen fertilizer rates on heights of sweet pepper varieties at various sampling periods at Samaru, Nigerian Guinea savanna during 2012 and 2013 rainy seasons are shown in Table 2. The heights of sweet pepper plants increased significantly with each increase in nitrogen fertilizer rates, though at 4 WAT, the

application of  $140 \text{ kg N ha}^{-1}$  in 2013 recorded the tallest plant, but statistically similar to the result obtained at 4 WAT in 2013 when applied with  $210 \text{ kg N ha}^{-1}$ . In consideration of varieties of sweet pepper, Yolo Wonder sweet pepper recorded taller plants throughout the production period in both years except in 2013 at 4 WAT when there was no significant difference in plant height of the varieties. Interaction of factors was not observed (Table 2).

**Table 1:** Physical and chemical characteristics of the soils of experimental sites at Samaru during the 2012 and 2013 rainy season

Physical Characteristics	2012	2013
Sand ( $\text{g kg}^{-1}$ )	462	426
Silt ( $\text{g kg}^{-1}$ )	285	304
Clay ( $\text{g kg}^{-1}$ )	253	270
Textural class	Loam	Loam
<b>Chemical Characteristics</b>		
pH ( $\text{H}_2\text{O}$ )	5.8	6.1
pH (0.01M $\text{CaCl}_2$ )	4.7	5.4
Organic Carbon ( $\text{g kg}^{-1}$ )	4.6	5.30
Available P ( $\text{mg kg}^{-1}$ )	10.19	7.6
Total Nitrogen ( $\text{g kg}^{-1}$ )	3.7	4.8
<b>Exchangeable bases (c mol. <math>\text{kg}^{-1}</math>)</b>		
Calcium ( $\text{Ca}^{2+}$ )	1.76	1.82
Magnesium ( $\text{Mg}^{2+}$ )	0.84	1.25
Potassium ( $\text{K}^+$ )	0.16	0.27
Sodium ( $\text{Na}^+$ )	0.2	0.19
Exchangeable acidity (Al + H)	0.18	0.21
Cation Exchange Capacity (CEC c mol $\text{kg}^{-1}$ )	7.23	8.3

### Effect of nitrogen fertilizer rates on stem diameter of varieties of sweet peppers

Application of nitrogen fertilizer rates significantly influenced the stem diameters on varieties of sweet peppers during the rainy seasons of 2012 and 2013 at Samaru (Table 3). Increase in N rate up to  $140 \text{ kg N ha}^{-1}$  resulted to an increase in the stem diameter of the varieties of sweet peppers in the both years except at 8 WAT. Further increase in nitrogen fertilizer rates to  $210 \text{ kg ha}^{-1}$  gave significantly similar larger stem diameter as compared to  $140 \text{ kg ha}^{-1}$ . The varietal differences were significant at 4, 6, 8 and 10 WAT in the seasons with Yolo Wonder variety having statistically greater stem diameter. There was no interaction of the factors observed.

### **Effect of nitrogen fertilizer rates on the leaf area index of varieties of sweet peppers**

LAI as affected by varying rates of nitrogen fertilizer on sweet pepper varieties at various sampling periods in 2012 and 2013 seasons at Samaru is presented in Table 4. Increasing nitrogen rate up to 210 kg N ha<sup>-1</sup> increased LAI per plant significantly in each of the years except at 4 WAT in 2013 and at 10 WAT when responses were only up to 140kg N ha<sup>-1</sup> beyond which resulted in statistically the same LAI per plant. Yolo Wonder variety generally produced plants with significantly higher LAI per plant than the California Wonder at all the sampling in the seasons.

### **Effect of nitrogen fertilizer rates on the crop growth rate of varieties of sweet peppers**

Table 5 presents the effects of nitrogen fertilizer rates on crop growth rate (CGR) per plant of two sweet pepper varieties at 4 - 6, 6 - 8 and 8 - 10 WAT in 2012 and 2013 rainy seasons at Samaru. Application of nitrogen at 210kg ha<sup>-1</sup> rate resulted in significant increase in the CGR per plant of the pepper varieties at 6 - 8 and 8 - 10 WAT. At 4 - 6 WAT in 2012 significant increase in the CGR was noted when 70kg N ha<sup>-1</sup> was applied. In 2013 CGR per plant increased significantly at up to 140kg N ha<sup>-1</sup> further increase to 210kg N ha<sup>-1</sup> decreased the CGR.

The two sweet pepper varieties show no significant differences in CGR values per plant at 4 - 6 WAT during 2012 and 2013 seasons at Samaru but Yolo Wonder variety had statistically higher CGR values than California Wonder. At 6 - 8 and 8 - 10 WAT the two sweet pepper varieties tested had statistically different values of CGR. It was observed that the Yolo Wonder variety produced significantly higher CGR per plant than the California Wonder in the seasons. There was interaction of nitrogen and variety on the CGR per plant at 6 - 8 WAT in 2012 and at 8 - 10 WAT in 2013 at Samaru (Table 5). The result of the interaction is presented on Table 6 and the result showed that, Nitrogen fertilizations up to 210 kg ha<sup>-1</sup> caused significant increase in the CGR per plant for both varieties. Yolo Wonder supplied with N at 210kg ha<sup>-1</sup> had the highest CGR values (46.15g wk<sup>-1</sup>) while both varieties given no N had identical least values of CGR per plant that were statistically the same. The significant interactions of nitrogen with variety on CGR per plant at 8 - 10 WAT in 2013 at Samaru (Table 6) revealed that application of

nitrogen fertilizer up to 210kg ha<sup>-1</sup> caused significant increase in the CGR per plant for both varieties. Yolo Wonder supplied with N at 210kg ha<sup>-1</sup> had the highest CGR values (46.15g wk<sup>-1</sup>) while both varieties given no N had identical least values of CGR per plant statistically.

### **Effects of nitrogen rate on yield and yield components of sweet pepper varieties**

Table 7 shows the responses of sweet pepper varieties to nitrogen fertilizer varieties rates on days to 50% flowering, fruit length, fruit diameter and fresh fruit weight during the 2012 and 2013 rainy seasons at Samaru. Increasing nitrogen rate was observed to delay flowering of sweet pepper varieties with those given 210kg N ha<sup>-1</sup> taking significantly longer time to flower (55 - 57 days after sowing = DAS) than for other N treatments. Those pepper given 70 and 140kg N ha<sup>-1</sup> did not differ in number of days to 50% flowering in 2013 at Samaru. All N treated plants took significantly longer to bloom than those of the control each of the years. Generally, the control plots were most early in flowering (46 or 47 DAS). There was significant variation in days to 50% flowering between the two varieties. California Wonder variety consistently bloomed earlier than the Yolo Wonder in each year at Samaru.

Table 7 also shows the effects of nitrogen fertilizer rates on fruit lengths of two sweet pepper varieties in 2012 and 2013 rainy seasons at Samaru. It was observed that application of 70 kg N ha<sup>-1</sup> improved fruit length significantly. Further increase to 140kg N ha<sup>-1</sup> generally had no significant effect on this parameter in the years but beyond this rate, resulted to decrease in fruit length generally. The two varieties of pepper had varying fruit lengths. California Wonder crops consistently recorded longer fruits (7.00 cm in 2013) than the Yolo Wonder each year at Samaru. There was no any significant factor interaction on fruit length.

Fruit diameters of the two sweet pepper varieties were significantly affected by various rates of nitrogen in 2012 and 2013 seasons at Samaru as illustrated in Table 7. It was observed that application of 70kg N ha<sup>-1</sup> significantly increased fruit diameter of peppers over the control but further increase to 140kg N ha<sup>-1</sup> had no significant influence on the fruit diameters of the sweet peppers in each of the year. Increase to 210kg N ha<sup>-1</sup> generally depressed fruit girth. The results showed that fruits of California Wonder

variety had larger fruit diameters than those of Yolo Wonder variety which was 3.36 cm in 2012 at Samaru. No significant interaction of factors on the fruit diameters of sweet pepper varieties was found.

The effects of nitrogen fertilizer rate on total fruit fresh yield (tons) per hectare at Samaru in 2012 and 2013 seasons are also presented in Table 7. The applications of 70 and 140kg N ha<sup>-1</sup> generally yielded statistically similar and highest

total fresh fruit weights (tons) per hectare. These were significantly greater than for those of other N rates and for the unfertilized controls. But further increase in N rate from 140 to 210kg ha<sup>-1</sup> significantly depressed the total fresh fruit yields in the two seasons. Of the two varieties California Wonder consistently produced significantly higher fresh fruit yield (tons) per hectare than Yolo Wonder. No significant factors interaction was recorded on the fruits produced.

Table 2: Plant height of sweet pepper varieties as affected by nitrogen fertilizer rates at Samaru during 2012 and 2013 rainy season

Treatments	Plant height (cm)							
	4 WAT		6 WAT		8 WAT		10 WAT	
	2012	2013	2012	2013	2012	2013	2012	2013
0	14.53 <sup>c</sup>	17.09 <sup>c</sup>	21.53 <sup>d</sup>	22.79 <sup>d</sup>	31.00 <sup>d</sup>	33.27 <sup>d</sup>	37.45 <sup>d</sup>	39.86 <sup>d</sup>
70	16.57 <sup>b</sup>	19.89 <sup>b</sup>	26.40 <sup>c</sup>	27.86 <sup>c</sup>	38.32 <sup>c</sup>	43.11 <sup>c</sup>	47.12 <sup>c</sup>	53.47 <sup>c</sup>
140	17.42 <sup>b</sup>	20.09 <sup>a</sup>	28.10 <sup>b</sup>	31.17 <sup>b</sup>	45.31 <sup>b</sup>	51.66 <sup>b</sup>	53.16 <sup>b</sup>	58.16 <sup>b</sup>
210	19.18 <sup>a</sup>	21.97 <sup>a</sup>	30.66 <sup>a</sup>	32.95 <sup>a</sup>	48.26 <sup>a</sup>	54.52 <sup>a</sup>	56.24 <sup>a</sup>	62.77 <sup>a</sup>
SE ±	0.426	0.384	0.559	0.421	0.695	0.507	0.835	0.462
<b>Variety</b>								
California Wonder	16.15 <sup>b</sup>	19.88	25.38 <sup>b</sup>	27.64 <sup>b</sup>	39.30 <sup>b</sup>	44.71 <sup>b</sup>	45.67 <sup>b</sup>	50.58 <sup>b</sup>
Yolo Wonder	17.70 <sup>a</sup>	20.16	27.96 <sup>a</sup>	29.74 <sup>a</sup>	42.14 <sup>a</sup>	46.57 <sup>a</sup>	51.32 <sup>a</sup>	56.56 <sup>a</sup>
SE ±	0.301	0.272	0.395	0.298	0.491	0.358	0.591	0.341
<b>Interactions</b>								
N x V	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant; \* = Significant, N = Nitrogen, V = Variety.

Table 3: Stem diameters (mm) per plant of sweet pepper varieties as affected by nitrogen fertilizer rates during the 2012 and 2013 rainy seasons at Samaru

Treatments	Stem diameter (mm)/plant							
	4 WAT		6 WAT		8 WAT		10 WAT	
	2012		2012	2013	2012	2013	2012	2013
0	2.67 <sup>c</sup>	3.10 <sup>c</sup>	3.86 <sup>c</sup>	4.83 <sup>c</sup>	7.29 <sup>c</sup>	7.86 <sup>c</sup>	8.46 <sup>b</sup>	9.48 <sup>c</sup>
70	2.77 <sup>bc</sup>	3.37 <sup>bc</sup>	4.63 <sup>b</sup>	5.64 <sup>b</sup>	8.91 <sup>b</sup>	9.46 <sup>b</sup>	11.17 <sup>a</sup>	12.39 <sup>a</sup>
140	3.03 <sup>ab</sup>	3.57 <sup>ab</sup>	5.40 <sup>a</sup>	6.29 <sup>a</sup>	9.26 <sup>b</sup>	10.67 <sup>a</sup>	10.58 <sup>a</sup>	12.03 <sup>a</sup>
210	3.14 <sup>a</sup>	3.84 <sup>a</sup>	5.75 <sup>a</sup>	6.53 <sup>a</sup>	10.00 <sup>a</sup>	10.38 <sup>a</sup>	10.83 <sup>a</sup>	11.34 <sup>b</sup>
SE ±	0.092	0.091	0.148	0.120	0.208	0.199	0.298	0.315
<b>Variety</b>								
California Wonder	2.64 <sup>b</sup>	3.05 <sup>b</sup>	4.45 <sup>b</sup>	5.36 <sup>b</sup>	8.22 <sup>b</sup>	8.65 <sup>b</sup>	9.67 <sup>b</sup>	10.85 <sup>b</sup>
Yolo Wonder	3.17 <sup>a</sup>	3.89 <sup>a</sup>	5.39 <sup>a</sup>	6.29 <sup>a</sup>	9.51 <sup>a</sup>	10.54 <sup>a</sup>	10.86 <sup>a</sup>	11.77 <sup>a</sup>
SE ±	0.065	0.064	0.105	0.085	0.147	0.141	0.211	0.223
<b>Interactions</b>								
N x V	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant; \* = Significant, N = Nitrogen, V = Variety.

Table 4: Leaf area index (LAI) per plant of sweet pepper varieties as affected by nitrogen fertilizer rates during the 2012 and 2013 rainy seasons at Samaru

Nitrogen Kg ha <sup>-1</sup>	Leaf area index (LAI)/plant							
	4 WAT		6 WAT		8 WAT		10 WAT	
	2012	2013	2012	2013	2012	2013	2012	2013
0	2.67 <sup>c</sup>	3.10 <sup>c</sup>	3.86 <sup>c</sup>	4.83 <sup>c</sup>	7.29 <sup>c</sup>	7.86 <sup>c</sup>	8.46 <sup>b</sup>	9.48 <sup>c</sup>
70	2.77 <sup>bc</sup>	3.37 <sup>bc</sup>	4.63 <sup>b</sup>	5.64 <sup>b</sup>	8.91 <sup>b</sup>	9.46 <sup>b</sup>	11.17 <sup>a</sup>	12.39 <sup>a</sup>
140	3.03 <sup>ab</sup>	3.57 <sup>ab</sup>	5.40 <sup>a</sup>	6.29 <sup>a</sup>	9.26 <sup>b</sup>	10.67 <sup>a</sup>	10.58 <sup>a</sup>	12.03 <sup>a</sup>
210	3.14 <sup>a</sup>	3.84 <sup>a</sup>	5.75 <sup>a</sup>	6.53 <sup>a</sup>	10.00 <sup>a</sup>	10.38 <sup>a</sup>	10.83 <sup>a</sup>	11.34 <sup>b</sup>
SE ±	0.092	0.091	0.148	0.120	0.208	0.199	0.298	0.315
<b>Variety</b>								
California Wonder	2.64 <sup>b</sup>	3.05 <sup>b</sup>	4.45 <sup>b</sup>	5.36 <sup>b</sup>	8.22 <sup>b</sup>	8.65 <sup>b</sup>	9.67 <sup>b</sup>	10.85 <sup>b</sup>
Yolo Wonder	3.17 <sup>a</sup>	3.89 <sup>a</sup>	5.39 <sup>a</sup>	6.29 <sup>a</sup>	9.51 <sup>a</sup>	10.54 <sup>a</sup>	10.86 <sup>a</sup>	11.77 <sup>a</sup>
SE ±	0.065	0.064	0.105	0.085	0.147	0.141	0.211	0.223
<b>Interactions</b>								
N x V	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant; \* = Significant, N = Nitrogen, V = Variety

Table 5: Crop growth rate (CGR) per plant of sweet pepper varieties as affected by nitrogen fertilizer rates during the 2012 and 2013 rainy seasons at Samaru

Nitrogen Kg ha <sup>-1</sup>	Leaf area index (LAI)/plant					
	4 -6 WAT		6 - 8 WAT		8 - 10WAT	
	2012	2013	2012	2013	2012	2013
0	4.20 <sup>b</sup>	4.55 <sup>c</sup>	7.85 <sup>d</sup>	7.98 <sup>d</sup>	18.70 <sup>d</sup>	20.24 <sup>d</sup>
70	6.31 <sup>a</sup>	6.33 <sup>b</sup>	12.70 <sup>c</sup>	15.97 <sup>c</sup>	33.10 <sup>c</sup>	34.30 <sup>c</sup>
140	6.40 <sup>a</sup>	6.46 <sup>a</sup>	16.07 <sup>b</sup>	19.33 <sup>b</sup>	41.23 <sup>b</sup>	42.91 <sup>b</sup>
210	6.19 <sup>a</sup>	6.39 <sup>b</sup>	17.97 <sup>a</sup>	20.34 <sup>a</sup>	45.01 <sup>a</sup>	45.56 <sup>a</sup>
SE ±	0.153	0.187	0.326	0.266	0.443	0.329
<b>Variety</b>						
California Wonder	5.68	5.72	12.91 <sup>b</sup>	15.58 <sup>b</sup>	33.78 <sup>b</sup>	34.88 <sup>b</sup>
Yolo Wonder	5.87	6.14	14.39 <sup>a</sup>	16.22 <sup>a</sup>	35.24 <sup>a</sup>	36.63 <sup>a</sup>
SE ±	0.130	0.147	0.146	0.188	0.313	0.232
<b>Interactions</b>						
N x V	NS	NS	*	NS	NS	*

Means followed by same letter in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant; \* = Significant, N = Nitrogen, V = Variety

Table 6: Interactions of nitrogen and Sweet pepper variety on crop growth rate (CGR) per plant (g wk<sup>-1</sup>) at 6 – 8 WAT in 2012 and 8 – 10 WAT in 2013 rainy seasons at Samaru

Nitrogen rates (kg ha <sup>-1</sup> )	Variety	
	California Wonder	Yolo Wonder
At 6 – 8 WAT in 2012		
0	7.39 <sup>f</sup>	8.91 <sup>e</sup>
70	11.70 <sup>d</sup>	13.47 <sup>c</sup>
140	14.81 <sup>b</sup>	16.50 <sup>ab</sup>
210	17.73 <sup>a</sup>	18.67 <sup>a</sup>
SE ±	0.461	
At 8 – 10 WAT in 2013		
0	20.69 <sup>f</sup>	22.33 <sup>f</sup>
70	33.85 <sup>e</sup>	34.21 <sup>d</sup>
140	42.56 <sup>c</sup>	43.82 <sup>b</sup>
210	43.54 <sup>b</sup>	46.15 <sup>a</sup>
SE ±	0.465	

Table 7: Crop growth rate (CGR) per plant of sweet pepper varieties as affected by nitrogen fertilizer rates during the 2012 and 2013 rainy seasons at Samaru

	Leaf area index (LAI)/plant							
	4 WAT		6 WAT		8 WAT		10 WAT	
Nitrogen Kg ha <sup>1</sup>	2012	2013	2012	2013	2012	2013	2012	2013
0	47.30 <sup>c</sup>	46.21 <sup>d</sup>	4.58 <sup>b</sup>	4.96 <sup>c</sup>	2.57 <sup>c</sup>	4.13 <sup>c</sup>	5.68 <sup>c</sup>	5.84 <sup>c</sup>
70	53.15 <sup>b</sup>	51.38 <sup>c</sup>	6.22 <sup>a</sup>	7.47 <sup>a</sup>	3.94 <sup>a</sup>	5.06 <sup>a</sup>	12.31 <sup>a</sup>	12.72 <sup>a</sup>
140	54.10 <sup>b</sup>	52.65 <sup>b</sup>	6.46 <sup>a</sup>	7.26 <sup>a</sup>	4.08 <sup>a</sup>	5.18 <sup>a</sup>	11.76 <sup>a</sup>	12.25 <sup>a</sup>
210	56.54 <sup>a</sup>	54.74 <sup>a</sup>	5.77 <sup>b</sup>	5.88 <sup>b</sup>	3.81 <sup>b</sup>	4.62 <sup>b</sup>	9.47 <sup>b</sup>	9.84 <sup>b</sup>
SE ±	0.490	0.489	0.089	0.099	0.064	0.067	0.299	0.314
<b>Variety</b>								
California Wonder	50.42 <sup>b</sup>	49.04 <sup>b</sup>	6.34 <sup>a</sup>	7.00 <sup>a</sup>	3.83 <sup>a</sup>	5.10 <sup>a</sup>	11.36 <sup>a</sup>	11.78 <sup>a</sup>
Yolo Wonder	55.01 <sup>a</sup>	53.43 <sup>a</sup>	5.19 <sup>b</sup>	5.77 <sup>b</sup>	3.36 <sup>b</sup>	4.38 <sup>b</sup>	8.28 <sup>b</sup>	8.52 <sup>b</sup>
SE ±	0.375	0.304	0.063	0.070	0.045	0.047	0.211	0.222
<b>Interactions</b>								
N x V	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant; \* = Significant, N = Nitrogen, V = Variety.

## DISCUSSION

The soil analyses of the experimental site in both years revealed that the soils were low in total nitrogen content and therefore additions of N to these soils had triggered enhanced productivity of these sweet pepper varieties. Applications of small to moderate amounts of nitrogen fertilizer to the soils produced greater growth and yield components of peppers when compared with the control. This conforms to Khan *et al.* (2010) who reported that the application of N rates between 50 to 150kg ha<sup>-1</sup> enhanced growth and yield of sweet peppers but raising N rate up to 224kg ha<sup>-1</sup> suppressed the growths of peppers. The results obtained from this study showed that most of the growth attributes of sweet pepper varieties like plant height, stem diameter, leaf area index (LAI) and crop growth rate (CGR) per plant responded positively to application of nitrogen fertilizer at all the sampling periods. This was not surprising because application of nitrogen to plants is known to stimulate vigorous vegetative growth generally. Ebenezer *et al.* (2000) reported an increased plant growth parameter, number of fruits and yield per hectare of four capsicum pepper varieties when different Nitrogen sources were used. All of these are important for healthy growth and development of the various plant parts. N application significantly increased the fat, protein, carbohydrate, and crude fibre and ash contents; and vitamin C and mineral nutrients of the fruits (Ayodele *et al.*, 2015). The positive responses of fruit length, fruit diameter and fresh fruit yield

per hectare to application of N as observed in this study could be attributed to low soil N status of the experimental sites. These parameters were highest at either 70 or 140kg N ha<sup>-1</sup> because further increase to 210kg ha<sup>-1</sup> suppressed their performances. This is an indication that these rates met the crops needs for these yield and yield components. This agrees with Ekwu and Okporie, (2000) and Aminifard *et al.* (2012) who reported similar results that sweet peppers supplied with 50 – 150kg N ha<sup>-1</sup> gave tallest plants, more leaves and branches, higher fruit number per plant and maximum fruit yield.

Performances of the sweet pepper varieties as obtained from the results showed that Yolo Wonder performed better than California Wonder in terms of the growth attributes indicated that crop varieties differ in their responses to the environment and differences in their genetic make ups. This conforms to the findings of Fawzy *et al.* (2011) that the growth and yield of any crop is a function of its genotype under the control of the environmental factors especially access to available nutrients, light and water. Anonymous (2013) stated that Yolo Wonder had more vigorous vegetative growth with dense foliage for protection against sun scald than the California Wonder.

The variations in yield and yield components between the two varieties of peppers observed in these trails show that Yolo Wonder variety took

longer to attain maturity than the California Wonder. This delayed flowering means shorter period for fruits formation and development which probably resulted into lower yields. This was in agreement with Numan and Nuri (2005) who reported that time to flowering in plants vary with cultivar type, photoperiod and temperature. In other yield characteristics studied such as fruit length, fruit width and fresh fruit yield in tons per hectare, the California Wonder variety performed better. This indicates that assimilates production in California Wonder variety favors fruits production and development rather than vegetative growth of the crops of Yolo Wonder variety.

The early flowering by California Wonder variety means longer period for fruit formation and development. Likewise, California Wonder used much of its dry matter for vegetative growth but most of these assimilates were mobilized for flowers and fruits formation as they mature. This conforms the report of Jain (2009) who stated that assimilates accumulated in most crops are usually converted to final fruit yields later in their life. From all the observations studied in the results obtained from this research, it could be concluded that applications of 70 kg N ha<sup>-1</sup> gave the greatest fresh fruit yields from these sweet pepper varieties. The California Wonder variety produced better fruit yield than the Yolo Wonder at Samaru Guinea savanna, Nigeria in 2012 and 2013 rainy seasons.

### Conclusion

The California Wonder variety of sweet pepper yield greater pepper fruits of the two varieties and the optimum nitrogen rate is obtained by application of 70kg ha<sup>-1</sup> urea fertilizer for maximum fresh fruit yield. Thus it could be recommended to farmers in Samaru to cultivate California Wonder variety of sweet pepper and application of 70kg ha<sup>-1</sup> urea fertilizer for maximum fresh fruit yield.

### REFERENCES

Abdulmalik, S. Y., Oluleye, F., Majin, N. S. and Isah, M. K. (2014). Effects of Nitrogen Levels and Harvesting Frequency on the Growth and Shoot Yield of *Solanum macrocarpon*. *Developmental Journal of Science and Technology Research*, 3(2): 177 - 184 pp.

Ayodele, O.J., Alabi, E.O. and Aluko, M. (2015). Nitrogen Fertilizer Effects on Growth, Yield and Chemical Composition of Hot Pepper (Rodo). *International Journal of Agriculture and Crop Sciences*, Vol., 8 (5), 666-673.

Amadala V. (2016). How to achieve maximum Sweet Pepper Yield. Retrieved July 10, 2017 from <http://www.farmbizafrica.com>

Amans, E. B. (2011). Pepper varieties, Nursery and Requirements for successful enterprise. In: *Proceedings of the 2011 Preseason Training for Extension Staff in the North-west zone, Nigeria*. Pp 37 - 43.

Aminifard M. H., Aroiee, H., Aziz M., Nemati H. and Jaafar H. Z. E. (2013). Effect of Composite on Antioxidant Component and Fruit Quality of Sweet Pepper (*Capsicum annuum* L.). *Journal of Central European Agriculture*, 14(2). Pp. 525 - 534.

Anonymous. (2010). NAERLS. Pepper production under irrigation. *Extension Bulletin No 206. Agric. Engineering Series No. 7, IAR, ABU, Zaria*. Pp. 1 - 20.

Anonymous. (2011). How To Grow Organic Pepper; On The Green Pepper. Retrieved September 14th, 2011 from <http://www.onthegreenfarms.com> and [www.livesrong.com](http://www.livesrong.com)

Anonymous 2013. *Indian Horticulture data base-2013*, National Horticulture Board, Gurgaon (Haryana).

Anonymous. (2014a). California Wonder. Retrieved July 10, 2014 from <http://www.mygardenlife.com>; [www.myfolia.com](http://www.myfolia.com); and [www.amazon.com](http://www.amazon.com)

Anonymous. (2014b). *Capsicum annuum* L. Retrieved July 07, 2014, from <http://www.prota4u.org> and How to Grow Yolo Wonder Pepper, <http://www.heirloom-organic.com>

Anonymous. (2014c). Bell Pepper. [Wikipedia.en.wikipedia.org](http://Wikipedia.en.wikipedia.org); MAOR- F1 Hybrid Sweet Pepper. Retrieved June 20, 2014 from <http://www.sakata.com>

Black, C. A. (ed) (1965). *Methods of Soil Analysis 2. Chemical and microbiological properties*. American Society of Agronomy. Madison, Wisconsin. 1972p.



- Crosby, M. R. (2008). Pepper. Microsoft® Encarta® 2009 (DVD). Radmond, W. A.: Microsoft Corporation, 2008.
- Ebenezer, O.O., Nkansah, G.O. and Dennis, E.A. (2000). Effect of sources of nitrogen on growth and yield of hot pepper (*Capsicum frutescens*). *Tropical Science*, VOL. 40(2):58-62
- Ekwu, L. G. and Okporie, E. O. (2000). Effects of Plant Spacing and Nitrogen Fertilizer on the Growth and Yield of Pepper, *Capsicum annum L. Journal of Agriculture, Food Environment and Extension*, Vol. 3(2). Pp. 1 – 4.
- Fawzy, Z.F., El-Bassiony, A.M., El-Nemr, A.M and El-Desu Ki, M. (2011). Improvement growth, yield and quality of two snap bean (*Phaseolus vulgaris*, L) varieties using some growth regulators. *Journal of Applied Sciences Research*, 7(12):2047-2055
- Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research. 2nd edition. John Wiley and Sons Inc., Singapore. 680p.
- Grundberg, E. (2014). A Pepper Primer - Introducing the Capsicum. USDA National Institute for Food and Agriculture, US; pp. 1 - 23.
- Havlin, J. L., Tisdale, S. L., Beaton, J. D. and Nelson, W. L. (2006). Soil Fertility and Fertilizers – An Introduction to Nutrient Management. Seventh edition. Prentice-Hall of India Private Limited, New Delhi – 110 001. Pp. 97-115.
- Hamma, I. L., Ibrahim, U. and Haruna, M. (2012). Growth and yield of pepper as Influenced by planting date and plant spacing at Samaru Zaria, Nigeria in 2010 and 2011 cropping seasons. *Journal of Agriculture, Food and Environment*, 8(1):63 – 66.
- Hoven, M. (2013). Do Red Bell Peppers Burn Fat? Metabolic Profiling. [www.livestrong.com](http://www.livestrong.com) Retrieved on August 25th, 2013.
- Jain, V. K. (2009). Fundamentals of Plant Physiology. 12th edition. S. Chand & Company Ltd, Ram Nagar, New Delhi, India. 110055. Pp. 112-162.
- Khan, M. S. I., Roy S. S., and Pall, K. K. (2010). Nitrogen and phosphorus efficiency on the growth and yield attributes of capsicum. *Academic Journal of Plant Sciences* 3: 71–78.
- Lawal, A. O. and Fagge, A. A. (2011). Economic Importance, Harvesting and Post-Harvest handling of Pepper. In: Proceedings of 2011 Pre-season Training for Extension Staff in the North-west Zone, Nigeria. Pp. 53-69.
- Marschener, H. 1993. Mineral nutrition of higher plants, 2nd ed. Academic press London.
- Nadeem, M., Anjum, F. M., Khan, M. R., Saeed, M. and Raiz, A. (2011). Antioxidants Potentials of Bell Pepper (*Capsicum annum L.*) – A Review. *Pak. J. Food sci.* 21(1- 4): 45-51.
- Numan, B. and Nuri, Y. (2005). The effect of Different Nitrogen and Phosphorus Doses and Bacteria Inoculation (*Rhizobium phaseolis*) on the yield and yield components of field beans (*Phaseolus vulgaris L.*). *Journal of Agronomy*, 4 (3); pp. 207 -215.
- Ogunlela, V. B. and Koomen, I. (2005). Paprika (*Capsicum annum L.*) field establishment and crop productivity under varying plant density and ammonium nitrate top-dressing. *Journal of Food, Agriculture and Environment*, Vol. 3(1): 185-189.
- Reddy, C. (2012). The Earth of India: All About Capsicum in India. [www.blogspot.com](http://www.blogspot.com) Retrieved on December 29th, 2014.
- Shafeek, R., Ngwa, M. K., Awatef, H., Beheiry, G. and Rizk, F. A. (2012). Productivity of sweet pepper (*Capsicum annum L.*) as affected by different nitrogen sources and sulphur fertilizers under newly reclaimed soil. *Journal of Applied Sciences Research*, 8(11): 5365 - 5371.
- Singh, R. V. and Naik, L. B. (1990). Effects of nitrogen, phosphorus and plant spacing on sweet pepper (*Capsicum annum L.*). *Haryana Journal of Horticultural Sciences*, Vol. 19(1-2): 168-172.
- Steel, R. G. and Torrie, J. W. (1984). Principles and Procedure of Statistics: A Biometrical Approach. Second ed. MacGraw-Hill Intern. Books, Auckland. Pp. 633.

Trinklein, D. H. (2010). Growing Sweet Pepper in Missouri. Extension. [missouri.edu/p/G6372](http://missouri.edu/p/G6372).

United States Department of Agriculture (USDA). (2011). World bell and Chile peppers : Productions 1990 - 2007. Wikipedia, the free encyclopedia.

Zarafi, A. B. (2011). Management of Insect Pests and Diseases in Pepper. In: Proceedings of the 2011 Pre-season Training for Extension Staff in the North-west Zone, Nigeria. Pp. 44-52.