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Planting Dates and Nutrition Management Regimes Impact Positively on Bulb Size, Quality and Yield of Rain-fed Onion

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Abstract

Bulb size, appropriate time of planting and sufficient growth nutrients may determine the quality of seeds and productivity of onion. Studies were conducted during the cropping seasons of year 2015 and 2016 to assess the effects of planting date and nutrients management regimes on bulb size, quality and yield of rain-fed onion using seeds of variety Prema as planting material. Three levels of transplanting dates namely early transplanting (N1)), transplanting of seedlings two weeks after early transplanting (N2), and transplanting of seedlings four weeks after early transplanting (N3) were factorially combined with the following six fertilizer application regimes: F1 (no fertilizer application), F2 (application of 375 kg/ha of NPK 23:10:10), F3 (application of 10 t/ha fertisoil compost), F4 (application of 187.5 kg/ha of NPK 23:10:10 plus 5 t/ha of fertisoil compost), F5 (application of 125 kg/ha of NPK 23:10:10 plus 6.6 t/ha of fertisoil compost) and F6 (application of 250 kg/ha of NPK 23:10:10 plus 3.3 t/ha of fertisoil compost). Seedlings from the above treatment combinations were planted using RCBD in three onion growing communities in the Northern Region of Ghana. At harvest, bulbs were sorted into three groups (large, medium and small bulbs). Results from the studies indicated that in each group of bulb size, N1 x F4 plants produced the highest bulb fresh weight and bulb diameter. Plants from these regimes also produced the highest bulb quality and bulb yield. Farmers should nurse onion seeds early, latest by first week of June in the rainy season, so as to transplant seedlings by first week of July and apply 187.5 kg/ha of 23:10:10 NPK plus 5 t/ha fertisoil compost for improved bulb sizes in the study area.

Keywords: *rain-fed onion, planting date, NPK 23:10:10, fertisoil compost, bulb size at harvest, bulb yield.*

INTRODUCTION

Among the spice crops, onion ranks second in terms of area coverage (37,560 ha) but attains top in production (153,000 Mt) covering about 15% of total area under spices and condiments (BBS, 2004). It is estimated that over 9.2 million acres of onion are harvested annually around the world (National Onion Association, 2011). The countries leading in production are China, India, United States, Turkey, Pakistan, Egypt, Algeria, Morocco, Nigeria, South Africa and Niger (FAOSTAT, 2008). According to Raemaekers (2001), onion forms an indispensable part of the human diet and it is a rich source of several minerals and vitamins. As food, it can be eaten raw, boiled, baked, fried, dried or roasted. Onion contains a variety of other naturally occurring chemicals that support in lowering blood pressure (Nisar *et al*., 2011).

In Ghana, onion is grown as cash crop and serves as livelihood for the resource poor farmers who cultivate the vegetable, and the commonest cultivar often grown is Bawku Red. However, other exotic cultivars such as Red Creole, Top-harvest, Texas Granos, Dramani, Safari, Prema and Ares have also been developed for growers in the country. Onion production in the country does not meet national demand due to the small acreage of production, low yields and seasonality in production. The vegetable responds well to the application of organic and inorganic fertilizers (Tweneboah, 2000). The use of improved cultivars and alteration of planting dates have been reported as effective strategies for reducing pest damage and improvement of crop productivity (Jackai *et al*., 1985). Climate change has also caused significant modification of the cropping seasons in different parts of Ghana, and this has resulted in alteration is variation in performance of crop species grown in different environments. The quality and quantity of every crop are affected by the amount and distribution of rainfall and the period of planting (Morakinyo and Ajibade, 1998). Seed supply from domestic production in most African countries is inadequate and most vegetable growers rely on imported seeds that have poor germination percentage, lack uniformity and are susceptibility to diseases (Lemma, 1998). Onion seed production increases not only with the land area cultivated, but also with good management practices. In crop production, the identification of appropriate time of planting is an important agronomic requirement needed for high and sustained productivity (Akande *et al.*, 2012). Similarly, location and seasonal factors of a place often affect crop production by interacting with cultivar and its traits (Akande, 2007).

Bulb size plays a good role in determining the quality of onion seeds produced (Mirshekari and Mobasher, 2006). For quality and economically feasible seed yield of onion, bulb size of 5.1-6.0 cm is recommended (Haile *et al.*, 2017). For commercial onion production, bulbs of suitable sizes are needed in order to produce quality seeds (Khokhar *et al*., 2001). It has been reported that (Ali *et al*., 1998) large bulb size (5.5 to 7.0 cm diameter) produced seed yield significantly higher than small sized bulbs. Asaduzzaman *et al*. (2012) also reported that larger sized bulb and wider spacing resulted in higher seed yield per plant. The availability of sufficient growth nutrients from fertilizers will improve cell activities; enhance cell multiplication and enlargement and luxuriant growth. Abdissa *et al*. (2011) reported that the application of NPK 15:15:15 significantly increased plant growth in onions. According to Sinnadurai (1992), bulb size is influenced by the addition of nitrogen, phosphorus and potassium to the soil. The need for fertilizer application in crop production is therefore widely recognized as it is readily observed that plants grown in soils with freshly applied fertilizer shows better response to growth and yield. The objectives of the present study were to determine the best planting date and/or best plant nutrition management regime that enhances the production of improved bulb sizes, bulb quality and productivity of rainy season onion cultivation in the Northern Region of Ghana.

MATERIALS AND METHODS

Site description

The field experiments were conducted in three communities in the Northern Region of Ghana namely Golinga, Ligba and Nyankpala which are located within the interior Guinea Savannah agroecological zone. The experimental areas are subjected to marked wet and dry season with a unimodal total annual rainfall of about 1022 mm which may be evenly distributed from May to October and reaching a peak in August or September. The average minimum temperature is 25˚C whilst the maximum average temperature is 35˚C (Lawson *et al*., 2013). The area is characterized with natural vegetation dominated by grasses with few shrubs. The vegetation is mainly grassland but it is interspersed with short trees such as *Parkia biglobosa*, and *Azadirachta indica* and weed species such as *Centrosema pubescens*, *Cyperus difformis* and *Striga hermontheca*. The soils generally have low nutrient properties and often require soil amendment to boost crop production (Addai and Alimiyao, 2015). Prior to field experimentation, soil physico-chemical characteristics of the area were determined and data are shown in Table 1.

Table 1: Physico-chemical properties of the soil prior to field studies

Soil parameter	Value
pH	5.36
Organic carbon (%)	0.51
CEC (Cmol/kg)	2.10
Nitrogen (%)	0.04
Available Phosphorus (mg/kg)	7.60
Exchangeable Potassium (mg/kg)	65.00
Exchangeable Calcium (Cmol/kg)	1.35
Exchangeable Magnesium (Cmol/kg)	0.40
Sand	52.60
Clay	0.26
Silt	47.14

Soil parameters presented in Table 1 were averages of the values recorded at the three experimental locations during the study period.

Nursery management and transplanting

The nursery sites were cleared and ploughed in all three communities and 1 m x 10 m beds were raised. Onion seeds (variety Prema) were nursed at two weekly intervals on 10th June 2016, 24th June 2016 and 8th July 2016 respectively for the first (N1), second (N2) and third (N3) nurseries respectively in all three locations in drills of 1-2 cm deep for 5 weeks before they were transplanted onto their permanent beds. Damping off disease at the nursery sites was controlled by application of Topsin-M 70% CM fungicide. Seedlings were hardened-up for quicker establishment in the field and water application was reduced seven days before seedlings were transplanted. Prior to transplanting, nursery beds were watered in order to ease seedling removal with little or no damage to the seedlings. The seedlings were transplanted at a depth of 2.5 cm and at planting distance of 10 cm x 12 cm.

Experimental design and crop management

Beds of 2 m × 10 m were raised with 1 m alleys in between them. The beds were laid out in randomized complete block design (RCBD) with three replications in each location. The following six levels of nutrient application were used: F1 (no fertilizer application), F2 (application of NPK 23:10:10 at the rate of 375 kg/ha), F3 (application of 10 t/ha of compost two weeks prior to transplanting of seedlings), F4 (application of 187.5 kg/ha NPK 23:10:10 plus 5 t/ha of fertisoil compost), F5 (application of NPK 23:10:10 at 125 kg/ha plus 6.6 t/ha of fertisoil compost), and F6 (application of NPK 23:10:10 at 250 kg/ha plus 3.3 t/ha of fertisoil compost). The time of transplanting seedlings in the field depended on the type or category of nursery from which seedlings were obtained. Thus the following levels of date of transplanting were involved: early transplanting (N1), transplanting two weeks after early transplanting (N2) and transplanting four weeks after early transplanting (N3). The treatment combinations were replicated in three onion producing areas namely

Nyankpala, Libga and Gollinga in the Northern Region of Ghana. A mixture of insecticide and fungicide was sprayed at 10 days interval to control pests and diseases in the field. The fields were also weeded three times manually with a hoe and the beds stirred regularly with hand cultivator to loosen the soil to ensure good drainage, filtration and aeration. After weeding, the weeds served as mulch to control other weeds and also to conserve soil moisture.

Data collection and analysis

Bulbs were sorted and graded into sizes (large, medium and small) at harvest using their diameter and fresh weight as guides. Bulbs with diameter above 5 cm were classified as large bulbs, those within 4-5 cm were classified as medium bulbs whilst bulbs that were less than 4 cm in diameter were classified as small bulbs. Moreover, bulbs having more than 60 g fresh weight were classified as large, those with fresh weight of 40-60 g were considered as medium bulbs whilst bulbs having less than 40 g as fresh weight were considered as small bulbs. The girths of necks of onion bulb were also measured. Bulb diameter and girth were measured using Vernier calipers whilst fresh weight was measured using electronic weighing balance. Total number of unrotten bulbs was countered and expressed as a percentage of total number of bulbs harvested. Count data were transformed using the formula $\text{Log}_{10}(x+1)$. Averages were computed for the data collected in both year 2015 and 2016 cropping seasons for each parameter before subjecting them to Analysis of Variance (ANOVA) using Genstat discovery, 12th edition. Means of data were separated using LSD at 5% probability level.

RESULTS

Variation in bulb size at harvest

Bulb diameter

The interaction between fertilizer management and time of transplanting significantly (P<0.05) affected large bulb diameter (>5.0 cm). Plants from F3 x N1 significantly recorded the highest bulb diameter whilst those from F1 x N1 produced the least (Figure 1). The main effects of fertilizer management and time of transplanting did not significantly (P>0.05) influence large bulbs diameter (>5.0 cm). The interaction between fertilizer management and time of transplanting had significant (P < 0.05) effect on medium bulb diameter. Plants from N1 x F4 produced the highest medium bulb diameter whilst those from N3 x F1 produced significantly (P < 0.05) the lowest value (Table 1). Small bulbs diameter was only significantly (P < 0.05) influenced by time of transplanting, and plants from N1 produced the highest value whilst N2 recorded the least (Figure 2).

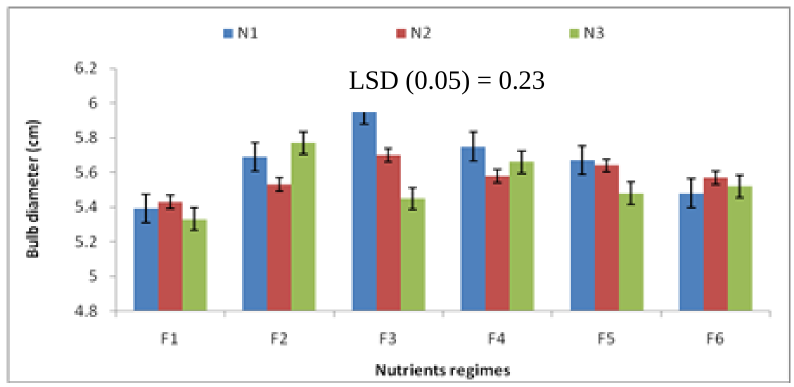

Figure 1: Distribution of large bulbs (diameter > 5.0 cm) in response to the combined influence of nutrients management regimes and time of transplanting. Bars indicate ±_standard error of the means.

Table 1: Distribution of medium bulbs (diameter 4 - 5.0 cm) in response to fertilizer management (F) and time of transplanting

Nutrients regimes	Time of transplanting		
	N1	N2	N3
F1	4.29	4.1	4.03
F2	4.52	4.32	4.25
F3	4.45	4.25	4.18
F4	4.64	4.43	4.36
F5	4.60	4.39	4.32
F6	4.47	4.27	4.20

LSD (0.05): Nutrients regime x time of transplanting = 0.21

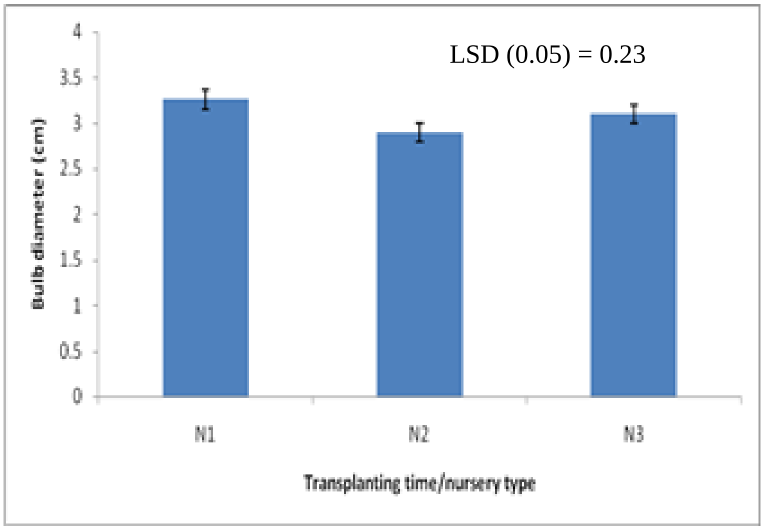

Figure 2: Distribution of small bulbs (diameter <4.0 cm) in response to time of transplanting. Bars indicate ±standard error of the means.

Bulb size in terms of fresh weight

Large bulb size (fresh weight >60g) varied significantly (P<0.05) for the single effects of fertilizer (nutrients) management regimes and time of transplanting (nursery type). The nutrients regimes x time of transplanting interaction was not significant (P>0.05). Plants from F5 and F1 produced the highest and lowest large bulb fresh weights respectively (Figure 3). Plants from N1 and N3 recorded the highest and lowest bulb sizes respectively with respect to the main effects of time of transplanting (Figure 4). The distribution of medium bulbs (fresh weight of 40-60g) followed a similar pattern as that of large bulbs (Table 2). Variation in the distribution of small bulb fresh weight (<40g) was significant (P < 0.05) only for transplanting time with plants from N1 recording the highest small bulb fresh whilst those from N2 and N3 did not significantly differ (Figure 5).

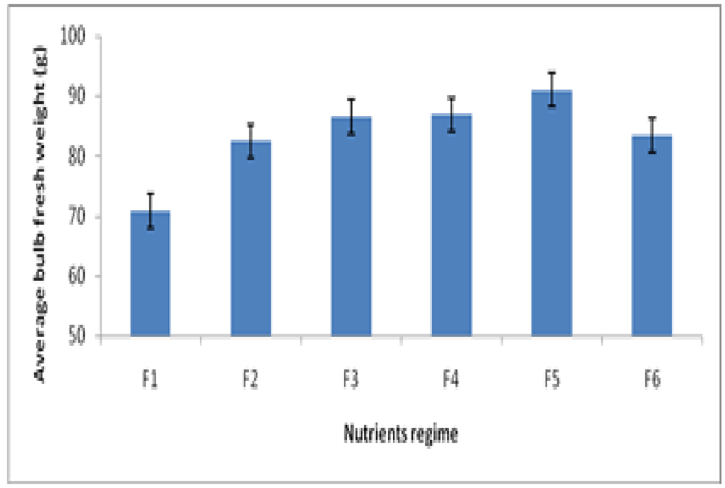

Figure 3: Distribution of large bulbs fresh weight (> 60 g) in response to fertilizer or nutrient management. Bars indicate ± standard error of the means.

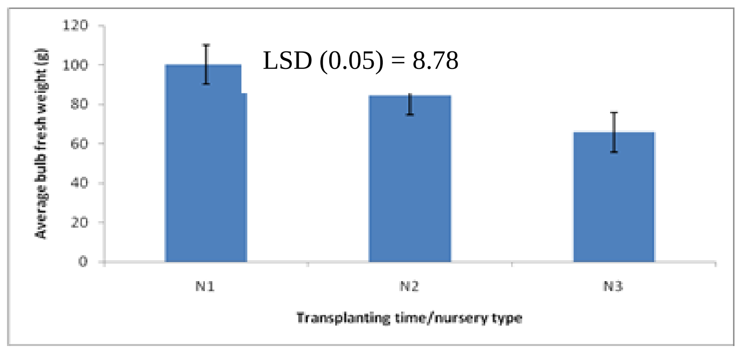

Figure 4: Distribution of large bulb fresh weight (> 60 g) in response to time of transplanting or nursery type. Bars indicate ± standard error of the means.

Table 2: Variation in medium bulb fresh weight in response to nutrients regimes x transplanting time

Nutrients regimes	Time of transplanting		
	N1	N2	N3
F1	45	46.61	31.34
F2	49	50.75	34.13
F3	42	43.50	29.25
F4	57	59.04	39.70
F5	60	62.14	41.79
F6	53	54.89	36.91

LSD (0.05): Nutrients regime x time of transplanting = 4.53

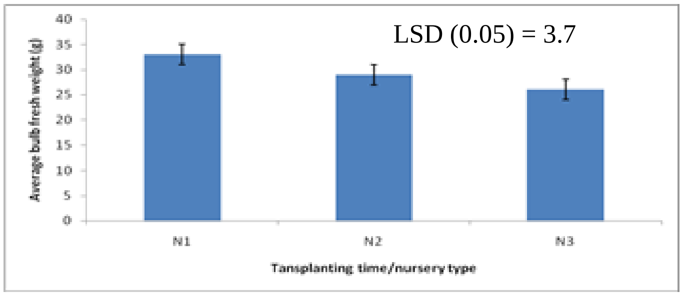

Figure 5: Distribution of medium bulb fresh weight (<40g) in response to time of transplanting/ nursery type. Bars indicate ± standard error of the means.

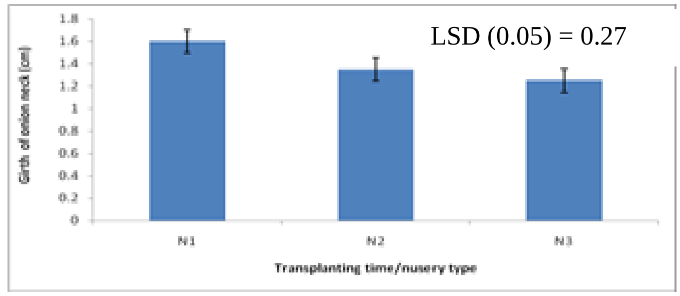

Figure 7: Variation in girth of onion neck in response to time of transplanting. Bars indicate ± standard error of the means.

Girths of bulk neck size and bulb quality

The interaction between fertilizer management and time of transplanting did not significantly (P>0.05) affect sizes of bulb neck girth. However, the main effects of fertilizer management regimes and time of transplanting significantly (P< 0.05) influenced this parameter. The F6 bulbs recorded the highest girth of bulb neck of 1.9 cm whilst the unfertilized control (F1) recorded the least values of 1.3 cm (Figure 6). Bulbs from N1 and N3 treatments recorded significantly the highest and lowest bulb girth, respectively (Figure 7). The main effect of time of transplanting significantly (P<0.05) influenced percentage of unrotten bulbs whilst variation with respect to single effect of nutrients management regimes as well as nutrients regime x time of transplanting was not significant. Plants from F3 and F2 produced the highest and lowest percentage of unrotten bulbs, respectively (Figure 8).

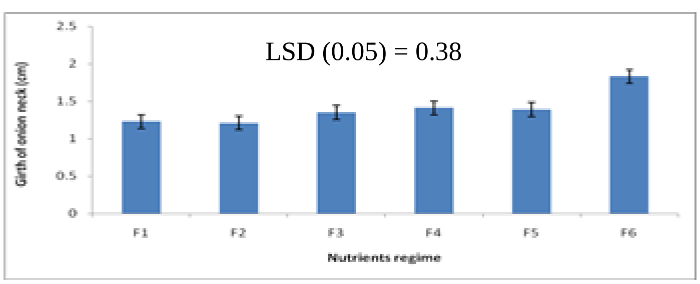

Figure 6: Variation in girth of onion neck in response to nutrients application. Bars indicate ± standard error of the means.

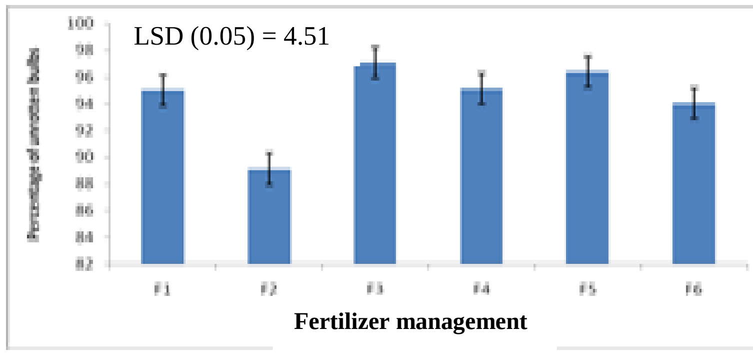

Figure 8: Effects of nutrients application on bulb quality at harvest. Bars indicate ± standard error of the means.

Bulbs yield at harvest

Total number of bulbs harvested was only significantly (P<0.05) affected by the interaction between fertilizer management and time of transplanting (Figure). Plants from F4 x N1 produced the highest total number of 891 bulbs whilst plants from F1 x N3 gave the least total number of 119 bulbs (Table 3). Total bulb fresh weight was significantly (P < 0.05) influenced by the single effects of nutrients management regimes and time of transplanting. Plants from F4 produced the highest bulb yield of 21.4 t/ha whilst the unfertilized control produced 5.4 t/ha (Figure 9). Plants from N1 and N2 produced significantly the highest bulb yield of 16.4 t/ha whilst N3 recorded the lowest bulb yield of 6.1 t/ha. (Figure 10).

Table 3: Variation in total number of bulbs harvested in response to the interaction between fertilizer management regimes and time of transplanting. Bars indicate ± standard error of the means

Nutrients regimes	Time of transplanting		
	N1	N2	N3
F1	301.00	160.00	119.00
F2	294.34	359.00	147.00
F3	662.34	546.34	211.34
F4	891.34	758.34	302.66
F5	598.34	723.34	230.34
F6	374.34	514.34	155.00

LSD (0.05): Nutrients regime x time of transplanting = 155.8

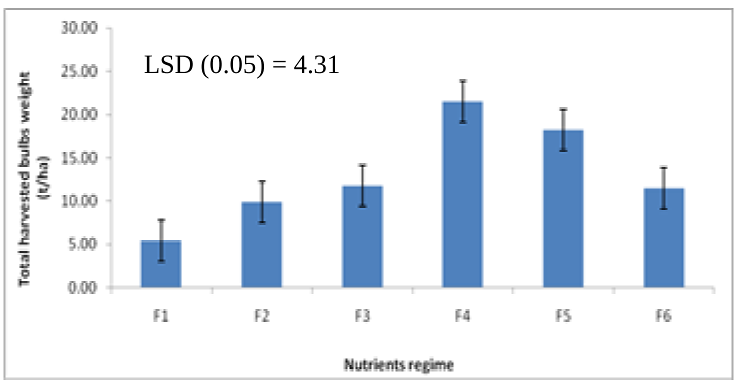

Figure 9: Effect of nutrients application on total bulb fresh weight. Bars indicate ± standard error of the means

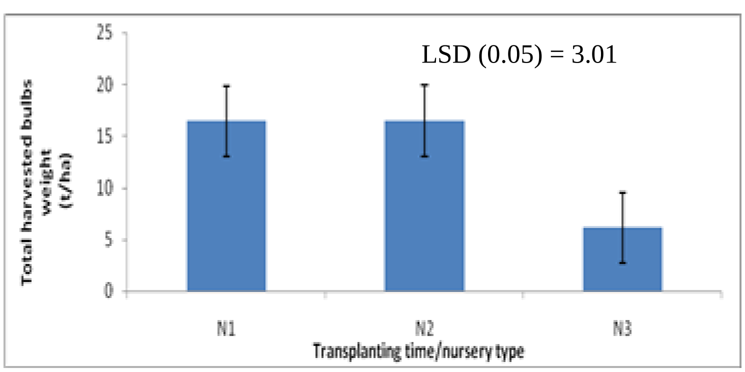

Figure 10: Effect of time of transplanting on total bulb fresh weight. Bars indicate ± standard error of the means.

DISCUSSION

Plants from fertilizer treated plots generally recorded bulbs of relatively high sizes, quality and yield than plants from the unfertilized control plots. This is in accordance with the finding of Addai and Alimiyao (2015) who reported that soils in Northern Ghana generally have low nutrient properties and often require soil amendment to boost crop production. Sinnadurai (1992) also said that bulb size is influenced by the addition of N, P and K to the soil. Results from the studies show that bulb sizes, quality and yield from plants treated with both compost and mineral fertilizer produced better results as compared with the results obtained from plots where only inorganic fertilizer or compost was applied. The data obtained here agrees with that of Dejene and Lemlem (2012) who noted that the simultaneous application of both organic and inorganic fertilizers is the best approach to maintain soil health and increase crop yield. The trend in results for the distribution of bulb size at harvest demonstrates the importance of the combination of organic and inorganic fertilizer in the soil for plant growth and development. The data presented in this study are similar to that of Tweneboa (2000) who made similar statement. Results from total bulb fresh weight, girth of onion neck, total number of bulbs at harvest and percentage of unrotten bulbs mimicked the distribution depicted by bulb size. In another but related study, Abdissa *et al*. (2011) also reported that the application of nutrients to plants during onion cultivation significantly increased bulb yield. The increases in fresh weight and diameter bulbs from all three categories of bulb sizes following the application of compost in combination with inorganic fertilizer as well as increases in bulb yield and quantities of quality bulbs from the compost and inorganic fertilizer were as a result of the role played by the nutrients supplied. The combined fertilizer as in F4 and F5 nutrient regime provided the essential primary nutrients for growth and development. The nutrients provided by the combinations probably enhanced meristematic activities and physiological processes of the treated plants that resulted in high values of these parameters. Plants from the N1 generally recorded higher values of bulb sizes, bulb quality and yield than those from N2 and N3. The observation made here suggests that planting date is an important agronomic consideration for high and sustained productivity (Akande *et al.*, 2012).. This result is also in accordance with the observation made by Jackai *et al*. (1985) that changes in planting dates is an effective strategies for improvement in crop productivity. The improvement in bulb sizes, yield and quality recorded from N1 as against plants obtained from N2 and N3 seedlings might have been due to variation in total amount and distribution of rainfall during experimentation. The N2 and N3 seedlings were transplanted late and parts of their growth and development coincided with drought whereas N1 seedlings were transplanted earlier and had relatively better rainfall pattern than the former. The results presented here are in conformity with that of Morakinyo and Ajibade, (1998) who reported that the quality and quantity of every crop are affected by the amount and distribution of rainfall and the time of planting.

CONCLUSION AND RECOMMENDATION

In each category of bulb size, N1 x F4 plants produced the highest fresh weight and bulb diameter. Plants from these regimes also produced the highest bulb quality and bulb yield. The study therefore recommends early transplanting of seedlings together with the application of 187.5 kg/ha of 23:10:10 NPK plus 5 t/ha fertisoil compost to onion farmers in the study area for quality bulb production and improved bulb sizes.

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