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Effects of Cultivar and Bulb Size on Growth and Bulb Yield of Onion (*Allium cepa* L.) in the Northern Region of Ghana

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Authors' contributions

Author IKA designed the study, supervised data collection and wrote the first draft of the manuscript. Author RKT performed the statistical analysis while author HT read through the manuscript and edited it after it has been drafted by author IKA.

Original Research Article

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ABSTRACT

Aims: To determine the effects of cultivar and bulb size at planting on growth and yield of onion production in Ghana.
Study Design: The experiment was laid out as a randomized complete block design and each treatment combination was replicated four times.
Place and Duration of Study: The study was conducted at the experimental fields of the University for Development Studies, Nyankpala in the Northern Region of Ghana from July to October in the year 2012 and repeated during the same period in year 2013.
Methodology: The three onion cultivars used for the study were 'Bawku red', 'White onion' and 'Nigel brown'. The bulb sizes used were large (45-60 mm in diameter), medium (30-45 mm in diameter) and small (15-30 mm in diameter) bulbs. Bulbs from these treatment combinations were planted in the field, and growth and yield parameters were measured.
Results: Bulb size at planting influenced vegetative growth and yield parameters of onion. The big bulb gave the best performance in terms of growth and yield whilst the small bulb gave the least of these parameters. No significant cultivar difference was observed in terms of growth, but 'Bawku red' and 'White onion' had higher bulb fresh mass than the other cultivar.

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Conclusion: Results indicated that the highest yield in the northern region of Ghana was obtained with the large (45-60 mm in diameter) bulbs of 'Bawku red' or 'White onion'.

Keywords: Leaf length; number of leaves; bulb fresh mass; sprouts.

1. INTRODUCTION

Onion (*Allium cepa* L.), according to [1], is one of the oldest crops known to man. [2] stated that onion has many uses and recent research findings suggest that onion has been used to treat a wide range of ailments but the most prominent ones have been cardiovascular diseases. In northern Ghana, as in many parts of the world, onion is used for flavouring and seasoning foods. Thus the crop forms an essential part of the diet. In fact, onion is not only a high value vegetable crop and a component of a balanced diet, but is also a source of income for the farmer. Commercial production of the crop in the country occurs in the Northern, Upper East and Upper West Regions. According to the Ministry of Food and Agriculture of the Republic of Ghana [3], a total of 7,542.78 Mt of onion is produced from 645.23 ha of land in the onion producing areas of the country. However, the average yields of the crop are low and highly variable as compared to those of other countries within Africa. Yields up to 30 t/ha have been reported in Ghana from research stations under the Council for Scientific and Industrial Research (CSIR) but under farmer conditions, such yields are rare, owing largely to the fact that most farmers in the country are not able to carry out the required cultural practices of the crop [4]. The local 'Bawku red' onion, which is the most popular cultivar, yields about 7t/ha but yields of 10 - 20 t/ha of the exotic 'Early Texas Grano' have been reported in Ghana [5].

In recent times, there has been tremendous interest in the influence of cultivar and bulb size at planting on growth and yield of onion in Northern Ghana. In onion production, it has been noted that the size of the bulb is dependent upon the number and sizes of the green leaves at the time of maturity. For each leaf there is a ring of onion and the larger the size of the leaf, the larger will be the ring. It has also been established that sound whole bulb sizes with diameters ranging from 45 to 55 mm should be used as planting material. [6] reported that medium sized bulbs were required for high bulb yield. Similar results were also reported by [7,8]. Planting using the bulb is probably the simplest method as compared to planting by using the seeds in Ghana. In fact, in using the bulb, development is faster and plants get strong and resist attack by thrips. The mother bulb size has been known to have pronounced effect on growth and yield of onion [9] but most farmers, especially in northern Ghana do not have adequate information on the right bulb size that needs to be planted for optimum bulb yield in the area. Planting different cultivars of the crop may also result in different growth, agronomic or yield characteristics. The present study therefore aimed at evaluating the influence of cultivar and bulb size at planting on growth and yield of onion.

2. MATERIALS AND METHODS

2.1 Site Description

The study was conducted at the University for Development studies, Nyankpala, which is 16 km West of Tamale in the Tolon-Kumbungu District of the Northern Region of Ghana. The site is located on latitude 09º 25' and longitude 0º58' of the equator and at an altitude of 183 m above sea level. The site has an annual rainfall of 1034.4 mm and mean monthly

minimum temperature of 21.5ºC and maximum of 34.1ºC. The mean monthly minimum relative humidity of the area is 53% while the maximum relative humidity value is 80%. The area is located within the Guinea Savannah agroecological zone of Ghana and the vegetation is made of mostly tall perennial grasses such as *Adropogon gayanus* intercepted with trees and shrubs. Soils of the area are described as alfisols under the USDA system of classification [9]. They are mostly brown, moderately drained sandy-loam and are free from concretions. They are very shallow with hardpan under the top few centimeters. The soils were developed from voltarian sandstone and classified as Nyankpala series or Plinthic Acrisol [10]. The pH of the soils used for the study ranged from 4.71 to 5.32, the effective CEC was 2.73 – 3.92 Cmol/kg and the available N content ranged from 0.18 to 0.19 mg/kg. The P and K content were 2.86 – 2.94 mg/kg and 8.5–9.2 mg/kg, respectively while the organic matter composition was 0.81 – 0.86%.

2.2 Land Preparation, Experimental Design and Planting

The study was conducted in the rainy seasons (July – October) of year 2012 and repeated in the same manner and duration for year 2013. The field was ploughed and debris removed; it was demarcated using tape measure, pegs and garden line. Decomposed plant parts were mixed into the soil to serve as organic matter before raising the beds. The field was divided into plots each having a dimension of 1.0 m x 1.0 m. Plots were separated from each other by an alley of 1.0 m whilst blocks were separated from each other by a distance of 1.5 m. With the aid of a hoe, beds were raised to the height of 0.30 m, each having a dimension of 0.30 m x 1.0 m. The study made use of a 3 x 3 factorial experiment laid out in randomized complete block design (RCBD) with 4 replications. The following cultivars: 'Bawku red', 'White onion' and 'Nigel brown', which are the dominant cultivars in the study area, were used. Three bulb sizes viz. large (45-60 mm in diameter), medium (30-45 mm in diameter) and small (15-30 mm in diameter) bulbs were planted for each cultivar. About one-third of the top of each bulb was cut off before planting and one bulb per hill was planted directly on the beds at 4 cm depth from the soil surface and at a distance of 15 cm within rows but 20 cm between the rows.

2.3 Cultural Practices

Control of insect pests and diseases were not carried out because they were not encountered on the field, but weed control was done two times. The first and second weeding were done 2 and 4 weeks after planting, respectively. The study was conducted in the rainy season, but when the rains stopped for some time, plants were irrigated manually until the rains started again. The bulbs were harvested between the 9^{th} and 11^{th} week after planting.

2.4 Data Collection

Leaf length was measured as distance from the point of attachment of the longest leaf to the stem (basal plate) with a metre rule. Leaf and tiller (sprout) numbers were obtained by counting their total numbers per plant. These parameters were collected every two weeks starting from 2 weeks after planting to 6 weeks after planting. Five plants per replicate were considered for data. The two growth parameters (leaf length and number) were measured up to six weeks after planting because after this period, growth had almost ceased. At harvest, total number of bulbs per hill (cluster bulb mass) was obtained by counting and they were manually weighed with an electronic balance. Bulbs were graded into sizes according to

their fresh mass. Means of data collected in the two years were computed prior to entering them into the spread sheet for analysis of variance (ANOVA) using Genstat statistical software. The means were separated with Fisher LSD test at 5 %.

3. RESULTS

3.1 Leaf Length

Leaf length did not vary significantly among cultivars. The parameter, however, differed among bulb sizes. Fig. 1a shows the influence of bulb size of 'Bawku red' cultivar on leaf length. At 2 weeks after planting, the small bulb recorded the highest mean leaf length of 16.68 cm while the medium and big bulbs recorded values of 13.89 cm and 13.13 cm, respectively. From 4 - 6 weeks after planting, the three bulb sizes recorded almost the same values of leaf length. From Fig. 1b, it can be observed that, bulb size influenced leaf length of White onion significantly. At two weeks after planting, there was a highly significant difference between the big bulb and the other two bulb sizes. The big bulb recorded the highest leaf length followed by the small bulb with the medium bulb recording the lowest value. At 4 weeks after planting, leaf length value for the big bulb was 27.26 cm, while the small and medium bulbs recorded 18.88 cm and 16.25 cm, respectively. At 6 weeks after planting, however, the big, medium and the small bulbs recorded 31.79, 28.50 and 23.26 cm, respectively of leaf lengths. Fig. 1c shows the leaf length distribution of the 'Nigel' cultivar. It was observed that, there was rapid growth of leaves from 2-4 weeks after planting. At 6 weeks after planting, the growth of leaf of the medium bulb slowed down as the small and big bulbs increased. The trend in the growth pattern changed. The big bulb and the small bulbs recorded significantly higher and similar values of length as compared to that of the medium bulb. The Leaf length of plants from the medium bulb decreased drastically from week 4 to week 6.

3.2 Number of Leaves

As in the case of leaf length, Number of leaves did not vary significantly among cultivars but differed significantly among bulb sizes. Fig. 2a shows the distribution of leaf number of 'Bawku red' onion. Number of leaves was significantly different for the various bulb sizes. Generally number of leaves increased from 2 to 6 weeks after planting. At 2 weeks after planting, plants from the medium bulb recorded the highest leaf number while those from the big and small bulbs recorded significantly the same values. At 4 weeks after planting, plants produced from the medium and big bulbs had significantly similar leaf numbers while those from the small bulbs recorded the least. At 6 weeks after planting, plants from the big bulb recorded the highest leaf number followed by those of the medium bulb and the small bulb in that order. In the case of 'White onion' (Fig. 2b), plants from the big bulb produced the highest number of leaves from 2-6 weeks after planting. Plants from the small and medium bulbs did not significantly vary in leaf number from 2–4 weeks after planting but at 6 weeks after planting, plants from the small bulb recorded the least number of leaves. Fig. 2c shows the leaf number distribution among the various bulb sizes of Nigel brown cultivar. Plants from the medium bulb recorded the highest number of leaves at 2 weeks after planting whilst those of the big bulb recorded similar number of leaves as those of the small bulbs. At 6 weeks after planting, plants from the big bulb recorded significantly the highest number of leaves while those of the small and medium had similar values.

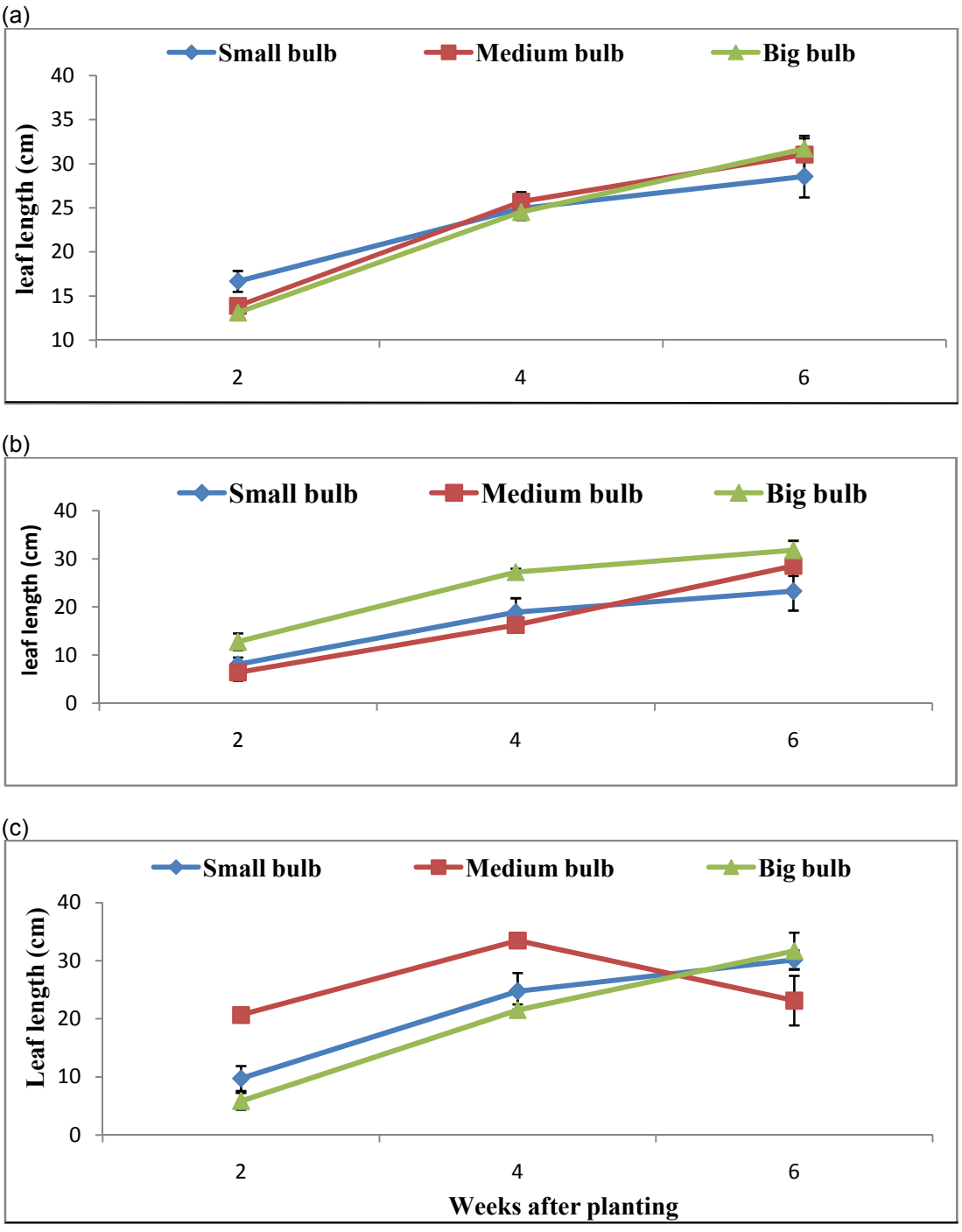

Fig. 1. Effect of bulb size on leaf length of (a) 'Bawku red', (b) 'White onion' and (c) 'Nigel brown' onion

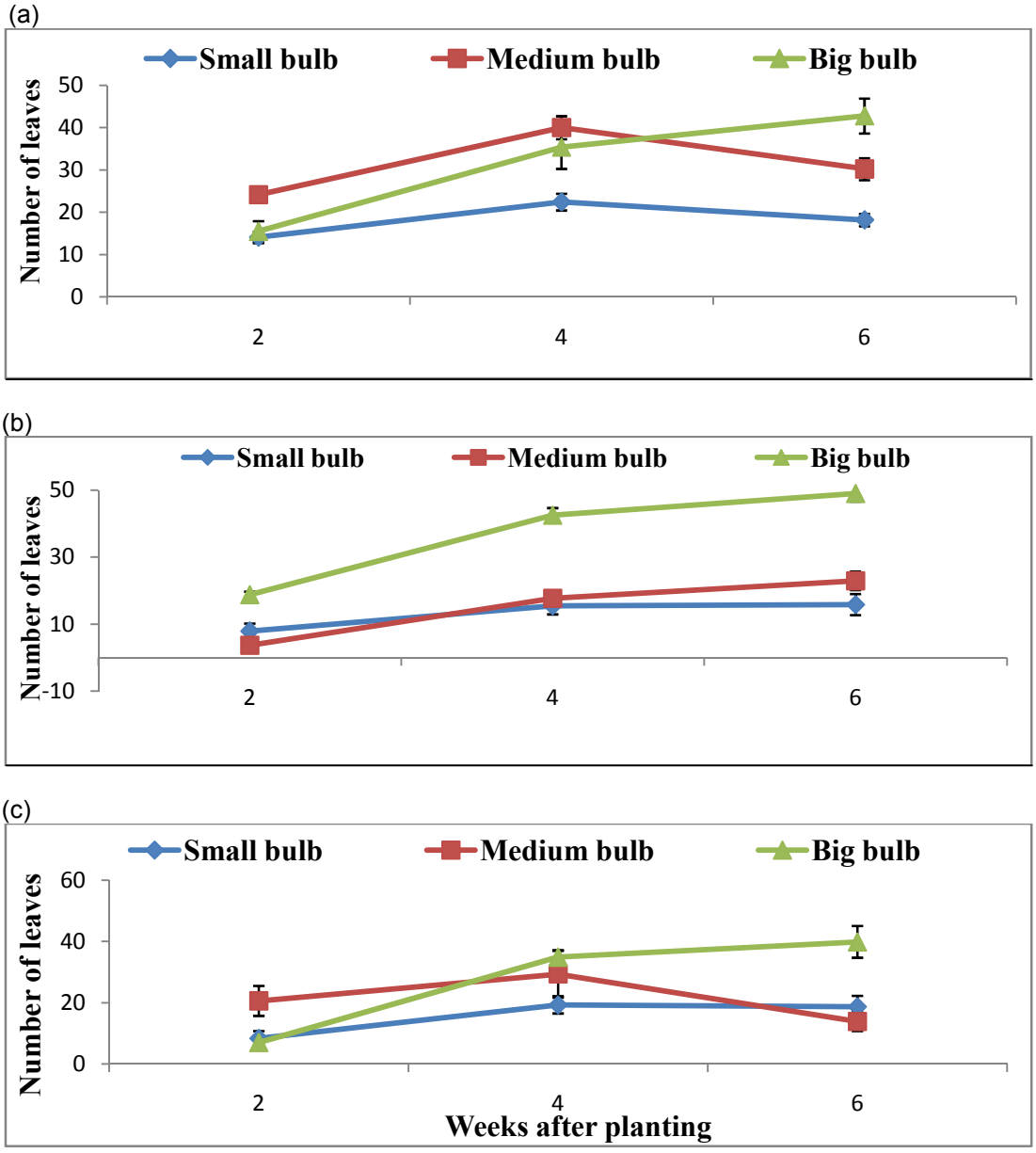

Fig. 2. Effect of bulb size on leaf production of (a) 'Bawku red', (b) 'White onion' and (c) 'Nigel brown' onion

3.3 Number of Tillers (Sprouts) and Harvested Bulbs Per Mother Bulb

The interaction between cultivar and bulb size was significant (Table 1). Among the bulb sizes, tiller number decreased in the order big bulb > medium bulb > small bulb but this decrease was not significant for all cultivars. In the case of cultivar, the decreasing trend was 'Bawku red' > 'White onion' > 'Nigel brown'. In general, plants produced from big bulbs of 'Bawku red' and White onion gave the highest tiller production while small bulbs of 'Nigel

brown' recorded the least number of tillers. Bulb sizes at planting also affected number of bulbs at harvest significantly ($p < 0.001$), though no significant difference was observed between plants produced from the small and medium bulbs. Cultivar, however, had no significant influence on number of bulbs produced (Table 2). The interaction between cultivar and bulb size was not significant.

Table 1. Influence of cultivar and bulb size at planting on tiller (sprout) number of onion

Cultivar	Bulb size			Mean
	Small bulb	Medium bulb	Big bulb	
Bawku red	12.75	21.25	32.50	22.17
White onion	13.25	15.50	32.75	20.50
Nigel brown	12.25	18.75	26.50	19.17
Mean	12.75	18.50	30.58	

CV (%) =20.8; LSD (0.05) Cultivar = Not significant; LSD (0.05) Bulb size = 3.61; LSD (0.05) Cultivar x Bulb size = 6.25

Table 2. Influence of cultivar and bulb size at planting on number of bulb at harvest

Cultivar	Bulb size			Mean
	Small bulb	Medium bulb	Big bulb	
Bawku red	11.50	14.50	17.75	14.58
White onion	8.00	9.75	21.75	13.17
Nigel brown	10.00	16.00	18.75	14.92
Mean	9.83	13.42	19.42	

CV % = 28.0; LSD (0.05) Cultivar = Not significcant; LSD (0.05) Bulb size = 4.55; LSD (0.05) Cultivar x Bulb size = Not Significant

3.4 Bulb Fresh Mass at Harvest per Mother Bulb

At harvest, 'Bawku red' gave the highest bulb fresh mass from all bulb sizes. Bulb fresh mass of 'White onion' was also high and was not significantly different from that of 'Bawku red' when big bulb was used for planting; however, 'White onion' recorded the least bulb fresh mass from either the small or medium bulb Fig. 3.

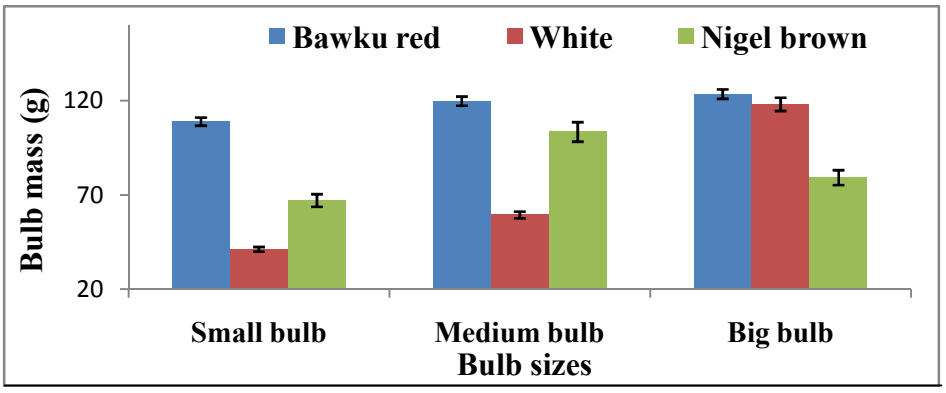

Fig. 3. Influence of bulb size on fresh mass at harvest of the three cultivars of onion used for the study

4. DISCUSSION

Results of the current study indicated that the larger the mother bulb size, the greater the bulb fresh mass at harvest. A similar observation has been reported elsewhere [11] and this was attributed to the relatively higher growth exhibited by plants produced from the big bulbs. The growth parameters decreased with decreasing bulb size in all cultivars. These observations are also consistent with the findings made by [12]. The increases in number of leaves were also directly related to the number of sprouts produced. That is the higher the number of sprouts the higher the number of leaves produced. In fact, research findings by [13] and those of [14] are in conformity with the observations made in the present study. In general, it has been established that large bulbs contain higher amounts of reserved carbohydrates [11,12] than small bulbs. The higher food reserves of large bulbs as compared with those of small bulbs were probably responsible for the higher sprouting initials and the production of higher number of leaves and sprouts of the large as compared to the small bulbs in this present study. In fact, it has already been established that [15], reserves stored in bulbs are used for the development of newly formed organs and once the leaves mature to become the photosynthate source, resources may be stored in the old and new leaf bases.

In general different bulb sizes exhibit significant variation in respect of leaf numbers per plant. In this study, the number of leaves per plant gradually increased in each cultivar from two to six weeks after planting but there was a reduction in this parameter in plants from the small bulbs as compared with those of the large ones. This reduction in leaf numbers in the case of the small bulbs probably was as a result of drying of the lower leaves of plants from this bulb group. Similarly, the increases in number of sprouts of large bulbs may be attributable to more shoot premodia formed. Each sprouted bulblet is capable of producing one or more bulbs. Therefore, the higher the number of sprouts produced, the higher were the number of bulbs counted at harvest. Sprouts and bulb production did not, however, vary significantly among the cultivars.

The highest bulb fresh mass was obtained from the big bulb. According to [16], big mother bulbs do not only have a higher food supply but they also have relatively high water content as compared to small and medium bulbs. According to [17] increases in moisture content significantly enhanced growth and bulb yield of onion. Thus in the present study, the relatively high water content of big bulbs might have aided growth and the production of high bulb mass. Similar trends in results have been reported by other workers [18,19,20,21,22]. It has been reported that [23], environmental conditions prevailing in an area may favour some traits over others and this results in some varieties or cultivars becoming relatively more adapted and superior to others. 'Bawku red' onion had superiority in terms of adaptation to the environmental conditions in Northern Ghana as compared to the other cultivars. This, among other factors, explains why this cultivar had advantage in almost all the growth and yield parameters considered in this study.

5. CONCLUSION

The study has revealed that the size of the bulb used for planting onion is very important for the growth and bulb production of the crop. Large bulbs produced higher number of leaves, sprouts and bulb fresh mass of onion as compared to those of small bulbs. The three cultivars used did not show any significant differences in vegetative growth, but large or big bulbs from 'Bawku red' or 'White onion' had higher bulb fresh mass than the other cultivar.

The study concludes therefore that when farmers use large bulb size (45-60 mm in diameter) of 'Bawku red' or 'White onion' as planting materials they will obtain good bulb production in Northern Ghana.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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