

INFLUENCE OF BULB SIZE AT PLANTING AND DROUGHT STRESS ON GROWTH AND DEVELOPMENT OF ONION (*Allium cepa* L.) IN THE NORTHERN REGION OF GHANA

ABSTRACT

Aims: To determine the effects of drought and bulb size on growth and bulb yield of onion bulb in the Northern Region of Ghana.

Study design: Levels of bulb sizes and watering regimes were factorially combined and replicated three times in randomised complete block design.

Place and Duration of Study: The study was conducted at the plant house of the University for Development Studies, Nyankpala in the Northern Region of Ghana from the 15th of July to 30th October, 2013.

Methodology: Three onion bulb sizes namely large bulb (44.3g), medium bulb (26.1g) and small bulb (16.7g) were planted in pots, each of capacity 0.01m³, and subjected to three levels of watering regimes: watering weekly throughout the experimental period, from the time of planting up to three weeks after planting, and from the time of planting up to five weeks after planting using randomised complete block design with three replications. Growth parameters, plant vigour and bulb yield at harvest were collected for statistical analysis.

Results: Drought stress did not significantly affect vegetative growth and bulb yield of onion but it played a crucial role in influencing plant vigour. Bulb size, however, influenced plant vigour, vegetative growth and bulb yield at harvest. In general, as the size of the planted bulb increased, growth and yield parameters also increased in proportion to the size of the planted bulb.

Conclusion: Onion growers in the Northern Region of Ghana should use large bulb sizes (44.3g) at the time of planting in order to get optimum bulb yield at harvest. Growers should also have access to irrigation facilities to supply water on their farms during the time of drought to maintain the vigour of plants especially when the crop is produced by planting small or medium bulbs.

Keywords: onion, bulb size at planting, drought stress, growth and development, plant vigour

1.0 INTRODUCTION

In West Africa, the cultivation of onion (*Allium cepa* L.) is concentrated in Burkina Faso, Northern Nigeria, Niger, Senegal and Northern Ghana. In Ghana, however, the crop is grown commercially in the Northern and Upper Regions especially in areas around Bawku, Bolgatanga and the Kusasi districts. Other production areas are Ashiama, Dawhenya, Akatsi, Nsawam, Prestea, Koforidua, Kwahu, Mankessim and the Berekum districts [1]. Onions are low in saturated fats, cholesterol and sodium and it is a good source of dietary fibre, vitamin B6, vitamin C and folate [2]. Onion is also used for the treatment of various ailments. For instance, the crop is used in the treatment of headache, snakebite and hair loss. Onion improves blood circulation and may reduce the incidence of heart attack and strokes [3]. It is also very useful in treating cancer and lowering cholesterol levels in man [4].

The use of onion bulb as planting material is preferred by most onion growers as compared to onion seeds during planting. This is because bulbs are easier to use as compared to seeds. Planted bulbs also sprout and mature earlier than seeds. In addition, bulbs produce true-to-type plants. But majority of onion farmers in the Northern Region of Ghana do not have good knowledge about the right bulb size to be used at the time of planting in order to get maximum bulb yields at harvest. Selection of optimum onion bulb size for planting is thus important, and onion growers must address this concern at the time of planting. [5] reported that in bulbous crops, bulb size affect plant height, number of leaves, length of scape, effective fruit per umbel, percentage of fruit set and seed yield. It is known that [6], large mother bulb has a high food and water supply as compared to a smaller bulb and therefore plants produced from the former are characterised by more vigorous growth and higher yields than those of the latter.

Onion is shallow rooted and sensitive to water stress. The crop requires regular watering throughout its growth for best production. [7] reported that drought stress may decrease growth and bulb yield at harvest. [8] stated that water deficits should be avoided especially during the period of bulb formation in order to obtain high bulb yield at harvest. Studies in the United States have indicated that onion plants stressed prior to bulb formation recorded reduced bulb sizes that were not acceptable as market grades. Those plants stressed after bulb formation were also prone to re-growth problems which resulted into serious storage problems [9]. The time of water stress in onion therefore determines the degree of yield and grade loss. [10] observed that soil water stress at any growth stage leads to reduction in marketable yield at varying levels. Knowing the response of onion to drought stress in the Northern Region of Ghana will improve productivity of the crop in the area. Similarly, a good knowledge about the right size of bulb for planting in the area will not only increase the yield but improve the quality of onion produced. This study was therefore conducted to determine the influence of drought on development of onion, and also to know which bulb size at planting will produce the best growth and bulb yield at harvest in the study area.

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67 **2.0 MATERIALS AND METHODS**

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69 **2.1 Description of the experimental site**

The study was conducted at the University for Development Studies, Nyankpala in the Northern Region of Ghana. The experimental site was located on an altitude of 183 m above sea level, but on latitude 09° 25' 41" N and longitude 0° 58' 42" W of the equator. The relative humidity of the area rises to a maximum monthly value of about 87% during September and with a minimum monthly value of 44% in January. The annual rainfall is about 316.41 mm per annum while the annual temperature is 24°C in January and 39°C in March. The area lies within the interior Guinea Savannah agroecological zone of Ghana. The vegetation is dominated by grasses and few shrubs. The soil is considered to be an alfisol under the USDA system of classification [11]. It is brown, moderately drained sandy-loam free from concretions, very shallow with hardpan under the top few centimeters developed from voltarian sandstone and classified as Nyankpala series or Plinthic Acrisol [12]. The soil has a pH range of 4.85 – 5.15; effective CEC of 2.65 – 3.85 Cmol/kg; 0.18 g/kg available N; 2.88 mg/kg P; 8.8 – 9.0 mg/kg K; and 0.85% organic matter.

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83 **2.2 Design and layout of experiment**

The most popular onion cultivar 'Bawku red' in the area was used for the study. Three groups of bulb sizes namely 44.3g, 26.1g and 16.7g representing the large, medium and small bulbs, respectively, were planted in pots, each of capacity 0.01 m³, filled with Nyankpala soil series (Plinthic Acrisol). The bulbs were placed upright and planted at a depth of 2 cm from soil surface. The planted bulbs were subjected to the following three levels of watering regimes after emergence: watering plants throughout the experimental period as and when watering was necessary, watering plants from the time of planting up to three weeks after planting and watering plants from the time of planting up to five weeks after planting. The treatment combinations were replicated three times in a randomized complete block design.

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2.3 Data collection and analysis

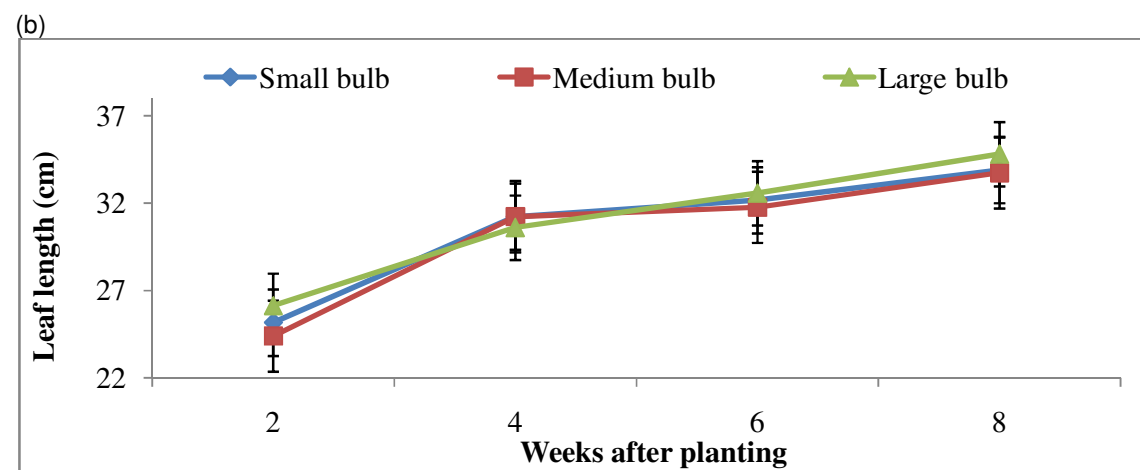
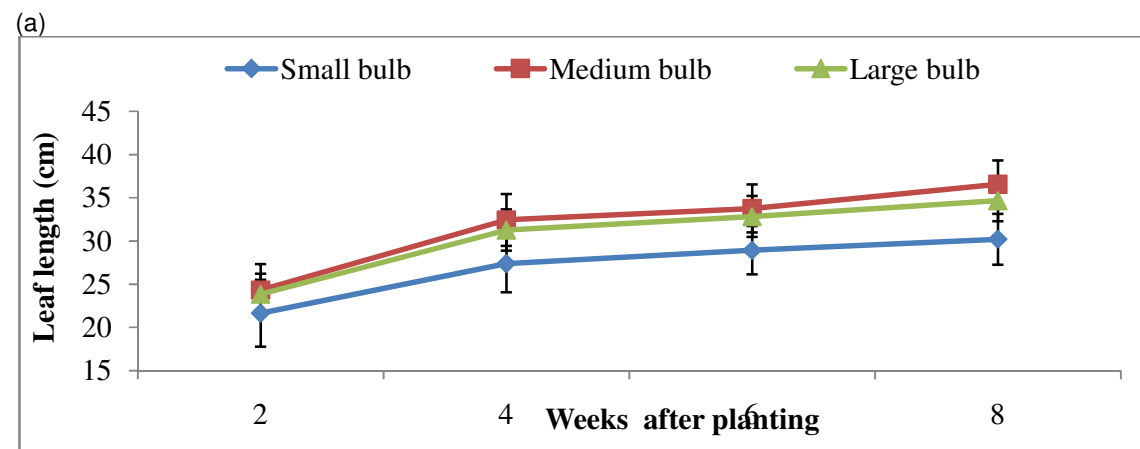
Data were collected on leaf length, number of leaves, numbers of tillers and bulb fresh weight at harvest. Plant vigour was also scored based on physical appearance and health of the plant stand. Considerations were given to the general plant performance and plant weakness resulting from water stress. Characteristics such as leaf greenness, plant growth rate, wilting or drooping of leaves were of paramount importance during scoring. In general, plants were scored on a scale of 1 – 5, where 1 = very weak plant, 2 = weak plant, 3 = moderately weak plant, 4 = healthy plant and 5 = very healthy plant. The vigour score data were transformed using the formula $\log_{10}(x+1)$ where x = raw vigour score values of the plants and 1 = transformation constant. All data collected were subjected to the

Analysis of Variance using Genstat (Discovery Edition) and the least significant difference (LSD) was used to separate the treatment means at $P = 0.05$.

3.0 RESULTS

3.1 Leaf length

In general, values recorded of leaf length did not differ significantly ($p > 0.05$) among the three bulb sizes irrespective of the level of water stress (Figs 1a, b and c).



(c)

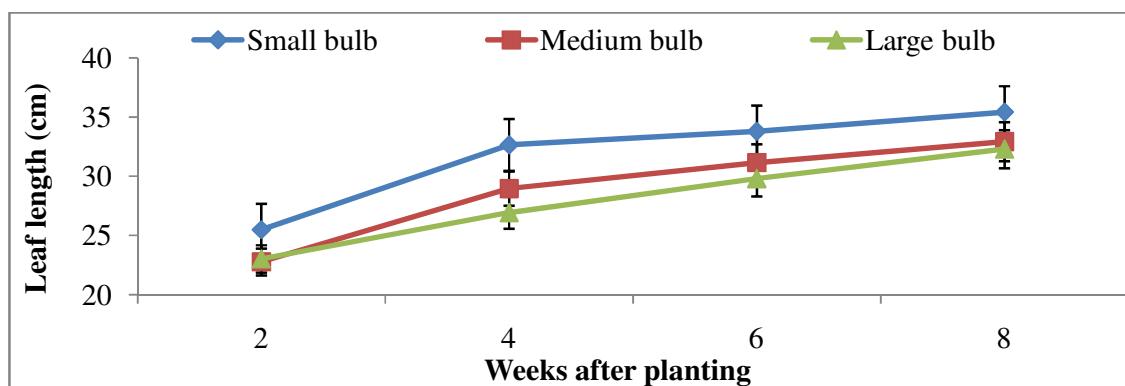
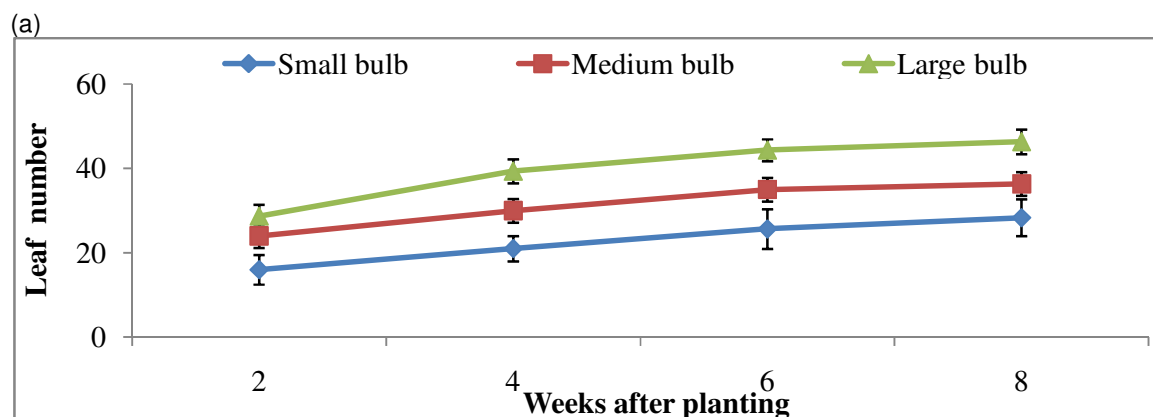


Fig 1: Variations in leaf length of onion when plants were watered (a) throughout the experimental period (b) up to three weeks after planting and (c) up to five weeks after planting. Bars represent means $\pm$ SE of 3 replicates.

3.2 Leaf number

Leaf production varied significantly ($p < 0.05$) among the various bulb sizes. Plants obtained from the large bulbs consistently and significantly recorded the highest leaf number, followed by those from the medium bulbs, while plants obtained from the small bulbs gave the lowest values of leaf number in all watering regimes (Figs 2a, b and c). Number of leaves produced did not vary significantly ($p > 0.05$) among the various drought regimes. When plants were watered throughout the experimental period (Fig 2a), leaf numbers recorded from 2 to 8 weeks after planting ranged from 29-46, 24-36 and 16-28 for plants obtained from the large, medium and small bulbs, respectively (Fig 1a). During that same period, plants subjected to water stress at three weeks after planting also produced 34-47, 19-29 and 17-26 leaves from the large, medium and small bulbs, respectively (Fig 1b). Similarly, plants stressed at five weeks after planting produced from 34-48, 21-33, and 18-27 leaves from the large, medium and small bulbs, respectively (Fig 1c).



(b)

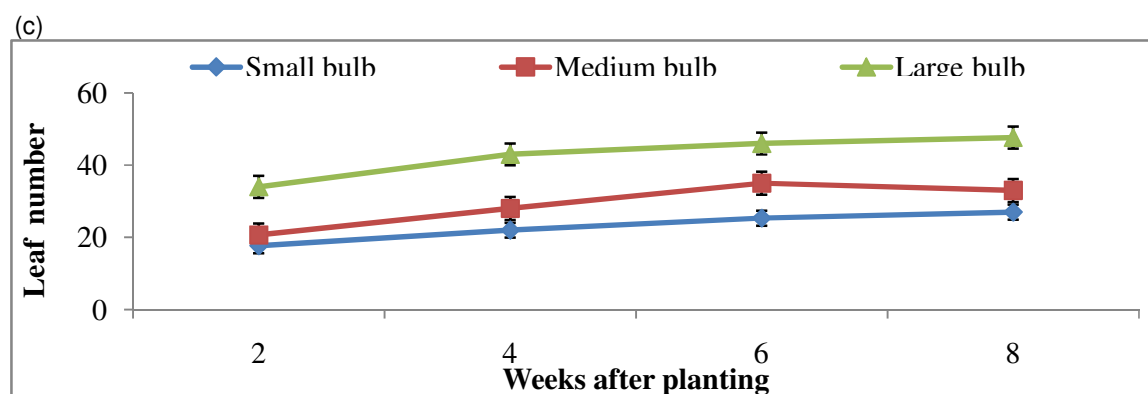
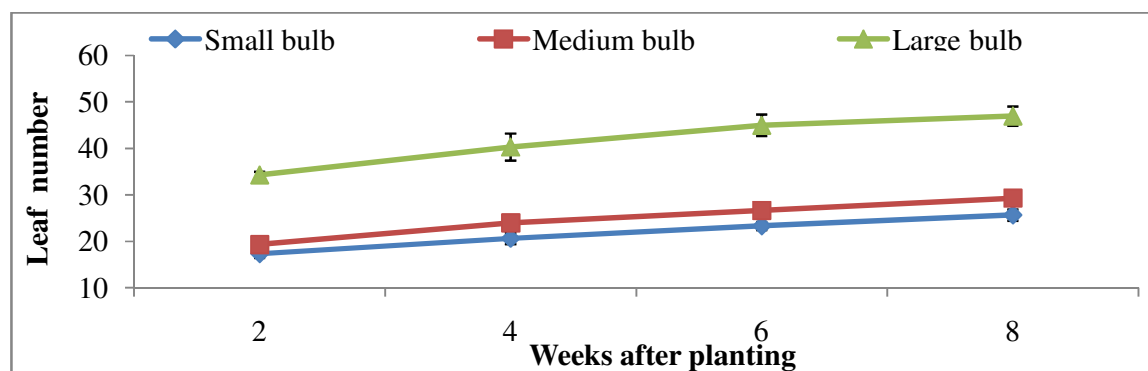


Fig 2: Variations in leaf number of onion when plants were watered (a) throughout the experimental period (b) up to three weeks after planting and (c) up to five weeks after planting. Bars represent means $\pm$ SE of 3 replicates.

3.3 Vigour score

Values for vigour rating were similar for the various bulb sizes when plants were watered either throughout the experimental period or up to five weeks after planting (Figs 3a and c). However, when plants were subjected to water stress at three weeks after planting, the plants obtained from the large bulb significantly recorded ($p < 0.05$) the highest vigour especially at 8 weeks after planting (Fig 3b).

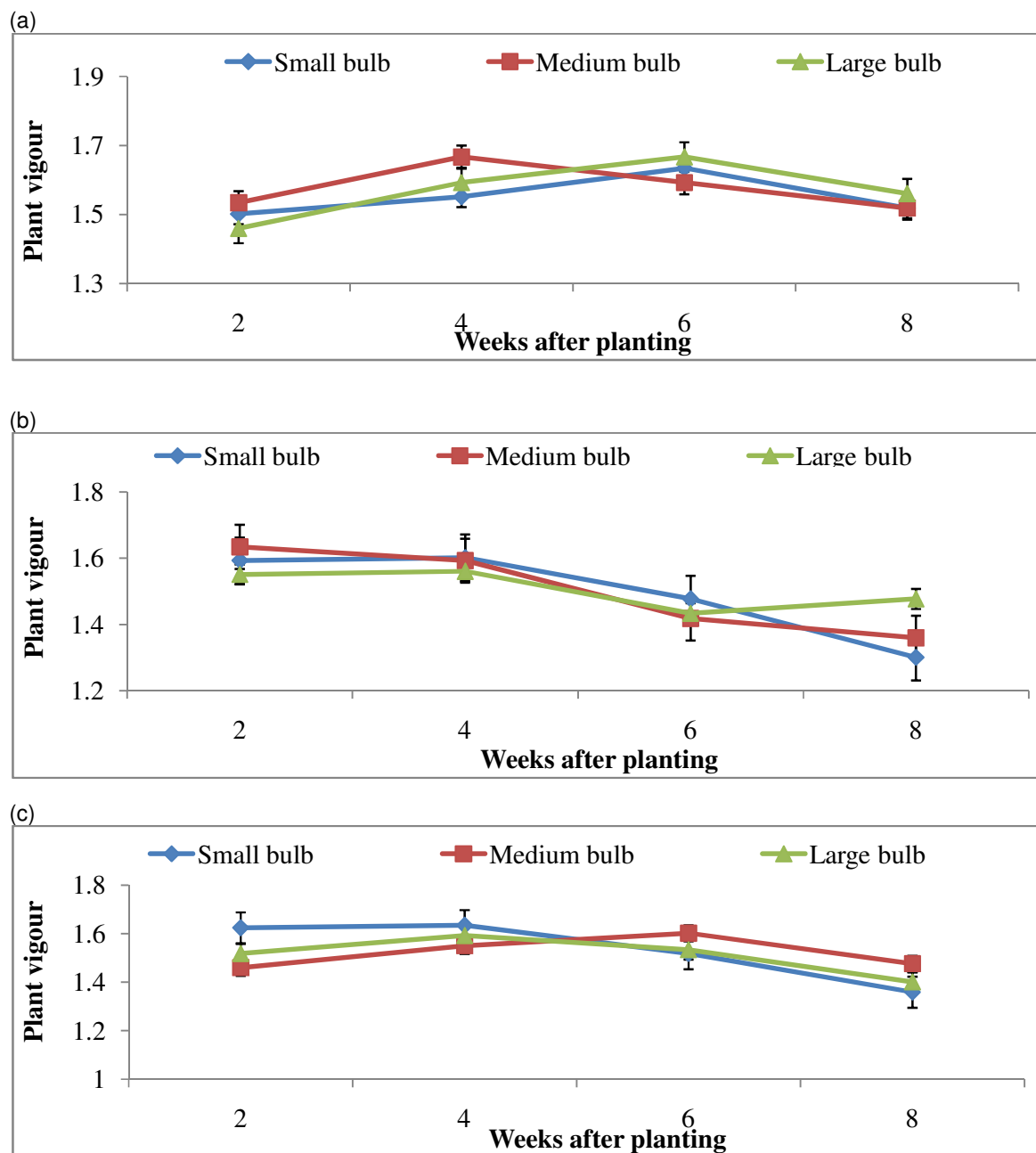


Fig 3: Variations in plant vigour of onion when plants were watered (a) throughout the experimental period (b) up to three weeks after planting and (c) up to five weeks after planting. Bars represent means $\pm$ SE of 3 replicates.

3.4 Number of tillers

For tiller production, a highly significant variation ($p < 0.01$) existed among bulb sizes but no significant differences ($p > 0.05$) were observed among the three watering regimes. The interaction between bulb size and watering regime was also significant ($p < 0.05$). The single effects of bulb size

indicate that there was no significant difference between the small (mean of 5.22) and medium bulb (mean of 6.44), but significant difference existed between the small and the large bulb or the medium and the large bulb. Plants from the large bulb produced the highest tiller number while those from the small bulb recorded the lowest. In all, the highest number of tillers was produced by plants of the large bulb that were subjected to water stress at three weeks after planting (Table.1).

Table 1: Variations in tiller number of the three bulb sizes

Bulb size	Watering regimes			Mean
	Watered	Watered up to three	Watered up to five	
	throughout	weeks after planting	weeks after planting	
Small bulb	5.67	4.67	5.33	5.22
Medium bulb	8.00	5.33	6.00	6.44
Large bulb	10.33	12.00	11.00	11.11
Mean	8.00	7.33	7.44	

LSD (0.05): Bulb size = 2.16; Watering regimes = 2.16; Bulb size × Watering regime = 3.73

3.5 Bulb yield at harvest

Bulb fresh weight at harvest differed significantly ($p < 0.05$) among bulb sizes but no significant variations ($p < 0.05$) were observed among the watering regimes. The interaction between bulb size and watering regime was also significant. Plants from the large bulb produced the highest bulb fresh weight at harvest while those from the small bulb recorded the least. The highest bulb fresh weight was obtained when plants of the large bulb were subjected to water stress at three weeks after planting (Table.2).

Table 2: Variations in bulb fresh weight of the three bulb sizes at harvest (g)

Bulb size	Watering regimes			Mean
	Watered	Watered up to three	Watered up to five	
	throughout	weeks after planting	weeks after planting	
Small bulb	6.78	5.78	6.44	6.33
Medium bulb	9.11	6.44	7.11	7.55
Large bulb	11.44	13.11	12.11	12.22
Mean	9.11	8.44	8.55	

LSD (0.05): Bulb size = 1.12; Watering regimes = 1.26; Bulb size × Watering regime = 2.54

4.0 DISCUSSION

Bulb size used for planting is very important in the selection of planting materials for bulb production. In the present study, bulb size influenced vegetative growth and bulb yield of onion at harvest. In general, as the size of the planted bulb increased, leaf lengths, leaf numbers, tiller numbers and fresh weight of bulbs at harvest also increased. The observation made here agrees with the results reported by [13]. According to these authors, higher vegetative growth and yield occurred when large bulbs were used as planting materials while small bulb sizes recorded low growth rate. The increase in number of leaves was also directly related to the number of tillers produced. [14] also worked on Irish bulb and reported that weight was an important indicator for flowering in that species. In onion, as in other bulbous crops, vegetative growth is observed mainly as increase in tiller and leaf production. The observed increase in growth or number of leaves and tillers in the present study could be explained using the concept of source-sink relationship. Leaves and tillers are important sink organs that depend on the reserves stored in the bulb for growth and development. The increase in leaves and tillers in this study was proportional to the size of the planted bulb. In fact, the observed increase in vegetative growth of plants produced from the large bulb also led to high bulb yield as compared to those from the medium and the small bulbs. According to [15], in vegetatively propagated plants, large planting materials are characterized by higher and more conspicuous reduction in weight during sprouting than small bulbs, and the higher the reduction in weight during sprouting, the higher the vegetative growth and yield at harvest. A large bulb does not only have a large food supply but also high water content [6], and all these enhanced good vegetative growth, high plant vigour and high bulb yield at harvest. The results presented in this study also confirm the findings of my earlier work [16] on ornamental geophytes that reserved carbohydrates play a crucial role in the growth and development of bulbs.

Subjecting the plants to drought at 3 or 5 weeks after planting in the present study did not significantly affect vegetative growth of onion. According to [17], onions are more sensitive to water stress during bulb elongation than they do in the vegetative stage. [18] also stated that the most critical growth period of onions to water stress is the bulb formation and development stage. The effect of water stress not being significant on vegetative growth of onion, among other factors, could be attributed to the duration of the stress period. Either the duration of drought might not have been long enough to adversely affect the parameters measured on the crop, or that the variety of onion used in this study was genetically tolerant to drought stress. In fact, [19] reported that reducing or cutting irrigation by 25% had little effects on onion growth and bulb yield whereas large irrigation reductions resulted in large yield drops. Results from the present study also revealed that, in general, increases in plant vigour were associated with increase in bulb size at planting. This finding is in agreement with the observation made by [6] who reported that plants obtained from a large mother bulb recorded vigorous plant growth. In the present study, plants produced from the large bulb significantly recorded higher vigour (Fig 3b) than those from the small or medium bulbs. Vigour ratings were similar for the various bulb sizes when plants were watered either throughout the experimental period or watered up to 5 weeks after planting. But when plants were subjected to water stress at 3 weeks after planting, the plants obtained from the large bulb significantly recorded the highest vigour. Subjecting plants to drought stress at 3 weeks after planting implies that these plants had a longer period of drought stress than those stressed at five weeks after planting. Thus when plants were stressed for this longer period (watered up to 3 weeks after planting), only plants obtained from the large bulbs were vigorously growing. The higher plant vigour associated with plants produced from large bulbs probably was as a result of their higher storage reserves and water content as compared with those of small or medium bulbs. The low vigour rating which characterized plants from the small or medium bulbs during water stress is an indication that application of water to onion especially when they are planted from small or medium bulbs would be important in maintaining vigour for increased bulb yield and quality at harvest. Similarly, the relatively higher vegetative growth of plants obtained from the large bulb is an indication that in bulbous crops, plants produced from large bulbs mature quickly to reach senescence earlier (Volaire, 2002) than those obtained from medium and small bulbs.

5.0 CONCLUSION

In onion production, the bulb size used for propagation is very important in the selection of planting materials for bulb production. Bulb size influenced vegetative growth, plant vigour and bulb yield of onion at harvest in this study. In fact, as the size of the planted bulb increased, growth and yield parameters also increased. However, drought stress did not significantly affect these parameters probably because the duration of drought was not long enough to adversely affect the parameters measured, or perhaps the variety of onion used was tolerant of drought. Onion farmers in the Northern Region of Ghana should use large (44.3g) bulb size for planting in order to achieve good quality and high bulb yield at harvest. Farmers should also have access to irrigation facilities to supply water on their farms during the time of drought to maintain the optimum plant vigour particularly if small or medium bulbs are used as planting materials for propagation.

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AUTHORS CONTRIBUTION

Dr. I.K. Addai designed the study, supervised data collection and wrote the first draft of the manuscript. Mr. G. Oduro performed the statistical analysis while Mrs H. Takyi read through the work and edited it after it had been drafted by Dr. I. K. Addai.

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