CHAPTER ONE

INTRODUCTION

Common onion (*Allium cepa* L.) is one of the main most important vegetable crops in the world. It is grown for many purposes, namely, fresh shoots for salad, cooked, pickled, processed and dehydrated bulbs for enhancement of other food flavor or sets for seed production (Randle, 2000 and Brewster, 2008).

The world onion production increases with the extreme increases of onion demands and consumption (Ansari *et al*., 2009). The world total area under onion is 364.04 million hectares with production of 742.51 million tons. China is the largest onion producer followed by India (205.08 and 133.72 million tons, respectively, (Anonymous, 2012). In Sudan the area under onion is 33% of the total area devoted for vegetables (102 thousand hectares) with production of 158.3 thousand tons (Anonymous 2015).

Onion can be raised either by one of three methods: direct seeding, seedlings or sets. In the Sudan onion is produced predominantly in the winter season from seedlings (bulbules) raised in the nursery (August-October) and transplanted in the field. Direct seeding is not adopted due to short winter season and scarcity of machinery. However, one of the most important methods is off-season production from onion sets (Nourai *et al*., 2010).

Onion sets are small typical bulbs weighing 2-3 g fresh weight and 20-25mm in diameter. They are produced by direct seeding at very high seed rate (1000-2000 plants/m^2).Thereafter onion sets are planted for off-season onion production. Because of their size, the sets make more robust plants at emergence than seeds. (Brewster, 2008). Moreover they have advantages compared to the direct seeding;

namely, they are easy to transplant, store and handle compared to seedlings, they are highly competitive to weeds and give an early high off- season yield and so high returns. Nevertheless, they fill the gap of off-season demand and give potential for onion export and onion seed production. However, onion production from sets has some disadvantages; namely, they may be a –contamination source with soil borne pests and diseases (stem and bulb eelworm (*Ditylenchus dispsaci),* onion white rot (*Sclerotium cepivorum*), and yellow dwarf viruses disease).They are of poor quality bulbs (of high percentage of doubling, splits and bolting) in addition to high production costs (cost of set production, sets storage and off-season crop). Off-season production is practiced by few farmers in Naher El-Neil, Northern and Darfur states (Nourai *et al.,* 2010)

Onion is highly sensitive to nutrient deficiency because of its shallow and unbranched root system. It requires fertile, well drained, non crusting and light acidic (pH 6-6.8) soil.

Nutrient requirements vary with production location, and soil type. Organic fertilizers such as sheep and chicken manure were used to improve soil physical (structure and aggregation) and chemical properties (cation exchange capacity (CEC) and pH) and enhance root absorption of most nutrients. (Moradi, 2015).

Abdel Naby *et al.* (2012) reported that increasing the level of NPK fertilizers increased mineral uptake and so vegetative growth and yield of onion. However, few studies were carried out on the effect of the onion set size and their fertilizer requirements for off-season production. Therefore this study was carried out to achieve the following objectives:

- To find the best set size to have the highest yield and quality of early onion production.

- To study the effect of organic (Elkhasseb) and chemical fertilizers (Urea and NPK and the combination of Urea, NPK with the organic) on growth, yield and quality of off-season onion.
- To investigate the response of different onion set sizes to fertilizer applications.

CHAPTER TWO

LITERETURE REVIEW

2-1-1: Effect of set size on vegetative growth:

Set size and spacing influence plant growth and bulb size (Mondal *et al*., 1986). Many researchers (Mondal *et al*., 1986, Shalaby *et al*., 1991, Munoz *et* al., 1995 and Khokhar and Hadley, 2007) reported on the positive effect of set size on off-season onion growth and production. Islam *et al*. (1999) found that smaller sets (1.6 g) showed faster growth rate compared to large sets (2.44g) but the heaviest bulbs were obtained by the large ones. Yamaguchi (1980) and Khokhar (2008) reported that the diameter of the set is the primary factor that affects bulb or flower stalk production and the ideal size of the set should be 1.5-2.0 cm in diameter. Bulbs greater than 2.5 cm in diameter would be prone to early bolting.

Ansari *et al.* (2009) found that large set sizes (≥1.5-2.0 cm in diameter) were noted to have positive effect on the vegetative growth (tall plants, with high number of long leaves and high percentage of bolting).

2-1-2: Effect of set size yield and quality:

Seetohul and Hanoomanjee (1999) and Cheema *et al.* (2002) reported that small set size (1.5 - 2.0 cm) gave high bulb yield and quality. Islam *et al*. (1999) showed that large set size (2.4 g) gave the highest bulb yield (22.6 t/ha) with high nitrogen application (120 kg N/ha) compared to small set size (1.6 g). Smaller set gave more number of single bulbs. Matimati *et al*. (2006) showed that large sets produced triple unmarketable bulbs with comparable bulb weight. Similarly Ansari *et al*. (2009) reported that the large set (2.5 cm in diameter) produced the heaviest bulbs but more double bulbs than the small set. Khokhar *et al*. (2002), however,

recorded the highest marketable yield using medium set size. Moreover, it reduced the percentage of bolting bulbs, i.e. improved bulb quality.

2-2: Effect of fertilizer type:

Onion is more susceptible to nutrient deficiencies than most crop plants because of its shallow and unbranched root system. However, its response depends on growth stage (set size) and fertilizer type (Brewster, 1994 and Dapaah *et al.*, 2014). Application of chemical fertilizers (NPK) alone generates several deleterious effects on the environment and human health. They should be replenished every season because they are rapidly lost either by evaporation or by leaching in drainage water, causing dangerous environmental pollution (Aisha *et al.*, 2007). In addition, continuous usage of inorganic fertilizer affects soil structure and fauna. Hence organic manure can serve as alternative to mineral fertilizers (Naeem *et al*., 2009 and Abdel Naby *et al.*, 2012) .The amount to be applied depends on the type and fertility status of the soil, however, it requires identification of optimum fertilizer dose (organic, inorganic or combination). Integrated nutrient management is a vital strategy for promoting efficient use of chemical fertilizers in combination with organic manure (Yohannas *et al.*, 2013).

2-2-1-1: Effect of organic fertilizer on vegetative growth:

Mousa and Mohamed (2009), Dapaah *et al*. (2014) and Shedeed *et al*. (2014) stated that different types of organic fertilizers increased the onion vegetative growth parameters (plant height, leaf length and bulb diameter and fresh weight), in addition to uptake of N, P, K, Ca and Mg. Kwada *et al*. (2015) reported that application of 5.5 t/ha of poultry manure gave the highest plants. Similar results were reported by Reddy and Reddy (2005) and Bagali *et al*. (2012) showing that the application of different types of organic fertilizer (vermicompost at 6t/ha, poultry

manure at 3t/ha and farmyard manure at 30 t/ha) had similar significant effects on plant growth giving the highest plants and the highest number of leaves/plant.

Application of 15- 20 t/ha of poultry manure produced the highest number of leaves per plant than NPK and control. Kandil *et al*. (2013) reported that the lowest plant height and number of leaves were recorded by application of 35 t/ha organic manure. However, Reddy and Reddy (2005) observed that the highest plant height of onion was obtained with the highest combination of vermicompost (30 t/ha) and nitrogen (200 kg/ha) compared to the lowest dose (10 t/ha and 50 kg/ha).

2-2-1-2: Effect of organic fertilizer on yield and quality:

Addition of farmyard manures 15-20 t/ha gave the highest onion yield (Abdelrazzag, 2002, Eldardiry, 2015 and Kwada *et al*., 2015). However, Aisha *et al*. (2007) and Kandil *et al*. (2013) reported that the lowest onion yield and quality (total soluble solids and dry matter) were obtained with addition of the lowest (4 t/ha) or the highest (35 t/ha) dose of farmyard manure. Nevertheless, Abdel Naby *et al.* (2012) found that it had significant positive effects on bulbs fresh weight and diameter and total yield compared to other organic fertilizer or NPK alone.

2-2-2: Effect of nitrogen fertilizers:

Nitrogen is the principal plant nutrient required in higher quantities. It is the important component of proteins, enzymes and vitamins in plants and it is the central part of essential photosynthetic molecule and chlorophyll. Moreover, it is an important component of most metabolic processes. (Marschner, 1995).

2-2-2-1 Effect of nitrogen fertilizers on vegetative growth:

Many researches (Kumar *et al*., 2001, Lemma and Shimelis (2003), Khan *et al.*, 2007, Dina *et al*., 2010, and Abdissa *et al*., 2011) studied optimum dose of nitrogen to have optimum plant growth and yield. Their recommendations, however, varied widely. Nasreen *et al.* (2007) found that addition of 120 kgN/ha increased significantly the number of leaves/plant and plant height compared to control. Islam *et al.* (1999) stated that addition of nitrogen up to 180 kgN/ha gave the highest plants and the highest number of leaves/plant.

Yaso *et al*. (2007) and Moradi (2015) revealed that increasing mineral nitrogen levels (214 kgN or 300 kg urea/ha) led to significant increases on plant height and number of leaves of onion. However, Abdissa (2011) stated that the application of 69- 92 kgN/ha increased significantly number of leaves/plant, leaf length and plant height of onion. Kumar *et al*. (2001) stated that the highest doses of nitrogen up to 130 kg/ha gave the highest number of green leaves.

2-2-2-2: Effect of nitrogen fertilizers yield and quality:

The increase of vegetative growth due to nitrogen application (120 up to 150 kg urea/ha or 120 kgN/ha) was reflected on onion yield (bulb size and weight) as stated by Moradi (2015) and Nasreen *et al*. (2007). Moreover, Tsegaye *et al.* (2016) showed that the lowest nitrogen dose (100 kg/ha) gave the highest marketable and total yield of onion compared to the highest doses (150 – 200 kgN/ha). Similar results were also obtained by Islam *et al.* (1999) showing that the largest bulbs and the highest yield were obtained at 120 kgN/ha compared to 180 kgN/ha.

However, Moursy *et al.* (2007) found that addition of a higher nitrogen dose (190 kgN/ha) gave significant increases in onion yield and quality (bulb diameter and total soluble solids) compared to lower rate (95 kg/ha).

Many researchers (Romamoorthy *et al.*, 2000, Yaso *et al.*, 2007, Abdissa, 2011, and Soleymani and Shahrajabian, 2012) reported that higher doses of nitrogen up to 214 kg N/ha increased both onion yield (bulb weight) and quality (marketable yield, bulb diameter, dry matter and total soluble solids).The same result was reported by Yohannas *et al.* (2013) showing that the maximum rate of nitrogen (150 kg/ha) increased bulb length compared to control.

Brewester (1987) reported that the neck-thickness is a physiological disorder that is influenced by season, site and cultivars. However, Jilani (2004) reported that neck-thickness of onion bulb was due to high nitrogen doses (200 kgN/ha). Fatideh and Asil (2012) reported that using nitrogen at 150 kg/ha reduced the bulb weight and recorded higher bulb dry matter. Whereas, Moradi (2015) found that application of 300 and 1500kg/ha urea increased fresh weight, bulb volume, bulb diameter and nitrate concentration compared to control. Moreover, Tsegaye *et al.* (2016) reported that increasing nitrogen and irrigation frequency increased bulb size.

2-2-3-1: Effect of combination of nitrogen, phosphorus and potassium (NPK) on vegetative growth:

The positive significant effects of balanced NPK fertilizer on growth of many vegetables compared to a single dose of nitrogen, phosphorus or potassium were reported by many researchers. Abdel Naby *et al.* (2012) found that a balanced combination of NPK fertilizer gave the highest value of plant height. Moreover, many investigators (Bagali *et al.*, 2012, Kandel, *et al.* 2013 and Shedeed *et al.*, 2014) reported that the NPK combination of 162-214 kg N/ha, 32-71 kg P/ha and

57-148 kgK/ha, respectively, increased onion vegetative growth (plant height and number of leaves /plant) compared to their application as single doses.

2-2-3-2: Effect of combination of nitrogen, phosphorus and potassium (NPK) on yield and quality:

Yoldas *et al.* (2011) showed that the recommended dose (120:100:150 NPK) influenced significantly bulb width, number of storage leaves, bulb yield and bulb weight and height. Also many researchers, Bagali *et al.* (2012), Kandil *et al.* (2013) and Kadiri *et al.* (2015) reported high onion yield (bulb weight) and quality (increased marketable yield, total soluble solids and dry matter) due to high combination of NPK(81-214 kgN/ha,16-71 kgP/ha and 57-148 Kg K/ha) compared to single doses of them. Rahman (2006) reported high bulbs dry matter with a combination of NPK alone or with organic fertilizer.

2-2-4-1: Effect of combination of organic and mineral fertilizers on vegetative growth:

Reddy and Reddy (2005) observed that the highest number of leaves/plant was recorded with 30 t/ha vermicompost with 200 kgN/ha. Singh and Ram (2011) reported that maximum onion vegetative growth (plant height, number of leaves and bulb diameter) were obtained with 50% farm yard manure and the recommended dose of NPK. Yohannas *et al.* (2013) reported that the addition of 45 t/ha farmyard manure with 150 kgN/ha gave the highest number of leaves.

2-2-4-2: Combination of organic and mineral fertilizers on yield and quality:

Yohannas *et al.* (2013) reported that the addition of 45 t/ha farmyard manure with 100 or150 kgN/ha increased the bulb weight and gave the highest marketable yield. Aisha *et al*. (2007) obtained the highest bulb weight, length and diameter as well as chemical value (TSS and mineral content) with town refuse (organic fertilizer) and NPK application. Moreover, Yoldas *et al*. (2011) Dapaah *et al*. (2014) , Shadeed *et al*. (2014) and Kadiri (2015) found that the combinations of cattle or poultry manure with NPK recorded the highest bulb yield and quality compared to single fertilizers alone, Singh and Ram (2014) reported high onion yield with fertilizer combination (Organic + nitrogen) compared to single fertilizer.

CHAPTER THREE

MATERIALS AND METHODS

Location of experiment:

The experiment was conducted at the Experimental Farm of Shambat Research station, Agricultural Research Corporation, Khartoum North, Sudan, (Lat 15° 40´N and long. 23° 32´ E. and 281m above sea level), during the period August-December 2015.

The maximum and minimum temperatures were 35 °C and 25°C, respectively. The mean daily temperature was 30°C.The average relative humidity (RH) and rain fall were 33% and 22.5 mm, respectively. (Appendix 1).

The Materials:

The planting material used was onion set of the cultivar Baftaim (S). (Appendix 2). They were produced by direct seeding during the main season (December to May) and stored in normal store till planting in August (0ff-season).

Methods:

Two set size, namely large (2-3cm) and medium (1-2cm) in diameter, were selected from previously mentioned stock. Three fertilizer types namely Elkhasseb (Appendix 3), Urea and NPK 15:15:15 were used.

Treatments:

The treatments tested consisted of two set size (large and medium) and four fertilizer combinations, namely Urea, Urea +Elkhasseb, Elkhasseb and Elkhasseb + NPK, which were combined as follows:

1. Large sets + 240 kg/ha urea.
2. Large sets+ 240 kg/ha urea +20 t/ha Elkhasseb.
3. Large sets +20 t/ha Elkhasseb.
4. Large sets +20 t/ha Elkhasseb +120 kg/ha NPK.
5. Medium sets +240 kg/ha urea.
6. Medium sets +240 kg/ha urea +20 t/ha Elkhasseb.
7. Medium sets+20 t/ha Elkhasseb.
8. Medium sets + 20 t/ha Elkhasseb +120 kg/ha NPK.

Cultural practices:

The soil was ploughed, leveled, and divided into plots (Experimental units). Each plot consisted of 60 cm ridge wide, each of 3m in length. The gross area of the plot was (10.3 m^2) and its net area planted was (5.4 m^2). Each plot contained 3 ridges.

Onion sets were planted on 18th and19th August, 2015 in three rows on each ridge at 10 cm within row spacing. They were irrigated at 7-10 days intervals (16 irrigations). The missed plants were replanted after 11days from planting.

Weeds were controlled by the herbicide Goal after 24 days from planting and four times manually, thereafter.

Elkhasseb was added by broadcasting as one dose before planting. Urea and NPK were applied in two doses after one and two months from planting, respectively. The crop was harvested after 156 days from planting (at neck - fall).

Data collected:

- Vegetative growth parameters:

  After 3 and 4 months from planting 5plants were randomly selected from each experimental unit to evaluate the following parameters:

1. Plant height (cm):

The height of the five plants was measured from the base of bulb to the tip of the last leaf and the average plant height was recorded.

2. Number of leaves:

The number of leaves of the same plants was counted and the average leaf number per plant was recorded.

3. Leaf length (cm):

The leaf length of the same plants was measured from the leaf base to the tip and the average leaf length was recorded.

- Yield and yield components:

1. Bulb weight (g):

Five bulbs were selected randomly from sound harvested bulbs weighed and the average weight per bulb was calculated.

2. Total yield (t/ha):

The total yield /plot was recorded from meter square and the yield /ha was calculated as follows:

$$\text{Yield (t/ha)} = \frac{\text{Yield/plot(t)}}{\text{Planted plot area (ha)}}$$

3. Marketable yield (sound bulbs) (t/ha):

The total yield of sound bulbs/plot was recorded and the yield/ha was calculated as for total yield.

4. Percentage of double bulbs (%):

The double bulbs/plot were weighed and their percentage from the yield/plot was calculated.

5. Percentage of bolter bulbs (%):

The weight of bolted bulbs/plot was recorded and their percentage weight was calculated as for double bulbs.

6. Bulb diameter (cm):

Five sound bulbs were randomly selected from each experimental unit to measure bulb diameter using the vernier and the average diameter was calculated.

7. Number of rings:

The number of rings of the same five bulbs was calculated and the average number per bulb was recorded.

8. Total soluble solids (T.S.S.):

The T.S.S of the same five bulbs was recorded using a digital refractometer and the average per bulb was recorded.

9. Bulb dry matter (%):

The fresh weight of the same five bulbs was recorded before T.S.S. estimation. They were oven dried at 80°Cfor 48hours. Their dry weight was recorded and the percentage of bulb dry mater was calculated using the following equation:

$$\% \text{ of dry matter/bulb} = \frac{\text{Bulb dry weight}}{\text{Bulb fresh weight}} \times 100$$

- Experimental design and Statistical analysis:

  The experimental units were in complete randomized block design arranged in split plots with three replications. The data were analyzed using GenStat (Computer Program) Version4 and the means were separated using Duncan Multiple Range Test (DMRT) at $P \leq 0.05$ (Gomez and Gomez, 1984).

CHAPTER FOUR

RESULTS

1-Vegetative growth:

Generally, it was clear that the medium set size growth (Table1, 2 and 3) was highly responsive to a combination of Elkhaseeb and mineral fertilizer rather than one type alone compared to large set size.

1-1 Plant height (cm):

As in Table 1 no significant effects of set size or fertilizer type on plant height were noticed both after 3 and4 months from planting. The combination of Elkhaseeb and Urea fertilizer however, gave the highest plants. Also the same effects were reflected by the interactions among the set size and fertilizer type .The highest plants, however, were obtained by the combination of Elkhaseeb and Urea fertilizer on medium set size after 4 months from planting.

1-2 Number of leaves /plant:

The results (Table 2) reflected no significant effects due to set size or fertilizer type on number of leaves per plant both after 3and 4 months from planting.

However, the highest number of leaves was obtained by the application of Urea irrespective of set size after 4 months from planting.

Table 1: Effect of set size and fertilizer type (Elkhasseb, Urea and NPK) on plant height (cm) of Baftaim onion cultivar after three and four months from planting:

Set size (cm)	Plant height(cm)									
	After 3 months from planting					After 4 months from planting				
	Fertilizer type					Fertilizer type				
	Urea	Organic Elkhasseb +Urea	Organic Elkhasseb	Organic Elkhasseb +NPK	Mean	Urea	Organic Elkhasseb +Urea	Organic Elkhasseb	Organic Elkhasseb +NPK	Mean
Large size (2-3)	5.7	7.6	6.2	6.0	6.4	12.9	15.7	14.7	14.1	14.3
Medium set (1-2)	5.6	6.7	5.9	6.2	6.1	13.9	17.8	15.5	14.6	15.5
Mean	5.6	7.2	6.1	6.1		13.4	16.8	15.1	14.4	
C.V. %	13.2					17.9				

Means having the same letter(s) within the same column or row were not significantly different using D M RT at $P \leq 0.05$.

Table 2: Effect of set size and fertilizer type (Elkhasseb, Urea and NPK) on number of leaves of Baftaim onion cultivar after three and four months from planting:

Set size (cm)	Number of leaves									
	After 3months (a) from planting					After 4 months (b) from planting				
	Fertilizer type					Fertilizer type				
	Urea	Organic Elkhasseb +Urea	Organic Elkhasseb	Organic Elkhasseb +NPK	Mean	Urea	Organic Elkhasseb +Urea	Organic Elkhasseb	Organic Elkhasseb +NPK	Mean
Large size (2-3)	9.4	10.2	9.9	9.2	9.7	13.0	12.2	12.8	12.1	12.5
Medium set (1-2)	9.2	9.2	7.7	9.1	8.8	13.2	12.7	12.5	12.5	12.7
Mean	9.3	9.7	8.8	9.2		13.1	12.4	12.7	12.3	
C.V. %	13.1					7.4				

Means having the same letter(s) within the same column or row were not significantly different using D M RT at $P \leq 0.05$.

1-3 Leaf length (cm):

Significant effects (Table3) on leaf length were noticed due to set size or fertilizer type both after 4 months from planting, the means of all fertilizes were significantly higher than urea. However, the combination of Elkhaseeb and Urea gave the longest leaves both after 3 and 4 months from planting.

Moreover, the longest leaves were obtained by the interaction of medium set size and Elkhaseeb and Urea combination both after 3 and 4 months from planting.

2- Yield and yield components:

2-1 Yield:

2-1-1 Total bulb yield (t/ha):

The results (Table 4) showed significant increases in average yield/ha due to medium set size (40.1 t/ha) above the large set size (32.9 t/ha), especially on addition of combination Elkhaseeb and urea (44.3 t/ha).

Moreover it was clear that medium set size yield was highly responsive to fertilizer application, showing that the highest yield was obtained by a combination of Elkhaseeb and Urea (51.1 t/ha) compared to each alone or in combination with Phosphorus and Potassium.

2-2 Yield components:

2 -2 -1 Bulb weight (g):

It was clear that both set size and fertilizer type have no significant effects on bulb weight (Table 5). However, the combination of Elkhaseeb and urea on large set

Table 3: Effect of set size and fertilizer type (Elkhasseb, Urea and NPK) on leaf length (cm)of Baftaim onion cultivar after three four months from planting:

Set size (cm)	Leaf length (cm)									
	After 3 months (a) from planting					After 4 months (b) from planting				
	Fertilizer type					Fertilizer type				
	Urea	Organic Elkhasseb +Urea	Organic Elkhasseb	Organic Elkhasseb +NPK	Mean	Urea	Organic Elkhasseb +Urea	Organic Elkhasseb	Organic Elkhasseb +NPK	Mean
Large size (2-3)	48.2 a	47.8 a	44.6 a	46.7 a	46.9 a	50.6 c	59.0 ab	56.6 ab	54.9 ab	55.3 a
Medium set (1-2)	46.3 a	56.0 a	48.9 a	47.7 a	49.7 a	53.1 ab	70.4 a	64.2 ab	58.8 ab	61.6 a
Mean	47.3 a	51.9 a	46.8 a	47.2 a		51.8 c	64.7 a	60.4 ab	56.9 ab	
C.V. %	12.6					16.2				

Means having the same letter(s) within the same column or row were not significantly different using D M RT at P≤0.05.

Table 4: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on total yield (t/ha) of Baftaim onion cultivar:

Set size (cm)	Total yield (t/ha)				Mean
	Fertilizer type				
	Urea	Elkhaseeb+urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	24.5 i	37.6 cde	37.9 cde	31.5 efg	32.9 b
Medium size (1-2)	43.8 ab	51.1 a	38.7 cd	26.9 gh	40.1 a
Mean	34.1 cd	44.3 a	38.3 ab	29.2 e	
C.V. %	14.9				

Means having the same letter(s) within the same column or row were not significantly different using D M R T at P≤0.05.

Table 5: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on average bulb weight (g) of Baftaim onion cultivar :

Set size (cm)	Average bulb weight (g):				Mean
	Fertilizer type				
	Urea	Elkhaseeb +urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	83.3	96.2	66.2	65.5	77.8
Medium size (1-2)	72.2	81.1	78.2	71.5	75.7
Mean	77.8	88.6	72.2	68.5	
C.V. %	27.1				

size or irrespective of set size gave the heaviest bulbs (96.2g) compared to urea alone or other combinations.

2-2-2 Yield of Marketable bulbs (t/ha):

Using medium set size with mineral fertilizer alone or in combination with Elkhaseeb fertilizer (Table 6) resulted in significant increases in marketable bulb yield (9.4 t/ha) compared to large set size (7.3 t/ha) or Elkhaseeb fertilizer alone (5.9 t/ha).The highest yield of marketable bulbs (13.1 t/ha) was obtained by the interaction of medium set size and urea alone.

2-2-3 Yield of unmarketable bulbs:

This includes double and bolting bulbs (Table 7 and 8) which were increased by using large set size especially, the yield of bolted bulbs (8.1%) compared to medium set size (4.0%).

The highest percentage of unmarketable bulbs (double and bolting) were obtained by using medium or large set size and combination of Elkhaseeb and mineral fertilizers (7.2 and 10.0 t/ha, respectively).

2-2-3-1 Percentage of double bulbs (%):

The results (Table 7) showed significant differences between large size (4.4) and medium size with (Elkhaseeb + NPK) on percentage of double bulbs due to set size, fertilizer type or their interactions.

The highest percentage of double bulbs, however, was noticed by the interactions of medium set size and either Elkhaseeb and Urea or Elkhaseeb and NPK combinations.

Table 6: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on marketable yield (t/ha) of Baftaim onion cultivar :

Set size (cm)	Marketable yield (t/ha)				Mean
	Fertilizer type				
	Urea	Elkhaseeb +urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	8.5 bc	6.1 bc	5.1 c	9.7 ab	7.3 b
Medium size (1-2)	13.1 a	9.7 ab	6.7 bc	8.3 bc	9.4 a
Mean	10.8 a	7.9 ab	5.9 c	9.0 a	
C.V. %	27.0				

Means having the same letter(s) within the same column or row were not significantly different using D M R T at P≤0.05.

Table 7: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on percentage by weight of double bulbs of Baftaim onion cultivar:

Set size (cm)	Percentage by weight of double bulbs				Mean
	Fertilizer type				
	Urea	Elkhaseeb +urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	6.7 ab	6.6 ab	5.7 ab	4.4 b	5.8 a
Medium size (1-2)	5.1 ab	7.2 a	6.5 ab	7.2 a	6.5 a
Mean	5.9 a	6.9 a	6.1 a	5.8 a	
C.V. %	21.0				

Means having the same letter(s) within the same column or row were not significantly different using D M R T at P≤0.05.

2-2-3-2 Percentage of bolting bulbs (%):

There was a significant difference in percentage of bolting bulbs. Table 8 showed that the medium set size gave significantly lower percentage of bolters (4.0%) compared to the large set size (8.1%). It was clear that there were significant differences between both Urea, Elkhaseeb + Urea and Elkhaseeb in bolting percentage due to fertilizers type; however the highest percentage was obtained by addition of Urea, whereas the Elkhaseeb gave the lowest bolting percentage (3.8%).

Moreover there were no significant differences among the interactions of large set size and fertilizer compared to the medium set size and fertilizer combination. The highest bolting percentages were obtained by all fertilizer combinations and large set size (6.2and 10.0%).

The lowest bolting percentage obtained by medium set size and fertilizer type was less than 2.0% except for Urea and Elkhaseeb and Urea where the percentages were 7.2 and 5.8% respectively.

3-1-1 Bulb diameter (cm):

No significant differences (Table 9) were noticed in bulb diameter due to set size, fertilizer type and their interactions.

Table 8: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on (%) of bolting bulbs of Baftaim onion cultivar :

Set size (cm)	(%) of bolting bulbs				Mean
	Fertilize type				
	Urea	Elkhaseeb +urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	7.8 a	8.2 a	6.2 a	10.0 a	8.1 a
Medium size (1-2)	7.2 a	5.8 ab	1.4 b	1.7 b	4.0 b
Mean	7.5 a	7.0 a	3.8 b	5.8 ab	
C.V. %	28.4				

Means having the same letter(s) within the same column or row were not significantly different using D M R T at P≤0.05.

Table 9: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on bulb diameter (cm) of Baftaim onion cultivar :

Set size (cm)	Bulb diameter (cm)				Mean
	Fertilizer type				
	Urea	Elkhaseeb +urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	5.3	5.6	4.8	4.8	5.1
Medium size (1-2)	5.0	5.3	5.3	5.0	5.1
Mean	5.2	5.4	5.0	4.9	
C.V%	12.0				

3- 1- 4 Number of storage leaves (rings)/bulb:

No significant differences (Table 10) were noticed in number of storage leaves (rings)/bulb due to set size, fertilizer type and their interaction.

3-1-5: Total soluble solids:

As shown in table 11 there were no significant differences in total soluble solids due to set size and fertilizer type.

The total soluble solids, however, varied significantly between the interactions of medium and large set size with Elkhaseeb + Urea combination with the values 15.8 and 12.3, respectively.

3-1-6: Dry matter content:

The results (Table 12) indicated that there were no significant differences in dry matter due to set size. There were significant differences in dry matter noticed due to fertilizer type. The highest dry matter was obtained by Elkhaseeb alone or in combination with minerals (18.9, 17.8 and 17.5% respectively). The same effect on dry matter was also noticed by Elkhaseeb application with the medium and large set (19.4 and 18.3% respectively). Generally the lowest value was obtained by addition of Urea alone with medium set size (16.1%) or addition of Urea and Elkhaseeb on large set size (17.2%).

Table 10: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on number of storage leaves (rings) / bulb of Baftaim onion cultivar:

Set size (cm)	Number of storage leaves (rings)				Mean
	Fertilizer type				
	Urea	Elkhaseeb +urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	10.1	9.9	9.1	9.6	9.7
Medium size (1-2)	10.1	9.4	9.1	10.1	9.7
Mean	10.1	9.6	9.1	9.8	
C.V. %	9.1				

Table 11: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on total soluble solids (T.S.S.) of Baftaim onion cultivar:

Set size (cm)	Total soluble solids (T.S.S.)				Mean
	Fertilizer type				
	Urea	Elkhaseeb +urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	13.3 b	12.3 b	12.7 b	12.8 b	12.8 a
Medium size (1-2)	13.0 b	15.8 a	12.8 b	13.2 b	13.7 a
Mean	13.1 a	14.1 a	12.7 a	13.0 a	
C.V. %	10.8				

Means having the same letter(s) within the same column or row were not significantly different using D M R T at P≤0.05.

Table 12: Effect of set size and fertilizer type (Elkhaseeb, Urea and NPK) on percentage dry matter of bulbs of Baftaim onion cultivar:

Set size (cm)	Percentage dry matter of bulbs				Mean
	Fertilizer type				
	Urea	Elkhaseeb+urea	Elkhaseeb	Elkhaseeb +NPK	
Large size (2-3)	17.5 bc	17.2 bc	18.3 ab	17.8 abc	17.7 a
Medium size (1-2)	16.1 c	17.8 abc	19.4 a	17.7 abc	17.7 a
Mean	16.8 b	17.5 b	18.9 a	17.8 ab	
C.V. %	5.5				

Means having the same letter(s) within the same column or row were not significantly different using D M R T at P≤0.05.

CHAPTER FIVE

Discussion

Effect of set size:

Vegetative growth:

The results indicated no significant differences in the vegetative growth (plant height, number of leaves and leaf length) due to set size both after three and four months from planting. However, it could be indicated that the growth rate of medium set size was faster than the large set size within the first three months from planting as it has compensated the initial differences in size. Similarly Khokhar *et al.* (2002) showed that the time to bulb maturation decreased significantly with decreasing of set size. The smaller set size took relatively shorter time to mature compared with either medium or large set size. Mondal *et al*. (1986) concluded that set size and spacing influenced plant growth and bulb size. Also many researchers (Shalaby *et al*., 1991, Munoz *et al*., 1995 and Khokhar and Hadley, 2007) reported on the positive effect of set size on onion off-season growth and production. Islam *et al*. (1999) found that smaller sets (1.6g) showed faster growth rate compared to large sets (2.44g) but the heaviest bulbs were obtained by the large ones.

Ansari *et al.* (2009) found that large set sizes (≥1.5-2 cm in diameter) were noted to have positive effect on the vegetative growth (tall plants, with high number of long leaves and high percentage of bolting).

Bulb yield and quality:

There was no significant difference in vegetative growth. Medium set size produced higher onion bulb yield compared to large set size. Similar results were

obtained by Cheema *et al*. (2002) and Khokhar *et al.* (2002) who reported that small set size (1.5-2 cm) gave the highest bulb yield and quality. Yamagushi (1980) and Khokhar (2008) reported that the diameter of the set is the primary factor that affects bulb or flower stalk production and the ideal size of the set should be 1.5-2.0 cm in diameter. Bulbs greater than 2.5 cm in diameter would be prone to early bolting. However, Islam *et al*., (1999) obtained the highest bulb yield by using large set size compared to small one. Khokhar *et al*. (2002) recorded the highest marketable yield using medium set size. Moreover, it reduced the percentage of bolting bulbs, i.e. improved bulb quality.

Effect of fertilizers types:

Vegetative growth:

The results indicated that there was no significant effect on vegetative growth due to fertilizers. The highest plants, however, were obtained by the combination of organic fertilizer, Elkhaseeb, and urea compared to single fertilizers (organic, Urea or NPK alone). Moreover, it was noticed that the medium set size showed higher response to fertilizer combination than the large set size. These results were supported by Reddy and Reddy (2005) who observed that the highest plant height of onion was obtained with the highest combination of vermicompost (30t/ha) and nitrogen (200kg/ha) compared to the lowest dose (10t/ha and 50kg/ha). Yohannas *et al*. (2013) reported that the addition of farmyard manure with nitrogen gave the highest number of leaves.

Similar results were reported by Mousa and Mohamed (2009), Dapaah *et al*. (2014) and Shedeed *et al*. (2014). They showed that different types of organic fertilizers increased the onion vegetative growth parameters (plant height, leaf length and bulb diameter and fresh weight), in addition to uptake of N, P, K, Ca and Mg. Bagali *et*

al. (2012) and Kwada *et al*. (2015) reported that the application of different types of organic fertilizer (vermicompost at 6 t/ha, poultry manure at 3 t/ha and farmyard manure at 30 t/ha) had similar significant effects on plant growth giving the highest plants and the highest number of leaves/plant.

Moreover, Abdel Naby *et al.* (2012) stated that organic fertilizer have very important role in plant growth and yield. They are considered a source of nutrients in addition to it is positive effects on the physical, chemical and biological characteristics of soil which influence plant growth and yield.

Bulb yield and quality:

Also the response of medium set sizes to fertilizer combination (organic + Urea) was reflected as higher yield than that of large set size. The highest yields, however, were obtained by both set sizes with a combination of the organic fertilizer Elkhaseeb and urea compared to single fertilizer. Similar results were obtained by Seetohul and Hanoomanjee (1999) who found that the response of set size 1.1-2 cm to fertilizer was higher, showed better growth and gave the best yield of many cultivars. Moreover, Kumar (2001), Singh and Ram (2014) and Tsegay *et al*. (2016) reported high onion yield with fertilizer combination (Organic + nitrogen) compared to single fertilizer.

The onion quality was also affected by set size and fertilizer combination (organic + Urea) as the highest marketable yield was obtained by medium set size and fertilizer combination (organic + Urea or urea alone). The percentage of double bulbs was not affected by set size; however, the highest percentage was obtained with medium set size and fertilizer combination (organic + chemical fertilizer).The large set size gave the highest percentage of bolting bulbs. Nevertheless, he noticed that large set size showed high tendency to bolting particularly if exposed for a long period to low temperature before they start to bulb. However, no significant

effect on percentage of bolting bulbs by medium set size was noticed. Similar results were obtained by Kokhar *et al*. (2002) who reported a highest marketable bulb yield using 1.8 cm diameter set size. Yahannas *et al*. (2013) found that the application of nitrogen with farmyard manure gave the highest marketable yield. Moreover, Brewester (1994) reported the lowest percentage of bolting bulbs with medium set size (1.6 cm) compared to large sets. Ansari *et al*. (2009) reported that vernalization of onion plants depend on set size. Plants produced from large sets vernalize faster in appropriate temperature, light and nutrient conditions compared to small set size.

Other quality characteristics (Bulb diameter and length, total soluble solids and number of rings were not affected by either set size or fertilizer type. However, the T.S.S. and dry matter content increased significantly by medium set size with Elkhaseeb alone or in combinations with mineral fertilizers.

Romamoorthy *et al*. (2000), Cheema *et al*. (2002) and Yaso *et al*. (2007) reported that the highest bulb quality was obtained by medium set size. Abdissa (2011), and Soleymani and Shahrajabian (2012) reported that higher doses of nitrogen and medium set size increased onion dry matter. Moreover, Rahman (2006), Bagali *et al*. (2012), Kandial *et al*. (2013), and Kadiri *et al*. (2015) reported high bulbs dry matter with a combination of NPK alone or with organic fertilizer.

Conclusion

It can be concluded that:

1. Set size has no significant effect on growth parameters (plant height, number of leaves and leaf length) tested after three months from planting or more.
2. Addition of single fertilizers (Urea, organic or NPK alone) showed no significant effect on onion vegetative growth compared to a combination of organic and mineral fertilizer which gave the highest vegetative growth.
3. Medium set size gave the highest total of marketable bulb yield compared to large set size.
4. The combination of organic and mineral fertilizers gave the highest percentage of double and bolting bulbs (unmarketable bulb yield) compared to single fertilizer.
5. Medium set size resulted in high percentage of double bulbs, while the large set size resulted in the highest percentage of bolting bulbs, especially with single fertilizers compared to their combinations.
6. Other quality characteristics (bulb diameter and length, neck diameter, number of rings, total soluble solids) were not significantly affected by set size or fertilizer type. Their higher values were recorded with large set size and fertilizer combination.

7. Whereas Elkhaseeb alone or with mineral fertilizers recorded the highest dry matter.

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Appendices

Appendix (1): Monthly mean maximum and minimum air temperature (°C), relative humidity (%) and rainfall (mm) at Shambat during growing season August 2015- Feb.2016).

Month	Mean temperature (˚c)		Relative humidity (%)	Rainfall (mm)
	Max.	Min.		
August	38.7	25.8	43	40.1
September	40.6	26.4	40	18.3
October	40.0	26.4	34	9.2
November	34.1	20.5	27	0
December	28.7	14.2	31	0
January	28.9	12.4	28	0
February	33.3	15.7	29	0

Source: Ministry of Environment, Forestry and Physical Development
Meteorological Authority Weather –Climate data.
Shambat Metrological Station.

Appendix (2): Variety Description and characteristics

I. Name:

Allium cepa L. (Scientific)
Onion (English)
Basal (Arabic)

II. Recommended variety name:

Baftaim (S)
(S) بافطيم

III. Morphological characteristics:

A. Leaves:

1. Foliage attitude: Erect
2. Leaf surface: Smooth
3. Leaf shape: Cylindrical
4. Leaf waxiness &degree: Present, medium
5. Leaf color: Green.
6. Leaf number/plant (mean & range): 12(9-14)
7. Leaf length: 64cm (48-75cm)
8. Foliage size & vigor: Dense and vigorous under Optimum growing conditions
9. Nature bulbs: Single bulb
10. Bulb position during development: Above ground.
11. Neck characteristics (% of thick necks): Abscent at full maturity (0%).

B .Mature bulb:

1. Basic skin color: Red.
2. Basic bulb shape-uniformity: Round-uniform.
3. Skin retention: Good.
4. Internal doubling: Several growing points (multi centers).
5. Flesh color: White-reddish/white-pinkish.
6. Density of flesh color: Uniform density.
7. Number of flesh scale: ±7
8. Thickness of bulb skin: Medium.

9. Firmness of the flesh: Firm.

10. Pungency: Very pungent.

C. Roots:

1. Position of root disc: Flat.

2. Diameter of root disc: Small (1.0-1.5cm).

D. Flowers:

1. Color of the umbel spathe: White with reddish streaks.

2. Flower color: White.

3. Another color: Yellowish.

E. Seeds:

1. Size: Average (normal)

2. TSW: 4-5g.

Source: Mohamedali, G. H. (2007). A proposal for the release of Baftaim as a high yielding red onion (*Allium cepa* L.) in Sudan. A paper submitted to the Variety Release Committee, Khartoum, Sudan.

Appendix (3): Compost Elkhaseeb analysis:

OM%	79.17
CO%	45.92
N%	2.22
P%	2.32
K ppm	56.97
Ca ppm	68.00
Mg ppm	5.05
Na ppm	28.34
Fe ppm	27.92
Mn ppm	27.92
Cu ppm	0.362
Co ppm	0.083
Pb ppm	0.12
Zn ppm	1.461
Humidity %	10.34
ECe ds/m	23.5
pH	8.1
C : N	20.7

Source: Elkhaseeb International Industrial and trading co.Ltd

Appendix (4): Analysis of variance tables

1-Variate: Plant height (cm) after three months from planting

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	0.0012	0.0006	0.00	
Reps.*Units* stratum					
Size	1	0.4931	0.4931	0.73	0.407
F	3	7.8257	2.6086	3.87	0.033
Size.F	3	0.9729	0.3243	0.48	0.701
Residual	14	9.4404	0.6743		
Total	23	18.7333			

2-Variate: Plant height (cm) after four months from planting

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	34.746	17.373	2.46	
Reps.*Units* stratum					
Size	1	7.493	7.493	1.06	0.321
F	3	36.942	12.314	1.74	0.204
Size.F	3	1.997	0.666	0.09	0.962
Residual	14	98.960	7.069		
Total	23	180.138			

3-Variate: Number of leaves after three months from planting

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	14.535	7.268	4.96	
Reps.*Units* stratum					
Size	1	4.463	4.463	3.05	0.103
F	3	2.620	0.873	0.60	0.628
Size.F	3	4.254	1.418	0.97	0.435

Residual	14	20.500	1.464		
Total	23	46.372			

4-Variate: Number of leaves after four months from planting

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	14.4300	7.2150	8.20	
Reps.*Units* stratum					
Size	1	0.2017	0.2017	0.23	0.639
F	3	2.2183	0.7394	0.84	0.494
Size.F	3	0.4583	0.1528	0.17	0.912
Residual	14	12.3167	0.8798		
Total	23	29.6250			

5- Variate: Leaf length (cm) after three months from planting

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	201.67	100.84	2.74	
Reps.*Units* stratum					
Size	1	49.80	49.80	1.35	0.264
F	3	105.89	35.30	0.96	0.439
Size.F	3	84.46	28.15	0.77	0.532
Residual	14	514.66	36.76		
Total	23	956.48			

6- Variate: Leaf length (cm) after four months from planting

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	237.28	118.64	1.32	
Reps.*Units* stratum					
Size	1	243.46	243.46	2.71	0.122
F	3	535.47	178.49	1.99	0.162
Size.F	3	71.65	23.88	0.27	0.849

Residual	14	1257.04	89.79		
Total	23	2344.91			

7- Variate: Total yield (t/ha)

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
Reps stratum	2		72.89	36.44	1.23	
Reps.*Units* stratum						
Size	1		313.98	313.98	10.62	0.014
F	3		738.60	246.20	8.32	0.010
Size.F	3		547.70	182.57	6.17	0.022
Residual	7	(7)	207.05	29.58		
Total	16	(7)	1531.53			

8- Variate: Average bulb weight (g)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	1094.2	547.1	1.27	
Reps.*Units* stratum					
Size	1	25.1	25.1	0.06	0.813
F	3	1390.0	463.3	1.07	0.393
Size.F	3	771.5	257.2	0.59	0.629
Residual	14	6053.3	432.4		
Total	23	9334.1			

9- Variate: Marketable yield (t/ha)

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
Reps stratum	2		25.706	12.853	2.51	
Reps.*Units* stratum						
Size	1		26.578	26.578	5.20	0.046
F	3		74.934	24.978	4.89	0.024
Size.F	3		31.340	10.447	2.04	0.172

Residual	10	(4)	51.122	5.112	
Total	19	(4)	177.570		

10- Variate: Percentage by weight of doubled bulbs

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	31.447	15.723	9.38	
Reps.*Units* stratum					
Size	1	2.642	2.642	1.58	0.230
F	3	4.773	1.591	0.95	0.444
Size.F	3	14.473	4.824	2.88	0.074
Residual	14	23.477	1.677		
Total	23	76.812			

11- Variate: Percentage of bolting bulbs

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
Reps stratum	2		95.063	47.531	16.28	
Reps.*Units* stratum						
Size	1		98.800	98.800	33.83	0.010
F	3		49.733	16.578	5.68	0.094
Size.F	3		48.809	16.270	5.57	0.096
Residual	3	(11)	8.761	2.920		
Total	12	(11)	139.979			

12- Variate: Bulb diameter (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	0.4689	0.2344	0.62	
Reps.*Units* stratum					
Size	1	0.0022	0.0022	0.01	0.940
F	3	0.9899	0.3300	0.87	0.478
Size.F	3	0.6682	0.2227	0.59	0.631

Residual	14	5.2827	0.3773		
Total	23	7.4119			

13- Variate: Bulb length (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	0.2647	0.1323	0.81	
Reps.*Units* stratum					
Size	1	0.0003	0.0003	0.00	0.964
F	3	0.3933	0.1311	0.80	0.512
Size.F	3	0.2005	0.0668	0.41	0.748
Residual	14	2.2807	0.1629		
Total	23	3.1395			

14- Variate: Neck diameter (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	0.03990	0.01995	0.60	
Reps.*Units* stratum					
Size	1	0.05900	0.05900	1.76	0.206
F	3	0.09958	0.03319	0.99	0.426
Size.F	3	0.06375	0.02125	0.63	0.605
Residual	14	0.46923	0.03352		
Total	23	0.73146			

15- Variate: Number of storage leaves (rings)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	2.0090	1.0045	1.30	
Reps.*Units* stratum					
Size	1	0.0057	0.0057	0.01	0.933
F	3	3.1991	1.0664	1.38	0.289
Size.F	3	0.7752	0.2584	0.34	0.800

Residual	14	10.7836	0.7703		
Total	23	16.7727			

16- Variate: Total soluble solids (T.S.S.)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	28.722	14.361	7.11	
Reps.*Units* stratum					
Size	1	4.960	4.960	2.45	0.140
F	3	6.164	2.055	1.02	0.415
Size.F	3	14.373	4.791	2.37	0.114
Residual	14	28.291	2.021		
Total	23	82.509			

17- Variate: Percentage dry matter of bulbs

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Reps stratum	2	8.5597	4.2798	4.58	
Reps.*Units* stratum					
Size	1	0.0067	0.0067	0.01	0.934
F	3	13.9099	4.6366	4.96	0.015
Size.F	3	5.0472	1.6824	1.80	0.193
Residual	14	13.0789	0.9342		
Total	23	40.6023			