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Original Research Article

EFFECT OF INTRA-ROW SPACING ON GROWTH AND YIELD COMPONENTS OF ADAMA RED ONION (*ALLIUM CEPA* L.) CULTIVAR UNDER IRRIGATION IN FICHE, NORTH SHOA ETHIOPIA

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Abstract: A field experiment was conducted at Addis Ababa University, Selale Campus Horticulture department demonstration farm to assess the Effect of plant density (intra-row spacing) on growth (days to maturity, plant height, leaf length and leaf number) and yield components (mean bulb weight, bulb dry weight, fresh biomass yield and dry biomass yield) of Adama red onion (Allium cepa L.) cultivar in 2014/15 under irrigation. The experiment was conducted using randomized complete block design with three replicates. The analyzed result using ANOVA shows significance difference among the treatments. Closer plant spacing enhanced maturity, while wider plant spacing showed slightly delayed maturity. Best plant height (45.90cm), highest leaf length (28.57cm), maximum mean bulb weight (53.34g), maximum dry bulb weight (28.13g), fresh biomass yield (56.56g) and highest dry biomass yield (42.00g) was recorded in plants spaced at 10cm intra-row spacing. Therefore, it could be conclude that, under Fich condition, good quantity of Adama red onion is possible to produce with intra-row spacing of 10cm which was dominant over the other treatments.

Keywords: Adama red, cultivar, growth, Intra-row, Irrigation, onion, spacing, yield,

Introduction: Onion (*Allium cepa* L.) belongs to the genus *Allium* of the family *Alliaceae* (Hanlet, 1990). Onion as bulb onion and/or shallot is probably cultivated in all countries of tropical Africa including Ethiopia (Grubben and Denton, 2004). Onion requires adequate soil moisture due to the relatively short and small root system (Kebede, 2003).

Onions are spread throughout the country being cultivated under both irrigated as well as rain fed conditions in different agro-climatic regions due considerably increasing its important in the daily Ethiopian diet (Lemma and Herath, 1992). All the plant parts are edible, but the bulbs and the lower stem sections are the most popular as seasonings or as vegetables in stews (MoARD, 2009). Fresh onion contains about 86.6% moisture, 11.6% carbohydrate including 6-9 soluble sugar, 1.2% protein, 0.1% fat, 0.2 - 0.5% Ca, 0.05% P, traces of Al, Cu, Fe, Mn, Zn, pantothenic acid and vitamins (A, B, and C)

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(EL-Mesery and Mwithiga, 2012, Malik, 2000). It is one of the richest sources of flavonoid in the human diet and flavonoid consumption has been associated with a reduced risk of cancer, heart disease and diabetes. In addition it is known for anti bacterial, antiviral, anti-allergenic and anti-inflammatory potential and used as preservative and medicinal plant (MoARD, 2009, Vohra *et al.*, 1994).

In Ethiopia onion crop is one of the most important vegetables produced by small hold farmers mainly as a source of cash income and for flavoring the local stew 'wet. Even though the crop has great contribution both in economic and health issues its production and productivity is not scaled to the required level. Because, the use of appropriate agronomic management practices and improved technology inputs are not still highly used which have an undoubted contribution in increasing crop yield potential. One of the important measures to be taken in increasing the productivity of onion is determining spacing (plant population) for each agro-ecology since full package of information is required for each growing region of the country to optimize onion productivity (Gupta *et al.*, 1994). Different cultural practices and growing environments are known to influence growth and yield of onion. So far, research in the country was mainly focused on the identification of superior cultivars of onions and adopting improved management practices (Lemma and Shimeles, 2003).

In Ethiopia, the crop is believed to be more intensively consumed than any other vegetable crops and a lion share of 95% of the vegetables and fruits produced in the country comes from the small holder sector. Despite this, productivity of the crop remains low (10.02t ha^{-1}) according to CSA (2013) which is very low compared to the world average of 19.7t ha^{-1} (FAO, 2012) and is far below the potential productivity of the crop obtained in other countries such as Ireland (58t ha^{-1}), Korea Republic (57t ha^{-1}), USA (55.88t ha^{-1}), Spain (52t ha^{-1}), Chile (48.50t ha^{-1}) and Australia (49t ha^{-1}).Thus, there is a huge gap in productivity reflecting the huge scope to increase onion yields in Ethiopia (Negasi, 2014).

Onion growers in the study area are producing both for home consumption as well as for market demand by irrigation during dry or off season even though, productivity of the crop is low due to poor agronomic management practices and improved technology usage. Moreover, lack of improved varieties and seed, undetermined recommended nitrogen fertilizer rate and plant spacing are the pertinent problems of the study area. Currently the nationally recommended plant spacing of 10cm is used for onion production with no consideration of soil type in all onion producing potential areas (Lemma and Shimeles, 2003). However, farmers in Fich area have no experience of applying the nationally recommended plant spacing rather they practice undetermined plant spacing. In view of these, the present study was initiated to determine and suggest appropriate intra-row spacing for Adama red onion cultivar growth and yield components for fiche district.

Materials and Methods:

Description of the Study Area

The study was conducted at Fiche, Addis Ababa University, Selale campus Horticulture department demonstration farm. The experimental site lies on an altitude of about 2750m above sea level and is located at latitude of 9◦48"0" N and longitude of 38°42′′0′′ E. Fich district is characterized by highland agro-ecological zone which have a cold temperature with annual average temperature of 16.5◦c and average rainfall of 1150 mm $year^{-1}$. The soil type of the study area is clay with pH of 6.4 (Fiche meteorological station, 2014/15).

Experimental Material

Adama red onion cultivar which is widely cultivated in the study area was used for the experiment as a test crop. This cultivar is a selection from onion materials imported from Sudan in 1970 which is dark red colour and firm, very pungent and flat glob shaped. It is well accepted by both producer and consumer and successfully produces by small farmer and commercial grower scattered in most regions of the country. The bulk of this cultivar is grown in

Awash Valley and Lake Regions. DAP (100kg ha^{-1}) and Urea (150kg urea ha^{-1}) fertilizers were used as per the recommended rate for the crop uniformly in all treatments (Lemma and Shemeles, 2003, EARO, 2004).

Treatments and Experimental Design

A field experiment was conducted on three different level of intra-low spacing (5, 7.5 and 10cm). The experiment was laid out in randomized complete blocked design (RCBD) with three replications and there was a total of 9 plots. The size of each plot was $2x3m^2$ containing five double rows (ridges) per plot accommodating 40 plants, 27 plant and 20 plant per row for each 5,7.5 and 10cm intra-raw spacing respectively. The distance between plots and blocks was 0.5m and 1m respectively.

Experimental Procedure

Seedlings of Adama Red onion cultivar were raised in a nursery at Addis Ababa university selale campus under plastic greenhouse demonstration room on raised bed with size of $1.2x5m^2$. Seed was obtained from Melkassa Agricultural Research center. Three raised nursery beds were prepared and seeds were sown on 10cm distance between rows lightly covered with soil and mulched with grass. The mulch was removed after seedlings were fully emerged (2-5cm height from the soil). Seedlings in the nursery were managed (watering, weeding, fertilizing and pest management) as per the requirement of the crop for 45days, after which it was transplanted to the main experimental plots.

Before sowing seeds, the experimental field was plowed and harrowed by using ox drawn plowing. Large clods was broken down in order to make the land fine tilth, and then 9 plots with size of $2x3m^2$ was measured and laid out. The plots was leveled; furrows and ridges was made at a spacing of 40cm. The nursery bed was irrigated one day before uprooting the seedlings to facilitate the uprooting and subsequent good field establishment of seedlings. The field experiment was conducted under irrigation using furrow irrigation method, which is the most commonly used irrigation system in Fiche district. A four day irrigation interval was maintained for the 1st four weeks and then extended to seven days interval (EARO, 2004) until 15 days to harvest, when irrigation was stopped completely. Other recommended agronomic practices like, weeding, plant protection, etc., was kept uniform for all treatments. Gap filling (re-planting) was carried out within one week to replace those seedlings which was damaged and failed after transplanting. Harvesting of onion bulbs was done when 70% plants show neck fall and bulbs was cured for four days by windrowing on the ground before topping (EARO, 2004)..

Data Collection

The agronomic and yield data were collected by sampling plants randomly from the three central ridges of each plot except days to maturity which was determined on plot basis. Accordingly, the following data were collected.

Days to maturity: Days to maturity was the actual number of days from the day of transplanting to the time when 70% of plants' foliage fall down (EARO, 2004) in the field experiment.

Plant height (cm): plant height was measured in centimeter from the soil surface to the tip of matured leaf in the plant at maturity by a ruler.

Leaf number per plant: refers to the mean number of leaves produced by sampled plants and was calculated by dividing the total number of leaves counted from the sampled plants to the number of sampled plants to get mean leaf number per plant.

Leaf length (cm): the length of three leaves per plant (from upper, medium and lower) was measured at maturity by using ruler and the average leaf length was taken.

Mean bulb weight (g): was the average weight of matured bulbs of sampled plants, was taken using a sensitive balance after harvesting and curing.

Bulb dry weight (g): sampled bulbs were chopped in to small pieces with the help of stainless steel knife, samples were placed on drying materials and kept under open sun for seven days and then placed in paper bags and dried in an oven at 65^oC for 48 hours until a constant weight was obtained. Each sample was weighed after drying using digital sensitive balance and the average was computed and recorded as dry weight of bulb.

Fresh biomass yield (g plant^{-1}): was recorded as the sum of the fresh weight above ground parts and bulbs of sampled plants taken as soon as the crop was harvested at maturity. Then the average fresh biomass yield per plant was calculated and recorded.

Dry biomass yield (g plant^{-1}): was recorded as the sum of dry weight of above ground parts and bulbs of sampled plants taken after oven drying. The average dry biological yield of sampled plants was calculated and recorded as dry biological yield per plant.

Data Analysis

The collected data was subjected to analysis of variance (ANOVA) and least significant difference (LSD) was used to separate means at $p<0.05$ probability levels of significance.

Results and Discussion

Phenology and Growth Parameters

Days to maturity, Plant height and Leaf length were significantly ($P<0.05$) influenced by the effect of intra-row spacing. However, leaf number was not significantly ($P<0.05$) affected by intra-row spacing (Table 1).

Table 1: The effect of intra raw spacing on plant height (cm), leaf length (cm), leaf number (No) and days to maturity (days) of Adama red onion

Intra-row spacing (cm)	DM	PH	LL	LN
5	112.60	36.70	23.76	6.80^{NS}
7.5	116.60*	40.80*	26.98	6.86 ^{NS}
10	121.00**	45.90**	28.57**	7.70 ^{NS}
LSD $_{0.05}$	6.4	1.6	4.0	
CV (%)	6.96	2.69	22.2	1.54

* = Statistically significant at P<0.05, ** = statistically highly significant at P<0.01, DF= degree of freedom, NS = non-significance, DM= Days to maturity, PH= Plant Height, LL= Leaf Length, LN= Leaf number.

Days to maturity

Days to maturity is significantly ($P<0.05$) affected by intra-row spacing (Table 1). Closer plant spacing of 7.5cm and 5cm enhanced maturity by about 116.6 and112.6 days, respectively, while wider plant spacing of 10cm showed slightly delayed maturity of 121 days. This might be attributed due to competition for light and nutrient in closer spacing, causing early bulb maturity while wider spacing allowed plants to have access for the most growth factors which prolong maturity. Maturity was shortened from 134 to124 days as reported by Hendrickson and Swanson (2003) when seeding rate increase from100,000 to 200,000 per acre. The result is in agreement with the findings of Brewster (1990;1994) who noted that bulb maturity is advanced by higher density planting, which is associated with a high leaf area index and hence light interception by the leaf canopy that advance the date of bulb scale initiation.

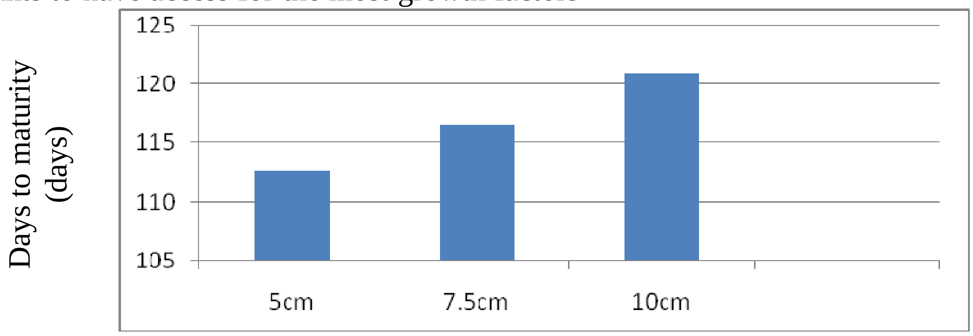

Figure 1: Effect of intra raw spacing on average physiological maturity day of Adama red onion.

Plant height (cm): Plant spacing significantly affected the plant height in onion production. Maximum height (45.9cm) was recorded in the plants spaced10cm, followed by 7.5cm (37.8cm long) and 5cm (36.7cm long) intra-row spacing. Similarly, Khan *et al.*, (2002) also reported that due to higher competition amongst the lowest plant spacing, it produced least response for plant height in onion. The reduction in plant height at increased plant density might be attributed to the possible competition for soil moisture and nutrients as it was the case in Ibrahim (1994), Bodnar *et al.* (1998), Karaye and Yakubu (2006). Moreover, results are also in agreement with the finding of Kantona *et al*. (2003) on onion.

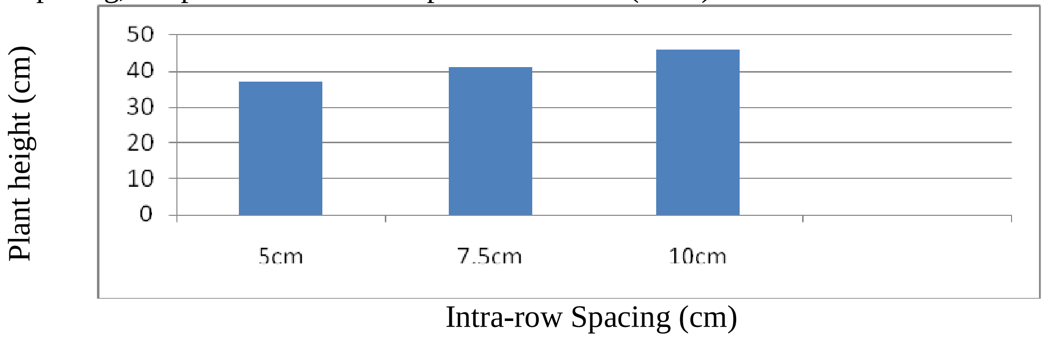

Figure 2: Effect of intra raw spacing on plant height of Adama red onion

Leaf number

The result of the field experiment showed that there is no significance difference among treatments with reference to leaf number per plant. Statically there was no difference between treatment one (5cm), treatment two (7.5cm) and treatment three (10cm). Even though, there was no significant difference statistically, numerical value differences among the mean values were observed. The highest leaf number per plant (7.6) was recorded from treatment three (10cm) whereas the lowest leaf number (6.8) was recorded at treatment one (5cm). Similarly, Karaye and Yakubu (2006) also reported that garlic planted at10cm, 15 and 20cm intra-row spacing produced no significant difference in number of leaves per plant.

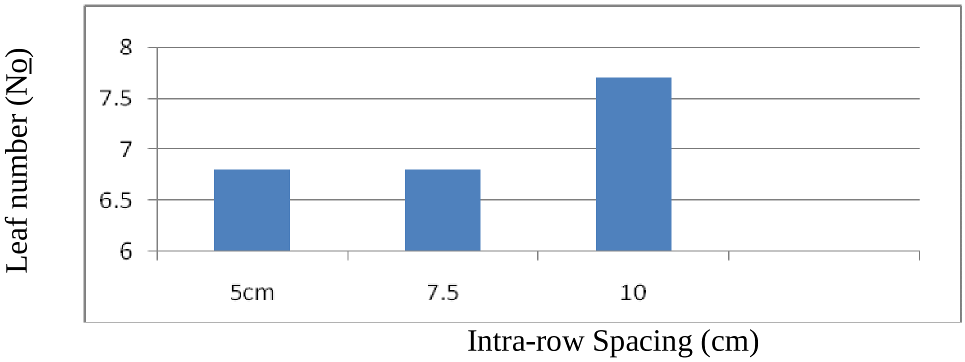

Figure 3: Effect of intra raw spacing on leaf number of Adama red onion

Leaf Length (cm):

Highly significant variation ($p<0.01$) in the leaf length was observed at the different intra-row spacing treatments. Intra-row spacing of 10cm produced the longest leaf length (28.5cm) and the shortest (23.7cm) was recorded at the narrow 5cm intra-row spacing. This might be due to less competition for light in wider spacing and higher competition occurred in closer plants. Jilani and Ghaffor (2003) suggested that plant densities could affect length of leaf. Lowest plant density can give highest leaf length. Jilani *et al*. (2010) also reported that highest leaf length is recorded at wider spacing whereas shortest leaves correspond to the closest plant spacing. This is probably, attributed to increased competition for nutrients and moisture at higher plant density.

Yield Component Parameters

Mean bulb weight, dry bulb weight, fresh biomass yield and dry biomass yield of Adama red onion cultivar was significantly (P<0.05) influenced by the effect of intra-row spacing (Table 3).

Table 3: The effect of plant spacing on mean bulb weight (g $plant^{-1}$), dry bulb weight (g $plant^{-1}$), fresh biomass yield (g $plant^{-1}$) and dry biomass yield (g $plant^{-1}$) of Adama red onion

intra-row spacing (cm)	MBW	DBW	FBY	DBY
5	24.43	10.3	47.36	36.9
7.5	28.69	13.74*	49.17 ^{NS}	39.11*
10	53.34**	28.13**	56.56*	42**
LSD $_{0.05}$	14.34	3.40	5.6	1.91
CV (%)	17.9	8.7	4.04	2.17

* = Statistically significant at P<0.05, ** = statistically highly significant at P<0.01, DF= degree of freedom, NS = non-significance, MBW= Mean bulb weight, DBW=Dry bulb weight, FBY =Fresh biomass yield, DBY= Dry biomass yield.

Mean bulb weight (g $plant^{-1}$)

The result was once again showed the supremacy of widest spacing as it produced much heavier bulbs as compared to the other spacing. Significantly maximum bulb weight (53.3g) was recorded in plants spaced at 10cm (Figure 4). Nevertheless, there was no significant difference between spacing of 5 and 7.5cm. Production of heavier bulbs in wider spacing might be attributed to the fact that, widely spaced plants experienced little or no competition for limited environmental resources compared to closely spaced plants. This result is in agreement with observation by Khan *et al.* (2002) who reported that plants spaced at 9cm gave the lowest average weight for a single onion bulb while in 15 cm spaced plants, the weight of the bulbs was maximum. Similar result was also reported by Dereje *et al.* (2012) where bulbs of "Huruta" shallot planted at 20cm intra-row spacing produced the highest bulb weight per plant while those planted at 10cm intra-row spacing produced the lowest bulb weight per plant. The result is in accord with Kahsay *et al.* (2013) who reported an increased mean bulb weight was observed as intra-row spacing increased from 5cm to 10cm.

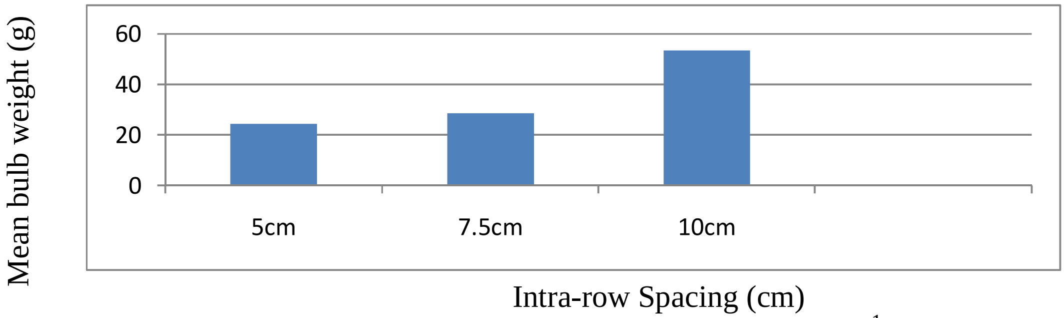

Figure 4: Effect of intra raw spacing on mean bulb weight (g $plant^{-1}$) of Adama red onion

Bulb dry weight (g $plant^{-1}$)

The effect of intra-row spacing was also highly significantly (p< 0.05) influenced bulb dry weight. As intra-row spacing increased from 5cm to 10cm, the bulb dry weight was also increased from 10.3g to 28.13g (figure 5). This might be due to the fact that closer spacing between plants resulted in competition for nutrients, moisture and light, thus reducing amount of assimilate produced and stored in the bulbs which reduced their bulb weight. This result is in line with khan *et al.* (2002) findings who reported that plants spaced at 9cm gave the lowest average weight for a single onion bulb while in plants spaced at 15cm; the weight of the bulb was maximum. Similar result was also reported by Dereje *et al*. (2012) who observed that shallot bulbs planted at 20cm intra-row spacing produced greater bulb dry weight per plant than those planted at 15 and 10cm intra-row spacing. Abubaker (2008) also reported that pod dry weight of bean tended to be higher under the lower plant density. In crop plants, dry matter accumulation is a result of nutrient uptake and one of the measures of plant growth (Noggle and Fritz, 1983).

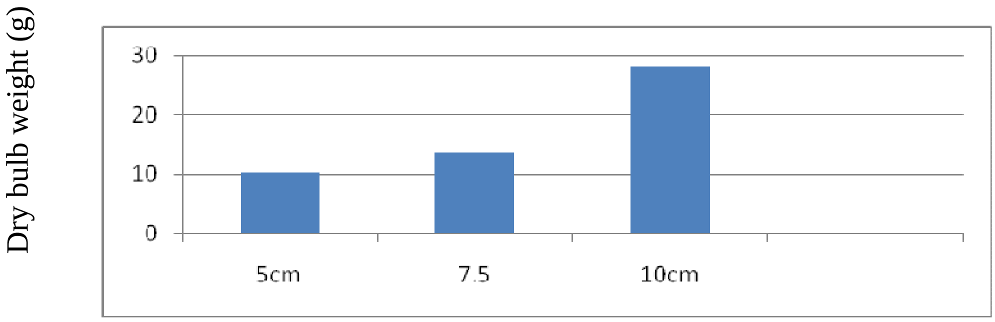

Figure 5: Effect of intra raw spacing on bulb dry weight (g plant^{-1}) of Adama red onion

Fresh biomass yield (g plant^{-1})

The effect of intra-row spacing was also significantly influenced bulb fresh weight. As intra-row spacing increased from 5 cm to 10cm, the bulb fresh weight was also increased from 47.3 to 86.5g (Figure 6). However, there was no significant difference between spacing of 5 and 7.5cm. This might be due to the fact that closer spacing between plants resulted in competition for nutrients, moisture and light, thus reducing amount of assimilate produced and stored in the bulbs which reduced their bulb weight. Result of this study is in agreement with Dereje *et al.* (2012) who reported that shallot bulbs planted at 20cm intra-row spacing grow more vigorously and obtained more biological yield per plant than those planted at 10cm spacing. Many other authors (Shaikh *et al*., 1987; Patel and Patel, 1990, Khan *et al*., 2002 and Akuon, 2004) also reported that the increased bulb weight and above ground vegetative parts of onion were obtained from plants grown in wider spacing and higher rates of nitrogen application which ultimately increased the fresh biomass yield of onion.

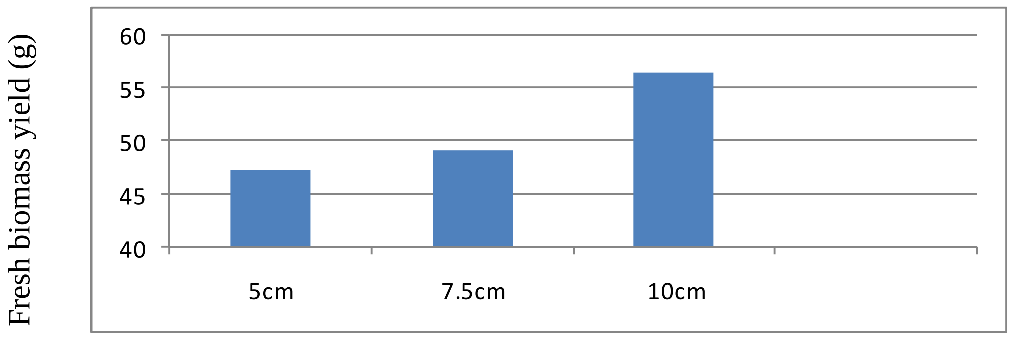

Figure 6: Effect of intra raw spacing on fresh biomass yield (g plant^{-1}) of onion

Dry biomass yield (g plant^{-1})

The effects of intra-row spacing was significantly ($p<0.01$) influenced average dry biomass yield. As intra-row spacing increased from 5 to 10cm, average dry biomass yield was also increased from 36.93g to 42g (Figure 7). The result is in line with the findings of Rashid and Rashid (1987) who noticed that onion bulb size and weight increases with increasing inter, and intra-row spacing, but recorded lower total bulb yield that increases with closer spacing. Densely populated plants produced lower bulb weight as compared to thinly populated plants. Increasing plant spacing resulted in heavier onion bulbs (Jilani *et al*., 2009). Mean bulb weight and plant height decreased as population density increased (Mohamed, 1988). Jan *et al.* (2003) also reported that at narrower spacing (17x4.5cm) minimum bulb weight was produced.

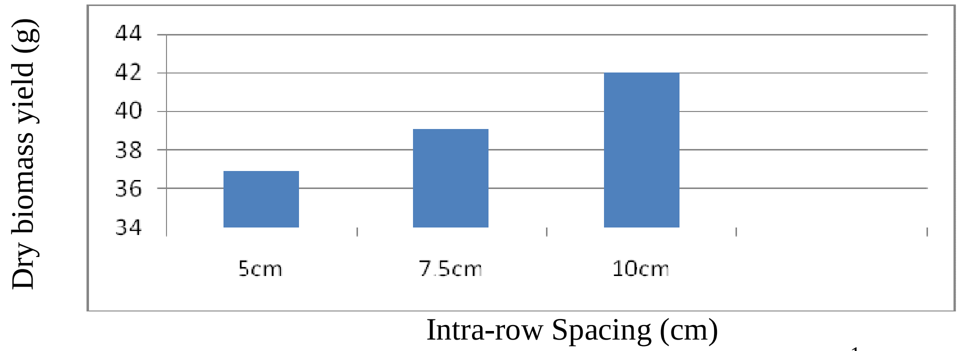

Figure 7: Effect of intra-raw spacing on dry biomass yield (g plant^{-1}) of Adama red onion

Conclusion

Onion is among the most widely cultivated crop in Ethiopia and is rapidly becoming a popular vegetable crop by producers and consumers. In Fiche district, onion is produced in the same way as other parts of the country for home and as a cash crop by irrigation. However, lack of improved varieties and inappropriate production practices and absence of technologies are the major bottleneck of onion production and productivity in the area. Therefore, a field experiment was conducted at Addis Ababa University, Selale campus horticulture department demonstration farm to determine appropriate intra-row spacing of Adama red onion for the area. Results of the field experiment revealed that the effects of intra-row spacing showed a significant effect on days to maturity, plant height, leaf length, bulb length, mean bulb weight, bulb dry weight, fresh biomass yield and dry biomass yield, while leaf number was not significantly affected by the factor.

Therefore, it could be conclude that, under Fich condition, good quantity of Adama red onion is possible to produce with intra-row spacing of 10cm. However, this intra-row spacing cannot be generalized for all onion cultivars and locations in areas of Fiche district. Therefore, the experiment should be repeated over locations and seasons by including intra-row spacings narrower than 5cm as well as higher than 10cm.

Akcnowledgemnt

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