Effect of Nitrogen Fertilizer Rates and Intra Row Spacing on Bulb Yield of Onion (*Allium cepa* L.) at Shire, Northern Ethiopia

Kiros Gebretsadik[1], Nigussie Dechassa[2]

[1]Department of Plant Sciences, Aksum University, Shire Campus P.o.box 314 Shire, Ethiopia

[2]Department of Plant Sciences, Haramaya University P.o.box 138 Dire Dawa, Ethiopia

Abstract: ***A field experiment was conducted to study the effect of nitrogen (N) fertilizer rates and intra row spacing on yield of onion (Allium cepa L.) cultivar Bombay Red. Treatments consisted of a factorial combination of four rates of N (0, 50, 100 and 150 kg N ha^{-1}) and four intra row spacing (4, 6, 8, and 10 cm) with inter row spacing of 20 cm. The experiment was laid out as a Randomized Complete Block Design with three replications. The analysis of variance revealed that the main effects of N and intra row spacing significantly affected average fresh bulb weight, bulb diameter, marketable yield, and total bulb yield. 100 kg N ha^{-1} was found the best rate of N to get optimum marketable bulb yield (31.455 t ha^{-1}), total bulb yield (32.84 t ha^{-1}) and average bulb weight (86.50 g). The results also revealed that intra row spacing of 6 cm was optimum. Combined Spacing of 6 cm x 20 cm with 100 kg N ha^{-1} is most favourable for onion cultivar Bombay Red production at Shire, northern Ethiopia.***

Keywords: Nitrogen fertilizer, Intra row spacing, Onion, bulb yield

1. Introduction

Onion (*Allium cepa* L.) is a vegetable crop grown for its pungent bulbs and flavourful leaves. It belongs to the genus *Allium* of the family *Amaryllidaceae* [1]. Generally, all plant parts of alliums can be consumed by humans except perhaps the seeds [2]. Onions have significant contributions to the nutritional requirements of human beings and have also medicinal values and are primarily consumed for their unique flavour or for their ability to enhance the flavour of other foods [3].

Onion and/or shallot are probably cultivated in all countries of tropical Africa including Ethiopia [4]. Onion is important in the daily Ethiopian diet, cultivated both under rain fed and irrigated conditions. In 2010/11 during the rainy season 22,035.8 ha of land was planted and about 2.37 million tons of bulbs were obtained with an average yield of 10.75 t ha^{-1} [5] which is low compared to other onion producing countries like the Republic of Korea (66.15 t ha^{-1}), USA (56.13 t ha^{-1}), the Netherlands (51.64 t ha^{-1}), Japan (46.64 t ha^{-1}) and Egypt (36.16 t ha^{-1}) in the production year of 2011 [6].

One of the major bottlenecks of onion production in Ethiopia particularly at Shire area is improper agronomic practices used by farmers. The optimum level of any agronomic practices such as plant population density and fertilizer application varies with the environment, purpose of the crop and variety. To optimize onion productivity a full package of information is required for specific growing system [7], [8]. The use of optimum plant population density has a dual advantage. It avoids strong competition between plants for growth factors such as water, nutrients, and light. Conversely, it enables efficient use of available crop land without wastage [9].

Spacing of 10 cm between two adjacent plants and 30 cm between rows was recommended when transplanting onions to permanent fields [10]. However, this spacing is not optimum under all conditions of growth as well as crop or varietal characteristics. Varieties of onion may differ in root architecture, foliage and other growth characteristics. A cultivar performs differently under different agro climatic conditions and various cultivars of the same species grown even in the same environment often yield differently [11].

Performance of a cultivar mainly depends on the interaction of genetic makeup and the environment [12] reported that the recommended spacing for improved onion production in Ethiopia is 10 cm x 20 cm x 40 cm spacing where 10 cm is the spacing between plants, 20 cm is the spacing between rows and 40 cm is the width of plant bed including irrigation water path used for watering the plant. However, this recommendation was given irrespective of onion cultivars and only for furrow irrigation system. There is scanty of information on appropriate plant spacing for rain fed onion production in the study area.

Ethiopian Institute of Agricultural Research [13] recommended 100 kg DAP ha^{-1} and 150 kg urea ha^{-1} for onion production with no indication and consideration of appropriate spacing, cultivar, soil type and environmental conditions. Whereas, [14] suggested 200 kg DAP and 100 kg Urea in sandy loam soils of Ethiopia was recommended. Hence, there is lack of improved techniques of fertilizer rates in onion production in northern Ethiopia particularly in the study area. This research is, therefore, initiated with the objective to determine the influences of intra row spacing and nitrogen fertilizer on bulb yield of onion.

2. Materials and Methods

2.1 Description of the study site

The experiment was conducted at the Well Foundation Farmers' Training Centre at Shire Tigray Region, northern Ethiopia. It is located at an altitude of 1900 m above sea level [15]. The site is situated at latitude of 14°6′N and longitude of 38°17′E. The mean annual rainfall is 990 mm and average annual minimum and maximum temperatures are 12.4^o C and 28.5^o C, respectively. The rainy season extends from May to September and the maximum rain is received in the months of June to August. The field has sandy clay loam soil with pH of 6.57, organic carbon 1.29%, total nitrogen 0.08%, available P of 43.62 parts per million, exchangeable K of 1.55 cmol (+) kg^{-1} and CEC of 14.93 cmol kg^{-1} soil. The rural area around the study site is known for the mixed crop-livestock farming system [16].

2.2 Treatments and experimental design

The treatments consisted of four intra row spacing (4, 6, 8, and 10 cm) with the same inter row spacing of 20 cm and four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) laid out as a randomized complete block design (RCBD) in a 4 x 4 factorial arrangement and replicated three times.

Seeds were sown in a nursery on a well prepared seed bed. Fifty five days after sowing, seedlings with three to four green true leaves were transplanted to the experimental field. Only vigorous and healthy seedlings were transplanted. Nitrogen was applied at the specified rates in three splits (1/4th at transplanting, ½ at active stage of vegetative growth, and 1/4th at the start of bulbing). Phosphorus in the form of TSP was applied to all plots equally at 92 kg P_2O_5 ha^{-1}. All the required amount of TSP was applied in band just before transplanting at the depth of 10 cm below the soil level of positioning the roots of the seedlings.

At physiological maturity when 70 % of their leaves senesced, plants were harvested and used for determining yield components [13]. Plants in the border rows as well as those at both ends of each harvested row were left to avoid edge effects. All other cultural practices such as weeding, supplementary irrigation control of pests and diseases were performed as per the regional recommendations.

2.3 Statistical Analysis

Data were subjected to analysis of variance using SAS Statistical Software package. Means that differed significantly were separated using the Least Significant Difference (LSD) test procedure at 5 % level of significance. Pearson Correlation coefficients were determined for parameters using the same software.

3. Results and Discussion

The statistical analysis in Table 1 shows that average fresh bulb weight (g plant^{-1}), bulb diameter (cm) and dry total biomass (g plant^{-1}) show significant difference at 5 % significant level among treatments.

3.1 Average fresh bulb weight

When the rate of nitrogen was increased from 0 to 50 kg N ha^{-1}, bulb fresh weight increased per plant by 9.0 % (Table 1). Increasing the rate of nitrogen from 50 to 100 kg N ha-1 increased the bulb fresh weight further by 12 %. However, increasing the rate of N from 100 to 150 kg N ha-1 decreased bulb fresh weight significantly by 5 %. This result was similar with [17] who reported significant increases in the bulb weight of onion due to increased nitrogen application. The significant decline of fresh bulb weight in response to increasing rate of nitrogen from 100 to 150 kg N ha-1 may be attributed to overdose or supra optimal supply of the nutrient which may have led to excessive growth of vegetative parts at the expense of growth and development of bulbs. Increasing the intra row spacing from 4 to 6 cm, increased bulb fresh weight by 16 %. Further widening the intra row spacing from 6 to 8 cm did not change bulb fresh weight. However, when the intra row spacing was widened to 10 cm, then bulb fresh weight was increased by 7.45 %.

3.2Bulb diameter

The statistical analysis in Table 1 revealed that significant difference at 5% significant level among treatments. Increasing nitrogen rate from 50 kg to 100 kg N ha^{-1} significantly increased bulb diameter by 5%. However, increasing nitrogen rate from 0 to 50 kg N ha^{-1} and 100 to 150 kg N ha^{-1} did not affect bulb diameter of onion. N rate significantly increased bulb diameter by about 16% due to 150 kg N ha^{-1} in reference to the control, which may be due to the increase in dry matter production and allocation to the bulb. This was in agreement with the results of [18] who reported a significant increase in the diameter of bulbs due to the application of N up to 120 kg ha^{-1}. Also it was found significantly increased bulb diameter by about 12% due to N 138 kg ha^{-1} fertilization [19]. Similarly bulb diameter was significantly influenced by intra row spacing where 6 cm gave significantly the highest bulb diameter of 5.673 cm compared with the narrow intra row spacing of 4cm which gave 4.826cm. This may be due to less competition for resources in the case of wider plant spacing.

Table 1: The main effects of nitrogen and intra row spacing on average bulb weight, bulb diameter, dry total biomass yield and shoot dry weight

N (kg ha^{-1})	Average bulb weight (g plant^{-1})	Bulb Diameter (cm)	Dry total biomass (g plant^{-1})	Shoot dry weight (g)
0	70.667c	4.907b	47.228d	18.963c
50	77.250b	5.358ab	59.654c	23.195b
100	86.500a	5.628a	65.743b	25.412a
150	82.333b	5.693a	72.756a	26.691a
F-test	**	*	**	**
Intra row Spacing (cm)				
4	69.333c	4.826b	53.843d	16.689d
6	80.250b	5.673a	58.518c	21.343c
8	80.583b	5.443a	64.204b	25.80b
10	86.583a	5.643a	68.815a	30.428a
F-test	**	*	**	**
LSD(0.05)	4.943	0.519	3.298	2.1678
CV (%)	7.486	11.543	6.449	11.034

Means sharing a common letter are not significantly different at 5%level of significance Ns = non significant. ***, **** shows *significance at 5% and 1% level of significance respectively*

3.3 Dry total biomass yield

Dry total biomass yield of the onion crop increased linearly with the increases in the rate of nitrogen application (Table 1). As the rate of nitrogen application increased from 0 to 50 kg ha^{-1}, dry total biomass yield increased significantly by 26 %. Increased application of nitrogen from 50 kg N ha^{-1} to 100 kg N ha^{-1} further increased dry total biomass yield by 10 %. When the rate of nitrogen was further raised to 150 kg N ha^{-1} from 100 kg N ha^{-1}, dry total biomass yield increased by 11 %. A previous field research also showed that application of N fertilizer at the rate of 150 kg N ha^{-1} increased dry total biomass [18]. The marked increase in total biomass yield in response to the increased rate of N application could be attributed to an increased photosynthetic area in response to fertilization that enhanced assimilate production and partitioning to the bulbs.

Widening the inter-row spacing from 4 cm up to 10 cm linearly increased the dry total biomass yield of the crop. Widening the spacing from 4 to 6 cm was increased dry total biomass yield by 9 %. Further widening the intra row spacing from 6 to 8 cm increased the dry total biomass yield by 10 %. When the intra row spacing was further widened to 10 cm, dry total biomass yield increased further by 7 %. The dry total biomass yield of plants grown at the intra row spacing of 10 cm exceeded the dry total biomass yield of plants grown at the spacing of 4 cm by 28 %. This result demonstrates that plants grown at the widest spacing produced the highest dry total biomass yield possibly due to less stiff competition among them for growth factors.

3.4 Shoot dry weight

The analysis of variance of shoot dry weight showed that the main effects of nitrogen and intra-row spacing highly significantly ($P < 0.01$) influenced shoot dry weight of onion plants (Table 1). In response to increasing the rate of nitrogen from 0 to 50 kg N ha^{-1}, shoot dry matter yield increased by 22%. Increasing the rate of nitrogen from 50 to 100 kg N ha^{-1} increased the shoot dry matter yield further by 10%. However, increasing the rate of nitrogen beyond 100 kg N ha^{-1} did not change shoot dry matter yield. The increase in shoot dry matter yield in response to increasing the rate of nitrogen from 0 to 100 kg N ha^{-1} amounted to 34%. This result shows that nitrogen enhanced assimilate production and dry matter accumulation in onion plants. The result is in accord with that of [18] who reported that, higher shoot dry weight was recorded when nitrogen supply was raised up from nil to 150 kg ha^{-1}.

Similarly, shoot dry weight significantly increased with increasing intra row spacing. Widening the intra-row spacing, from 4 to 6 cm, increased shoot dry matter yield by about 28%. Further widening the intra-row spacing from 6 to 8 cm again increased shoot dry matter yield by 21%. When the intra-row spacing was widened to 10 cm, the shoot dry matter yield increased further by 10%. The shoot dry matter yield of plants grown at the intra-row spacing of 10 cm exceeded the shoot dry matter yields of plants grown at the spacing of 4 cm by 82% (Table 1). The result showed that plants grown at the widest spacing produced the highest shoot dry matter yield possibly due to less completion among them for growth factors such as light, water and mineral nutrients. At wider spacing, due to less competition for light and other resources, plants apparently accumulated more shoot dry weight. This may be due to the fact that the crop plants should cover the soil to intercept maximum sunlight to produce higher dry matter as the intercepted solar radiation and dry matter production are directly related. .

3.5 Marketable Yield:

Statistical analysis shows that marketable yield (t ha^{-1}) was significance difference among treatments at 5% level of significance (Table 2).The highest marketable yield was recorded at 100 kg N ha^{-1} (31.455 t ha^{-1}). Increasing the rate of N from 0 to 50 kg N ha^{-1} markedly increased marketable fresh bulb yield by 45%. Increasing the rate of N from 50 to 100 kg N ha^{-1} increased the marketable fresh bulb yield further by 30%. However, increasing the rate of N from 100 to 150 kg N ha^{-1} tended to decrease marketable fresh bulb yield by 5%. Thus, 100 kg N ha^{-1} resulted in the production of optimum fresh marketable bulb yield, and there is no need to increase the rate of the nutrient above this rate. An experiment carried out on onions using N rates ranging from 0 to 180 kg ha^{-1} and found that the highest yield and percentage of marketable bulb production occurred in response to 60 kg N ha^{-1} while, 180 kg N ha^{-1} resulting in yield that was even lower than that of the treatment without N [20] .

Widening the intra row spacing from 4 to 6 cm significantly increased the fresh marketable bulb yield by 10 %. However, widening the intra row spacing to the higher levels did not change marketable fresh bulb yield. This result shows that plants grown at the wider spacing of 6, 8, and 10 cm produced the highest fresh marketable bulb yields due to less competition than plants grown at the narrowest intra row spacing of 4 cm.

3.6 Unmarketable yield

Unmarketable fresh bulb yields decreased (1.81 to 1.39 t ha^{-1}) with the increase in the rate of N application (Table 2). Thus, the highest unmarketable fresh bulb yields were obtained from plots that received 0 and 50 kg N ha^{-1}. The smallest unmarketable fresh bulb yields were obtained from plots that received 100 and 150 kg N ha^{-1}. This shows that N improves marketability or decreases unmarketable of onion bulbs through the positive role it plays in increasing average bulb fresh weight.

Widening the intra row spacing tended to decrease the yield of unmarketable bulbs of the crop (Table 2). Only plants grown at the intra row spacing of 4 cm and 8 cm differed significantly in the yield of unmarketable bulbs. Thus, plants grown at the spacing of 4 cm produced 27.5% more unmarketable bulb yields than at the intra row spacing of 8 cm. This shows that growing onion at the narrow intra row spacing of 4 cm produced the highest unmarketable bulb yields followed by intra row spacing of 6 cm. Small sized and misshaped bulbs may contribute to the amount of unmarketable bulb yield due to the stiff inter plant competition for growth factors. For the widest intra row spacing, production of considerable numbers of too large bulbs may contribute to the amount unmarketable fresh bulb yield due to low inter plant competition for growth factors.

Table 2: The main effects of nitrogen and intra row spacing on marketable,unmarketable, total fresh bulb yields and Total Soluble Solids

N (kg ha^{-1})	Marketable yield (t ha^{-1})	Unmarketable yield (t ha^{-1})	Total yield (t ha^{1})	Harvest Index (%)
0	16.588c	1.72ab	18.31c	73.033c
50	24.114b	1.81a	25.93b	74.535cb
100	31.455a	1.39b	32.84a	75.904ab
150	29.669a	1.43b	31.10a	77.642a
F-test	**	*	**	*
Intra row Spacing (cm)				
4	24.23b	1.81a	26.03b	81.803a
6	26.72a	1.60ab	28.32a	76.205b
8	25.43ab	1.42b	26.85ab	72.979c
10	25.45ab	1.52ab	26.97ab	70.128d
F-test	*	*	*	**
LSD (0.05)	2.097	0.360	2.156	2.716
CV (%)	9.882	27.196	9.563	4.327

Means sharing a common letter are not significantly different at 5%level of significance Ns=non significant.
*, ** shows *significance at 5% and 1% level of significance respectively*

3.7 Total bulb yield

From Table 2, similar trend to marketable yield was observed. Increasing the rate of N from 0 to 50 kg N ha^{-1} markedly increased total bulb yield by 42 %. Increasing the rate of nitrogen from 50 to 100 kg N ha^{-1} increased the total bulb yield further by 27 %. However, similar to the marketable bulb yield, increasing the rate of N from 100 to 150 kg N ha^{-1} tended to decrease total bulb yield by 5 %. Increasing the rate of N from nil to 100 kg N ha^{-1} significantly increased total fresh bulb yield by 79 %. Thus, similar to the marketable fresh bulb yield, 100 kg N ha^{-1} resulted in the production of optimum total bulb yield (32.84 t ha^{-1}). Therefore; further addition of nitrogen doses above 100 kg ha^{-1} did not increase yield of the onion crop.
Several researchers reported similar results. It was also found that increase in N dose up to 100 kg N ha^{-1} resulted in increased yield of onion bulbs but further increase of nitrogen to 150 kg N ha^{-1} did not significantly increase the yield [21]. A report indicated that maximum yield of onion bulbs was obtained from application of mineral N fertilizer at the rate of 100 kg N ha^{-1} [17]. Similarly, [22] reported that yield incensement in the range of 0 to 150 kg ha^{-1} after which it decreased.

Increasing the intra row spacing from 4 to 6 cm significantly increased the total fresh marketable bulb yield by 9% (Table 2). However, increasing the intra row spacing to all higher spacing did not change total bulb yield. This result shows that plants grown at intra row spacing of 6 cm produced the higher mean total bulb yields. [23] (1991) also reported that, closer intra row spacing of 5 cm increased bulb yield by 7.6% over 10 cm. Similarly, [24] also found that in Bombay Red at the intra row spacing of 4 cm produced the highest yield compared with 10 cm intra row spacing at the rift valley of Ethiopia. However, experimental result showed that optimum yield at 10 cm x 20 cm spacing after compared with 12 × 20 cm and 6 × 20 cm. Such difference may be difference in soil condition, variety of onion used or agro ecological variability [25].

3.8 Harvest index

Harvest index increased with the increase in the rate of nitrogen application (Table 2). The highest harvest index, (77.642 %), was produced at the application of 150 kg N ha^{-1}, which increased the parameter by about 6 % compared with the control. This indicates that application of higher amounts of N is important for onion to produce more assimilates for growth, development, and bulb production. Similarly, [19] indicated that N application improved harvest index in onion by increasing both bulb dry weight and total biomass yield.

Increasing the intra row spacing of onion, linearly and significantly decreased harvest index (Table 2). Widening the intra row spacing from 4 to 6, 8, and 10 cm significantly reduced harvest index by 7, 4, and 4%, respectively in the order mentioned here. The harvest index of plants grown at the narrowest intra row spacing of 4 cm exceeded the harvest index of plants grown at the widest intra row spacing of 10 cm by 14 %. This result demonstrates that bulbs of plants grown at the narrowest spacing were compact and had more dry matter relative to the smaller biomass produced due to stiffer competition between plants. On the other hand, bulbs produced by plants grown at the widest spacing produced higher bulb dry biomass yield but also that of above ground dry biomass yield due to relatively sufficient growth factors for photo-assimilation, thereby reducing the relative ratio of bulb dry matter to the dry matter of total biomass, which is harvest index.

4. Conclusion

Lack of improved production practices have been the major bottlenecks of onion productivity in northern Ethiopia particularly at Shire area. Keeping optimum intra row spacing and N fertilizer, helps to maintain higher yield and also to get marketable bulb size. Optimum marketable yield was found from plots that were planted using 6 cm intra row spacing and application of 100 kg ha^{-1} N compared with other treatments. Therefore, it could be concluded that Onion Bombay Red cultivar should be planted during the rainy season at optimum spacing of 6 cm x 20 cm with application of 100kg N ha^{-1} at Shire area to attain maximum yield.

5. Acknowledgement

Special thanks to The Well Foundation Organization in Shire for allowing me to use their farm and facility.

References

[1] Welbaum.G.E., 2015. Vegetable Production and Practices. Virginia Tech University, USA http://www.cabi.org 486pp.
[2] Rabinowitch H.D. and Currah L. (eds.), 2002. *Allium* Crop Science: Recent advances. CABI Publishing. Wallingford, UK. 515 pp.
[3] Randle, W.M. and Ketter, C.A. 1998. Pungency assessment in onions. Proceedings of the19 workshop conference of the Association for Biology Laboratory Education (ABLE). pp177-196. http://www.zoo.utoronto.ca
[4] Grubben, G. J. H. & Denton, O. A. (eds). 2004. Plant resources of Tropical Africa 2. Nordic Journal of Botany, 23(3): 298. doi:10.1111/j.1756-1051.2003.tb00397.x
[5] CSA (Central Statistics Authority). 2011. Agriculture sample survey. September to 2010. Report on Area and production of major Crops (Private peasant holdings, meher season). Bulletin. Vol. I. Addis Ababa, Ethiopia.
[6] FAO STAT Data. 2012. http;//www.fao.org. Accessed on February 13 2013.
[7] Gupta, R.P., Sharma, V.P., Singh, D.K., and Srivastav, K.J. 1999. Effect of organic manures and inorganic fertilizers on growth, yield and quality of onion variety Agrifound Dark Red. *News Letter National Horticultural Research and Development Foundation* India. 19(2-3):7-11.
[8] Lemma Dessalegn and Shimeles Aklilu. 2003. Research Experiences in Onion production. Research Report No. 55. Ethiopia Agricultural Research Organization. Addis Ababa.
[9] Zubelidia, A. and Gases, J.L. 1977. Effect of spacing and Number of stem on the Earliness and Total yield of Tomato cultivars. *Product. Veg*. 7: 73.
[10] FAO. 1995. STAT Data. Production yearbook. Italy, Rome.
[11] Jilani, M. S. 2004. Studies on the management strategies for bulb and Seed production of different cultivars of onion *(Allium cepa L.)*. a dissertation submitted to NWFP. Agriculture University, Peshawar, Pakistan. http://eprints.hec.gov.pk/1013/1/744.html.htm
[12] Lemma Dessalegn. 2004. Onion Production Pamphlet (Amharic version). EARO, Melkassa Research Center. Ethiopia.
[13] EIAR (Ethiopian institutes of Agricultural Research). 2004. Directory of released crop Varieties and their recommended cultural practices. Addis Ababa, Ethiopia.
[14] Nikus, O. and Fikre Mulugeta. 2010**.** Onion seed Production Techniques. A Manual for Extension Agents and Seed Producers. FAO. Crop Diversification & Marketing Development Project. Asella, Ethiopia.
[15] Finneran Niall. 2005. The Archeological Landscape of the Shire Region, Western Tigray, Ethiopia. In: Annales d'Ethiopie. Volume 21, année pp. 7-29; doi: 10.3406/ethio.2005.1091http://www.persee.fr/doc/ethio_0066-2127_2005_num_21_1_1091
[16] Yayneshet, T., 2010. Feed resources available in Tigray region, northern Ethiopia for production of export quality meat and Livestock. Addis Ababa. www.igad-data.org/livestock-production/doc/feed-resources-assessment-in-tigray-regional-state-ethiopia.
[17] Khan, H.M. Igbal, Ghaffoor, A. and Wasseem, K. 2002. *Effect of various plant spacing and different levels of nitrogen on the growth and yield of onion (Allium cepa L). Journal of Biological Science*. 2;545-547
[18] Nasreen, S, Haque, M.M., Hossain, MA. and Farid ATM .2007. Nutrient uptake and yield of onion as influenced by nitrogen and sulphur fertilization. *Bangladesh J. Agric. Res.*32(3): 413-420
[19] Abdissa Yohannes, Tekalign Tsegaw and Pant, L.M. 2011. Growth, bulb yield and quality of Onion (Allium cepa L.) as influenced by nitrogen and phosphorus fertilization on vertisol I. growth attributes biomass production and bulb yield. *African Journal of Agricultural Research Vol. 6(14), pp.3252-3258*. http://www.academicjournals.org/AJAR.
[20] Cizauskas, A., Viskelis, P., Dris, R. and Oladele, OI. 2003. Influence of nitrogen rates on onion yield quality and storability. *Moor Journal of Agricultural Research*. ISSN: 1595-4153.V0l.4(1) 2003: *85-8.www.ajol.info/index.php/mjar/article/view/31758*
[21] Aliyu, U., M.D. Magaji, A. Singh and S.G. Mohammed, 2007. Growth and Yield of Onion (*Allium cepa* L.) as Influenced by Nitrogen and Phosphorus Levels. *International Journal of Agricultural Research, 2: 937-944*.DOI: 10.3923/ijar.2007.937.944.URL**:** http://scialert.net/abstract/?doi=ijar.2007.937.944.
[22] Brewester, J.L.1994. Onions and other vegetable *Alliums*. CAB International. Wallingford. UK. p. 236.
[23] Mohamed, E.N.O.M. 1991. Effect of plant population and nutrition on yield and quality of onion in Kassala, Sudan. http://arcsudan.sd/arc/conferences/meeting37/pdf/5.pdf
[24] Geremew A., Teshome A., Kasaye T. and Amenti C., 2009. Effect of intra-row spacing on yield of three onion *(Allium cepa l.)* Varieties at Adami Tulu Agricultural Research center (mid rift valley of Ethiopia). *Journal of Horticulture and Forestry*. Vol. 2(1) pp. 007-011.http://www.academicjournals.org/jhfJanuary. (accessed 22.01.15).
[25] Viloria, A., Arteaga, L., Díaz, L. and Delgado, D. 2003. Effect of N-P-K fertilization and planting distance on onion (Allium cepa L.) yield. *Bioagro*. 15:129–133.
[26] Russo, V.M. 2008. Plant Density and Nitrogen Fertilizer Rate on Yield and Nutrient Content of Onion Developed from Greenhouse grown Transplants. *Hort. science* 43(6):1759–1764. http://hortsci.ashspublications.org/content/43/6/1759.full.pdf.

Author Profile

Kiros Gebretsadik received his B.Sc in Plant Science from Debub (now Hawassa) University and M.Sc. degrees in Horticulture from Haramaya University in 2006 and 2013, respectively. During 2006-2010, he worked at Shire Agricultural TVET College. Now he is Lecturer, Research and Community service officer at Aksum University, Shire Campus.