Influence of Nitrogen Rates on Growth, Yield and Quality of Onion (*Allium cepa* L.) Varieties in West Dembia District, North Western Ethiopia

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ABSTRACT

Onion (Allium cepa L.) is highly important vegetable in the daily diets of Ethiopians as flavoring of dishes, sources of important carbohydrate, protein and several nutrient elements. However, its productivity is low mainly due to low soil fertility, improper fertilizer application and limited use of improved onion varieties. Hence, a field experiment was conducted under irrigation to evaluate the effects of nitrogen rates on growth, yield, and quality of onion varieties. The treatment consisted of a factorial combination of six levels of nitrogen rates (0, 46, 69, 92, 115 and 138 kg N ha^{-1}) and two improved onion varieties (Adamared and Bombayred), which were laid out in a randomized complete block design in three replications. The collected data were analyzed using SAS software. The analysis of variance showed that the main effect of nitrogen rates on all tested parameters was significant while the main effects of varieties had significant effect on all parameters except plat height, number of leaves and unmarketable yield. Adamared variety gave higher marketable bulb yield (15.56 t ha^{-1}) than Bombayred (13.89 t ha^{-1}). The application of 138 kg N ha^{-1} gave the highest marketable bulb yield (19.23 t ha^{-1}) and the maximum net benefit (253965 birr ha^{-1}) with acceptable marginal rate of return (2804%). However, application of 138 kg N ha^{-1} reduced quality parameters of onion bulbs. It increased neck diameter, decreased dry matter content and total soluble solids. It also caused the highest percent rots, sprouts and weight losses of bulbs during the eight month storage life. It can be concluded that application of 138 kg N ha^{-1} for Adamared variety can be used for better productivity in the study area.

***Keywords**: Economic feasibility, Fertilizer, Shelf life, Storage, Vegetable*

INTRODUCTION

Onion (*Allium cepa L.*) is widely produced vegetable crop in many parts of Ethiopia by small holder farmers. It can be grown under a wide range of climatic conditions. Day temperature of 20°C - 26°C and 11 - 15°C night temperature are ideal for bulb production. In Ethiopia, onion can be grown at 700-2000 m.a.s.l (Zeleke & Derso, 2015). The crop is produced both under rain fed and irrigation conditions. The area under onion is increasing from time to time mainly due to its high profitability per unit area, ease of production and the increases in small scale irrigation areas (Nigussie et al., 2015). Its total production in Ethiopia is 262,479 tons from area coverage of 28185 ha in the main cropping season of 2018/19. The two major onion producing regions are Orimia and Amhara, sharing 33 and 52% total production from area coverage of 45 and 37%, respectively (CSA, 2019).

Onion occupies an economically important place among vegetables in Ethiopian. It is considerably important in the daily Ethiopian diets for the preparation of traditional foods. It is primarily used as flavoring of dishes, sauces, soup, and sandwiches (Awas *et al*., 2010). Its bulb is used as raw, sliced seasoning salads and cooked with other vegetables and meat. It is a rich source of carbohydrate, protein, several minerals (Ca, Mg, Al, Cu, Fe, Mn, Zn) and vitamins (A, B, C and E) (Kumar *et al*., 2010). It has also nutritional value that helps alkaline reaction in our body and important in neutralizing the acid substance produced during the course of digestion of meat and cheese (Yousuf *et al*, 2013). Moreover, it has a range of health benefits which reduced risk of cancer, heart disease and diabetes, anti bacterial, antiviral and anti-allergenic. Moreover, it has antibiotic properties, which can reduce bacterial contamination. The bulbs are also used in culinary preparations at home remedy for many infections, inflammations, respiratory and digestion problems (Ashwini & Sathishkumar, 2014).

Though onion is an important and widely produced vegetable crop in Ethiopia for its daily consumption and economic benefits, its national average yield is very low (9.3 t ha^{-1}) (CSA, 2018) as compared to the average yield of the world (19 t ha^{-1}) and Africa (15 t ha^{-1}) (Zeleke & Derso, 2015). The low yield of onion in Ethiopia is due to different production constraints such as diseases, insect pests, improper application of fertilizers, high costs of chemical fertilizers and limited use of improved onion varieties (Alemayehu *et al.,* 2015).

Onions is more susceptible to nutrient deficiencies than most other crop plants because of its shallow and un branched root system. Nitrogen is the most limiting nutrient in plant growth and yield (Walworth, 2013). Hence, onion responds well to nitrogen fertilizer application. Conversely, excessive rate of nitrogen result in excessive vegetative growth, succulent plants, delayed maturity, and enhances plants to be sensitive to water and temperature stress, diseases and pest incidence. It consequently affects dry matter contents, yield, quality and storability of bulbs (Messele, 2016).

To alleviate constraints of onion production, various researches have showed that improved varieties and fertilizers application such as nitrogen containing fertilizers are very important. The agricultural research system of the country has made efforts to generate different improved onion varieties such as Adamared, Bombayred and others varieties (Lemma & Shimelis, 2003; Zeleke & Derso, 2015). However, the optimum nitrogen rate for onion production might vary with environment and crop variety. Rates of nitrogen fertilizer vary depending on soil type, rainfall, plant populations and method and timing of applications (Zakirullah *et al*., 2018). It is difficult to give general recommendations for different agro ecological zones. Therefore, optimum fertilizer application and cultivation of suitable varieties in specific environment are necessary to improve the productivity of onion. However, information on site specific fertilizer application and varieties is limited in the study area. Therefore, the study was conducted to evaluate the effects of nitrogen rates on growth, yield and quality of Adamared and Bombayred varieties of onion in the study area.

MATERIAL AND METHODS

Description of the Experimental Site

A field experiment was conducted at Gorgora Horticulture Research and Demonstration Site of College of Agriculture and Environmental Sciences of University of Gondar from December 2018 to May 2019. The site is found 65 km south of Gondar town. It is in West Dembia District, is located at longitude of 37°, 20' 224" east, latitude of 12°, 25', 609" north and altitude of 1800 meters above sea level which is suitable for the production of a wide range of crops including onion. The average rainfall is about 1083 mm. The average daily minimum and maximum temperatures are 17 ^{0}C and 28 ^{0}C, respectively. The soil texture of the experimental field was clay loam, with slightly acidic pH (6.51) according to the rating of Murphy (1968). The total nitrogen (0.19%), organic carbon (2.31%) and organic matter (3.99%) contents of soil were moderate according to the rating of Murphy (1968). The soil had high available phosphorous (35.81ppm) according to the rating of Olsen *et al*. (1954). The cataion exchange capacity was (38.90 Cmol (+) kg^{-1}), which is high based on the categorization of Hazelton and Murphy (2007) (Table 1).

In addition, a storage experiments was conducted in the laboratory of College of agriculture and environmental sciences, Teda campus of University of Gondar. The site is located at latitude of 12^{o} 28'5'' North, longitude of 37^{o} 29' 25'' East and has an altitude of 1977 meters above sea level. The minimum and maximum daily temperature is 12.7 ^{0}C and 27.3 ^{0}C, respectively.

Table 1. Soil physic-chemical properties of experimental site before planting

Soil chemical properties	Value	Rating	Reference
pH	6.51	slightly acidic	Murphy 1968)
Organic carbon (%)	2.31	Moderate	Murphy 1968)
Organic matter (%)	3.99	Moderate	Murphy 1968)
Total N (%)	0.19	Moderate	Murphy 1968)
Available p (ppm)	35.81	high	Olsen *et al*. (1954)
CEC (mol(+)/kg)	38.9	High	Hazelton & Murphy (2007)
Soil particle proportion (%)			Textural Class
Silt	Clay	Sand	
27	30	43	Clay loam

Experimental Materials

Two onion varieties (Adamared and Bombayred) were used as test crop. Seeds were obtained from Adet Agricultural Research Centre. The two varieties grow within the altitude of 700 to 2000 m.a.sl. Adamared variety takes 110-130 days to mature. It has light green leaf and dark-red bulb, weighing 60-80 g. It can give a yield of 9-15 t ha^{-1}. Bombayred takes 110-120 days to mature. It has dark-green leaf and light red bulb skin weighing 85-100 g. It can give a yield of 13 to 16 t ha^{-1} (Lemma & Shimelis, 2003). The source of nitrogen and phosphorus for the experiment was urea (46% N) and triple super phosphate (46% P_2O_5), respectively.

Treatments and Experimental Design

Both field and storage experiments were conducted. The field experiment consisted of a factorial combination of six nitrogen rates (0, 46, 69, 92, 115 and 138 kg ha^{-1}) and two onion varieties (Adamared and Bombayred). The treatments were laid out in a randomized complete block design in three replications. The gross plot size was 3.6 m^2 (2 m x 1.8 m) with a distance of 1 m and 2 m between plots and blocks, respectively. The net plot size was 2.94 m^2 (1.84 m x 1.6 m).

Crop management

Seedlings were raised on well prepared nursery bed, having 1 m width and 5 m length. The onion seeds were drilled in rows of 20 cm spacing. Cultural practices were uniformly carried out until the seedling become ready for transplanting (3 to 4 leaf stage). Healthy and uniform seedlings were transplanted in to the main field at 60 cm between two double rows, 20 cm between single rows within double rows and intra-row spacing of 8 cm. There were 3 double rows, 6 single rows and 25 plants per row, with the total plant population of 150 per plot. For fertilized plots, half of the nitrogen dose at each rate was applied during transplanting, while the remaining half was applied 45 days after transplanting. All the recommended rate of triple super phosphate (200 Kg ha^{-1}) was uniformly applied to all plots at transplanting time. Other cultural practices were performed uniformly for all plots according to the recommendation for the crop.

Soil sampling and analysis

Pre-planting soil samples were taken randomly from the experimental field at five spots at the depth of 0 - 30 cm using an auger. The soil samples were mixed to make 1 kg composite soil sample, which was filled in to a polythene bag, labeled and taken to the soil laboratory of Amhara Design and Supervision Works Enterprise to analyze soil texture, pH, CEC (Cation exchange capacity), total N, available P and organic carbon. The soil pH was measured at 1:1.25 soils: water ratio suspension by using a glass electrodes pH meter (Jackson, 1967). Total nitrogen was determined by micro Kjeldhal procedure (Jackson, 1970). Available phosphorous content was determined by the procedure of Olsen *et al*. (1954). Organic carbon was determined by using the methods of Walkley & Black (1934). Organic matter was calculated as OM = OC x 1.72 (Nelson & Sommers, 1982). After harvesting, soil samples were also collected from each plot and soil samples were mixed to make 1 kg composite soil sample of similar treatments. The samples were then filled in to a polythene bag, labeled and taken to soil laboratory to analyze total nitrogen in the soil.

Storage Experiment

After harvesting, 30 marketable bulbs were taken from each net plot area and stored in the storage room for 60 days for further shelf life experiment. The storage experiment was arranged in randomized complete block design with three replications. The six levels of nitrogen rates (0, 46, 69, 92, 115 and 138 kg N ha-1) and two onion varieties (Adama Red and Bombey Red), which were treated on field experiment were used as treatment effects.

Data Collection

Days to physiological maturity was recorded as the number of days from date of transplanting to the date when about 70% of the leaves fell down and turned yellow. In each experimental plot, ten plants were randomly selected from net plot area to collect data on growth and yield related parameters of onion. Plant height was measured from the soil surface to the tip of the longest leaf using a ruler. Number of leaves was counted from ten randomly selected plants from the net plot area and divided by the number of plants to record as number of leaves plant^{-1}. The diameter and vertical lengths of ten randomly selected mature bulbs from each treatment was measured at the maximum wider portion by using veneer caliper and the mean values of the samples were recorded. Healthy bulbs that were greater than 20 g were categorized as marketable bulbs, while bulbs which were under sized (less than 20 g), diseased, misshaped, decayed, or discolored bulbs were categorized as unmarketable (Lemma & Shimelis, 2003; Tekle, 2015). The sum of marketable and unmarketable bulbs yields were recorded as total marketable bulb yield.

Data on quality parameters including neck diameter, total soluble solids and bulb dry mater content were recorded during the field study. Neck diameter was measured from ten randomly selected plants in the net plot using veneer calliper and then mean values of the samples were recorded. The total soluble solid (TSS) was determined at harvesting time from ten randomly selected bulbs from the net plot areas. Aliquot juice was extracted from bulbs and two drops of clear juice were placed on hand refractometer for TSS measurement. To measure bulb dry mater content, **b**ulbs were chopped in to smaller pieces with the help of sharp knife. Chopped bulbs (20 g) were oven dried at 70°C until a constant weight obtained (Benti, 2017). Finally bulb dry matter content was calculated as follows:

$$\text{Dry matter (\%)} = \frac{Weight\ of\ sample\ after\ drying\ (g)}{Initial\ weight\ of\ sample} \times 100 \qquad [1]$$

Data collection during bulb storage

During 60 days storage data were recorded on weight loss, rotten and sprouted bulbs every 15 days (15, 30, 45 and 60 days).

Rotten bulbs were recorded by counting the number of rotten bulbs and calculated as:

$$\text{Rotten bulbs (\%)} = \frac{\text{number of rotten bulb}}{\text{total number of bulbs}}\ x\ 100 \qquad [2]$$

Sprouted bulbs were recorded by counting the number of sprouted bulbs and calculated as:

$$\text{sprouted bulbs (\%)} = \frac{\text{number of sprouted bulb}}{\text{Total number of bulbs}}\ x\ 100 \qquad [3]$$

Weight losses of bulbs were calculated as:

$$\text{Bulb weight loss (\%)} = \frac{Final\ bulb\ Weight}{Initial\ weight} \times 100 \qquad [4]$$

Partial budget analysis

The marketable yields were adjusted down by 10% to consider management level variability between a researcher and a farmer (CIMMYT, 1988). The price of urea (14.00 birr kg^{-1}) and labor cost (80.00 birr day^{-1}) for nitrogen fertilizer application were used to calculate total variable cost. Total variable cost was calculated as the sum of all the costs that vary among treatments. The gross benefit was calculated as the product of the adjusted marketable yield (t ha^{-1}) and the farm get price of onion bulbs (15.00 birr kg^{-1}). Net benefit was calculated by subtracting the total variable cost from the gross benefit. Dominance analysis was carried out by first listing the treatments in order of increasing total costs that vary. There was no dominated treatment as all N treated treatment have net benefits greater than those of adjacent treatment with lower costs that vary. Therefore, all treatments were included for calculation of marginal rate of return. The marginal rate of return was calculated as percentage change in net benefit over change in total variable cost.

Data Analysis

The collected data from the field and storage experiments were subjected to analysis of variance using SAS software program version 9.1 (SAS, 2003). When the analysis of variance indicated significant difference, mean separation was done using Least Significant Difference (LSD) at 5% probability level.

RESULTS

Soil Nitrogen Status After Harvest

Postharvest soil nitrogen result showed that the highest total soil nitrogen (0.46%) was obtained from the plots treated with the highest nitrogen rate (138 kg N ha^{-1}) followed by application of 115 kg N ha^{-1} (0.40%), while the lowest total nitrogen obtained from unfertilized plot (0.11%), which is less than the nitrogen content (0.19) before planting of onion (Figure 1). Generally, the result indicated that external application of nitrogen on the farm has increased soil N while growing onion without nitrogen application depletes the soil nitrogen status in the growing season of onion. The result agreed with that of El-hamady (2017), who found the highest soil nitrogen content from highest nitrogen application rate (138 kg N ha^{-1}).

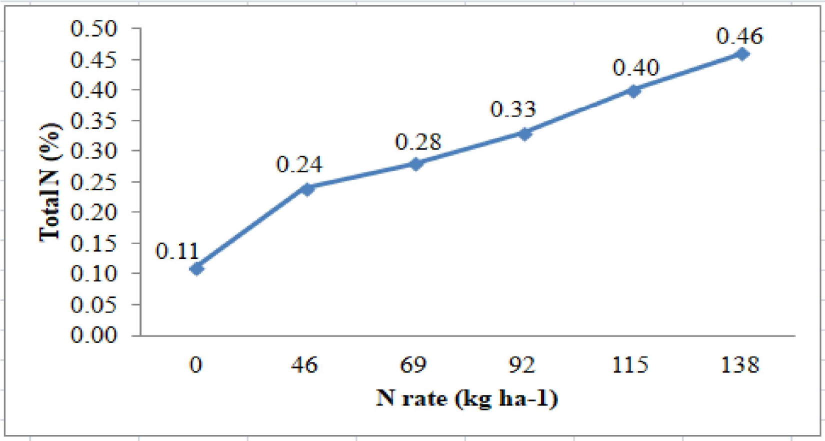

Figure 1. Soil nitrogen status after onion was harvested at different N rates

Days to Physiological Maturity

The results showed that the main effects of varieties and nitrogen rates on days to physiological maturity were significant ($P < 0.01$). However, the interaction effects of the two factors were not significant. Bombayred variety (96.78 days) matured 9 days earlier than Adamared (105.78 days) (Figure 2). Application of nitrogen at the highest rate (138 kg N ha^{-1}) prolonged days to physiological maturity (114.33 days), whereas the earliest days (93.17) to maturity was observed from unfertilized treatment (Figure 2). Increasing the nitrogen rate from zero to138 kg ha^{-1} increased days to physiological maturity by 21.16 days.

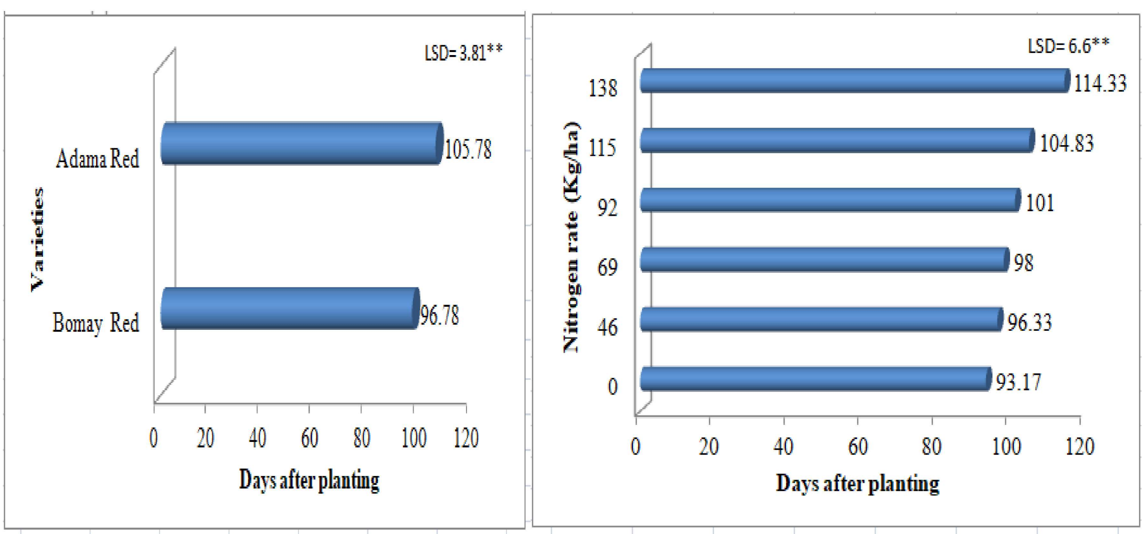

Figure 2. Main effects of nitrogen rates and varieties on days to physiological maturity

Plant Height and Number of Leaves per Plant

Plant height was significantly ($P < 0.01$) influenced by the main effects of nitrogen rates and varieties, while number of leaves per plant was significantly ($P < 0.01$) affected by nitrogen rates but was not significantly influenced by the main effects of varieties. Moreover, the interaction effect of the two factors was not significant on plant height and number of leaves per plant. Adamared variety produced taller plants (48.08 cm) than Bombayred (43.53 cm). Among the nitrogen treatments, the tallest plant (57.12 cm) and the most numerous leaves (12.20) were observed from plot that received 138 kg N ha^{-1} and the shortest values (35.98 and 6.48 cm), respectively were obtained from the unfertilized plots (Table 2). As the nitrogen rate increased from zero to 138 kg ha^{-1} plant height and number of leaves per plant was increased by 59 and 88%, respectively.

Bulb Diameter and Length

The main effects of verities and nitrogen rates on diameter and length of onion bulbs were significant ($P < 0.01$), while the interaction effect was not significant. Adamared variety gave wider (5.38 cm) and longer (4.13 cm) bulbs than Bombayred variety (4.51 and 3.84 cm, respectively). Of the different nitrogen rates, the widest (6.49 cm) and longest (4.89 cm) bulbs were recorded from 138 kg N ha^{-1}, whereas the narrowest (3.47 cm) and the shortest (3.26 cm) bulbs were observed from the control plot, which was statistically similar with the values obtained at 46 Kg N ha^{-1} (Table 2). The result showed that increasing the nitrogen rate from 0 to 138 kg N ha^{-1} increased the diameter and length of bulbs by 87 and 50%, respectively.

Table 2. Main effects of nitrogen rates and varieties on plant height, number of leaves per plant, bulb diameter and bulb length of onion

Treatments	PH	NL	BD	BL
N rate (Kg ha^{-1})				
0	35.98^{e}	6.48^{e}	3.47^{d}	3.26^{d}
46	40.57^{de}	7.42^{d}	4.05^{d}	3.31^{d}
69	43.02^{cd}	9.08^{c}	4.84^{c}	3.76^{c}
92	47.13^{bc}	9.72^{c}	5.17^{bc}	4.32^{b}
115	51.00^{b}	11.13^{b}	5.64^{b}	4.37^{b}
138	57.12^{a}	12.20^{a}	6.49^{a}	4.89^{a}
LSD	5.94**	0.91**	0.71**	0.40**
Varieties				
Bombayred	43.53^{b}	9.27	4.51^{b}	3.84^{b}
Adamared	48.08^{a}	9.40	5.38^{a}	4.13^{a}
LSD	3.43**	NS	0.41**	0.23**
CV (%)	10.84	8.12	12.05	8.46

PH= plant height, NL= number of leaves per plant, BD= bulb diameter, BL= bulb length

Bulb Yields

The main effects of varieties and nitrogen rates had significant ($P < 0.01$) effects on marketable and total bulb yield, but their interaction effect was not statistically significant. Unmarketable bulb yield was significantly ($P < 0.01$) affected by nitrogen rates but it was not statistically influenced by varieties (Table 3). Adamared variety gave higher marketable (15.56 t ha^{-1}) and total (15.95 t ha^{-1}) bulb yields than Bombayred variety (13.89 and 14.27 t ha^{-1}). Application of nitrogen at the rate of 138 kg N ha^{-1} produced the highest marketable (19.23 t ha^{-1}) and total (19.55 t ha^{-1}) bulb yields whereas the lowest marketable (10.04 t ha^{-1}) and total (10.62 t ha^{-1}) bulb yields were obtained from the unfertilized plot (Table 3). The highest N rate (138 kg N ha^{-1}) increased marketable bulb yield by 91.53% as compared to the unfertilized one. On the other hand the highest unmarketable bulb yield (0.59 t ha^{-1}) was obtained from the unfertilized plot and the lowest value (0.13 t ha^{-1}) from 138 kg N ha^{-1}.

Table 3: The main effect of nitrogen rates and varieties on unmarketable, marketable and total bulb yields of onion

Treatments	UBY ($t\ ha^{-1}$)	MBY ($t\ ha^{-1}$)	TBY ($t\ ha^{-1}$)
N rate ($kg\ ha^{-1}$)			
0	0.59^{a}	10.04^{e}	10.62^{e}
46	0.48^{b}	12.13^{d}	12.61^{d}
69	0.47^{bc}	14.02^{c}	14.49^{c}
92	0.40^{c}	15.54^{c}	15.94^{c}
115	0.25^{d}	17.38^{b}	17.63^{b}
138	0.13^{e}	19.23^{a}	19.36^{a}
LSD	0.07**	1.53**	1.55**
Varieties			
Bombayred	0.38	13.89^{b}	14.27^{b}
Adamared	0.39	15.56^{a}	15.95^{a}
LSD	NS	0.88**	0.89**
CV (%)	14.51	8.65	8.57

Means followed by the same letters within a column are not significant at 5% probability; NS = non significant; **= significant at 1% probability, CV= Coefficient of variation; LSD= Least significant difference, UBY, MBY and TBY = unmarketable, marketable and total bulb yields, respectively

Quality Parameters of Onion

Neck diameter, dry matter content and total soluble solids

The main effects of nitrogen rates and varieties had significant ($P < 0.01$) effect on quality parameters (neck diameter, dry matter content and total soluble solids), while the interaction effect was not significant. The wider neck diameter (0.71cm), higher percentage of dry matter content (11.67%) and total soluble solids (13.29%) were obtained from Adamared variety compared to Bombayred (Table 4), Application of the highest nitrogen rate (138 kg N ha^{-1}) resulted in bulbs with widest neck diameter (0.85 cm), lowest percentage of dry matter contents (9.67%) and total soluble solid (10.68%), whereas the narrowest neck diameter (0.52 cm), highest percentage of dry matter contents (12.58%) and total soluble solid (14.83%) were recorded from the unfertilized plots (Table 4).

Table 4: Main effect of N rates and varieties on neck diameter (ND), dry matter content (DNC) and total soluble solid (TSS) of onion bulb

Treatments	ND (cm)	DMC (%)	TSS (%)
N rate (kg ha^{-1})			
0	0.52^{e}	12.58^{a}	14.83^{a}
46	0.59^{d}	12.33^{a}	14.05^{a}
69	0.66^{c}	12.33^{a}	13.95^{a}
92	0.70^{c}	11.17^{b}	12.57^{b}
115	0.77^{b}	10.33^{c}	11.40^{c}
138	0.85^{a}	9.67^{c}	10.68^{c}
LSD	0.06**	0.71**	0.99**
Varieties			
Bombayred	0.65^{b}	11.14^{b}	12.53^{b}
Adamared	0.71^{a}	11.67^{a}	13.29^{a}
LSD	0.03**	0.41**	0.57**
CV (%)	7.38	5.17	6.44

Means followed by the same letters within a column are not significant difference at $p < 0.05$; CV= Coefficient of variation;
LSD= Least significant difference;

Quality Parameters During Storage

Bulb Weight Loss During Storage: The main effects of N rates and varieties on bulb weight loss at all measuring within the storage time were significant ($P < 0.01$) except that the main effect of varieties at 2nd week was not significant. The interaction effect of the two factors on bulb weight loss was not significant at all measuring time during the storage. Of the two varieties, the bulb weight loss of Bombayred was higher than that of Adamared at the storage periods of 4th, 6th and 8th weeks. Among the N levels, the highest percents of bulbs weight losses were obtained from bulbs fertilized with 138 kg N ha^{-1}, while the lowest weight loss was obtained from the unfertilized plots at all measuring days of the storage period (Figure 3).

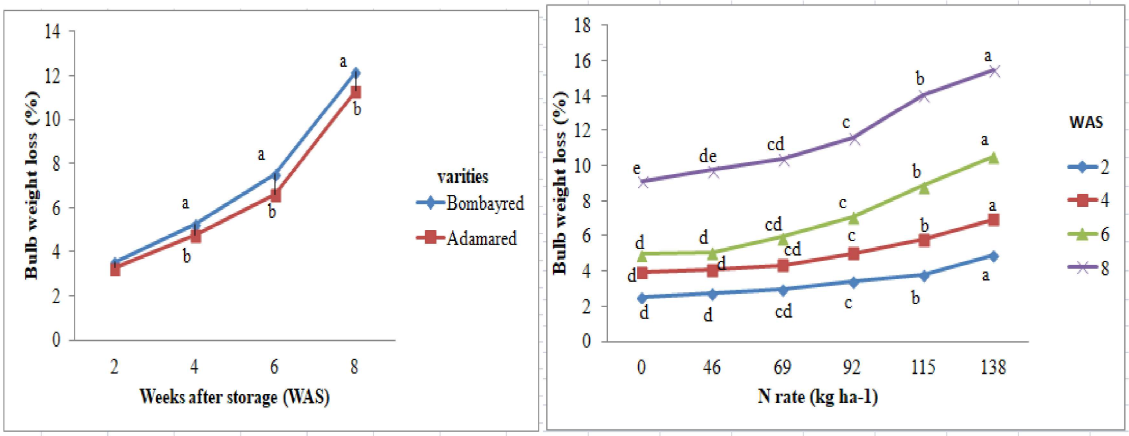

Figure 3: Main effect of N rates and varieties weight on loss of onion bulb at different weeks of storage (WAS).

Sprouted and Rotten Bulbs During Storage: The main effects of N rates and varieties significantly ($P \leq 0.01$) affected the sprouting and rotting percentage of bulbs at 6th and 8th weeks of storage but the effects at 2nd and 4th weeks were not significant. Higher percents of sprouted and rotten bulbs were observed from Bombayred than from variety (Figure 6). Among the N rates applied, the highest percent of sprouted and rotten bulbs were observed on bulbs fertilized with 138 kg N ha^{-1} at the storage periods of 6th and 8th weeks, while the lowest percent of sprouted and rotten bulbs were observed from bulbs produced on untreated plots (Figure 6).

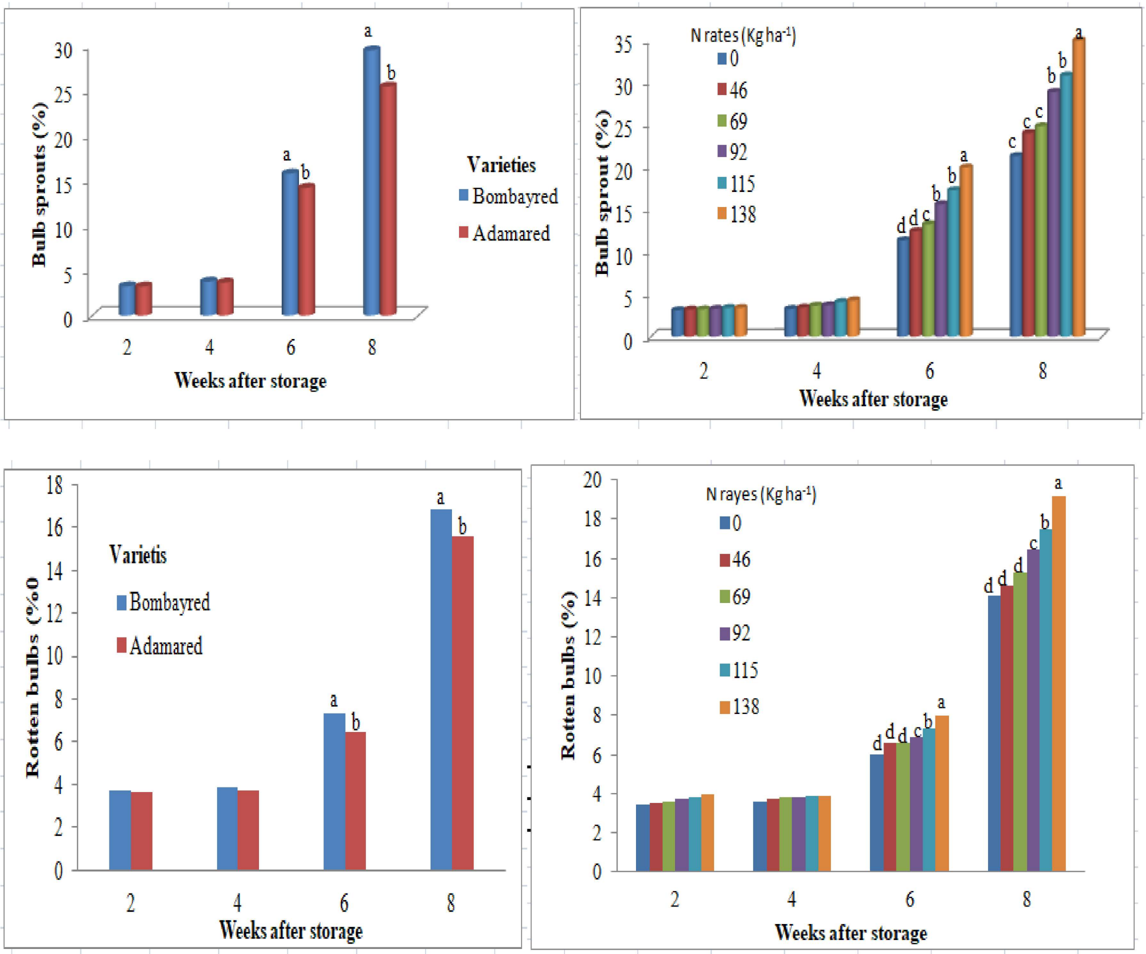

Figure 4: Main effect of N rates and varieties on sprouted and rotten bulb (%) after different weeks of storage period

Partial Budget Analysis

The result of partial budget analysis showed that increasing N level from zero to 138 Kg ha^{-1} increased the net benefit. Application of 138 kg N ha^{-1} gave the highest net benefit (253965 birr ha^{-1}). On the other hand, the lowest net benefit (135540 birr ha^{-1}) was obtained from unfertilized treatment (Table 5). The marginal rate of return value of 2804% implies that a farmer can obtain a net benefit of 28 birr for each additional cost of 1 birr incurred when a farmer wants to apply 138 Kg N ha^{-1} instead of applying 115 Kg N ha^{-1}.

Table 5: Economic feasibility of N rates for onion production

N rates (Kg ha^{-1})	MBY (t ha^{-1})	Adj MY (t ha^{-1})	GB (birr ha^{-1})	TVC (birr ha^{-1})	NB (birr ha^{-1})	MRR (%)
0	10.04	9.036	135540	0	135540	-
46	12.13	10.917	163755	2200	161555	1183
69	14.02	12.618	189270	3060	186210	2867
92	15.54	13.986	209790	3920	205870	2286
115	17.38	15.642	234630	4780	229850	2788
138	19.23	17.307	259605	5640	253965	2804

Adj. MY= adjusted marketable yield; TVC = total variable cost; GB= gross benefit, NB = net benefit; MRR = marginal rate of return

DISCUSSION

Bombayred variety matured earlier than Adamared. The variation in days to physiological maturity between the two varieties might be due to their genetic difference. The present result is similar with the findings of Kahsay *et al*. (2013) and Gebretsadkan *et al*. (2018), who reported that Bombayred was the earliest variety to physiologically mature compared to Adamared.

The finding showed that increasing the nitrogen rate from zero to138 kg ha^{-1} increased days to physiological maturity. This could be due to the stimulation of nitrogen for vegetative growth that prolong days to physiological maturity. The result is consistent with the finding of Gebretsadik & Dechassa (2016) who observed the longest and earliest days to maturity from 150 kg N ha^{-1} and unfertilized treatments, respectively.

Adamared produced taller plants than Bombayred while there was no variation in number of leaves per plant between the two varieties. The current result agrees with the finding of Walle *et al*. (2018) and Dhital *et al*. (2015), who reported no statistical variation of number of leaves among varieties while plant height varied among onion varieties. Simon *et al*.(2014) observed that the number of leaves and plant height were statically similar between Adama red and Bombe red varieties.

Application of nitrogen considerably improved growth parameters of onion. As the nitrogen level increased from zero to 138 Kg ha^{-1}, plant height and number of leaves per plant also increased. The increase in vegetative growth with increase of N rates could be due to the role of nitrogen as building blocks of amino acids that form proteins required for plant growth (Marschner, 1995). In line with the present result, Dechassa (2016) and Etana (2019) found the tallest onion plant from 150 kg N ha^{-1}. Similarly, Seifu *et al*. (2015) obtained the maximum plant height from 138 kg N ha^{-1}. Zakirullah *et al*. (2018) found the maximum number of leaves per plant from highly fertilized plots (100 kg N ha^{-1}) whereas minimum numbers were from the control plots.

The finding indicated that application of nitrogen considerably improved length and diameters of onion bulb. As the nitrogen level increased from zero to 138 Kg ha^{-1}, length and diameters of onion bulb also increased. This could be due to the increased in the vegetative growth and then translocations of photosynthates to bulbs when high nitrogen is applied (Elhamady, 2017). The result is supported by the research findings of Zakirullah *et al*. (2018); Fitsum *et al*. (2016); Tsegaye et al. (2016) and Etana, (2019), who observed the highest diameter and length of onion bulbs from the highest nitrogen rates.

The present result indicated that Adamared gave higher length and diameter of bulbs than Bombayred . The variation of bulb diameter and length between the two varieties might be due to their genetic difference. The present result agrees with the findings of other researchers. Gautam *et al.* (2006) reported that bulb diameter significantly varied among varieties. Tolessa (2018) also found the longest bulb length from Adamared and the shortest from Melkam varieties.

Marketable and total bulb yield increased with increase in nitrogen rates up to 138 kg N ha^{-1}. The improvement of bulb yields with increase in N rate could be due to the fact that nitrogen helps accelerate the assimilation rate and accumulate photosythates in storage organ of bulbs resulting in an increased in weight of bulbs (Abdissa *et al*., 2011). The result agrees with findings of Aregay *et al*. (2009); El-hamady (2017); Zakirullah *et al*. (2018) and Gateri *et al*. (2018), who found significant increment of total and marketable bulb yields with increasing nitrogen fertilizer rates. Tsegaye *et al*. (2016) found the lowest (16.51 t ha^{-1}) and the highest (26.23 t ha^{-1}) marketable bulb yield of onion from 0 and 100 kg ha^{-1} N, respectively. The partial budget analysis of the current study also indicated that application of nitrogen is important for economically profitable production of onion. The result agrees with finding of Gebretsadik & Dechassa (2016) who obtained the highest net benefit (ETB 266028) by application of 100 N kg ha^{-1}.

Adama red produced higher Marketable and total bulb yields compared to Bmbeyred. The variation of marketable bulb yield between verities is in line with the work of Gebretsadkan *et al*. (2018) and Awas *et al*. (2010), who found significant variation of bulb yields from different varieties. Simon *et al*. (2014) also reported that unmarketable bulb yield had no significant difference among varieties, but higher marketable and total bulb yield from Bombay Red than Adama Red.

The current result revealed that highest rates of nitrogen significantly reduced quality parameters of onion (neck diameter, dry matter content and total soluble solids). It was also well documented that excessive nitrogen induces vegetative growth and reduces accumulation of dry matter into the bulb and hence reduced quality of onion (Brewster, 1994; Sørensen & Grevsen, 2001). Similarly, Gebretsadik & Dechassa (2016) reported that increasing the rates of nitrogen from 0 to 150 kg N ha^{-1} increased neck diameter. Other findings showed that increasing the nitrogen rates decreased the dry matter content of bulb and total soluble solids (Sigh *et al*., 2010; Tsegaw *et al.,* 2012). The variation in dry matter content, neck diameter and total soluble solid in the present result is also supported by Simon *et al*. (2014), Benti (2017) and Kahsay *et al*. (2013) who reported that there was a significant difference among varieties in dry matter content neck diameter and total soluble solid.

The weight losses of bulbs were increased as N rates increased throughout the storage period of 8 weeks. This could be due to the increase nitrogen rates leads to the bulb size to become large that have higher rate of respiration. Similarly, Benti (2017) reported that increasing nitrogen rates from zero to higher rates increased bulb weight loss in the storage periods of 90 days. The higher weight loss of onion bulbs from Bombey red than that of Adamared during the storage time of the present study is in line with the findings of Benti (2017), who observed the highest percent of sprouted and rotten bulbs from Bombayred variety compared to Nasik and Adamared varieties at 60 and 70 days storage period. Kahsay *et al*. (2013) and Dinka *et al*. (2015) also reported that there was a significant difference among varieties on weight loss of bulbs.

The increased in percent of sprouted and rotten bulbs with increase in nitrogen rates might be due to greater access of oxygen and moisture at the wide neck diameter produced from high nitrogen rates. The present result agreed with Gateri *et al*. (2018), who reported that when application of nitrogen rates increased, the percent of sprouted and rotten bulbs also increased. Tsegaw *et al*. (2012) and Benti (2017) also reported that the highest percent of rotten bulbs were obtained from the application of the highest rates of nitrogen. Etana (2019) recorded the highest percent of rotten bulb in the plots that received 150 kg N ha^{-1} and the least percentage from unfertilized plots.

CONCLUSION

Adamared variety gave higher marketable bulb yield (15.56 t ha^{-1}) than Bombayred (13.89 t ha^{-1}). Application of N had significantly increased the growth and yields of onion varieties but reduced the quality parameters of onion bulbs, except it increased neck diameter, decreased dry matter content and total soluble solids. It also caused the highest weight losses, rotten and sprouted of bulbs during the eight month storage life. The highest rate of N (138 kg N ha^{-1}) gave the maximum marketable bulb yield (19.23 t ha^{-1}) and the highest net benefit (253965 birr ha^{-1}) with acceptable marginal rate of return (2804%). The applacation of 138 kg N ha^{-1} and using Adamared variety can be used for profitable onion production in the study area.

REFERENCES

Abdissa, Y., Tsegaw, T., & Pant, L.M. (2011). Growth, bulb yield and quality of onion (*Allium cepa* L.) as influenced by nitrogen and phosphorous fertilization on vertisol. *African Journal of Agricultural Research.* 6(14), 3252 - 3258.

Alemayehu, M., Tesfa, F., Bizuayehu S., & Ayele B. (2015). Amhara Region Horticultural Development Strategy 2015 - 2020. Retrieved from http://cgspace.cgair.org.

Aregay, N., Haile, M., & Yamoah, C.(2009). Growth and Bulb Yield Response of Onion (*Allium cepa* L.) to Nitrogen and Phosphorous Rates under Variable Irrigation Regimes in Mekelle, Northern Ethiopia. *Journal of the dry lands.* 2(2), 110-119.

Ashwini, M., & Sathishkumar,R. (2014). Onion (*Allium cepa* L.) Ethnomedicinal and therapeutic properties: handbook of medicinal plants and their bioactive compounds. Retrieved from https://semanticscholar.org.

Awas, G., Abdisa, T., Tolesa K., & Chali. A. (2010). Effect of intra- row spacing on yield of three onion (*Allium cepa* L.) Varieties at Adami Tulu. *Journal of Horticulture and Forestry.* 2 (1), 7- 11.

Benti, D. (2017). Influence of nitrogen rate and varieties on storage periods of onion (*Allium cepa* L.) in Fedis district, eastern Ethiopia. *International Journal of Information Research.* 4 (4), 4097-4105.

CIMMYT (International Maize and Wheat Yield Improvement Center). (1988). From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely revised edition, Mexico. Retrieved from http://apps.commyt.org.

CSA (Central Statistical Agency of Ethiopia). (2018). Report on area and production of major crops: agricultural sample survey. Statistical bulletin. (Volume I). Addis Ababa, Ethiopia.

CSA (Central Statistical Agency of Ethiopia). 2019. Report on area and production of major crops: agricultural sample survey. Statistical bulletin. (Volume I). Addis Ababa, Ethiopia.

Dhital, M., Shakya, S. M., Sharma, M. D & Dutta, J.P. (2015). Effect of different levels of nitrogen on commercial onion varieties for off season green production in Western Chitwan, Nepal. *International Journal of Horticulture.* 5(3), 289-294. *doi: http://dx.doi.org/10.4314/ejst.v.*

Dinka, H., Makonnen, A., & Yimenu, M. (2015). An investigation on the influence of intra-row spacing and variety on yield and shelf life of onion. *International Journal of Agricultural Sciences.* 5 (3), 559-567.

El-hamady, M. M. (2017). Growth and Yield of Onion (*Alum cepa* L.) as Influenced by Nitrogen and Phosphorus Fertilizers Levels. *Canadian Journal of Agriculture and Crops*. 2(1), 34-41. dio: 10.20448/803.2.1.34.41.

Etana, M.B., Mohammed, A., & Nebiyu, A. (2019). Effects of different Level of nitrogen fertilizer application on Growth, Yield, Quality and Storage Life of Onion (*Allium cepa* L.) at Jimma, South Western Ethiopia. Journal of Natural Sciences Research. 9(10), 32-40. DOI: 10.7176/JNSR.

Gateri, M., Nyankanga, R., Ambuko, J. & Muriuki, A. (2018). Growth, Yield and Quality of Onion (*Allium cepa* L.) as Influenced by Nitrogen and Time of Topdressing. *International Journal of Plant & Soil Science.* 23(3), 1-13.

Gautam, I., Khatri, B. & Paudel, G. (2006). Evaluation of different varieties of onion and their transplanting times for off-season production in mid hills of Nepal. *Nepal Agricultural Research Journal*. 7 (1), 21-27.

Gebretsadik K., & Dechassa, N. (2016). Response of Onion (*Allium cepa* L.) to nitrogen fertilizer rates and spacing under rain fed condition at Tahtay Koraro, Ethiopia. *Journal of Biology, Agriculture and Healthcare*. 6 (21). 2016

Gebretsadkan, G., Gebremicael, Y., Asgele, K., Abebe, E., Gebrelibanos, W., & Tsehaye, Y. (2018). Enhancing Productivity and Production of Onion (*Allium cepa* L .) Through the use of Improved Varieties at North Western Zone of Tigray, Ethiopia. *International Journal of Plant Science and Agriculture.* 3 (3), 756 -761. doi.org/1022161/ijeab/3.3.6.

Hanelt, P.(1990). Taxonomy, evolution and history. In: Rabinowitch, H.D. and J.L. Brewster (eds.), Onions and Allied Crops. CRC Press Boca Raton, Florida. Retrieved from http://www. scencedomain.org/ review-history/25178.

Jackson, M.C. (1970). Soil Chemical Analysis. Prentice Hall, Inc. Englewood Cliffs N.J. Retrieved from https://www.scirp.org.

Jackson, M.L. (1967). Soil Chemical Analysis. Practice Hall of India, New Delhi. Retrieved from https://www.scirp.org.

Kahsay, Y., Abay, F., & Belew, D. (2013). Intra row spacing effect on shelf life of onion varieties (*Allium cepa* L.) at Aksum, Northern Ethiopia. *Journal of Plant Breeding and Crop Scien*. 5(6), 127-136. doi: 10.5897/JPBCS12.071.

Lemma, D., & Shimelis A., (2003). Research experiences in onion production. Research Report (Number 55). EARO (Ethiopian Agricultural Research Organization). Addis Ababa, Ethiopia.

Marschner, H. (1995). Mineral Nutrition of Higher Plants, (2nd ed.). Academic press. London. Retrieved from https://www.scirp.org.

Messele. B. (2016). Effects of Nitrogen and Phosphorus Rates on Growth, Yield, and Quality of Onion (*Allium cepa* L.) at Menschen Für Menschen Demonstration Site, Harar, Ethiopia. *Agricultural Research and Techecnology*. 1(3), 5-7.

Molla, G. (2013). Challenges and Prospects of Sustainable Tourism Development in and around Gorgora, North Gondar, Amhara Region. (Unpublished master's thesis). Addis Ababa, Ethiopia.

Nelson, D.W & Sommers, L. E. (1982). Total carbon, organic carbon and organic matter. In. Page, A.L., (eds.), Methods of Soil Analysis. Part 2. Chemical and microbiological properties. (Agronomy Series No. 9). Madison.

Nigussie A, Kuma Y, Adisu A, Alemu T, Desalegn K. (2015) Onion Production for Income Generation in Small Scale Irrigation Users Agro-pastoral Households of Ethiopia. *Journal of Horticulture*, 2(3), 145. doi:10.4172/2376-0354.1000145.

Olsen, R. A. & Kurtz, L.T. (1982). Crop nitrogen requirements, utilization and fertilization: Nitrogen in Agricultural Soils (Pp. 567-604). Madison, Wisconsin, USA. Retrieved from https://www.sciencedirect.com.

Seifu,W., Woldetsadik, K., & Mohammed, W. (2015). Onion (*Allium cepa* L) bulb traits as affected by nitrogen fertilizer rates and intra-row spacing under irrigation in Gode, South-Eastern Ethiopia. *Journal of Horticulture*. 4(6), 239-245. doi: 10.4172/2376-0354.1000160.

Singh, R.B., Singh, D.P & Dabbas, M. R. (2010). Effects of nitrogen, phosphorus and Potash on growth, yield and quality of onion (*Allium cepa* L.) raised from onion sets. *Asian Sciences*, 5(1), 49-52.

Simon, T. , Tora, M., Shumbulo, A., & Urkato, S. (2014). The Effect of variety, nitrogen and Phosphorous fertilization on Growth and Bulb Yield of Onion (*Allium Cepa* L.) *Journal of Biology Agriculture and Healthcare.* 4(11), 89-95.

Sørensen, J.N., & Grevsen, K .(2001). Sprouting in bulb onions (*Allium cepa* L.) as influenced by nitrogen and water stress. *Journal horticultural Sciences and Biotech*. 76, 501-506.

Tekle, T. (2015). Growth, Yield, and Quality of Onion (*Allium Cepa* L.) as Influenced by Intrarow Spacing and Nitrogen Fertilizer Levels in Central Zone of Tigray (Unpublished master's thesis), Haramaya, Ethiopia.

Tsegaw, T., Abdisaa Y., & Pant, L. M. (2012). Growth, bulb yield and quality of onion (*Allium cepa* L.) as influenced by nitrogen and phosphorus fertilization on vertisol. *African Journal of Agricultural Research,* 7 (45), 5980-5985. doi:10.5897/AJAR10.1025.

Tsegaye, B., Bizuayehu, T,, Woldemichael A., & Mohammed A. (2016). Yield and Yield Components of Onion (Allium cepa L.) as Affected by Irrigation Scheduling and Nitrogen Fertilization at Hawassa Area Districts in Southern Ethiopia. *Journal of Medical and Biological Science Research*. 2 (2), 15-20.

Walkley, A. & Black, I., A. (1934). An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, 37(1), 29-38.

Walle, T., Dechassa, N,, & W/Tsadik, K.(2018). Yield and Yield Components of Onion (*Allium cepa* L.) Cultivars as Influenced by Population Density at Bir Sheleko, North-Western Ethiopia. *Academic Research Journal of Agricultural Science and Research.* 6(3), 172-192.

Waskar, D. P., Khedlar, R. M & Garande, V. K. (1999). Effect of postharvest treatment on shelf life and quality of pomegranate in evaporative cool chamber and ambient conditions. *Journal of Food Science and Technology,* 2(36), 114-117.

Yousuf, M. N., Akter, S., Haque, M. I & Zaman, M.S. (2013). Compositional nutrient diagnosis of onion (*Allium cepa L.*). *Bangeladesh Journal of Agricultural Research.* 38(1), 271-287.

Zakirullah, M., Jan. T., Ahmad, S & Younas, M. (2018). Effect of Different Levels of Nitrogen on Onion (*Allium Cepa* L) Under the Agro Climatic Condition of Peshawar. *International Journal of agricultural environmental research.* 5(1), 124 – 127.

Zeleke A., & Derso, E. (2015). Production and management of major vegetable crops in Ethiopia. Retrieved from http://publication.eiar.gov.et.