Growth and Bulb Yield of Onion (Allium cepa **L.) Varieties as influenced by NPS Fertilizer at Dambi Dollo University Research Site, Western Ethiopia**

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Abstract

Onion is main crops in Ethiopian regular nutrition, cultivated year round under rain fed and irrigated conditions. The low production and productivity of onion crops in Ethiopia as compared to other onion producing countries was due to disease, insect pest, lack of improved varieties, low level use improved varieties of onion and improper agronomic practices used by farmers. A field experiment was conducted at Dambi Dollo University research site for two consecutive years (2020 and 2021 cropping season) under rain fed to evaluate effect of NPS fertilizer rates on performance of onion varieties (Allium cepa L.*). The experiment was laid out using Randomized Complete Block Design with three replication in factorial mixture of four levels of NPS fertilizer (0, 50, 100, 150 kg ha^{-1}) and three varieties (Adam red, Monarchy and Nafis). Variance Analysis indicated that NPS fertilizer and varieties were expressively affected days to 90% physiological maturity, marketable and unmarketable yield, and total bulb yield of onion crop but not significantly influenced by their interaction. The number of leaves per plant and plant height were significantly influenced by main effect of varieties, NPS fertilizer rates and their interaction. The highest values for number of leaves per plant (16.08) recorded at 150 kg ha^{-1} and monarch variety. Moreover, days to 90% physiological maturity (134.8 days) and total bulb yield (29.35 t ha^{-1}) were noted from the highest NPS application rate of 200 kg ha^{-1}. Similarly, the maximum plant height (16.08cm) and marketable onion bulb yield (26.41 t ha^{-1}) were obtained from 150 kg ha^{-1}NPS rate. Hence, based the highest marketable onion bulb yield gained, Nafis variety of onion crop and 150 kg ha^{-1} of NPS fertilizer rates should be advised for production in the study area and other areas with similar agro-ecological condition.*

Keywords: Growth**,** NPS fertilizer, Varieties, Onion, bulb yield

Introduction

The onion (*Allium cepa* L.) belongs to the Allium genus of the family *Alliaceae* which is believed to be originated in southwestern Asia, which is a breeding ground for diversity, since its first worldwide distribution and cultivated by over 4700. Years as years of year for bulb production purposes (Brewster, 2008). It is a vegetable plant grown because of its sharp leaves and delicious leaves and belongs to genus Allium of the Amaryllidaceae family (Welbaum, 2015).

Onion is very important in the Ethiopian diet (Rajan *et al.*, 2007). Commonly, all portions of alliums can be eaten by people except seeds (Rabinowitch and Currah, 2002). Onions play an important role in human nutritional needs and have medicinal properties and are mainly used because of their unique taste or ability to enhance the taste of other foods (Randle and Ketter, 1998).

Onions and/or shallot are grown almost in all tropical countries of Africa including Ethiopia (Grubben and Denton, 2004). Onions are important in the Ethiopian daily diet, grown under rainy and irrigated conditions.

In 2020/21 during the rainy season 38,952.58 hectares were planted and approximately 346,048.09 tons of onion bulbs were harvested at an average yield of 8.88 tone ha^{-1} (CSA, 20/21) which is lower than the other countries producing onion. The low productivity of onion crops in Ethiopia as compared to other countries which are involved in onion producing is due to diseases, pests, lack of improved varieties, low level use improved varieties of onion and improper agricultural practices by farmers.

Proper use of any agronomic practices may enhance the onion cultivation. The use of compound NPS fertilizer varies depending on the location, purpose of the crop and the variety. However, in the study area most onion producers use local varieties and in appropriate NPS blended fertilizer such as higher or lower recommended levels contribute for high yield reduction.

In addition, due to limited knowledge about the NPS on the vegetative growth and yield of onion many farmers still custom the same amount of NPS fertilizer for all varieties of onion in the study area. Research based recommendations on level of NPS fertilizer can increase onion crop production and increase the benefits of local farmers. Therefore, it is imperative to evaluate the optimum NPS fertilizer level for released onion varieties in order to increase the onion yield in the study area at different season. Therefore, this research was initiated for the following objectives.

To
evaluate effect of different rates of NPS fertilizer
on onion
varieties
.
To identify the optimum NPS fertilizer and best performing onion variety for the study area
.

Materials and Methods

Description of the study area

The study of field experiment was conducted at the Research site of Dambi Dollo University for two consecutive years (2020 and 2021) under rain fed conditions. The research site is located in Kellem Wollega Zone in the western part of Oromia, Ethiopia which is 652 km away from Addis Ababa to West direction at an altitude of 1500 - 1740 meter above sea level. The area gets rainfall of 850 to 1200mm yearly. The minimum and maximum temperatures of the area are 15 to 28c^{0} respectively. The study are soil was marked sandy loam (Degefa *et al.*, 2021).

Description of Treatments used and design of experiment

In this study, the experiment contained 15 treatments as a grouping of five combined NPS fertilizer (0, 50, 100, 150, 200 kg^{-1} ha) and three different varieties of onions (Adama red, monarch and Nafis) arranged as a Completely Randomized Block Design (RCBD) which is replicated three times. The total plot size of 3m * 1.2 m with spacing of 30 cm distance between row and a total of 10 rows were used and contains 12 plants per row. The total experimental area was 25 m x 12 m (300 m^2). The net plot size from which data was taken is 2.7 m x 1.1 m (2.97 m^2) leaving one outer rows of each sides of plot and row length of 1.2 m at both ends as border. The distance between the plots and blocks were 0.5 m and 1.5 m respectively.

Experimental procedures and management

The experimental field was plowed three times for good growth. The field repeatedly cultivated as a recommendation for the crop to control weed control. Seed beds were well prepared prior to sowing of seeds on nursery. After fifty five days of sowing, transplant of seedlings to the main field were done when the seedlings produce three to four true green leaves.

The seedling was transplanted by hand at a recommended spacing (30*10cm) by placing two seedlings per hill with depth of 7-10cm depend moisture status of the soil during transplanting and later thinned to one plant after survival of the plant. Only strong and healthy seedlings were transplanted. The recommended Urea fertilizer is applied in the formats specified in three divisions (1/4th when replanting, ½ in the active growth stage and 1/4th at the beginning of bulbing) but different NPS fertilizer applied per side dressing before transplanting in 10 cm depth below ground to place the seedling roots.

Agronomic practices such as cultivation, watering, pests and disease control are carried out according to regional recommendations. When the plants reach physiological maturity and 70% of the leaves are cut off, the plants are collected to determine yield components. Crops on the outer border rows and at both ends of each harvested row have been left to avoid edge side effects.

Data collected

Phenological and Growth Variables

Days to maturity: was recorded as the actual number of days from date of sowing until, 90% of the plant leaves senesced and reach maturity in each net plot.

Plant height: was measured in centimetre from 10 randomly selected plant samples per net plots as the height from the base of the plant to tip the plant using meter tape. The average of 10 sampled plants was considered as plant height.

Leaves number per plant: was recorded 80 days after transplanting and counted 10 randomly selected plants.

Marketable bulb yield (t ha^{-1}): The marketable bulb yield was identified after dumping of splitted bulbs, dense necked, unpleasant bulbs, marketable fresh bulb yield were computed from the harvest of net plot. The marketable bulb yield weight standard in Ethiopia is categorized as extra-large (above 160g), large (100-160g), medium (50 - 85g), smaller sized (21 -50g) (Lemma and Shimeles, 2003).

Unmarketable bulb yields (t ha^{-1}): were determined by classified as: under sized (<20g and >160g), contaminated, rotten, and disordered physiologically (thick-necked and divided bulbs). These bulbs weighed and expressed as unmarketable bulbs from net plot area and later extrapolated to per hectare basis.

Total bulb yield (t ha^{-1}): The sum of marketable and unmarketable bulb yield was computed in tons per hectare.

Statistical Analysis of Data

The data collected were subjected to analysis of variance (ANOVA) using general linear model of Genstat 16 th edition statistical package. Treatment means that exhibited significance difference was separated using Duncan Multiple range test (DMRT) at 5% level of significance.

Results and Discussion

Phenological and Growth variables

Days to 90% physiological maturity

The result from the variance analysis showed days to maturity of onion varieties was very significant (P<0.00 1) affected by the impact of varieties and NPS fertilizer level in both testing years. Conversely, these two factors did not significantly affect days to physiological maturity (Table 1).

The late days to maturity (132.9 days) were observed from variety Monarch and the early days to maturity (103.5days) were observed in the variety Nafis in 2021 growing season. This means that the varieties of onion Nafis took 103.5 days to reach maturity which was 29 days and 24 days before the Monarch and Adama red respectively (Table1). The variation in maturity may be due to differences in the variety of onions . The variability in maturity between onion varieties may be due to their genetic diversity and reaction of the varieties in the environment. This finding is concomitant with the results of Selamawit *et al*. (2013); Yemane *et al.* (2014) and Tesfalgn and Mohammed. (2015) who reported that Bombay Red matured significantly earlier than Adama Red.

The late days to maturity (135 days) of onion crops were noted in the high application of NPS fertilizer at 200 kg ha^{-1} while the early days to 90% physiological maturity (104.2 days) were obtained due to non-use of NPS fertilizers in 2021 growing season (Table 1).

This means that as NPS fertilizer levels increase at 0 kg^{-1} ha to 200 kg ha^{-1}, the number of days to 90% physiological maturity has increased. This may be due to an increase in the levels of NPS fertilizer which contributes to increasing the amount of nitrogen fertilizer in NPS which has encouraged the growth of onion plants. This result was consistent with the finding of Gupta and Sharma (2000) who reported that nitrogen promoted plant growth and greenness thus slowing the ripening of Onion plants.

Moreover, this result is concomitant with finding of Yamasaki and Tanaka, (2005) and Nebret. (2012) who reported that a high nitrogen application levels are significantly delayed maturity. Early maturation at the control level may be due to insufficient nutrient intake that slows plant growth; thus it entered the fertility phase and matured earlier.

Marketable yield

The result from the variance analysis showed that the commercial yield of the onion variety was very important (P<0.01) affected by the significant impact on NPS fertilizer levels and significantly the varieties. On the other hand, these two factors did not significantly affect marketable bulb (Table 1).

The highest marketable yields (25.07 t ha^{-1}) were obtained from the Nafis variety while the lowest commercial yields (17.25 t ha^{-1}) were obtained from monarch varieties in 2021 growing season (Table 1). This difference in yield between onions may be due to differences in genetic diversity. Consistent with this result, Tolesa *et al.* (2018), who reported that variety Nafis provided the highest marketable bulb, yield (36.24 t ha^{-1}).

Also, the highest commercial yield (27.52 ha^{-1}) of onions was harvested at NPS application rates of 150 kg ha^{-1} and 200 kg ha^{-1} and the lowest commercial yield (9.20 t ha^{-1}) obtained for non-use of NPS fertilizer in 2021 growing season (Table 1). Increasing the NPS fertilizer level from 0 to 150kg ha^{-1} increases the marketable yield of onion crop to a higher level but otherwise reduces the yield.

Significant decrease in the maximum marketable yield due to an increment of NPS level of more than 150 kg ha^{-1} may be due to overcrowding or total nutrient uptake which may lead to overgrowth of vegetation components in terms of crop growth and development of bulbs that contribute for yield reduction. In line with this result Nigatu *et al*. (2018) found that high yield bulbs were recorded using complete NPS fertilizer estimates.

Table 1: Main effect of Varieties and NPS fertilizer rates on days to 90% physiological maturity, marketable yields, unmarketable yield and total bulb yield of onion varieties grown at Dambi Dollo under rain fed condition during 2021 growing season.

Treatment	**Days to maturity**		**Marketable yield**		**Unmarketable Yield**		**Total Yield t ha^{-1}**	
Varieties	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**
Adama red	128.0^{b}	127.0^{b}	20.05^{ab}	19.05^{b}	1.21^{a}	1.32^{a}	21.31^{b}	20.21^{c}
Monarchy	131.9^{a}	132.9^{a}	18.0^{b}	17.25^{c}	1.06^{ab}	1.02^{b}	21.86^{b}	20.86^{b}

Nafis	104.5^{c}	103.5^{c}	23.03^{a}	25.07^{a}	0.90^{b}	0.80^{c}	25.28^{a}	26.28^{a}
LSD (5%)	3.2	3.12	3.406	2.45	0.17	0.25	2.120	2.35
NPS (kg^{-1} ha)			**Marketable yield**		**Unmarketable Yield**		**Total Yield t ha^{-1}**	
0	106.6^{e}	104.2^{e}	10.39^{c}	9.20^{e}	1.85^{a}	1.94^{a}	12.42^{d}	11.42^{d}
50	114.4^{d}	115.6^{d}	16.0^{b}	15.0^{d}	1.35^{b}	1.30^{b}	18.08^{c}	18.28^{c}
100	121.6^{c}	123.8^{c}	23.92^{a}	22.92^{c}	0.87^{c}	0.78^{c}	26.08^{b}	27.54^{b}
150	129.9^{b}	130.5^{b}	26.41^{a}	27.52^{a}	0.69^{cd}	0.59^{cd}	28.15^{ab}	30.35^{a}
200	134.8^{a}	135.0^{a}	25.16^{a}	24.16^{b}	0.53^{d}	0.54^{d}	29.35^{a}	29.15^{ab}
CV (%)	3.5	3.6	22.4	21.15	21.4	22.65	12.4	14.25
LSD (5%)	4.132	3.85	4.397	3.84	0.2190	0.19	2.737	2.60

Means within a column followed by the same letter(s) are not significantly different at 5% level of significance. LSD: Least Significance Difference, Marketable and unmarketable yield were measured by t ha^{-}

Non-marketable bulb crop

The result from the variance of analysis showed that unmarketable yield of onion variety was very important ($P<0.01$) affected by the significant impact of NPS fertilizer and significantly by variety. Conversely, these two factors did not significantly affect unmarketable bulb yield (Table 1).

The least unmarketable bulb yield of onions (1.32 t ha^{-1}) was obtained from the red Adam variety while the lowest unmarketable bulb yield (0.80 t ha^{-1}) was obtained from the Nafis variety in 2021 growing season (Table 1). Similar to this effect, Fikre *et al.* (2021) reported that a high yield of unsold bulb was achieved in the Adam variety.

The highest unmarketable yield (1.94 ha^{-1}) of onion was harvested at zero NPS application rates in 2021 growing season and the lowest unmarketable yield (0.53 t ha^{-1}) was obtained at the 200 kg ha^{-1} fertilizer application rates in 2021 growing season (Table 1). As the combined NPS fertilizer levels increase from 0 kg ha^{-1} to 200 kg ha^{-1}, the non-marketable yield of onion variety has been reduced. This may be due to an increasing in NPS fertilizer levels and an increase in the amount of nitrogen fertilizer which reduces the yield of onion tuber that can be sold for the progressive role and it plays in increasing the new bulb weight ratio. This finding was similar to the results of Fikre *et al.* (2021) who reported that the maximum amount of unsold onion bulb yields was obtained at zero kg per Hecate of NPS fertilizer.

The total yield of the bulb

The result from the analysis of variance showed that the total yield of bulb of onion variety was very significant ($P=0.001$) affected by the main effect of NPS fertilizer rates and significantly by variety. On the contrary, these two factors did not significantly affect the total bulb yield of onions (Table 1).

The variety of onions Nafis produced the highest bulb yield (26.28 t ha^{-1}) and the lowest bulb yield (20.21 t ha^{-1}) was recorded in Adama red variety in 2021 growing season. This yield difference between onions may be due to differences in the genetic make-up of onion plants. This result has been in agreement with Tolesa *et al.* (2018), who reported that variety Nafis provide the highest total bulb yield (36.28 t ha^{-1}). The present result agrees with findings of Simon *et al.* (2014) who obtained the highest total bulb yield in different Nafis than other species.

The maximum total bulb yield (30.35 ha^{-1}) of onions was harvested at the input rates of NPS 200 kg ha^{-1} and the minimum total bulb yield (11.42 t ha^{-1}) obtained from 0 kg ha^{-1} NPS fertilizer application rates in 2021 growing season (Table 1). As the combined NPS fertilizer levels increased from 0 kg ha^{-1} to 200 kg ha^{-1}, the total bulb yield of onion variety was increased.

This may be due to an increase in bulb size and bulb weight due to the use of NPS fertilizers which may increase photosynthesis, and subsequently, enhanced growth and expansion of vegetative growth as a whole, and ultimately significantly higher carbohydrate to the bulbs at maturity. This result is in consistent with the findings of Tibebu *et al.* (2014), who reported that high onion bulb yields in response to nitrogen use. Kokebe *et al*. (2007) also reported a steady increase in the yield of onion bulbs due to an increase in nitrogen levels in the NPS from 0 to 100 kg N ha^{-1}.

Number of leaves per plant

Number of leaves per plant was significantly affected ($P<0.01$) by the main effect of NPS fertilizer levels and varieties and their interaction showed significant differences ($p<0.01$) in number of leaves per plant (Table 2).

The large number of leaves per plant (17.30) were recorded in monarchy variety with a fertilizer rate of 150 kg ha^{-1} in 2021 growing season and the minimum number of leaves (6.37) was recorded at 0 NPS kg ha^{-1} applied at Nafis variety in 2020 growing season. The use of increased NPS fertilizer increases the number of onion leaves. The reduced leaf yield at a low levels of fertilizer may be due to a lack of sufficient nutrients and to a combination of growth. Increased in leaf number per plant with high NPS fertilizer may be due to the availability of macro and micronutrients that allow the leaves to grow vigorously. Nitrogen and sulfur fertilization had the potential to increase nutrient uptake and thus improve plant nutrient uptake.

The result of the present work is consistent with the finding of Nasreen *et al.* (2007) who reported that the consumption of 120 kg N ha^{-1} significantly increased the number of leaves in the onion plant and a further increase of nitrogen supply to 160 kg ha^{-1} tends to reduce it. Abdissa and Pant. (2011), report that nitrogen fertilization had a significant impact on the number of leaves produced by the onion plant. Uzma *et al.* (2016), report that low application rate of phosphorus fertilizer leads to reduced leaf enlargement and leaf area, as well as the number of leaves in garlic. Nigatu (2016), reported a very high number of engraved leaves as a result of combined use of 105:92:16.95 N: P_2O_5: S and a small number of leaves from unfertilized plants.

Plant height

Plant height was very important ($P<0.01$) affected by the significant effect of NPS fertilizer levels, varieties and significantly (P?0.05) its interaction (Table 2).

The highest plant height (70.25 cm) was found in monarch varieties with a maximum of NPS of 150 kg ha^{-1}, which was statistically equivalent to Adama red variety at 200 kg ha^{-1} and monarchy variety at 200kg ha^{-1} NPS rates. Whereas the lowest plant height (43.21 cm) was recorded from Adama red variety and Nafis variety at 0 kg ha^{-1}NPS application rates at both growing season (Table 2).

The difference in onion crop yields due to increased NPS fertilization may be due to increased nitrogen fertilizer content in NPS fertilizers which contributes to overgrown crop growth and crop height. And the height of the plants depends on the genetic makeup of the onion plants.

Possible cause of crop failure may be due to increased nitrogen utilization which contributes significantly to amino acids, cell proliferation, cell proliferation, chlorophyll synthesis, and protein synthesis that promotes onion growth. This result agrees with Nasreen *et al.* (2007); Gustafson *et al.* (2010) and Agumas *et al.* (2014), who reported that the use of nitrogen fertilizer increased vegetative growth of onions due to its ability to increase the rate of photosynthesis.

Table 2: Interaction effect of NPS fertilizer rates and Varieties on plant height (cm) of onion crop.

Treatment			
NPS (kg ha^{-1})	**Plant height (cm)**		
	Adama red	**Nafis**	**Monarchy**

	2020	2021	2020	2021	2020	2021
0	44.07^{g}	43.21^{g}	47.2^{g}	46.2^{g}	52.42^{f}	51.42^{f}
50	53.35^{ef}	52.35^{ef}	51.97^{f}	52.7^{f}	62.37^{bc}	61.27^{cd}
100	57.95^{cd}	56.59^{ef}	57.4^{de}	58.4^{de}	64.59^{ab}	63.25^{c}
150	58.55^{cd}	57.25^{ed}	68.8^{bcd}	59.8^{d}	68.58^{a}	70.25^{a}
200	67.66^{a}	66.56^{b}	58.9^{cd}	57.8^{e}	67.21^{a}	65.25^{bc}
LSD (5%)	4.59	4.84				
CV (%)	4.7	6.51				

Means sharing similar letter(s) are not significantly different at p<5% according to LSD (Least Significance Difference) test,

Table 3: Interaction effect of NPS fertilizer rates and Varieties on number of leaves of onion crop.

Treatment						
NPS (kg ha^{-1})	**Number of Leaves**					
	Adama red		**Nafis**		**Monarchy**	
	2020	**2021**	**2020**	**2021**	**2020**	**2021**
0	10.94^{hi}	12.19^{hi}	6.37^{j}	7.62^{j}	11.05^{gh}	12.3^{gh}
50	12.06^{fgh}	13.3^{fgh}	9.52^{i}	10.77^{i}	14.05^{cd}	15.3^{cd}
100	13.65^{cde}	14.9^{cde}	10.82^{hi}	12.07^{hi}	14.76^{abc}	16.1^{bc}
150	13.16^{def}	14.4^{def}	12.45^{efg}	13.7^{efg}	16.08^{a}	17.3^{a}
200	15.8^{ab}	17.05^{b}	14.5^{bcd}	15.76^{cd}	14.75^{abc}	16.0^{c}
LSD (5%)	1.47	1.2				
CV (%)	7.0	8.5				

Means within a column followed by the same letter(s) are not significantly different at p<5% according to LSD (Least Significance Difference) test,

Conclusion

In conclusion, the major impact of the variety and fertilizer level of the NPS greatly affects all phenological, growth variables and yield contributing traits of onion crops at both growing season. Analysis of variance showed that day to 90% physiological maturity of the onion crop, marketable and unmarketable bulb yield, and over-all bulb yield of onion crop were significantly affected by main effect of varieties and NPS fertilizer rates but not affected significantly by their interaction. Both the height of the plant and the number of leaves per plant were greatly influenced by interaction of the variety and fertilizer level of the NPS. From the three tested onion varieties tested, the highest marketable onion bulb yield is harvested in the variety of Nafis. Similarly, an increase in NPS fertilizer rate from 0 kg ha^{-1} to 200 kg ha^{-1}was increases the number of leaves per plant, plant height, days to 90% physiological maturity and total bulb yield but reduces yield of unmarketable bulb of onion plant. Therefore, based on the highest marketable bulb yield obtained, Nafis varieties of onion plants and 150 kg ha^{-1} of NPS fertilizer level should be recommended for production in the study area. Moreover, in the absence of Nafis variety, Adama red variety with an NPS level of 150 kg ha^{-1} can be considered as alternative variety to be recommended for the farmers in the study area based on the research finding conducted in 2020 and 2021 cropping season.

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