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The Effect of Variety, Nitrogen and Phousphorous Fertilization on Growth and Bulb Yield of Onion (*Allium Cepa* L.) at Wolaita, Southern Ethiopia

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Abstract
Field experiment was conducted to evaluate growth, yield and yield components of different onion (Allium cepa) varaties under different nitrogen and phosphorous levels from May to December, 2012 in wolaita zone Humbo wereda Ampokoysha district of southern Ethiopia. The study consisted of 3 released Onion varieties (Adama Red, Bombe Red and Nafis), 4 levels of nitrogen (0, 23, 46 and 69 kg N ha^{-1}) and 4 levels of phosphorous (0, 23, 46 and 69 kg P_2O_5 ha^{-1}) in RCB design with three replications. Data were collected for growth, bulb yield and yield components. Analysis of variances (ANOVA) revealed that varieties differed significantly ($P \leq 0.05$) in plant height, bulb diameter, bulb fresh weight, total bulb yield, marketable yield, harvest index, bulb dry matter content. Nitrogen affected positively and significantly ($P < 0.05$) plant height produced the bulbs of greatest marketable yield, and total bulb yield where as Phosphorous affected positively and significantly ($P < 0.05$) plant height, Harvest index, bulb diameter and bulb dry matter content. There was no significant interaction between variety, nitrogen and phosphorous levels for all observed parameters. In this study, the highest bulb yield of 2.72 t/ha was achieved using Nafis variety with application of 69 kg N/ha and 46 kg P_2O_5/ha. According to the partial budget analysis, the highest economic benefits of 74,096 birr/ha was also obtained using Nafis variety at 69 kg N/ha and 46 kg P_2O_5/ha. Therefore, Nafis variety with application of 69 kg N/ha and 46 kg P_2O_5/ha could be appropriate for Onion production in the test area.
Keywords: Onion, Variety, Nitrogen, Phosphorus, Growth, Yield, Ethiopia.

1. **Introduction**

Onion (*Allium cepa)* was domesticated in the southwestern part of central Asia about 6000 years ago (Bednarz, 1994). Very early cultivation is known to have occurred in Egypt and India and now it is grown in almost all inhabited parts of the world and is an introduced bulb crop in the agriculture community in Ethiopia (Tindall, 1983).

In terms of global weight of vegetable produced, at nearly 28 million tons per annum, only tomatoes and cabbages exceed bulb onions in importance (FAO, 1991). In Ethiopia, onion is grown widely in rift valley and lake regions of the country (Lema and Shimeles, 2003). Estimates of area in hectarage, total production of onion in Ethiopia for all seasons and all holdings that is both rural and urban is 20,443.92 and 2,572,052.63, respectively (CSA, 2003). Yield potential of properly cured dry bulbs at the research centers in the country ranges between 25-35 t ha^{-1}, whereas in the farmers field it ranges between 9-15 t ha-^{1} (Lema and Shimeles, 2003).

Onion productivity could be increased substantially through use of improved cultivars and optimum use of fertilizers (Shaheen, 2007). The quantity of nutrients to be applied depends on the yield potential of the cultivar, the level of available nutrients in the soil, and growing conditions (Marschner, 1993).

In Ethiopia, also the fertilizer recommendations are made according to the nutrient uptake from the soil and the expected yield. Growers in rift valley apply different levels of organic fertilizers (Lemma and Shimmeles, 2003). The result of fertilizer trial on onion conducted on a sandy loam soil in a semi-arid region of Ethiopia, indicated as irrigated onions benefited from application of 50 to 150 Urea (23-69 Nkg ha^{-1}) and 0 to 150 $kgha^{-1}$ DAP (0-69 P_2O_5) for commercially growing farmers compared to unfertilized crops (Shimmeles, 1997). Generally in Wolaita zone, and particularly at Humbo wereda where this experiment was conducted, onion is grown on 80 hectares at different Kebles using rain fed and irrigation schemes with little use of Nitrogen and phosphorus fertilizer and about 220 households are engaged in onion production. However, in area, there is little or no information on the optimum level of NP fertilizer application and use of well adapted cultivar for the maximum yields of onion varieties. Therefore, determining the influence of nitrogen and phosphorous fertilization on the yield of onion and to investigate the response of different onion varieties to nitrogen-phosphorous application under the agro-climatic conditions of Wolaita is the objectives of the study presented in this paper.

2.0 Materials and Methods

A field experiment were conducted during 2012 dry season in farmers at Ampo koysha kebele Ella mesno vilage in Humbo Woreda found in wolaita Zone of Southern Ethiopia. Humbo is located in the Southern Nation Nationalities and Peoples Regional State. It is located at 6 40’46"N latitude and 37 46’56"E longitude at an altitude of 1450 m.a.s.l. The area has bimodal rainfall distribution with mean annual rainfall of 500 mm. Seventy percent of the woreda has hot to warm climate with mean minimum and maximum air 24 ^{o}C and 32 ^{o} C, respectively. The soil is Nitisol, reddish brown in color and temperature of 24 classified as sandy loam in texture (Gebre, 2007).

The treatments consisted of three varieties of onion named as Adama Red, Bombay Red and Nafis, four N levels (0, 23, 46, and 69kg N ha^{-1}) and four P levels (0, 23, 46, and 69 kg P_2O_5 ha^{-1}). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications in factorial arrangement. Each replication consisted of 48 plots corresponding to the 48 treatment combinations. The plot size was 4.84 m^2 (2.2 m x 2.2 m) and consisted of six rows. A distance of 0.5 m and 1 m were left between plots and blocks, respectively. Spacing of 40 x 20 x 10 cm was used between furrows, rows and plants, respectively and there were 22 plants planted per row with a total of 132 plants per plot.

Certified seeds of the three varieties used in the experiment were obtained from Melkassa Agricultural Research Center. Seeds were sown at a rate of 3.5-4 kg ha^{-1} on nursery beds having 1 m width and 10 m length on May 30, 2012. Sowing of seed was done on rows separated by 15 cm and at the depth of 1.5 cm, keeping 4 cm distance between seeds. The nursery beds were placed under shade in order to maintain adequate moisture level and to curtail the effect of rain droppings.

Seeds and seedling were watered throughout the nursery stage of the 8 weeks duration. Watering was gradually reduced and stopped at about a week before transplanting. Shade was removed and seedlings were exposed to sun. The experimental field was ploughed, smoothed and leveled very well before transplanting commenced. Seedlings with 10-12 cm height, 4-5 true leaves and with no disease and pest sign were transplanted one seedling/hill on August 1, 2012 for all varieties. Transplanting was done by surface irrigation system and supplementary water was given during flowering and fruiting by furrow irrigation system.

Nitrogen fertilizer was applied by split application method in the form of urea the first three weeks after transplanting and the second at first fruiting. Phosphorus was applied in the form of TSP at the time of transplanting. Weeding was manually done continuously with hoe during the whole growing season to make the plot weed free. Disease and insect pest (bacterial soft rot, bacterial wilt, army worm, bacterial blight) occurrence was also thoroughly supervised through application of chemicals as per the recommendation dosage.

Data were collected on Plant height (cm), Number of leaves per plant, Shoot dry weight (g plant^{-1}), Average bulb weight (g plant^{-1}), Bulb dry matter content (%), Bulb diameter (cm), Harvest index (HI), Marketable yields (t ha^{-1}), Unmarketable yields (t ha^{-1}), Bulb yield (t ha^{-1}).

Where PH=Plant height, LN= Leaf number, BD=Bulb diameter (cm), BDMPP=Bulb dry matter content per plant (g/plant), BFWPP=Bulb fresh weight per plant (g/plant), HI=Harvest Index, TY=Total Bulb Yield (t/ha), MkY =Marketable Yield (t/ha), UMkY= Unmarketable Yield (t/ha)

Data were subjected to analysis of variance (ANOVA) procedure using (SAS, 2003) and the mean were separated using least significant difference (LSD) test.

Simple partial budget analysis was employed for economic analysis of fertilizer. Estimation of the total costs, mean market prices of onion and urea were taken from market assessment at the time of planting. The economic analysis was based on the formula developed and used by CIMMYT (1988).

3. Results and Discussion

3.1. Vegetative growth

3.1.1. PLANT HEIGHT

Variety had significant ($P \leq 0.05$) effect on mean plant height of Onion (Table 4). It was observed that mean plant height of variety Naffis was significantly higher than both Adama red and Bombe red where as mean plant height of Adama red and Bombe red variety were statically similar (Table 1).

N had significant ($P \leq 0.05$) effect on mean plant height of Onion (Table 4). Mean plant height of Onion continued to increase with increasing N level reaching a maximum at 69 kg N ha^{-1} which were significantly higher than all the lower N rates; whereas mean plant height of Onion at 23 and 46 kg N ha^{-1} were statistically similar but mean plant height of Onion at all rates were statistically higher than the control (Table 1).

Plant height of Onion thus responded positively to N. The results are in consonance with those of Kumar *et al*. (1998) and Aregawi (2006) who reported that application of N at 150 kg N ha^{-1} and 180 kg N ha^{-}, respectively increased plant height than in plots that received no N fertilization. Generally in this study, plant height increased with increasing N up to 69 kg N ha^{-1}.

The reasons for increase in plant height under N application might be due to the increased vegetative growth with increasing N and this could be due to increase in N supply leads utilization of carbohydrate to form protoplasm and more cells to enhance growth. Plants deprived of N show decreased cell division and expansion (Hewitt and Smith, 1974). Phosphorous had a significant ($P \leq 0.05$) effect on mean plant height of Onion (Table

4). Mean plant height of Onion at application of 0 and 23 kg P_2O_5 ha^{-1} as well as 23, 46 and 69 kg P_2O_5 ha^{-1} were statistically similar but mean plant height of Onion at application of 46 and 69kg P_2O_5 ha^{-1} were significantly higher than the control; the highest plant height of 36.86 cm was obtained from application of 69 kg $P_2O_5ha^{-1}$ where as the lowest 32.11cm was recorded at control. Thus the mean plant height of Onion is increased due to P fertilization. All interaction effects of variety, N and P_2O_5 on plant height were non-significant ($P \leq 0.05$). The response of plant height of Onion to variation in genotype, N and P level is thus the same irrespective of the nature of variation

3.1.2. LEAF NUMBER

Differences in mean number of leaves per plant between varieties were non significant ($P \leq 0.05$) (Table 4). However, Nafis recorded the highest mean number of leaves per plant (10.60cm) followed by Adama red (10.17) while the variety Bombe Red had the lowest (9.69) mean number of leaves per plant (Table 1).

N levels had non-significant effect on the number of leaves per plant. This result is consistent with the result of Karic *et al*. (2005) who investigated the response of leek to different levels of nitrogen and observed no effect on the number of leaves per plant in all N levels.

Phosphorous had non significant ($P \leq 0.05$) effect on mean leaf number per plant (Appendix 1). However, the maximum numbers of leaves were recorded at 69 kg P_2O_5 while the minimum values were recorded at 23 kg P_2O_5 ha^{-1}. Similarly, Stroeheline *et al*. (1979) reported that application of P_2O_5 showed no non significant difference on leaf number.

All interaction effects of variety, N and P_2O_5 on number of leaves per plant were non-significant ($P \leq 0.05$) at all growth stages (Table 4).

3.2. Bulb characteristics

3.2.1. BULB DIAMETER

There was significant ($P \leq 0.05$) difference amongst varieties in mean bulb diameter (Table 4). Nafis scored the highest mean bulb diameter (3.90cm) which was, however, not significantly different from the mean bulb diameter of Bombe Red. The lowest mean bulb diameter of 3.18 cm was recorded for Adama Red (Table 2). The studies of Katwale and Sarat (1991) support the present findings who reported variable bulb size in different cultivars of onion.

Mean bulb diameter per plant was not significantly ($P \leq 0.05$) affected by N level (Table 4). However; the highest mean bulb diameter of 3.74 cm was recorded at 46 kg N ha^{-1} followed by 69 kg N ha^{-1} while the minimum bulb diameter (3.55cm) was observed at the control (Table 2). The finding is contrary to the result reported by Khan *et al*. (2002) who reported that N an increase in application of N increased bulb size.

Phosphorous had significant ($P \leq 0.05$) effect on mean bulb diameter (Table 4). The maximum mean bulb diameter (3.81m) was recorded at 69 kg P_2O_5/ha while the minimum values (3.32cm) were recorded at control which is significantly lower application at 69kg P_2O_5/ha. Treatments with 69 kg P_2O_5 ha^{-1} achieved significantly higher bulb diameter followed by those with 46 kg P_2O_5 ha^{-1}. Treatments with 23 kg P_2O_5 ha^{-1}, 46 kg P_2O_5 ha^{-1} and 69 kg P_2O_5 ha^{-1} performed the same (Table 2).

All interaction effects of variety, N and P_2O_5 on mean bulb diameter were non-significant ($P \leq 0.05$) (Table 4).

3.2.2. FRESH WEIGHT OF BULB PER PLANT

There was significant ($P \leq 0.05$) difference amongst varieties in mean fresh weight of bulb (Table 4).Nafis scored the highest mean fresh weight of bulb (17.62) which was, however, not significantly different from the mean fresh weight of bulb of Bombe Red (17.18) but significantly higher than the lowest mean fresh weight of bulb of 10.65 cm was recorded for Adama Red (Table 2).

The average weight of bulb is an important parameter contributing to yield. The effect of N levels on mean weight of bulb was non significant ($P \leq 0.05$) (Table 4). However, the highest mean weight of bulb (17) was recorded at highest 63 kg N ha^{-1} while the minimum was observed (13.68) at 23 kg N ha^{-1} (Table 2). This study is contrary to Kumar *et al*. (1998) and Kebede (2003) who reported that bulb weight increased significantly with increasing level of N fertilization up to 100 kg N ha^{-1} for onion and shallot crops, respectively.

Phosphorous had no significant ($P \leq 0.05$) effect on mean fresh weight of bulb (Table 4). Similarly, Stroeheline *et al*. (1979) reported that application of P showed no significant difference on average weight of bulb. All interaction effects of variety, N and P_2O_5 on mean fresh weight of bulb were non-significant ($P \leq 0.05$) (Table 4).

3.2.3. BULB DRY MATTER CONTENT

There was significant ($P \leq 0.05$) difference amongst varieties in bulb dry matter content (Table 4).. Nafis scored the highest bulb dry matter content (38.97) which was, however, statistically similar to the bulb dry matter content (38.66) of Bombe Red. The lowest mean bulb diameter of 31.83 was recorded for Adama Red which was significantly lower than both variety Nafis and Bombe Red (Table 2).

The mean analysis for bulb dry matter percentage revealed no significant for N levels (Table 4). All the treatments were statistically similar for bulb dry matter content at harvest.

Phosphorous had significant ($P \leq 0.05$) effect on mean dry matter content (Table 4). The maximum mean dry matter content of (38.1) was recorded at highest rate of 69 kg P_2O_5 while the minimum values (33.2) were recorded at control and as the rate of P increases dry matter content of onion increased. However, there is some inconsistency (Table 2). All interaction effects of variety, N and P_2O_5 on mean bulb dry matter percentage were non-significant ($P \leq 0.05$) (Table 4).

3.3. Harvest index

Varieties affected harvest index significantly ($P \leq 0.05$) (Table 4). The maximum harvest index was observed in Naffis which is not siginificantly differ from Bombay Red while the minimum harvest index was noticed in Adama Red (Table 3).

N levels had no significant ($P \leq 0.05$) effect on harvest index (Appendix 1). But harvest index of onion consistently increased with increasing N levels and reached a maximum at highest level of 69 kg N ha^{-1}. The lowest harvest index was observed at 0 kg N ha^{-1} (Table 3). Walton *et al*. (1999) also found that harvest index of Australian canola crops typically varies between 0.25 and 0.35.

Phosphorous had significant ($P \leq 0.05$) effect on harvest index (Table 4). The lowest harvest index of 0.54 was obtained from 0 kg P_2O_5 ha^{-1} whereas the highest 0.63 was obtained from 46 kg P_2O_5 ha^{-1} which is statistically similar to 69 kg P_2O_5 ha^{-1} but significantly differ from the control (Table 3). This result is in line with the work of Baiyeri (2002) who found that harvest index of plantain significantly ($P \leq 0.05$) increased with increasing P level up to 448 kg P_2O_5 ha^{-1} and then declined.

3.4 Yield characteristics

3.4.1. TOTAL BULB YIELD PER HECTARE

Significant ($P \leq 0.05$) variation existed among varieties with respect to mean total bulb yield (Table 4). It varied from17.7 to 10.6 t ha^{-1} which is comparable to average yield at farmers' condition. Nafis gave 17.76 t ha^{-1} proved superior in this regard which was, however, statistically similar with the mean total bulb yield of Bombay Red 17.2 6 tha^{-1} while Adama Red gave the minimum mean total bulb yield of 10.6 6 t ha^{-1} (Table 3). The above yields of varieties in lower than the range reported by other researchers in Ethiopia.

The highest dried bulb yield 17 t ha^{-1} was recorded from 69 kg N ha^{-1} while the lowest 13.9 t ha^{-1} was from 0 kg N ha^{-1} and as the level of N increases the yield increased consistently. However, there was no significant difference on dried bulb yield between N applications of 0, 23, and 46 kg N ha^{-1} (Table 3). This result suggests that N application to the soil is important to improve bulb yield of onion significantly. This might be due to nitrogen is an integral component of many essential plant compounds like chlorophyll, proteins and it is a major part of all amino acids (Brady and Weil, 2002). It increases the vegetative growth and produces good quality foliage and promotes carbohydrate synthesis through photosynthesis and ultimately increased yield of plants (Mengel and Kirkby, 1987).

Phosphorous had no significant ($P \leq 0.05$) effect on total bulb yield (Appendix 1). However, the lowest total bulb yield of 13.28 t ha^{-1} was obtained from 0 kg P_2O_5 ha^{-1} whereas the highest 16.28 t ha^{-1} was obtained from 46 kg P_2O_5 ha^{-1} and there is no consistency for yield increament as the level of P increases (Table 3).

This result is somewhat contrary to the observation of Baghour *et al*. (2001) in his study of onion that vegetative growth yield and quality of onion significantly improved through nitrogen and phosphorous fertilization. All interaction effects of variety, N and P on total bulb yield were non-significant ($P \leq 0.05$) (Table 4).

3.4.2. Unmarketable yield

The mean analysis for unmarketable yield revealed no significant differences among Varaties. The unmarketable yield 1.68, 1.52 and 1.48 t ha^{-1} was obtained by Variety Nafis, Bombe Red and Adama Red respectively. Similarly Nitrogen and Phosphorous had no significant ($P \leq 0.05$) effect on unmarketable yield of Onion and All interaction effects of variety, N and P for unmarketable yield were also non-significant ($P \leq 0.05$) (Table 4).

3.4.3. MARKETABLE YIELD

Varieties affected mean marketable yield significantly ($P \leq 0.05$) (Table 4). It varied from 9.17 to 15.94 t ha^{-1}. The maximum mean bulb dry weight (15.94) was observed in Nafis followed by Bombay Red (15.67) which was, however, statistically similar, while the minimum mean marketable yield (9.17) was noticed in Adama Red (Table 3). Rajcumar (1997) also reported highly significant differences between onion varieties in marketable yields which ranged from 8.4-38.7 t ha^{-1}.

N levels affected mean marketable yield significantly ($P \leq 0.05$) (Table 4). With the increase in dose of N up to 69 kg N ha^{-1} the mean marketable yield was increased. It ranged from 12.34 to 15.69 t ha^{-1}. The highest mean marketable yield of onion was at an application rate of 69 kg N ha^{-1}, which was significantly different from the control but not significantly different from the mean marketable yield at 23 kg N ha^{-1} and 46 kg N ha^{-1} (Table 3). Similarly the minimum mean marketable yield was produced from control plots. Similarly Henriksen (1987) and Kumar *et al*. (1998) reported that the yield of marketable onion bulbs increased with N application.

Phosphorous had no significant ($P \leq 0.05$) effect on mean marketable yield (Table 4). However, the lowest mean marketable yield of 11.79 t ha^{-1} was obtained from 0 kg P_2O_5 ha^{-1} whereas the highest 14.70 t ha^{-1} was obtained from 46 kg P_2O_5 ha^{-1} (Table 3).

All interaction effects of variety, N and P_2O_5 for unmarketable yield were also non-significant ($P \leq 0.05$) (Table 4).

4. Conclusion

The growth and yield parameters studied in this paper indicated that the varieties had significant differences in plant height, bulb diameter, bulb fresh weight, total bulb yield, marketable yield, harvest index, bulb dry matter content. Amongst the varieties Nafis performed best by producing higher bulb yields and vegetative growth followed by Bombe Red. The lowest yield as well as vegetative growth performance was recorded in Adama red. The effect of N fertilizer levels on the performance of different onion varieties suggested that N levels significantly enhanced plant height, produced the bulbs of greatest marketable yield, total bulb yield. In this study, the highest bulb yield was achieved using 69 kg N ha^{-1}. The effect of P fertilizer levels on the performance of different onion varieties suggested that p levels significantly enhanced plant height, Harvest index, bulb dry matter content and bulb diameter. In this study, the highest bulb yield was achieved using 46 kg P_2O_5 ha^{-1}. The partial budget analysis also indicated that Nafis variety application of nitrogen at a rate of 69 kg N/ha and phosphorus at a rate of 46 kg P_2O_5/ha was profitable.

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Table1. Mean plant height (cm) and Leaf number of Onion as affected by Varieties, Nitrogen, and Phosphorous at Humbo Wolaita, 2012

Treatments	LN	PH
Variety		
Adama Red	10.17a	31.45b
Bombe Red	9.69a	32.21b
Naffis	10.60a	37.27a
LSD 0.05	Ns	2.02
N (kg ha^{-1})		
0	10.26a	30.83c
23	10.41a	34.17ab
46	9.85a	33.52b
69	10.10a	36.09a
LSD 0.05	Ns	2.34
P (kg ha^{-1})		
0	10.11a	32.11b
23	9.66a	33.14ab
46	10.28a	34.50a
69	10.59a	38.86a
LSD 0.05	Ns	2.34
CV%	23.46	14.86

PH=Plant height, LN= Leaf number
Note: Means with the same letters within the columns are not significantly differ at $P < 0.05$

Table 2. Yield components of Onion as affected by Varieties, Nitrogen, and Phosphorous at Humbo, in 2012

Treatments	BD	BDMPP	BFWPP
Variety			
Adama Red	3.18b	31.83b	10.65b
Bombe Red	3.87a	38.65a	17.18a
Naffis	3.90a	38.97a	17.62a
LSD 0.05	0.33	3.33	3.62
N (kg ha^{-1})			
0	3.55a	35.49a	14.89a
23	3.62a	36.22a	13.68a
46	3.68a	36.78a	15.03a
69	3.74a	37.45a	17.00a
LSD 0.05	0.38	3.84	4.18
P (kg ha^{-1})			
0	3.32b	33.20b	13.28a
23	3.78a	37.76a	15.66a
46	3.69ab	36.86ab	16.28a
69	3.81a	38.10a	15.38a
LSD 0.05	0.38	3.84	4.18
CV%	22.52	22.52	29.04

BD=Bulb diameter (cm), BDMPP=Bulb dry matter content per plant (g/plant), BFWPP=Bulb fresh weight per plant (g/plant)

Table 3. Harvest index and yield characteristics of Onion as affected by varieties, nitrogen, and phosphorous at Humbo, in 2012

Treatments	HI	TY	MkY	UMkY
Variety				
Adama Red	0.48b	10.60b	9.17b	1.48a
Bombe Red	0.66a	17.2a	15.67a	1.52a
Naffis	0.62a	17.7a	15.94a	1.68a
LSD 0.05	0.07	3.6	3.47	ns
N (kg ha^{-1})				
0	0.55a	13.90b	12.34b	1.56a
23	0.58a	14.37b	13.00ab	1.37a
46	0.59a	15.00ab	13.34ab	1.66a
69	0.61a	17.00a	15.69a	1.32a
LSD 0.05	Ns	3.10	2.9	ns
P (kg ha^{-1})				
0	0.54b	13.28a	11.79a	1.49a
23	0.58ab	15.66a	14.42a	1.25a
46	0.63ab	16.28a	14.71a	1.57a
69	0.58a	15.38a	13.45a	1.93a
LSD 0.05	0.079	ns	ns	ns
CV%	11	19	13	33.9

HI=Harvest Index, TY=Total Bulb Yield (t/ha), MkY =Marketable Yield (t/ha), UMkY= Unmarketable Yield (t/ha)

Note: Means with the same letters within the columns are not significantly differ at P < 0.05

Table 4: Mean square values for growth, yield and yield components of Onion on the effect of varieties, nitrogen, and phosphorous at Humbo area in wolaita, in 2012.

		Mean Square								
Source	DF	PH	LN	MkY	UMkY	TY	BDMPP	BFWPP	BD	HI
Replication(R)	2	52.01^{ns}	147.71^{ns}	9.26^{ns}	0.02^{ns}	10.07	967.28^{ns}	1003.2^{ns}	8.00^{ns}	0.27^{ns}
Variety (V)	2	477.13*	9.91^{ns}	7.06**	0.01^{ns}	7.32**	780.18*	732.64**	7.8**	0.44*
Nitrogen (N)	3	170.25**	2.12^{ns}	0.85**	0.01^{ns}	0.68**	24.70^{ns}	67.96^{ns}	0.25^{ns}	0.03^{ns}
Phosphorus (P)	3	57.80**	5.40^{ns}	0.63^{ns}	0.02^{ns}	0.61^{ns}	182.27*	61.18^{ns}	1.82**	0.04*
V*N	6	50.62ns	1.41^{ns}	0.15^{ns}	0.07^{ns}	0.23^{ns}	69.07^{ns}	23.14^{ns}	0.69^{ns}	0.01^{ns}
V*P	6	78.34^{ns}	4.16^{ns}	3.38^{ns}	0.04^{ns}	3.35^{ns}	719.46^{ns}	334.7^{ns}	7.19^{ns}	0.12^{ns}
N*P	9	11.32^{ns}	2.69^{ns}	0.36^{ns}	0.02^{ns}	0.49^{ns}	63.46^{ns}	48.55^{ns}	0.63^{ns}	0.03^{ns}
V*N*P	18	7.65^{ns}	2.33^{ns}	0.57^{ns}	0.05^{ns}	0.55^{ns}	50.91^{ns}	55.18^{ns}	0.51^{ns}	0.02^{ns}
Error	96	25.02	5.68	0.73	0.04	0.8	67.50	80.02	0.67	0.03

*, **, *** indicate significance at P < 0.05, P < 0.01, P < 0.001, respectively, 'ns' not significant.

PH=Plant height (cm), LN=Leaf number, MkY=Marketable yield (t/ha), UMkY=Unmarketable yield (t/ha), TY =Total Yield (t/ha), BDMPP= Bulb dry matter content (g/plant), BFWPP= Bulb fresh weight (g/plant), BD=Bulb diameter (cm), HI=Harvest index

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