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Influence of Nitrogen and Phosphorus fertilizer Rates on Seed Yield, Yield Components and Quality of Onion (*Allium cepa* L.) at Kulumsa in Arsi Zone, South East Ethiopia

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Onion is an important vegetable crop commercially grown both by large and small scale farmers in Ethiopia. Its production is highly dependent on availability of high and good quality seed, which is constrained by a number of problems including declining soil fertility and inappropriate fertilizer application. A study was conducted to investigate the effects of nitrogen (N) and phosphorus (P) fertilizer rates on onion seed yield and quality. The experiment was conducted at Kulumsa, South East Ethiopia, using four levels of N (0, 50,100 and 150 kg N ha^{-1}) and four levels of P (0, 35, 70 and 105 kg P_2O_5 ha^{-1}) fertilizers arranged in 4 × 4 factorial arrangements in randomized complete block design with three replications. The result of the study revealed that almost all of the yield and yield component parameters considered were significantly affected by the treatments. The crop phenology, growth and yield components were significantly influenced by the rate of N and P fertilizers and their interactions. More specifically, seed yield and seed quality were significantly (P<0.01) varied among treatment combinations. The combination of N at 100 kg N ha^{-1} and P at 70 kg P_2O_5 ha^{-1} gave the highest seed yield (1858.82 kg ha^{-1}) with yield increment of about 57.72% over the control (no fertilizer application). As main factors each of N and P fertilizers at rates of 100 kg N ha^{-1} and 105 kg P_2O_5 ha^{-1} resulted in highest germination percentage of onion seed. Therefore, a combined application of N at 100 kg N ha^{-1} and P at 70 kg P_2O_5 ha^{-1} rates can be recommended for onion seed producers in the study area and areas of similar agro-ecology.

Key words: Soil fertility, commercial fertilizers, Alliaceae, Tri- super phosphate, Urea.

INTRODUCTION

Onion (*Allium cepa* L.) belonging to the family *Alliaceae.* It is one of the most important vegetable crops commercially grown in the world. Onion is currently becoming a popular vegetable crop in Ethiopia despite of its recent introduction to the country. It is a vegetable crop with high yield potential per unit area, easy to propagate both by seed and bulb methods, and it is with high demand in domestic and export markets (Lemma and Shimeles, 2003; Dawit et al., 2004; Ashenafi et al., 2014; Asfaw and Eshetu, 2015). It contributes significant nutritional values to the human diet and has medicinal properties and is primarily consumed for its unique flavors or for its ability to enhance the flavors of other foods (Lemma and Shimeles, 2003).

In Ethiopia, onion is one of the most important cash crops, which contributes to commercialization of the rural economy and creates many off-farm jobs (Lemma and Shimeles, 2003; Nikus and Fikre, 2010). Onion seeds are well known to be highly perishable and poor in keeping quality and lose viability within a year. One of the problems of onion production in the tropics is lack of seed which is true to type with high germination and vigor (Currah and Proctor, 1990; Griffiths et al., 2002). Onion seed is usually produced in the temperate and subtropical countries.

Onion is produced in many of the regions of Ethiopia. During the 2017/2018 production year, the Oromia Region's onion production coverage was estimated about 13,669.5 ha from which 1,033,485.45 tons of onion bulbs were produced with an average productivity of 7.56 tons ha^{-1}. Arsi Zone is one of the potential areas in Oromia regional state for vegetable production where onion can be the best choice owing to relatively cool weather condition comparable with subtropical climate due to higher elevation (CSA, 2017). In addition to bulb production, the area is suitable for seed production that can fulfill the cooler temperature requirement for bolting of onion in certain seasons of the year. Therefore, the highlands of Arsi Zone have tremendous potential for onion seed production that can satisfy the demand for onion seed in the country.

The price of onion seed remains high in the season of onion cultivation in the country. Seed production is a vital part in onion production and is highly specialized business (FAO, 2013). The yield of onion seed in our country varies from 1000 - 1300 kg ha^{-1} (Lemma et al., 2006), 116.32 -118.2 kg ha^{-1} (Tamrat, 2006), 75.15 - 1155.75 kg ha^{-1} (Teshome et al., 2014) and 748.9-879.4 kg ha^{-1} (Getachew, 2014) which is very low compared to the average seed yield in some other countries of the world that ranged 600 - 2000 kg ha^{-1} (Chadha et al., 1997) and 828 - 1446 kg ha^{-1} (Aminpour and Mortzavi, 2004).

Nutrients from fertilizers play a significant role in improving productivity and quality of vegetable crops. Therefore, increasing the productivity of onion seed with a good quality is an important target for producers. Onions are the most weak crop plants in extracting nutrients, especially the immobile types, because of their shallow and unbranched root system; hence they require and often respond well to addition of fertilizers. Therefore, optimum fertilizer application and cultivation of suitable varieties with appropriate agronomic practices in specific environment are necessary for obtaining good yield of onion seed (Rizk et al., 2012).

Nitrogen (N) and phosphorus (P) are often referred to as the primary macronutrients because of the large quantities taken up by plants from the soil relative to other essential nutrients (Marschner, 1995). Nitrogen comprises 1-5% of total dry matter of plants and is a constituent of many fundamental cell components (Bungard et al., 1999). Phosphorus is making up about 0.2% of a plant's dry weight and it is essential for root development. Plants must have phosphorus for normal growth and maturity (Fairhurst et al., 1999).

According to Fairhurst et al*.* (1999) P deficiency is one of the largest constraints to crop production in many tropical soils, owing to low native content and high P fixation capacity of the soil. When the availability is limited, plant growth is usually reduced. In soils that are moderately low in P, onion growth and yield of onion seed can be enhanced by applied P. Quality of onion seed can be affected by mineral nutrition, irrigation schedule or rainfall (Lemma and Shimeles, 2003). Fertilizer practices for the onion seed crop vary widely among soil types and variety used. However, in Ethiopia there is no fertilizers recommendation for onion seed production and hence, most seed growers are using fertilizers rates recommended for bulb production (Lemma and Shimeles, 2003). Besides, research results in the rift valley region of Ethiopia showed that 90-135 kg P_2O_5 ha^{-1} and 81-144 kg N ha^{-1} is good for bulb production in sandy loam soil, while 92 kg N ha^{-1} can be used for seed production (Lemma and Shimeles, 2003; Dawit et al., 2004; Tamirat, 2006; Abdissa et al., 2011). Reports indicated that the low yield of onion seed in the country is due to low fertility of soil, inappropriate fertilizer use, lack of improved varieties, and poor management practices (Lemma and Shimeles, 2003). Among these constraints, inappropriate use of mineral fertilizers such as absence of optimum fertilizer rate recommendation is one of the most important factors in the study area (Arsi Zone) associated with the low onion seed yield. The majority of the farmers in the zone, however, use smaller doses of N and P fertilizers. Some of the farmers use higher doses of N fertilizer only in the form of urea and others do not use P fertilizer at all. Hence, application of appropriate rate and type of fertilizers are vital operations for high seed yield and quality of onions.

In order to fulfill the high demand of onion seed in Arsi Zone, high quality seed has to be produced locally in large quantity at reduced cost of production for

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commercial seed and bulb producers. This not only answers the local demand for onion seed but also reduces dependency on imported seed from abroad at country level. Therefore, this research was conducted to investigate the effect of N and P rates on onion seed yield and determine the optimum levels of N and P fertilizers for quality seed yield of onion.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at Kulumsa Agricultural Research Center (KARC) which is located at 8°00' to $8^{o}02$'N and 39°07' to 39°10'E and an altitude of 2210 m. a. s. l. in Tiyo district, Arsi Administrative Zone of the Oromia Regional State, Ethiopia. The site is found 167 km South East of Addis Ababa. The KARC is located on a very gently undulating topography with a gradient of 0 to 10% slope. It has a low relief difference with altitude ranging from 1980 to 2230 m. The agro- climatic condition of the area is wet with 811 mm mean annual rain fall and it is a uni- modal rainfall pattern with extended rainy season from March to September. However, the peak rainy season is from July to August. The mean annual maximum and minimum temperatures are 23.1 and 9.9°C, respectively. The coldest month is December whereas; May is the hottest month (Abayneh et al., 2003).

Experimental materials and bulb production

Seedlings of onion cultivar Nafis were raised in the seed bed at Kulumsa Agricultural Research Center in March 2017. After 45 days, seedlings were transplanted to the field at KARC for bulb production. Seedlings were transplanted with a recommended double row spacing of 40 cm × 20 cm × 5 cm (Lemma and Shimeles, 2003). All the recommended agronomic and crop protection practices such as cultivation, fertilization, weeding and fungicide/pesticide application were applied according to the national recommendations for onion. Once the onion is matured, bulbs were harvested and true to type bulbs which are healthy, well shaped and size were selected for the experiment.

Experimental design and procedure

The experimental field was cleared and ploughed three times by tractors plough according to Kulumsa Agricultural Research Center Practice and after which it was divided into three uniform blocks each containing 16 plots for each treatment. The sprouted onion bulbs were planted in double rows with spacing of 50, 30 and 20 cm between water furrows, rows and plants in rows, respectively (Lemma and Shimeles, 2003). Distances of 1 and 1.5 m were maintained between plots and blocks, respectively. Each plot had four rows (ridges) which consisted of 112 plants. The middle double rows were considered for recording of agronomic data. A plot size of 3.2 m × 2.8 m (8.96 m^2) was used for each experimental unit (plot).

The experiment was conducted under irrigation condition during the off- season of October 2017 to May 2018. The treatments consisted of four levels of N (0, 50, 100, and 150 kg ha^{-1} from urea (46-0-0) and four levels of P_2O_5 (0, 35, 70, and 105 kg $ha^{-1}$from TSP (0-46-0) in a 4×4 factorial combinations. The treatment combinations were arranged in randomized complete block design (RCBD) with three replications. Treatments were randomly assigned to the experimental plots of each replication. The full dose of Phosphorus applied at planting and half dose of N fertilizer were applied two weeks after planting and the remaining half dose of N was side-dressed forty five days after planting.

Data collection and measurement

Crop phenology and growth parameters

Days to bolting, days to flowering, days to maturity, plant height (cm), flowers stalk height (cm) and flower stalk diameter (cm) were measured.

Seed yield and yield components

Number of flower stalks per plant, number of umbel per plant, umbel diameter (cm), number of flowers per umbel, number of seeds per umbel, seed weight per umbel (g), seed yield per plant and seed yield per hectare were recorded.

Seed quality parameters

1000 seeds weight (g): Sample of seeds from the bulk in each plot was taken and 1000 seeds were counted in seed counter machine and weighed using a sensitive balance and then adjusted to the moisture content of 8%.

Germination percentage (%): One hundred seeds were placed on Petri dishes covered with filter paper and allowed to imbibe distilled water which was kept at room temperature until 15 days. The percent of germination has three replications using the total of 48 Petri dishes. A seed was considered germinated when the radicle protrusion attained approximately 1 mm. Then percent germination was determined from counts of normal seedlings and the total seeds placed on Petri dishes. Percent of seed germination were done after harvest.

$$\text{Germination \%} = \frac{\text{Number of germinated seed}}{\text{Total seed}} \text{x}100$$

Data analysis

The collected data were subjected to Analysis of Variance (ANOVA) using statistical analysis Software (SAS version 9.2, 2008). The mean separation was done using (LSD) test at 5% probability level and simple correlation was made to determine association of parameters by using Pearson analysis.

RESULTS AND DISCUSSION

Phenology and growth parameters

Days to bolting

The shortest days to bolting was recorded from the combination of N at rate of 0 kg ha^{-1} with P at rate of 70 kg and 105 kg P_2O_5 ha^{-1}. The combination of N at rate of 150 kg ha^{-1} with P at a rate of 0 kg P_2O_5 ha^{-1} delayed days to bolting as compared to other treatment combinations except the same N (150 kg ha^{-1}) combined with 70 kg P_2O_5 ha^{-1}. Days to bolting was decreased by about 7 days

Table 1. The interaction effect of N and P fertilizers on days to bolting, days to flowering, plant height and flower stalk diameter grown at Kulumsa in 2017/2018.

N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	Days to bolting	Days to 50% flowering	Plant height (cm)	Flower stalk diameter (cm)
0	0	52.33^{de}	88.00^{f}	80.17^{g}	1.75^{d}
	35	52.00^{e}	88.67^{f}	81.93^{g}	2.13^{cd}
	70	50.00^{f}	85.00^{gh}	84.57^{fg}	2.09^{cd}
	105	50.00^{f}	86.60^{h}	85.73^{fg}	2.11^{cd}
50	0	51.67^{ef}	90.67^{ef}	93.73^{cde}	2.16^{cd}
	35	53.33^{bcde}	91.67^{de}	94.73^{cde}	2.23^{cd}
	70	51.67^{ef}	91.00^{e}	94.97^{bcde}	2.09^{cd}
	105	52.33^{de}	90.33^{ef}	90.83^{ef}	2.17^{cd}
100	0	54.00^{bcd}	93.33^{bcd}	95.50^{bcde}	2.33^{bc}
	35	53.00^{e}	92.33^{cde}	92.60^{de}	2.41^{bc}
	70	52.00^{cde}	91.67^{de}	101.73^{a}	2.87^{a}
	105	54.00^{bcd}	93.67^{bcd}	99.73^{abc}	2.42^{bc}
150	0	56.67^{a}	96.67^{a}	95.50^{bcde}	2.27^{bc}
	35	55.00^{ab}	94.67^{ab}	95.26^{bcde}	2.36^{bc}
	70	52.67^{de}	94.67^{ab}	95.33^{cde}	2.51^{bc}
	105	54.67^{bc}	94.33^{bc}	97.13^{abc}	2.77^{ab}
LSD(0.05)		1.84	2.15	6.16	0.49
CV (%)		1.98	1.35	3.99	12.16

$LSD_{0.05}$ = least significant difference at 5%, CV (%) = Coefficient of variation. Means in the same column followed by the same letter(s) are not significantly different.

in response to the fertilization of 0 kg N ha^{-1} along with 70 and 105 kg P_2O_5 ha^{-1} as compared to the highest N rate of (150 kg ha^{-1}) with the lowest P rate of 0 and 35 kg P_2O_5 ha^{-1} treatment combinations. Generally, the combination of higher rate of N with the lower rates of P fertilizers delayed days to bolting, but the lower rates of N with the higher rates of P shortened bolting time (Table 1). This might be due to the effect of increased N fertilization as it prolongs the period of vegetative growth. The combination of the higher rates P with the lower rates of N resulted in significant earliness of bolting may be due to the role of phosphorus in the life cycle of the plant in enhancing many aspects of plant physiology, including the fundamental processes of photosynthesis, reproduction, flowering and fruiting (including seed production) and maturation (Brady and Weil, 2002). This was also observed by Ali et al. (2007) and Sorensen and Grevsen (2010) as too much nitrogen promoted excessive vegetative growth and delayed bolting and maturity of onion. The present study was in line with the findings of Tamirat (2006) who reported that the lower nitrogen and higher phosphorus fertilizers application resulted in early bolting of Bombe Red within 41- 47 days. Getachew (2014) reported that days to bolting of similar onion variety was between 63-67 days. On the other hand, Shemelis (2000) in his study of flower and seed production potential of onions at Melkasa, found that Adama Red was bolted in average within 24.7 days. However, in the present study, the earliest bolting was after 50 days and the last was up to 56.67 days in average. The differences in the number of days required for bolting could be due to the relatively cool climatic condition of the experimental site compared with Melkassa and the cultivars difference.

Days to flowering

The shortest days to flowering was recorded from the combination of N at rate of 0 kg ha^{-1} with of P at rates of 70 and 105 kg P_2O_5 ha^{-1}. The days to flowering was moderately increased when the levels of N increased to 50-100 kg ha^{-1} with similar rates of P_2O_5 (70 and 105 kg P_2O_5 ha^{-1}). Days to flowering was delayed most when the highest rate of N (150 kg ha^{-1}) was applied with all levels of P_2O_5 (Table 1). Days to 50% flowering decreased by about 12 days when 70 kg P_2O_5 ha^{-1} was applied without N fertilizer as compared to the highest N level (150 kg ha^{-1}) applied without P_2O_5. The combination of higher N levels with lower rates of P delayed days to flowering of onion. Due to the fact that Nitrogen may probably lead the crop to delayed flowering by its role in physiological

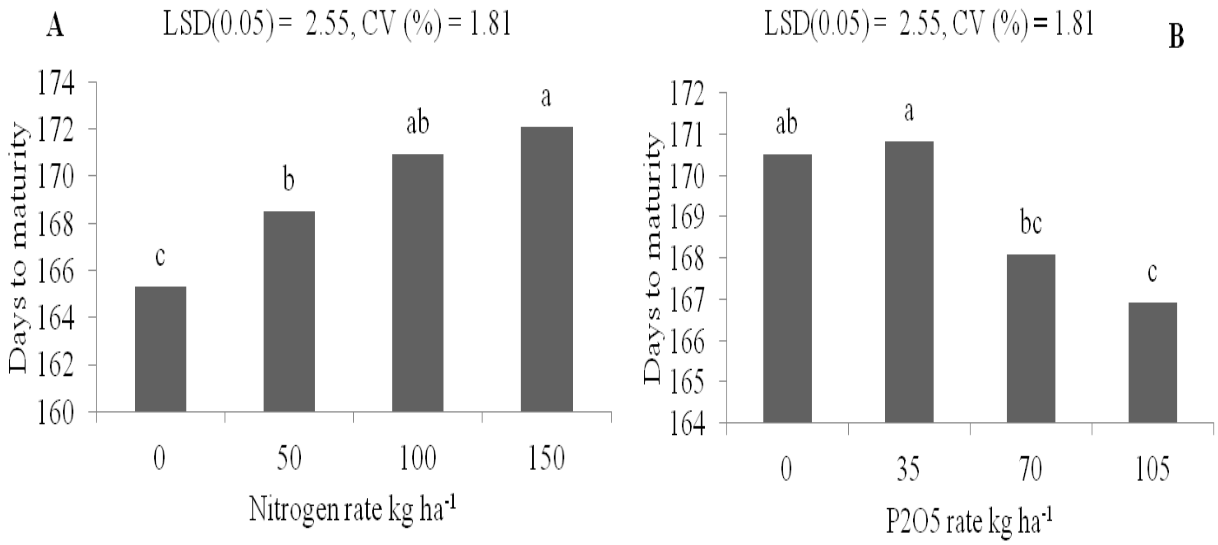

Figure 1. Effect of nitrogen (A) and phosphorus (B) fertilizers on days to maturity of onion seed at kulumsa in Arsi Zone, South East Ethiopia in 2017/2018.

and metabolic function in the plant cells. The nutrients absorbed from the soil could have diverted and sink into vegetative parts for photosynthesis and resulted in plants will end up with a luxurious foliage growth. The duration of flowering was expected to be affected by the growing condition. Nitrogen also has physiological functions in plant which increase the plumpness and succulence of crops thereby encourages the vegetative growth rather than reproductive structure development (Staurt and Griffin, 1946). The current study revealed that P fertilizer alone promoted early flowering while addition of N delayed flowering of onion. Further increase in N resulted in a progressive increase in days to flowering.

The current result is supported by Marschner (1995) who reported similar result. Similar results were also reported by Tamrat (2006) in that, increased days to flowering was obtained due to increased N fertilizer from 0 to 138 kg ha^{-1} on Adama Red onion variety. Ali et al. (2007) and Kiros et al. (2018) reported that nitrogen and phosphorous fertilizers have enhanced days to flowering.

Days to maturity

All levels of N fertilizer delayed maturity of onion as compared to the control treatment (no N fertilizer). Days to maturity was delayed most at the highest rate of N fertilizer (150 kg ha^{-1}) but this was not significantly different from 100 kg N ha^{-1} (Figure 1A). Days to maturity increased by about 6 and 7 days in response to the fertilization of 100 and 150 kg N ha^{-1}, respectively as compared to the control treatment. The delay in maturity in response to N fertilizer application could be due to the fact that N fertilization increases the vegetative growth of plants and an essential nutrient for plant development and reproduction (Marschner, 1995). Nitrogen is a significant component of nucleic acids such as DNA, the genetic material that allows cells (and eventually whole plants) to grow and reproduce. This is in agreement with the findings of Brewster (1994) and Sørensen and Grevsen (2001) who reported that too much N can result in excessive vegetative growth and delayed maturity. This result is consistent with the findings of Meena et al. (2007), Abdissa et al. (2011), Morsy et al. (2012) and Guesh (2015) who reported that maturity of onion plants was delayed in response to increasing nitrogen application. According to Kiros et al. (2018) seed maturity was significantly delayed when grown at 100% of 69 kg N and 92 kg P_2O_5 ha^{-1} fertilizer (133.3 days), a delay of 4 to 6 days compared to lower NP rates and the control treatments.

The number of days taken for maturity of onion seed was significantly reduced when 105 kg P_2O_5 ha^{-1} was applied as compared to the control treatment (Figure 1B). However, this treatment was not significantly different from the other treatment which received 70 kg P_2O_5 ha^{-1}. The maturity of onion seed was delayed at the control treatment (no P fertilizer) and P at a rate of 35 kg P_2O_5 ha^{-1}. Application of P at rate of 105 kg P_2O_5 ha^{-1} reduced days to maturity by 4 days as compared to control treatment. The early maturity effect of phosphorus application may be related to the phosphorus effect that initiated early flowering. So, it is known that, adequate P application leads to a general increment of most metabolic processes including cell division, cell expansion, respiration and photosynthesis. And by shortening the vegetative growth of a crop it could play an important role to hasten physiological activities

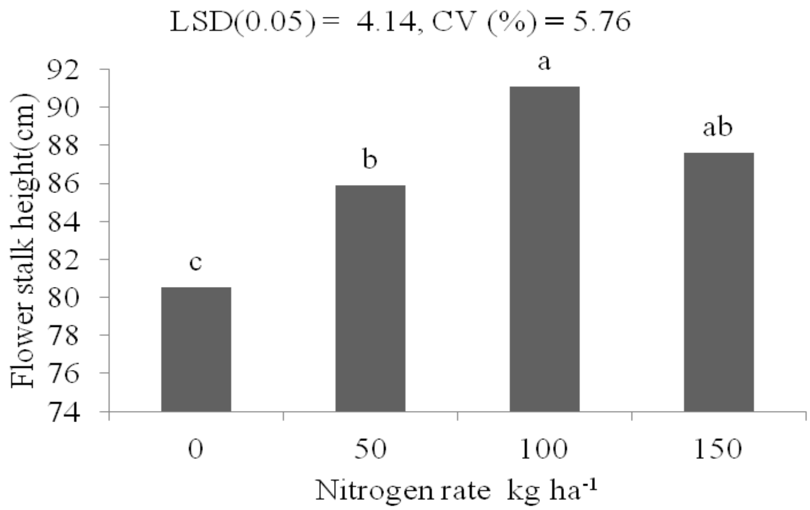

Figure 2. Main effect of nitrogen (N) fertilizer influenced on flower stalk height of onion grown at kulumsa in Arsi Zone, South East Ethiopia in 2017/2018.

(Hinsinger, 2001). In conformity with the present result, application of P has been reported to hasten maturity of onion crops (Tamrat, 2006). However, contradicting reports are also available which indicate non significant effect of P fertilizer on the maturity of onion (Getachew, 2014). This contradicting result could be due to soil variability, planting season, moisture levels, and variety response to fertilizers, light energy, biotic factors or other environmental factors affecting the influence of P fertilizer.

Plant height

The tallest plant was found in the combination of N and P fertilizers at a rate of 100 N and 70 kg P_2O_5 ha^{-1} which was statistically similar with the combination of the same N (100 kg N ha^{-1}) with 105 kg P_2O_5 ha^{-1}. The shortest plant height was observed in non fertilized plots of both nutrients (N and P). The combinations of N and P at 100 N and 70 kg P_2O_5 ha^{-1} respectively, brought about 21.14% increments in plant height over the control treatment of no fertilizers. In general, P fertilizer without N had no significant effect on the plant height of onion. As the rate of N increased, the height of the onion plant also increased regardless of P_2O_5. Our result clearly showed that N critically determined the height of the onion plant and particularly 100 kg N ha^{-1} combined with 70 kg P_2O_5 ha^{-1} favored plant height (Table 1). The increased plant height at the highest level of nitrogen was probably due to the availability of more nutrients, which helped, in maximum vegetative growth of onion plant. N contributed to the higher rates of vegetative growth and stem elongation. Increase in N supply leads to 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).

According to Gupta and Sharma (2000), Ali et al. (2007), Nasreen et al.(2007), Getachew (2014) and Birhanu (2016), increased in nitrogen fertilization increased the height of the plant up to certain stage at which the growth ceases or become decreased due to the toxicity of the fertilizer. Debashis et al. (2017) observed that application of nitrogen at rate of 175 kg ha^{-1} resulted in significantly higher plant height (55.23 cm) of onion plant.

Flower stalk height and diameter

The highest flower stalk height was recorded for N application at a rate of 100 kg ha^{-1} and this was statistically similar with 150 kg N ha^{-1}. The lowest flower stalk height was obtained from the control treatments. Application of N at 100 kg ha^{-1} brought by about 11.58% increments in flower stalk height as compared to the control (Figure 2). This increment of height by applied N in part could be due to major factor of N contributing to the higher rates of vegetative growth and stem elongation when nitrogen fertilizers are applied to the plants (Marschner, 1995; Gupta and Sharma, 2000). But P fertilization did not affect flower stalk heights. The result was in accordance with Tamrat (2006) and Debashis et al. (2017) who found stalk heights for other cultivar of onion in the range of 76-93 cm which was similar to height recorded in the present study. According to Abas et al. (2015) nitrogen fertilization significantly increased the length of flowering stalk. From all treatment combinations the highest flower stalk diameter was obtained when N and P was applied at the rate of 100 kg

Table 2. The interaction effect of N and P fertilizers influenced on number of flower stalk per plant, umbel diameter and number of umbels per plant grown at Kulumsa, South East Ethiopia in 2017/2018.

N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	Flower stalk (palnt^{-1})	Umbel diameter (cm)	Number of umbels (plant^{-1})
0	0	5.70^{h}	4.32^{f}	6.07^{i}
	35	7.53^{gh}	4.64^{ef}	7.30^{hi}
	70	10.57^{cdef}	5.11^{cde}	7.4^{hi}
	105	10.78^{cdef}	5.14^{cde}	8.30^{efgh}
50	0	8.33^{fg}	5.24^{cde}	8.03^{gh}
	35	8.95^{efg}	4.93^{def}	8.16^{fgh}
	70	9.98^{efg}	5.68^{bc}	9.33^{defg}
	105	10.00^{cdef}	5.53^{cd}	9.73^{cdef}
100	0	11.23^{bcde}	4.97^{cd}	9.83^{bcde}
	35	11.53^{abcd}	5.49^{def}	10.17^{bcd}
	70	12.80^{abc}	6.29^{ab}	14.60^{a}
	105	12.04^{abc}	5.41^{cd}	14.23^{a}
150	0	10.62^{cdef}	5.29^{cde}	11.30^{bc}
	35	10.63^{cdef}	5.33^{cde}	11.43^{b}
	70	13.50^{ab}	6.52^{a}	14.33^{a}
	105	13.86^{a}	6.26^{ab}	14.00^{a}
LSD (0.05)		2.45	0.69	1.63
CV (%)		14.28	7.03	9.22

$LSD_{0.05}$ = least significant difference at 5%, CV (%) = Coefficient of variation. Means in the same column followed by the same letter(s) are not significantly different.

N with 70 kg P_2O_5 ha^{-1} which was statistically similar with the combined effect of 150 kg N and 105 kg P_2O_5 ha^{-1}. Whereas, the lowest was recorded from control treatment no fertilizers. The combination of 100 kg N with 70 kg P_2O_5 ha^{-1} brought by about 39% increments in flower stalk diameters as compared with the control (Table 1).

The present result was in accordance with Kiros et al. (2018) who reported flower stalk diameter was highest (1.503 cm) when grown at 75% of 69 kg N and 92 kg P_2O_5 ha^{-1} fertilizer. Plants in the control treatment recorded the least (1.233 cm). Jones (1990) found that significant flower stalk diameter difference was obtained from N and P fertilizer received plants. Getachew (2014) reported that highest flower stalk diameter (1.56 cm) was recorded from NP fertilizers 115 P_2O_5 and 114 kg N ha^{-1} and the lowest (1.334 cm) was from control. Similarly Tamrat (2006) reported that flower stalk diameter was high at the rate of 138 kg N ha^{-1} followed by 92 kg N ha^{-1}. However, phosphorous fertilization did not show significant difference in flower stalk diameter.

Yield and yield components

Number of flower stalks per plant and flowers per umbels

Numerically the highest number of flower stalk per plant was obtained from the combination of N at a rate of 150 kg ha^{-1} with P at 105 kg P_2O_5 ha^{-1}. This combination was statistically similar when 100 kg N ha^{-1} combined with all none zero P_2O_5 rates as well as when 150 kg N ha^{-1} combined with 70 kg P_2O_5 ha^{-1} (Table 2). The lowest number of flower stalk per plant was recorded from the control treatments. Application of 150 kg N ha^{-1} with 105 kg P_2O_5 ha^{-1} brought about 58.87% increments in number of flower stalk per plant over control treatments. From the results, application of both N and P increased number of flower stalks per plant than N and P alone. Generally, as the combination of both N and P_2O_5 rates increased the number of flower stalk per plant also increased (Table 2). The present result is in line with that of Rashid and Singh (2000), Tamrat (2006) and Debashis et al. (2017) who reported that increase in nitrogen fertilization increases number of umbels and flower stalks per plant. However, our result contradicted with the report of Ahmed and Abdalla (2006) and Getachew (2014) who reported that nitrogen and phosphorus separately or in combination proved to have no effect on the number of branches or flower stalks produced per plant. This may be due to environmental factors, soil variability, planting season, varietal difference and past use of the land.

Numerically the highest number of flowers per umbel was obtained when N was applied at the rate of 100 kg ha^{-1} which was statistically similar with N at rate of 150 kg ha^{-1}. The lowest number of flowers per umbel was

Table 3. Main effect of nitrogen and phosphorus fertilizers affected on number of flowers per umbel and number of seeds per umbel onion seed grown at Kulumsa, South East Ethiopia in 2017/2018.

Treatment N (kg ha^{-1})	Number of flowers per umbel	Number of seed per umbel
0	302.23^{b}	722.71^{c}
50	357.27^{b}	821.78^{b}
100	459.06^{a}	945.16^{a}
150	426.73^{a}	977.8^{a}
LSD(0.05)	59.37	83.95
P_2O_5 (kg ha^{-1})		
0	320.58^{c}	642.67^{c}
35	380.16^{b}	849.94^{b}
70	403.52^{ab}	952.0^{a}
105	441.03^{a}	1022.84^{a}
LSD(0.05)	59.37	83.95
CV (%)	18.43	11.61

LSD $_{0.05}$ = least significant difference at 5%, CV (%) = Coefficient of variation. Means in the same column followed by the same letter(s) are not significantly different.

recorded in the control treatments (Table 3). Other report on onion indicated that application of N has been found to increase the number of umbels per plant and number of florets per umbel (Ahmed and Abdalla, 1984). The highest number of flowers (198.31) was obtained from 150 kg N ha^{-1} and the lowest (138.79) from control (Ali et al., 2007). According to Abas et al. (2015) nitrogen fertilization significantly increased number of flowers per umbel.

Similarly the number of flowers per umbel was affected by P fertilizer. The highest number of flowers per umbel was obtained when P was applied at the rate of 105 kg P_2O_5 ha^{-1} which was statistically similar with 70 kg P_2O_5 ha^{-1}. The lowest number of flowers per umbel was recorded from the control treatments. From the result the number of flowers per umbel increased at higher rates of both N and P fertilizers (Table 3). This result is in concordant with the findings of Muhammad et al. (1999) who reported that the highest (618.0) number of flowers per umbel was recorded by the application of N at rate of 75 kg ha^{-1} and P at rate of 46 kg P_2O_5 ha^{-1} and the lowest (523.80) was recorded from control treatments. The number of flower stalks per plant varied from1 to 15 per plant at Melkassa and the terminal number of 50-200 flowers produced per umbel on “Adama Red” depending on the number of shoots axis (Lemma, 1998). In onion there were commonly 200 to 600 flowers per umbel (Brewester, 1994).

Umbel diameter

Numerically the largest umbel diameter was recorded from N at a rate of 150 kg ha^{-1} with P at 70 kg P_2O_5 ha^{-1} which was statistically similar with the combination of 100 kg N ha^{-1} with the same rate of P_2O_5 as well as when 150 kg N ha^{-1} combined with 105 kg P_2O_5 ha^{-1}. The combinations of both fertilizers (N and P) at the higher rates in the current study resulted in larger umbel diameters. The lowest umbel diameter was recorded from control treatments (Table 2). Application of 150 kg N with 70 kg P_2O_5 ha^{-1} brought about 33.74% increments in umbel diameter over control treatments. The significant increasing of umbel diameter recorded in the study might be due to P nutrient which might encourage and stimulated flower setting and produce wider umbel size which has more number of flowers, then seed formation and related reproductive activities (Brady and Weil, 2002). These results were in accordance with the work done by Getachew (2014) regarding the NP fertilizers rates, the largest umbel diameter (6.267 cm) was obtained with the NP application rates of 115 kg P_2O_5 and 114 kg N ha^{-1}. The highest umbel diameter (5.69 cm) was obtained from treatments that received NP fertilizer at the rate of 75% of 69 kg N and 92 kg P_2O_5 ha^{-1}, which was significantly higher over the control (5.04 cm) (Kiros et al., 2018).

Number of umbels per plant

Numerically the treatment combinations of N and P at the rate of 100 kg N ha^{-1} with 70 kg P_2O_5 ha^{-1} revealed the highest number of umbel per plant. The combinations of higher rates of N (100 and 150 kg ha^{-1}) with P (70 and 105 kg P_2O_5 ha^{-1}) resulted in increased number of umbels per plant (Table 2). The lowest number of umbel per plant was recorded from control treatments. Application of 100 kg N ha^{-1} with 70 kg P_2O_5 ha^{-1} brought about 58.42% increments in number of umbel per plant over control treatments. Number of umbel was the most important trait for onion seed yield (Prats et al., 1996). The number of flowers stalks produced by a single plant usually varies, depending on the number of branches formed on the shoot axis during vegetative growth (Kadams and Amans, 1991).

Similar observations were made by Rashid and Singh (2000), Tamrat (2006) and Debashis et al. (2017) who reported that increase in nitrogen fertilization increases number of umbels per plant. Also the result of the present study supports the finding of Mohamed and Nourai (1988) and Nwadukwe and Chude (1995) who observed the main and interaction effects of applied N and P increased the number of umbels per plant at the rate of 50-100 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1}.

Number and weight of seeds per umbel

Numerically the highest number of seeds per umbel was recorded for plants which received N at a rate of 150 kg ha^{-1} which was statistically similar with 100 kg N ha^{-1}. The lowest number of seeds per umbel was recorded from control treatments (Table 3). Application of N at 150 kg ha^{-1} brought about 26.88% increments in number of seed per umbel over control treatments. Nitrogen has a great role that reduced the abortion of flowers on umbel, which might be the reason for its effect on increasing seeds number per umbel (Marschner, 1995).

Similarly the effect of applied P significantly increased the number of seeds per umbel. Numerically the highest number of seeds per umbel was recorded for plants which received P at a rate of 105 kg P_2O_5 ha^{-1} which was statistically similar with 70 kg P_2O_5 ha^{-1}. The lowest number of seeds per umbel was recorded from control treatments (Table 3). Application of P at rate of 105 kg P_2O_5 ha^{-1} brought about 37.17% increments in number of seed per umbel over control treatments. Generally, increasing application rates of N and P fertilizers increased the number of seed per umbel. This might be due to phosphorous has great effect of on flower and seed production. This could possibly be due to the fact that these two important plant nutrients might have complementary effect on retention of seed set per umbel. Moreover, they are the major constituents of physiologically active organic compounds in the plant system, leading to a combined increase in seeds number per umbel (Marschner, 1995).

This result was in line with Hossain et al. (2017) who reported the maximum number of seeds per umbel (555.20), which was found from 114 kg N and 42 kg P ha^{-1} and the minimum (494.00) was from 57 kg N and 21 kg P ha^{-1} treatments. According to Kiros et al. (2018), the highest numbers of seeds per umbel were recorded in plots which received 50, 75 and 100% of 69 kg N and 92 kg P_2O_5 ha^{-1} fertilizer rates (825.3, 897 and 860 respectively) compared with unfertilized (675) plots and lower rates (714.2). According to Debashis et al. (2017) nitrogen at 175 kg ha^{-1} recorded significantly highest (744.34) number of seeds per umbel.

Numerically the highest weight of seeds per umbel was recorded from the combination of N at the rate of 150 kg ha^{-1} with 105 kg P_2O_5 ha^{-1}. This combination was statistically similar when 100 kg N ha^{-1} combined with each of 70 and 105 kg P_2O_5 ha^{-1} rates as well as when 150 kg N ha^{-1} combined with 35 kg P_2O_5 ha^{-1} (Table 4). The lowest weight of seeds per umbel was recorded for the combinations involving no N and P application levels. The application of 150 kg N with 105 kg P_2O_5 ha^{-1} brought about 62.09% increments in weight of seeds per umbel over the control. High seed weight per umbel under high N and P fertilizers might be due to the role of nitrogen in the buildup of carbohydrate and different metabolites and the role of phosphorous on seed formation and development. The result was in agreement with Getachew (2014) and Ali et al. (2008) who reported that seed weight per umbel was significantly increased by NP fertilizer 115 kg N ha^{-1} and 114 kg P_2O_5 ha^{-1} and 150 kg N and 80 kg P_2O_5 ha^{-1} applications, respectively. Debashis et al. (2017) and Tamrat (2006) also reported the highest weight of seeds per umbel was obtained when N was applied at a rate of 175 and 92 kg ha^{-1} followed by 125 and 138 kg ha^{-1} respectively.

Seed yield per plant and per hectare

The combinations of higher rates of both N (100 and 150 kg ha^{-1}) and P (70 and 105 kg P_2O_5 ha^{-1}) resulted in better seed yield per umbel, seed yield per plant and seed yield per hectare. Phosphorus fertilizer increased seed yield even without N fertilizer as compared to the control treatments of no fertilizers at all. The lowest mean seed yield was recorded from control treatments (Table 4). The combinations of 100 kg N with 105 kg P_2O_5 ha^{-1} brought about 40.34% increments in seed yield per plant over the control. The combination of (100 kg N with 70 kg P_2O_5) ha^{-1} brought about 57.72% increments in seed yield per hectare over the control. In general, the seed yield showed an increasing trend with the combinations of higher N rates with higher P_2O_5.

The seed yield result of the present study is in analogous with the findings of Hossain et al. (2017) in that, the maximum seed yield per plant (4.21 g) was recorded from 114 kg N and 42 kg P ha^{-1} and 57 kg N and 21 kg P ha^{-1} produced the minimum seed yield per plant (3.20 g). Debashis et al. (2017) indicated that, Nitrogen at 175 kg ha^{-1} recorded significantly highest seed yield per plant. Tamrat (2006) also reported that seed yield per plant showed an increasing trend with the combinations of N up to 92 kg ha^{-1} and P_2O_5 up to 46 kg ha^{-1} and Nwadukwe and Chude (1995) have reported that N rate at 50 or 100 kg ha^{-1} with P at 50 kg ha^{-1} increased seed yield from 184 kg ha^{-1} to 226 kg ha^{-1} compared to the control treatment.

In the present study higher seed yield was recorded as

Table 4. The interaction effect of N and P fertilizers on seed yield per umbel, seed yield plant and seed yield per hectare grown at Kulumsa, South East Ethiopia in 2017/2018.

N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	Seed yield umbel^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield ha^{-1} (kg)
0	0	1.52^{h}	6.73^{g}	785.33^{f}
	35	2.11^{gh}	7.91^{ef}	1093.55^{e}
	70	2.58^{fg}	8.63^{de}	1454.11^{cd}
	105	2.67^{efg}	7.81^{efg}	1175.83^{e}
50	0	1.59^{h}	6.8^{fg}	1053.33^{e}
	35	2.89^{def}	7.54^{efg}	1196.57^{e}
	70	2.93^{cdef}	9.53^{cd}	1412.98^{cd}
	105	3.25^{bcde}	10.17^{abc}	1660.68^{b}
100	0	2.54^{fg}	7.84^{efg}	1126.73^{e}
	35	2.91^{cdef}	8.69^{de}	1394.38^{d}
	70	3.67^{ab}	10.82^{ab}	1858.82^{a}
	105	3.56^{abc}	11.28^{a}	1740.65^{ab}
150	0	2.19^{gh}	7.78^{efg}	1162.69^{e}
	35	3.39^{abcd}	9.71^{cde}	1591.40^{bc}
	70	3.03^{bcdef}	10.21^{abc}	1700.45^{ab}
	105	4.05^{a}	10.02^{bc}	1671.68^{ab}
LSD(0.05)		0.67	1.17	188.69
CV (%)		13.59	7.97	8.22

$LSD_{0.05}$ = least significant difference at 5%, CV (%) = Coefficient of variation. Means in the same columns with the same letter(s) are not significantly different.

compared to other reports in Ethiopia may be because of the reason that at kulumsa is conducive for onion seed production (cool climate) and the rainfall was uniform during bolting and flowering stage. The current result was in accordance with the findings of Hossain et al. (2017) in that, the maximum seed yield per hectare (957.6 kg) was found from 114 kg N and 42 kg P ha^{-1} and the minimum (776.6 kg) was obtained from 57 kg N and 21 kg P ha^{-1}. Getachew (2014) reported the highest seed yields per plot and per hectare were obtained from plants that received 115kg P_2O_5 and 114 kg N ha^{-1}. According to Debashis et al. (2017) nitrogen at 175 kg ha^{-1} recorded significantly highest seed yield per hectare. Ali et al. (2008) obtained phosphorous fertilization increased seed yield per umbel, per plot and per hectare. The application of nitrogen at 92 Kg N ha^{-1} in split doses and phosphorus at 46 kg P_2O_5 ha^{-1} appeared to be a promising combination with seed yield increment of about 42% over unfertilized seed onion crop (Lemma and Shimeles, 2003; Dawit et al., 2004; Tamrat, 2006; Abdissa et al., 2011).

Seed quality parameters

Thousand seeds weight: The highest 1000 seeds weight was obtained from plants which received P fertilizer of 70 kg P_2O_5 ha^{-1}. Plants which did not receive fertilizer produced the lowest 1000 seeds weight which in fact, was not significantly different from 1000 seeds weight at 105 kg P_2O_5 ha^{-1} (Figure 3). Application of 70 kg P_2O_5 ha^{-1} brought by about 9.73% increments in 1000 seed weight over the control treatments. Phosphorus in plants, improved flower formation and seed production, more uniform and earlier crop maturity, increased N-fixing capacity, improvements in crop quality, increased resistance to plant diseases, supports development throughout entire life cycle and it is actively involved as building block of the seed materials there by increased the weight of the seed of the onion crop (Brady and Weil, 2002). In agreement with the present study Ozer (2003), Ozden (2009) and Getachew (2014) reported that higher rates of fertilizers application produced heavy weight seeds. On the other hand, the current study results were in contrast to Tamrat (2006) and Ali et al. (2007, 2008) who reported that phosphorous fertilizers did not have significant effect on 1000 seed weight. The maximum weight (3.42 g) was gained from 114 kg N and 42 kg P ha^{-1} treatments and the minimum (3.18 g) was from 57 kg N and 21 kg P ha^{-1} treatments (Hossain et al., 2017).

Percentage of seed germination

Numerically the highest seed germination 30 days after harvest was recorded from the rate of N application at

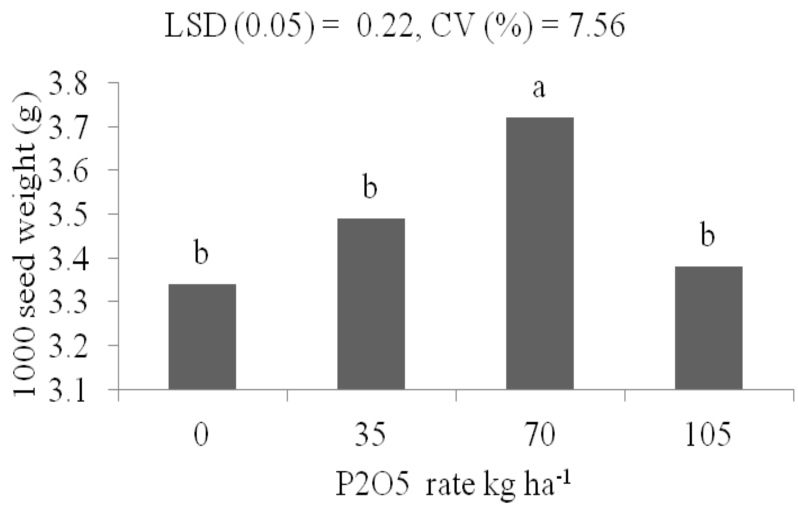

Figure 3. The main effect of phosphorus (P) fertilizer affected 1000 seed weight of onion at kulumsa in Arsi Zone, South East Ethiopia in 2017/2018.

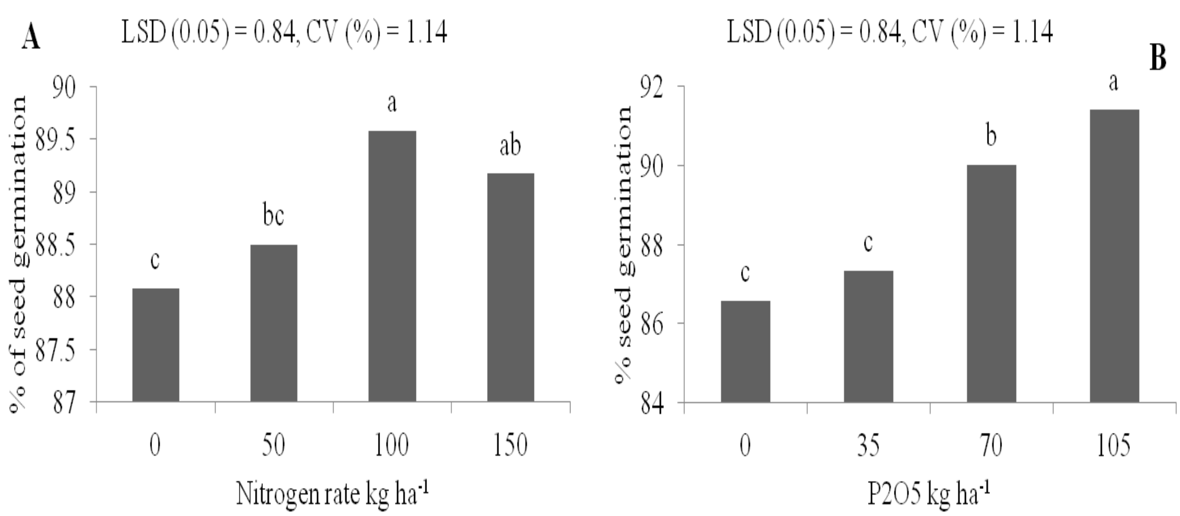

Figure 4. Percent of onion seed germination affected by the main effect of nitrogen (A) and phosphorus (B) fertilizers on onion plant at kulumsa in Arsi Zone, South East Ethiopia in 2017/2018.

100 kg ha^{-1} which was statistically similar with 150 kg N ha^{-1}. The lowest seed germination was recorded from non fertilized plots (Figure 4A). Similarly the application of P fertilizer significantly ($P<0.01$) increased the germination 30 days after harvest. Numerically the highest germination percentage was obtained from the application of P at a rate of 105 kg P_2O_5 ha^{-1} followed by 70 kg P_2O_5 ha^{-1}. The lowest seed germination was recorded from non fertilized plots. Generally, as the rate of P increased percent of seed germination 30 days after harvest was increased (Figure 4B). In agreement with the present study Debashis et al. (2017) reported that the highest germination percentage of harvested seed was observed in treatment received 175 kg N ha^{-1}. Tamrat (2006) and Ali et al. (2007) also reported that phosphorous and nitrogen fertilization had significant effect on seed germination percentage in which mostly higher germination percentage was recorded from high fertilizer application. Application of 143.6 kg P_2O_5 and 142.5 kg N ha^{-1} fertilizers gave highest germination percentage of onion seeds (Getachew, 2014).

Correlation analysis of agronomic and yield components

Days to bolting was highly significantly correlated with days to flowering (r = 0.75**) and days to maturity (r =

Table 5. Pearson Correlation among agronomic and yield components of onion in 2017/2018.

	DB	DF	Ph	MD	FSH	NFU	NFSP	FSD	UD	NUP	NSU	SYU	TSW	WSPL	Syha
DB		0.75**	0.43**	0.56**	0.27	0.29*	0.31*	0.18	0.19	0.45**	-0.12	0.01	-0.19	-0.03	-0.07
DF			0.67**	0.70**	0.48**	0.43**	0.49**	0.37**	0.41**	0.65**	-0.27	-0.17	-0.22	-0.19	-0.26
Ph				0.38**	0.82**	0.49**	0.38**	0.49**	0.56**	0.58**	-0.15	-0.13	-0.24	-0.16	-0.22
MD					0.15	0.233	0.29*	0.05	0.2	0.31*	-0.17	-0.14	-0.08	-0.15	-0.17
FSH						0.45**	0.38**	0.5**	0.45**	0.48**	-0.17	-0.19	-0.15	-0.2	-0.29
NFU							0.35*	0.41**	0.42**	0.74**	0.24**	0.19**	-0.13	0.23**	0.33**
NFSP								0.45**	0.59**	0.56**	0.79	0.75	0.5	0.43*	0.56**
FSD									0.54**	0.56**	0.86*	0.68*	0.79*	0.69*	0.78*
UD										0.58**	0.5*	0.32	0.15*	0.43*	0.77**
NUP											0.25	0.21	-0.64	0.56**	0.62**
NSU												0.92**	0.26	0.70**	0.77**
SYU													0.22	0.74**	0.77**
TSW														0.31*	0.39**
WSPL															0.94**
Syha															1

* & ** Significant at 5% and 1% probability levels, respectively. The decimal numbers without any asterics are non significant (P>0.05), DB-days to bolting, DF=days to flowering, DM=days to maturity, FSH=flower stalk height, FSD=flower stalk diameter, UD=umbel diameter, NUP=number of umbel per plant, NSU=number of seed per umbel, WSU =weight of seed per umbel, TSW=1000 seed weight, SYP-seed yield per plant, SY ha=seed yield per hectare.

Thus, the result implied that increase in days to bolting result in increasing days to flowering and onion seed maturity. Umbel diameter was positively and significantly correlated with number of seed per umbel (r = 0.50**), seed yield per plant (r = 0.43**) and seed yield per hectare (r = 0.56**). This result similarly implied that the increment of umbel size causes for the increment of number of seed per umbel and seed yield per plant and per hectare. This result is in accordance with the findings of Prats et al. (1996), Sidhu et al. (1996) and Tamrat (2006). Positive and statistically highly significant correlation was also obtained between number of seeds per umbel and weight of seeds per umbel (r = 0.92**). Similarly seed yield per plant was directly and highly significantly related with number of umbels per plant (r = 0.56**), number of seeds per umbel (r = 0.70**), weight of seeds per umbel (r = 0.74**) and umbel diameter (r = 0.43**) (Table 5). Seed yield per hectare was positively and statistically highly significant correlated with all yield and yield components, but negatively and not significantly correlated with phenology and growth parameters.

Conclusion

In conclusions, N application resulted in pronounced effect on vegetative characters of onion than the phosphorus effect in the combined application. As nitrogen rates increased, onion seed maturity delayed. The moderate amount of the experimental soil may compromise the applied P fertilizer on the vegetative characters owing to its little inherent contributions for vegetative growth. The seed yield increased with the increasing combinations or rate of nitrogen and phosphorus fertilizers. The seed yield obtained by the interaction effect of the two nutrients is greater than their individual effect. Therefore, a combined application of N at 100 kg N ha^{-1} and P at 70 kg P_2O_5 ha^{-1} rates can be recommend for onion seed producers in the study area and areas of similar agro-ecology.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Abayneh E, Demeke T, Gebeyehu B, Kebede A (2003). Soil of Kulumsa Agricultural Research Center. National Soil Research Center (NSRC), Soil survey and land evaluation, Technical Paper No.76.

Abas A, Sahar IE, Alia M, Osman E, Mohamed A, Nourai H (2015). Effect of nitrogen fertilization and bulb spacing on saggai red onion seed production in Berber area, River Nile State, Sudan Sudanese. The Journal of Agricultural Science 2:35-43.

Abdissa Y, Tekalign T, Pant LM (2011). Growth, bulb yield and quality of onion (*Allium cepa* L.) as influenced by nitrogen and phosphorus fertilization on vertisol. Growth attributes biomass production and bulb yield. African Journal of Agricultural Research 6(14):3252-3258.

Ahmed IH, Abdella AA (2006). Nitrogen and phosphorus fertilization in relation to seed production in onion *Allium cepa* L. ISHS. African Symposium on Horticultural Crops. Acta Horticulturae 143:8.

Ahmed IH, Abdulla AA (1984). Nitrogen and phosphorous fertilization in relation to seed production in onion (*Allium cepa* L.). Acta Horticulturae 48:119-125.

Ali MK, Alam MF, Alam MN, Islam MS, Khandaker SMAT (2007). Effect of nitrogen and potassium level on yield and quality seed production of onion. Journal of Applied Science and Research 3(12):1889-1899.

Ali MK, Alam MN, Islam MS, Islam MK, Baree MA (2008). Effect of Cow dung at Different Level of Phosphorus on Growth, Yield and Quality Seed Production of Onion. Journal of Agricultural and Biological Science 4(1):86-93.

Aminpour R, Mortzavi Bak A (2004). Effect of planting date and intra-row spacing on seed yield and germination of onion (*Allium cepa* L. cv.Texas Early Grano 502. Pajouhesh and Sazandegi 62:64-69.

Asfaw Z, Eshetu D (2015). Production and management of major vegetable crops in Ethiopia. Ethiopian Institute of Agricultural Research. Addis Abeba, Ethiopia pp. 32-51.

Ashenafi W, Helen T, Tibebu S (2014). Influence of bulb treatment and spacing patterns on yield and quality of onion (Allium cepa var. Cepa) seed at Humbo Larena, Southern Ethiopia. Journal of Biology, Agriculture and Healthcare 4(13):111-119.

Birhanu M (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 Technology 1(3):555563.

Brady NC, Weil RR (2002). The nature and properties of soils. Thirteenth edition. Pearson Education Asia. Delhi, India P 960.

Brewster JL (1994). Onions and other vegetable Alliums. CAB International, Wallingford, UK. P. 236.

Bungard RA, Wingler A, Morton JD, Andrews M (1999). Ammonium can stimulate nitrate and nitrite reductase in the absence of nitrate in Clematis vitalba. Plant, Cell and Environment 22(7):859-866.

Chadha ML, Altoveros EC, Womdim RN, Mndiga H (1997). Variety evaluation and seed production of vegetable crops. AVRDC Africa Regional Program, Arusha, and Tanzania 65(5):56-110.

Central Statistical Agency (CSA) (2017). Agriculture Sample Survey. Central Statistical Agency. Addis Ababa P 118.

Currah L, Proctor FJ (1990). Onion in tropical regions. Bulletin 35. National Resources Institute. Chatham, UK P 35.

Dawit A, Abera D, Lemma D, Chimdo A (2004). Domestic vegetable seed production and marketing. Research report. Nazareth, Ethiopia P 29.

Debashis M, MaityTK, Basu AK (2017). Response of Quality Seed Production of Onion (*Allium Cepa* L.) to Different Levels of Nitrogen and Potassium Application. Research Journal of Chemical and Environmental Sciences 5(2):38-45.

Fairhurst T, Lefroy R, Mutert E, Batjes N (1999). The importance, distribution and causes of phosphorus deficiency as a constraint to crop production in the tropics. In Agro forestry Forum pp. 2-8.

Food and Agriculture Organization (FAO) (2013). FAO Statistical Year book 2013; World Food and Agriculture. Food and Agriculture Organization, Rome, Italy, ISBN-13; 9789251073964. P 356.

Getachew A (2014). Effect of plant spacing and NP fertilizer levels on growth, seed yield and seed quality of onion (*Allium Cepa* Var Cepa) in MSc. Thesis Shewa robit, Northern Ethiopia P 66.

Griffiths G, Trueman L, Crowther T, Thomas B, Smith B (2002). Onions – a global benefit to health. Phytotherapy Research 16:603-615.

Guesh T (2015). Growth, Yield, and Quality of Onion (*Allium Cepa* L.) as Influenced By Intra-Row Spacing and Nitrogen Fertilizer Levels in Central Zone of Tigray, Northern Ethiopia. MSc. Thesis, Haramaya Universty, Ethiopia P 76.

Gupta RP, Sharma VP (2000). Effect of different spacing and levels of nitrogen for production of export quality onion bulbs planted on raised bed. News Letter National Horticulture Research and Development Foundation 20:13-16.

Hewitt EJ, Smith JA (1974). Plant mineral nutrition. The English Universities Press, London P 298.

Hinsinger P (2001). Bioavailability of soil inorganic phosphorus in the rhizosphere as affected by root-induced chemical changes. Plant and Soil 237(2):173-195.

Hossain MM, Khaleda KM, Haq E, Ahmed M, Shefat-Al-MM (2017). Macro and Micro Nutritional Effect on Seed Yield of Onion. Advances in Research 12(1):1-9.

Kadams AM, Amans EB (1991). Onion seed production in relation to field management in Nigeria. Onion Newsletter for the Tropics 3:47-49.

Kiros A, Kebede W, Fikreyohannes G (2018). Effect of inorganic NP fertilizers and vermicompost on growth, seed yield and yield components of onion (*Allium Cepa* L.) at Maitsebri, Northern Ethiopia. Journal of Horticulture and Forestry 10(6):89-96.

Lemma D, Shimeles A, Selamawit K, Chimdo A (2006). The Vegetable Seed Sector in Ethiopia: Current Status and Future Prospects. EHSS, Proceedings of the Inaugural and Third National Horticultural Workshop, Ethiopia 1:103-109.

Lemma D (1998). Seed production guideline for tomatoes, onion and hot pepper. Institute of Agricultural Research P 22.

Lemma D, Shemelis A (2003). Research Experiences in Onion production. EARO P 52.

Marschner H (1995). Mineral Nutrition and Yield Response. Mineral Nutrition of Higher Plants, (2ndedn), Academic press. London, UK pp. 184-200.

Meena PM, Umrao VK, Kumar A, Kumar R (2007). Effect of nitrogen doses on growth and yield of onion (*Allium cepa* L.) cv. 'Nasir red'. Agricultural Science Digest 27(2):144-145.

Mohamed A, Nourai M (1988). Effects of bulb source, sowing date and nitrogen nutrition on the seed yield of the white dehydration onion (*Allium Cepa* L.) in the Sudan. Journal of Horticultural Science 63(2):261-264.

Morsy MG, Marey RA, Karam SS, Abo-Dahab AMA (2012). Productivity and storability of onion as influenced by the different levels of NPK fertilization. Agricultural Research Kafer El-Sheikh University 38(1):171-187.

Muhammad B (1999). Effect of Nitrogen and Phosphorus on Seed Production of Three Onion (*Allium cepa* L.) Cultivars. Pakistan Journal of Biological Sciences 2(3):752-754.

Nasreen S, Haque MM, Hossain MA, Farid ATM (2007). Nutrient uptake and yield of onion as influenced by nitrogen and sulphur fertilization. Bangladesh Journal of Agricultural Research 32(3):413-420.

Nikus O, Fikre M (2010). Onion Seed Production Techniques: A Manual for extension agents and seed producers, FAOCDMDP, Asella, Ethiopia pp. 1-86.

Nwadukwe PO, Chude VO (1995). Effects of nitrogen and phosphorus fertilizer on seed crop of onion (*Alluimcepa* L.) in a semiarid tropical soil. Journal of Tropical Agriculture 72(3):216-219.

Ozden O (2009). Effects of Source and Rate of Nitrogen Fertilizer on Yield, Yield Components and Quality of Winter Rapeseed (*Brassica Napus* L.). Chilean Journal of Agricultural Research 70(1):132-141.

Ozer H (2003). Sowing date and nitrogen rate effects on growth, yield and yield components of two summer rapeseed cultivars. European Journal of Agronomy 19:453-463.

Prats PA, Munoz de Con L, Fundora MZ (1996). Influence of onion bulb size and its locality of origin of seed yield. Onion Newsletter for the Tropics 7:25-32.

Rashid MA, Singh DP (2000). A Manual on vegetable seed production in Bangladesh: 1st ed. AVRDC-USAID-Bangladesh Project-Horticulture Research Centre, Bangladesh Agricultural Research Institute Joydebpur, Gazipur 70, BANGLADESH 117.

Rizk FA, Shaheen AM, Abd El-Samad EH, Sawan OM (2012). Effect of different nitrogen plus phosphorus and sulphur fertilizer levels on growth, yield and quality of onion (*Allium cepa* L.). Journal of Applied Sciences Research 8(7):3353-3361.

Shimeles A (2000). Study on Flower and Seed Production Potential and Association of Characters with Seed Yield in Onion (*Allium cepa* L.). MSc Thesis Presented to the school of Graduate Studies of Alemaya University 160 p.

Sidhu AS, Kumar JS, Chadha ML (1996). Seed production potential of different genotypes of onion. Onion News Letter for the Tropics 7:38-41.

Sorensen JN, Grevsen K (2010). Sprouting in bulb onions (*Allium cepa* L.) as influenced by nitrogen and water stress. The Journal of Horticultural Science and Biotechnology 76:501-506.

Staurt NW, Griffin DM (1946). Some Nutrient Deficiency effects in the onion. Herbertia 2:337.

Tamrat T (2006). Effect of nitrogen and phospherous application on seed yield and nutrient uptake of onion (*Allium cepa* var. cepa). MSc. Thesis, Haramaya Universty, Ethiopia pp. 1-81.

Teshome A, Derbew B, Sentayehu A, Yehenew G (2014). Effect of planting and Mother Bulb size on onion seed yield and quality at Kobo woreda, Northern Ethiopia. International Journal of Agricultural Research pp. 1-11.