Effect of blended (NPSB) fertilizer rate on growth and yield of onion (*Allium cepa*. L.) varieties at Gubalafto district, North-Eastern Ethiopia

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Onion (*Allium cepa*, L) is one of the most important vegetable crops produced as a condiment for home consumption and income sources for many smallholder farmers in Ethiopia. However, the productivity of onion is low at national as well as regional levels; due to various limiting factors such as low soil fertility and lack of improved varieties. Therefore, a field experiment was conducted to determine the effect of blended (NPSB) fertilizer rates on growth and yield of onion varieties at Gubalafto district from September 2017 to March 2018 under irrigation conditions. Two onion varieties (Bombay Red and Adama Red) were evaluated using six levels of NPSB blended fertilizer rates (0.00, 81.34, 162.68, 244.02, 325.36, and 406.70 kg ha^{-1}) and laid out using the factorial arrangement in randomized complete block design with three replications. Data on growth and yield parameters were recorded and subjected to analysis of variance. Results revealed that days to maturity, leaf length, plant height, and the number of leaves, were significantly ($p \leq 0.05$) influenced by the main effect of NPSB blended fertilizer rate and varieties. The highest plant height (68.78 cm) was obtained from Adama Red variety when NPSB blended fertilizer was applied at a rate of 325.34 kg ha^{-1}. Higher total bulb yield (29.58 t ha^{-1}) was obtained from Bombay Red variety, while lower total bulb yield (25.27 t ha^{-1}) was recorded from Adama Red variety. Since this result is based on one season and location, it is suggested to repeat the experiment at the study district, different locations, and seasons by including other onion variety. The inclusion of organic fertilizer and cost-benefit analysis also is suggested as a future line of work to make a conclusive recommendation.

Key Words: *Adama Red; Bombay Red; Yield; Fertilizer*

INTRODUCTION

Onion (Allium cepa L.) is the most widely cultivated species of the genus Allium and belongs to the family Alliaceae [1,2]. It is one of the most important herbaceous, monocotyledonous, and cool-season vegetables. It is a biennial predominantly cross-fertilizing diploid species (2 n=2 x=16) in which a strong inbreeding depression is present [3].

Onion products are good in medicinal values and are recommended for curing different types of diseases. It is processed into various products such as ketchup, chutney, sauce, puree, salsa, dry soup mixture, etc [4]. The chemical flavonoids, anthocyanins, fructooligosaccharides, and organosulfur compounds found in the onion are considered as medicinal and health benefits to fight different diseases including cancer, heart, and diabetes [5].

It is grown in more than 170 countries in the world. In the 2016/2017 production year; the total area of 4,955,432 ha land was under onion production in the world, with a total of 93,168,548 tons and an average yield of 18.8 t ha^{-1} [6]. According to this report, China and India are the world's largest producers of onion, followed by the USA, Pakistan, Turkey, and Iran. According to CSA [7], in 2016/2017, the total area of 33,603.39 ha, with a total production of 327,475.2 tons with a productivity of 9.75 t ha^{-1} was under onion production in Ethiopia.

In Ethiopia, several production constraints cause low productivity of onion. These (among others) include lack of appropriate agronomic package, low fertility of the soil, inappropriate use of fertilizer rates, shortage of seeds of improved varieties, diseases, insect pests and poor extension services, high costs and limited availability of commercial fertilizer to small-scale farmers, especially at the peak growing period are the majors [8,9].

Onion is weak in extracting nutrients, especially the immobile types, because of their shallow and unbranched root system; hence they require and often respond well to the addition of fertilizers [10]. The availability of high yielding varieties that are adapted to the specific growing area is crucial in increasing the productivity of onion [11]. Therefore, nutrients play a significant role in improving productivity and quality of onion. The well-known onion varieties grown in Ethiopia are Adama Red, Bombay Red, Red Creole, Melkam, Mirmiru Brown, and Dereselign [12] among which Bombay Red and Adama Red varieties are widely grown in the country. However, these varieties are not distributed to all or most growing areas of the country and are not tested in the study area as well. Therefore, optimum fertilizer application and cultivation of suitable varieties with appropriate agronomic practices in the specific environment are necessary for obtaining a good yield of onion [13].

Most Ethiopian soils are deficient in macronutrients (N, P, and S) and micronutrients (Cu, B, and Zn) [14]. Yields have not increased as expected even when the recommended rates of N and P fertilizers are applied. This is mainly due to the use of two types of fertilizers (DAP and Urea) alone and this may cause unbalanced fertilizers to use [15]. The blanket recommendation of DAP and Urea fertilizers under the irrigated permanent field for onion crops are 200 and 100 kg ha^{-1}, respectively [16]. Like in most other parts of Ethiopia, farmers in Gubalafto district have been commonly using inorganic fertilizers like DAP and Urea for onion production [17]. Nutrients such as N, P, S, and B can often be included in new fertilizer formula when targeted to deficient soils, and these nutrients can significantly improve the yield of onion. According to the Ethiopian Agricultural Transformation Agency [18] N: P_2O_5:S: B (18.9N-37.7P2O5-6.95S-0.1B) fertilizer will substitute DAP soon in all over part of onion growing area of Ethiopia. However, the response of onion to the application rate of the newly introduced blended fertilizer (NPSB) under Gubalafto agro-ecological condition was not yet known. Therefore, the objective of the present work was initiated to determine the effect of rate/s of blended (NPSB) fertilizer on growth and yield of onion varieties.

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MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Lay Alawuha kebele in Guba Lafto district from September 2017 to March 2018 under irrigation conditions. Geographically the area is located between 39012`9`` and 39045`58`` East and 11034`54``and 11058`59`` North [19]. Lay Alawuha is located about 535 km away from Addis Ababa along the main road passing to Mekelle town. The study area is characterized by well-drained clay loam soil. The site has an average altitude of 1510 m.a.s.l and gets annual rainfall between 500-800 mm, with minimum and maximum temperatures of 150 °C and 310 °C, respectively [20].

Description of the experimental materials, treatments, and experimental design

Onion varieties used for this study were Bombay Red and Adama Red varieties. The treatments comprised of two onion varieties (Bombay and Adama red) and six levels of NPSB fertilizer levels (0, 81.34, 162.68, 244.02, 325.36, and 406.70 kg ha^{-1}). The experiment was laid out in a 2 × 6 factorial arrangement in a Randomized Complete Block Design (RCBD) replicated three times.

Experimental procedure

The experimental field was plowed and harrowed using oxen and plots were leveled manually. The experimental field consisted of 11 m width and 30.6 m length amounting to a total gross area of 336.6 m^2. The size of each unit plot was 3.0 m × 2.0 m (6 m^2), having a spacing of 40 cm between double rows, 20 cm in single rows and 10 cm between plants within the row was prepared. The blocks were separated by a 1.0 m wide open space whereas the plots within a block were separated by a 0.6 m wide space to provide appropriate agronomic management. NPSB fertilizer was used as a source of mineral nutrients and full doses which varied depending on treatments were applied as sideband placement at transplanting time. All important cultural practices were undertaken based on the recommendations made for the onion crop [21]. The experiment was conducted under furrow irrigation conditions. The remained urea was applied after 35 days after transplanting was done that facilitate the vegetative growth of onion [21].

Data collection

Days to 70% maturity: it was recorded as the actual number of days from the date of transplanting until more than 70% of plants showed neck fall [21]. Plant height (cm), leaf length (cm), and the number of leaves per plant of ten randomly pre-tagged plants from the net plot area were measured 92 days after transplanting. Total bulb yield (t ha^{-1}) was measured from the total harvest of the net plot as a sum weight of marketable and unmarketable yields.

Data analysis

All the collected data were first checked for fitting the analysis of variance (ANOVA) and examined for normality assumptions. Then, all data were subjected to (ANOVA) using SAS 9.3 version (SAS, 2012). Whenever the ANOVA shows significant differences between treatments, mean comparison and separation was done by using Least Significant Difference (LSD) test at a 5% level of significance.

RESULTS AND DISCUSSION

Days to 70% physiological maturity

The number of days required to reach 70% physiological maturity of onion was highly significantly ($p<0.01$) influenced by the effect of NPSB blended fertilizer rates and varieties. However, the interaction of blended fertilizer rate and varieties had no significant ($p>0.05$) influence on days to 70% maturity. The earliest days to physiological maturity were recorded from control treatment, which was statistically on par with the application of NPSB blended fertilizer at 81.34 kg ha^{-1}. Plants that received 325.36 kg ha^{-1} NPSB fertilizer rate matured late which were statistically on par with those plots fertilized with 244.02 kg ha^{-1} NPSB rate (Figure 1).

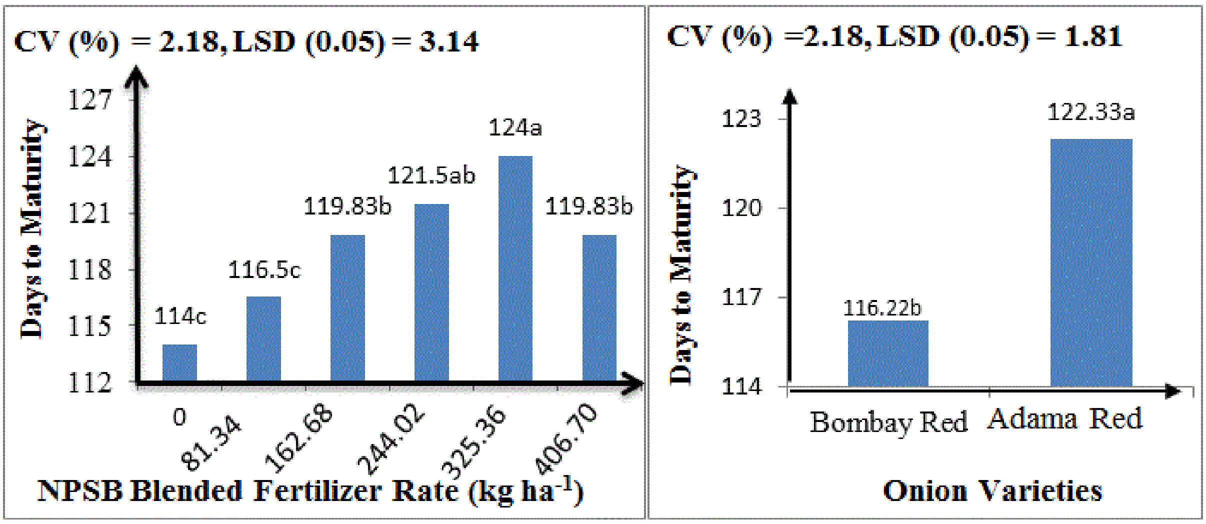

Figure 1) Days to 70% physiological maturity as influenced by NPSB blended fertilizer rate. Means followed by the same letter(s) within treatment are not significantly different at 5% significant.

The possible reason for the highest days of maturity at 325.36 kg ha^{-1} NPSB could be because nitrogen application extends the vegetative growth period of plants which in turn resulted in delayed maturity. The result of the present work is in agreement with the work of Yamasaki et al. [22] who revealed that the highest rate of nitrogen fertilizer extended the vegetative growth phase of onion. Moreover, Nebret et al. [23] reported that a high rate of nitrogen application significantly delayed physiological maturity. Early maturity at the control level might be due to insufficient supply of nutrients that shorten the duration of vegetative growth; thus entered into the reproductive phase and matured earlier.

On the other hand, the highest NPSB blended fertilizer rate (406.70 kg ha^{-1}) shortened days to maturity. It might be due to the effect of phosphorus, sulfur, and boron which accelerate maturity and ripening when applied at an optimum rate. This result is in agreement with Haruna et al. [24] who reported that the earliest days of maturity were attributed to the application of phosphorus which is responsible to hasten maturity. Similarly, Haneklaus et al. and Gupta et al. reported that the maturity of seeds and fruits is delayed in the absence of adequate sulfur, and boron is needed in protein synthesis and it is associated with an increased cellular activity that promotes maturity with an increased set of flowers, fruit, yield, and quality of the crop [25,26]. Sufficient nitrogen fertilizer application maintained physiological activity for an extended period and thereby continuing photosynthesis. Similarly, Nigatu et al. [27] observed extended time taken to reach 70% physiological maturity with the application of 136.5:119.6:22 kg ha^{-1} N: P_2O_5: S fertilizer rate.

Regardless of NPSB fertilizer rates, Bombay Red matured at 116.22 days while Adama red matured at 122.33 days after transplanting. This indicates that Bombay Red matured 6 days earlier than Adama Red (Figure 1). The variation in maturity among onion varieties might be due to their genetic differences and the response of varieties to the environment. This finding is consistent with the results of Selamawit et al., Yemane et al. and Tesfalgn et al. who reported that Bombay Red matured significantly earlier than Adama Red [28-30].

Plant height (cm)

The analysis of variance revealed that plant height was significantly ($p<0.05$) influenced by the interaction effect of fertilizer and onion varieties. Maximum plant height (67.88 cm) was observed in the interaction of 325.36 kg ha^{-1} NPSB blended fertilizer rate and Adama Red variety, which was statistically in parity with the plant height (67.74 cm) of Bombay Red variety which received 325.36 kg ha^{-1} NPSB, and that of Adama Red (66.20 cm) and Bombay Red (66.58 cm) varieties both of which received 406.70 kg ha^{-1} NPSB (Table 1). While minimum plant height (38.08 cm) was recorded in the control treatment for Bombay Red variety. The probable reason for higher plant height could be due to increased rates of nitrogen application that played a significant role in the building block of amino acids, enhancing cell division, cell elongation, chlorophyll synthesis, and protein synthesis which promote the growth of onion plants. This result is in agreement with Nasreen et al., Gustfson et al. and Agumas et al. who reported that the application of nitrogen fertilizer increases the vegetative growth of onion due to its potential to increase photosynthesis rate [31-33].

Phosphorus enhances photosynthesis, nitrogen fixation and encouraged root growth because it has a vital role in energy transfer held as a part of the chemical structures of ADP and ATP that drives the chemical reactions within the plant. Sulfur is important in the building block of protein and a key ingredient in the formation of chlorophyll. This is in agreement with the finding of [34] who observed that onion is a sulfur loving plant that is required for proper growth and bulb development. Boron is also an essential micronutrient that is necessary for normal cell division, nitrogen metabolism, protein formation, and phosphorus uptake. Assefa et al. [35] reported that plant height increased with an increase in the combined application of N, P, S, and Zn fertilizers. Mirete and Dechassa [36] reported that increasing the rate of nitrogen fertilizer to 96 kg N ha^{-1} significantly increased plant height. Ali et al. [37] also reported that different phosphorus levels significantly affect plant height, wherein the tallest plants were observed at higher rates. According to Manna [38] application of 0.5% boron significantly increased the plant height over the control.

The higher mean plant height (58.45 cm) was recorded by the Adama Red variety than Bombay Red variety (56.62 cm) (Table 1). Even if they have been grown in the same environment the difference in plant height among the onion varieties could be due to the difference in their genetic makeup. This result is in parity with the findings of Tegbew et al. [39] and Tesfalgn et al. [40] who reported maximum plant height for Adama Red variety as compared to Bombay Red variety. The result was also similar to the finding of Ghaffoor et al. [41] who indicated the presence of significant differences among onion varieties in plant height.

Leaf number

The analysis of variance for the interaction effects of NPSB blended fertilizer and varieties showed significant ($p<0.05$) difference in leaf number of onion. The highest leaf number per plant (17) was obtained from the interaction of 325.36 kg ha^{-1} NPSB blended fertilizer rate and Adama Red variety. However, the least number of leaves per plant (8.37) was recorded in the control treatment for Bombay Red variety (Table 1).

The application of an increased rate of NPSB blended fertilizer increased the number of onion leaves. The reduced leaf number at a lower level of fertilizer might be due to the lack of sufficient nutrients and assimilate for growth. The increase in leaf number per plant at a higher rate of NPSB blended fertilizer could be attributed to the availability of macro and micronutrients that permit leaves to grow vigorously. Nitrogen and sulfur fertilization had the potential to increase nutrients availability in the soil and thus enhance the uptake of nutrients by the plant. The result of the present work is in line with the finding of Nasreen et al. [42] who reported that the application of 120 kg N ha^{-1} significantly increased the number of leaves per plant of onion, and a further increase of nitrogen supply to 160 kg ha^{-1} tended to decrease it. Abdissa and Pant [43] reported that nitrogen fertilization significantly influenced the number of leaves produced by the onion plant. Uzma et al. [44] reported that a low level of phosphorus fertilizer application results in a reduction in leaf expansion and leaf surface area, as well as the number of leaves in garlic. Similarly, Nasreen et al. [45] reported maximum plant height and leaf number when sulfur was applied at the dose of 45 kg S ha^{-1}. Manna [46] also obtained the maximum number of leaves as a result of a 0.1% boron application. Nigatu [47] reported the highest number of leaves recorded as a result of the combined application of 105:92:16.95 N: P_2O_5:S and the least number of leaves from unfertilized plants.

TABLE 1
Interaction effects of NPSB blended fertilizer rate and variety on plant height and leaf number of onion.

Treatments		Variables	
NPSB fertilizer Levels (kg ha^{-1})	Varieties	Plant height (cm)	Number of leaves
	Adama Red	44.15_e	11.03_d
0	Bombay Red	38.08_f	8.37_e
	Adama Red	55.66_d	11.57_d
81.34	Bombay Red	49.14_e	12.27_{cd}
	Adama Red	57.21_d	13.60_{bc}
162.68	Bombay Red	55.94_d	13.50_{bc}
	Adama Red	59.59_{cd}	13.50_{bc}
244.02	Bombay Red	62.22_{bc}	13.73_{bc}
	Adama Red	67.88_a	17.00_a
325.36	Bombay Red	67.74_a	14.80_b
	Adama Red	66.20_{ab}	14.40_b
406.7	Bombay Red	66.58_{ab}	14.33_b
LSD (0.05)		**4.99**	**1.59**
CV (%)		**4.53**	**6.98**

Means with the same letter(s) within a column are not significantly different from each other at a 5% level of probability.

The higher mean number of leaves (13.52) was recorded by Adama Red, while the lower (12.83) was recorded by Bombay Red variety (Table 1). This result conforms with the findings of Tibebu et al. [48] who reported the highest leaf number per plant obtained from Adama Red variety than

Bombay Red. Similarly, Nasreen et al. [49] reported the existence of a significant difference among onion varieties concerning the number of leaves per plant.

Leaf length (cm)

The analysis of variance revealed that the leaf length of onion was highly significantly ($p<0.01$) influenced by NPSB blended fertilizer rate. However, variety and its interaction with NPSB blended fertilizer rate did not influence leaf length significantly ($p>0.05$). The maximum leaf length of onion (53.16 cm) was recorded at 325.36 kg ha^{-1} NPSB blended fertilizer rate, which was statistically in parity with the leaf length (50.73 cm) that received 406.70 kg ha^{-1} NPSB. On the other hand, the least leaf length (38.16 cm) was recorded from the control treatment (Figure 2). Compared to the control, plants supplied with 325.36 kg ha^{-1} rate of NPSB blended fertilizer increased the leaf length by 28.22%. The increase of leaf length of onion with an increase in NPSB blended fertilizer rate might be due to the availability of macro and micronutrients. This result is in agreement with the finding of Birhanu et al. [50] who reported a positive effect of nitrogen on leaf length may be due to its role in chlorophyll, enzymes, and protein synthesis. Similarly, Jilani et al. [51] reported an increase in the length of onion leaves with an increase in nitrogen rate.

Phosphorus increases the root and shoots the system of plants. This is consistent with Gustfson et al. [52] who reported that the increase in leaf length is attributed to phosphorus to form good root systems and strong stem, particularly in crops with restricted root systems like onion, thereby enhance the ability of the plant to explore nutrients vital for leaf growth. Fatma et al. [53] obtained the application of sulfur holding fertilizer positively affected all onion growth variables. Boron also maintains a balance between sugar and starch in the plant body. It translocates sugar and carbohydrates in different parts of the plant body which increases vegetative growth of onion.

The present result is in agreement with Nigatu et al. [54] who reported that the longest leaves were obtained from the application of 136.5:119.6:22 kg ha^{-1} of N: P_2O_5:S fertilizer. Forney et al. [55] reported that sulfur is essential for good vegetative growth. Sankaran et al. [44] also reported that the application of sulfur at 45 kg ha^{-1} significantly increased the uptake of N, P, and K. Hänsch and Mendel [56] stated essential role of boron in improving plant growth, through biosynthesis of endogenous hormones. Ghaffoor et al. [57] also reported that the application of phosphorus at 100 kg ha^{-1} produced higher onion leaf length.

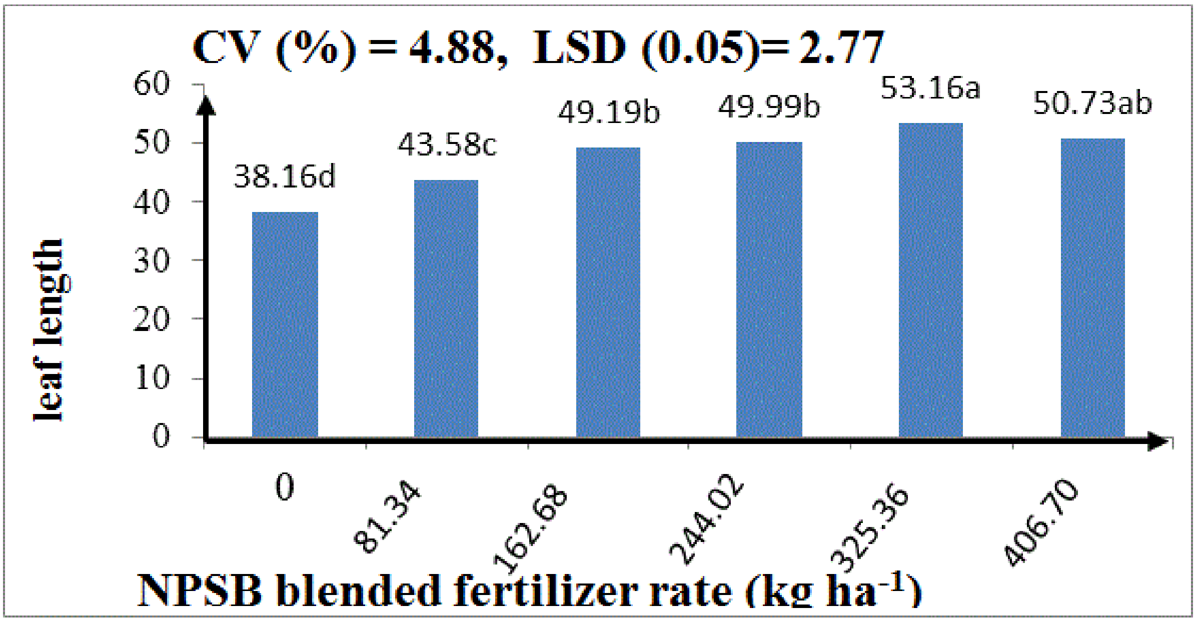

Figure 2) Leaf length of onion affected by NPSB blended fertilizer rate. Means followed by the same letter within treatment are not significantly different at 5% significant.

Total bulb yield (t ha^{-1})

The analysis of variance revealed that the interaction effects had significant ($p<0.05$) influence on total bulb yield per hectare of onion. The highest total bulb yield (42.38 t ha^{-1}) was observed in the interaction of 325.36 kg ha^{-1} NPSB blended fertilizer rate, and Bombay Red variety, which was statistically in parity with total bulb yield (38.87 t ha^{-1}) of Bombay Red variety which received 406.70 kg ha^{-1}. While, the least total bulb yield (9.99 t ha^{-1}) and (9.82 t ha^{-1}) was recorded in the control treatment with Adama Red and Bombay Red varieties, respectively (Table 2).

Increasing the rate of NPSB blended fertilizer from 0 to 325.36 kg ha^{-1} increased the total bulb yield of onion significantly and linearly. The total bulb yield of onion plants grown at a rate of 325.36 ha^{-1} kg NPSB exceeded the total bulb yields of onion plants grown at 0, 81.34, 162.68, 244.02 and 406.70 kg ha^{-1} NPSB by about 75, 53, 31, 20 and 5%, respectively. This may be due to the increase in bulb size and bulb weight in response to nitrogen application that might have increased photosynthesis, and in turn, enhanced growth and expansion of vegetative growth as a whole, and eventually partitioning of markedly higher carbohydrates to the bulbs at maturity. This result is in agreement with the finding of [48] who reported higher total bulb yields of onion in response to the application of nitrogen. Kokebe et al. [58] also reported progressive increments in bulb yield of onion as a result of an increase in the rate of nitrogen from 0 to 100 kg N ha^{-1}.

When onion matured, phosphorus translocation takes place into the bulb of the plant where high energy requirements are needed for the formation of bulbs because it is highly mobile in plants and translocated from old plant tissue to young actively growing areas. Assefa et al. [33] reported that combined effect of the contributions of nitrogen to chlorophyll, enzymes, and protein synthesis; as phosphorus is essential for root growth, phospho-proteins, and phospho-lipids that contribute for yield increment. The results are also consistent with the finding of Reddy et al. [41] who reported that the application of 150 kg nitrogen and 90 kg phosphorus ha^{-1} shown the maximum plant height, bulb diameter, and bulb yield of onion.

Sulfur is an important nutrient that increases the formation of vegetative structures for nutrient absorption and photosynthesis and increases the production of assimilates to fill the sinks, resulting in increased yield of onion. Zaman et al. [43] reported a bulb yield increase in garlic with increasing sulfur level up to 45 kg ha−1. Diriba et al. [12] also reported that yield and yield attributes of garlic bulbs increased significantly with the increasing rates of nitrogen, phosphorus, and sulfur. Similarly, the higher total bulb yield could be due to boron that it translocates sugar and carbohydrates in different parts of the plant body. Dake et al. [11] reported improvement in growth, yield, and quality of onion with the application of boron.

Bombay Red produced the higher total bulb yield (29.56 t ha^{-1}) and the least total bulb yield (25.51 t ha^{-1}) was produced from Adama Red variety (Table 2). This indicates Bombay Red exceeded Adama Red by about 13.70% in total bulb yield. The difference in bulb yield of onion varieties depends on variation in genotypes, climate, cultural practices, and their interactions. This result is in line with the study of Benti et al [5] who reported that the highest total bulb yield on the variety Bombay Red, whereas the lowest yield by Adama Red variety. Geremew et al. [20], [51,54], and [50] obtained a higher total bulb yield by Bombay Red than Adama Red variety.

TABLE 2
Interaction effects of NPSB blended fertilizer rate and variety on marketable bulb yield (t ha-1) and total bulb yield (t ha-1) of onion.

Treatments	Variables	
NPSB Fertilizer Levels (kg ha^{-1})	Varieties	Total Bulb Yield (t ha^{-1})
0	Adama Red	9.99_{g}
	Bombay Red	9.82_{g}
81.34	Adama Red	17.92_{f}
	Bombay Red	19.41_{ef}
162.68	Adama Red	22.95_{e}
	Bombay Red	31.44_{cd}
244.02	Adama Red	28.47_{d}
	Bombay Red	35.42_{bc}
325.36	Adama Red	36.99_{b}
	Bombay Red	42.38_{a}
406.7	Adama Red	36.68_{b}
	Bombay Red	38.87_{ab}
LSD (0.05)		**4.33**
CV (%)		**9.24**

CONCLUSION

The results of the present work revealed that the application of the NPSB blended fertilizer rate greatly improved the growth and yield of onion varieties. Accordingly, all the combinations of NPSB blended fertilizer rates with onion varieties showed better growth and yield variables as compared to the control treatment. Therefore, based on the results of the present work, the growth and productivity of onion can perform well in the study area and farmers can benefit more by practicing the combined application of 325.36 kg ha^{-1} NPSB blended fertilizer and Bombay Red variety that resulted in total bulb yield of onion. Since this result is based on one season and location work, it is suggested to repeat the experiment at the study district, different locations, and seasons by including other onion varieties. The inclusion of organic fertilizer and cost-benefit analysis also is suggested as a future line of work to make a conclusive recommendation.

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