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Effects of Blended Fertilizer Rate and Variety on Yield and Quality of Onion (*Allium cepa* L.) Seed production in Northeastern Amhara, Ethiopia

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ABSTRACT

Quality seed is an essential input for the production of quality onion bulbs. However, lack of quality vegetable seeds including onions are the major obstacle to producing a better yield and quality. Therefore, the research was carried out to study the influence of blended fertilizer rate and variety on onion seed yield and quality. Treatments contained seven blended fertilizer rates (0, 30.5, 61, 91.5, 122,152.5 and 183 kg ha-1 Nitrogen: Phosphorus: Sulphur: Boron (NPSB)) and two onion varieties (Bombay red and Nafis). Data were collected on growth, yield and quality parameters and analyzed using SAS version 9.4. Most parameters were significantly influenced by the main and interaction effects of variety and blended fertilizer. Bombay red gained the maximum seed yield (2.3 tonne ha-1) planted at Kobo with the application of 183 kg blended fertilizer ha-1. The highest germination percentage (92%) was recorded on both Bombay red and Nafis at Libso and Kobo with the application rates of 183 and 61 kg ha -1 NPSB, respectively. The partial budget analysis showed that Bombay red planted at Kobo with the application of 183 kg blended NPSB fertilizer ha-1 gave a maximum net benefit of 1,857,967.5 ETB ha-1 with a marginal rate of return of 48,186.14%. Therefore, Bombay red with combination of 183 kg NPSB blended fertilizer and 34.4 kg Urea ha-1 is advisable for better yield and quality of onion seed production in the study area and similar agro ecologies.

Keywords: Blended -Fertilizer, onion, quality, seed, variety, yield.

INTRODUCTION

Onion (*Allium cepa* L.) is a commonly consumed vegetable crop throughout the world. In Ethiopia, onion is an extremely important crop for increasing the income of producers and traders (Lemma & Shimeles, 2003). A total area of 28,185 hectares of land was under onion production with total bulb production of 262,478 tonnes (metric tons) and productivity of 9.1 tonnes ha-1 in Ethiopia (CSA, 2019). This indicates the productivity of onions in Ethiopia (9.1 t ha-1) is far below the world average (18.8 t ha-1). The factors affecting onion production could be inappropriate spacing, poor fertilizer application, and unavailability of quality seeds together with other agronomic practices (FAO, 2017).

Though the problem related to seed quality is one of the constraints for low productivity of onion bulb in Ethiopia, it is also constrained by many other issues. Among the major production constraints that cause low productivity and quality of onion seed in Ethiopia are lack of agronomic package, low soil fertility, inappropriate rates of fertilizer use, diseases, insect pests and poor extension services, high costs of commercial fertilizers (Melkamu et al., 2015).

Nutrients play a significant role in improving the productivity and quality of vegetable crops. Onions are the most susceptible crops to extracting nutrients, especially the immobile types, because of their shallow root system; hence they require and often respond well to the addition of fertilizers (Rizk et al., 2012). Fertilizer application affects the yield and quality of onion seed production (Nandpuri et al., 1990). Nitrogen has been found to increase the number of umbels per plant, the

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number of florets per umbel, umbel size, and seed yield (Nehra et al., 1988).

Using balanced fertilizers to improve onion seed yield and quality is one of the most important crop management practices to be considered. Nutrients such as N, P, S and B are included in the new fertilizer formula for deficient soils, since these nutrients can significantly improve fertilizerefficiency and crop profitability. According to the Ethiopian Agricultural Transformation Agency (ATA) (2016), N:P2O5:S:B (18.9 N – 37.7 P2O5 + 6.95S + 0.1B) fertilizer was substituted with Diammonium Phosphate (DAP). However, the response of onion to the application rate of the newly introduced blended fertilizer (NPSB) dose varies with location and so far the response has not been determined in Kobo and Libso areas. Therefore, this experiment was conducted to study blended fertilizer rates and onion varieties for onion seed yield and quality in the Kobo and Libso areas of northeastern Amhara, Ethiopia.

MATERIALS AND METHODS

Description of the study area:

The study was carried out under irrigation from September 2018 to May 2019 at Kobo research sub-center and Libso investment farm in northeastern Amhara. The Kobo site is located at 12° 08’ 21’’ N, and 39° 38’ 21’’ E, at an altitude of 1470 m. The long-term mean annual rainfall for the area is 510.6 mm with maximum and minimum temperatures of 31 °C and 15.1 °C, respectively. The Libso site is located at 11°33. 2’59’’ N and 39°39. 32’17’’ E, at an altitude of 1630 m. The long-term mean annual rainfall of the area is 848 mm with maximum and minimum temperatures of 30 °C and 11.6 °C, respectively (EAMSC, 2019). The textural class of Kobo soil is clay loam (36.25% sand, 32.5% clay, 31.25% silt). The soil contained total nitrogen (0.15%), available phosphorous (31.25 ppm), organic carbon (0.97%), organic matter (1.67%), pH (6.1), electric conductivity (0.2 ds m-1) and cation exchange capacity (39.8 meq 100g-1). The textural class of the Libso soil is also clay loam (33.75% sand, 37.5% clay, 28.75% silt). The soil contained total nitrogen (0.11%), available phosphorous (29.55 ppm), organic carbon (1.04%), organic matter (1.79%), pH (6.32), electric conductivity (0.21 ds m-1) and cation exchange capacity (40.6 meq 100g-1) (Table 1).

Treatments and experimental design:

The experimental treatments consisted of factorial combinations of two onion varieties (Bombay red and Nafis) and seven levels of Nitrogen: Phosphorus: Sulphur: Boron (NPSB) blended fertilizer (0, 30.5, 61, 91.5, 122, 152.5 and 183 kg ha-1) laid out in Randomized Complete Block Design (RCBD) with three replications. Gross and

Table 1: Physical and chemical properties of soil in the experimental sites

Location	Soil properties	Unit	Value
Kobo	Soil physical properties		
	Sand	%	36.25
	Clay	%	32.5
	Silt	%	31.25
	Textural classes		Clay loam
	Soil chemical properties		
	pH (water 1: 2.5 g soil)	-	6.07
	Total Nitrogen (N)	%	0.154
	Organic Carbon (OC)	%	0.970452
	Organic Matter (OM)	%	1.673059
	Available Phosphorus	ppm	31.25
	Electric conductivity (EC)	ds m^{-1}	0.2
	Cation exchange capacity (CEC)	meq100 g^{-1}	39.8
Libso	Soil physical properties		
	Sand	%	33.75
	Clay	%	37.5
	Silt	%	28.75
	Textural classes		Clay loam
	Soil chemical properties		
	pH (water 1: 2.5 g soil)	-	6.32
	Total Nitrogen (N)	%	0.112
	Organic Carbon (OC)	%	1.040719
	Organic Matter (OM)	%	1.7942
	Available Phosphorus	ppm	29.55
	Electric conductivity (EC)	ds m^{-1}	0.207813
	Cation exchange capacity (CEC)	meq 100 g^{-1}	40.6

net plot sizes were 5 m^2 (2.5m × 2m) and 3. 6 m^2 (2m ×1. 8m), respectively, with a spacing of 1 m between plots and 1.5 m between blocks.

The 4-5 cm sized onion bulbs were planted at a spacing of 50 cm between water furrows, 30 cm between rows, and 20 cm between plants. Agronomic practices such as plowing, weeding, and irrigation were applied as per the general recommendation for onions (EARO, 2004). Fertilizer application was done according to the trial plan and placed in rows 5 cm away from onion bulbs. The plots were irrigated at the interval of three days during the first phase of active growth of the plants. Later, the irrigation gap was increased to seven days intervals. Cultivation was done manually including keeping the plots free of weeds during the growing period. For the control of onion thrips, the insecticide selecron was used. Harvesting of umbels in the net plot area was done by a sharp sickle at the maturity of the umbel per plot. The umbels were dried on canvas in a shaded place and threshed by hand. The seeds were separated from stalks and other debris by winnowing, and the chaff seeds were separated from well-filled seeds by soaking seeds in water-filled buckets. The floated seeds were discarded as chaffy seeds because they are hollow and unviable, while the sinken ones are considered well-filled and viable. The sinken seeds were drained and dried under shade, weighed and recorded as seed weight per plot after being adjusted to 8% moisture content. Finally, seed quality tests were carried out.

Soil sampling and analysis:

Surface soil (0-30 cm depth) samples were collected by using an auger from different spots on the experimental field before planting and then composited to yield one representative sample. The samples were subjected to air drying and then ground by using mortar and allowed to pass through a 2 mm sieve before laboratory analysis. Working samples obtained from the submitted sample were analyzed for selected physical-chemical properties, mainly texture, soil pH, cation exchange capacity (CEC), electric conductivity (EC), organic carbon, organic matter (OM), total nitrogen and available phosphorus using standard laboratory procedures at soil laboratory of Sirinka Agricultural Research Center (SARC). The organic matter content of the soil was determined by the volumetric method (Walkley & Black, 1934). Total nitrogen was analyzed using the Kjeldahl digestion, distillation and titration method as described by Black et al. (1965) by oxidizing the OM in concentrated sulfuric acid solution (0.1N H_2SO_4). The pH of the soil was determined on a 1:2 (weight/volume) soil samples to water ratio using a pH meter (Motsara & Roy, 2008). Cation exchange capacity (CEC) was measured titrimetrically by distillation of ammonium that was displaced by sodium from NaCl solution (Chapman, 1965). Available phosphorus was determined by using the Olsen methods for estimation of available phosphorus in soils by extracting with sodium bicarbonate (Olsen et al., 1954). Soil texture was determined using Bouyoucos hydrometer method (Day, 1965) and then following the textural triangle.

Data collection:

Plant height was measured from the soil surface to the tip of ten plants after development of their umbels. Numbers of flower stalks of ten randomly selected plants per plot at central rows were counted and the average was calculated and recorded as the number of flower stalks per plant. Days to bolting were recorded as the number of days from date of planting up to 50% of the plants in a plot producing a flower stalk. Number of umbels from ten randomly sampled plants was counted and the average was calculated and expressed as the number of umbels per plant. The umbel diameter of ten randomly sampled plants in each plot was measured using a caliper. Five umbels were randomly selected from ten randomly sampled plants in each plot and the number of seeds per umbel determined. Five randomly sampled umbels were harvested and weighed to determine the number of seed weight per umbel. Seed yield in tonne ha-1 was estimated from seed yield per plot.

Germination percentage was determined according to ISTA (1985) rules. Seeds were placed in Petri dishes covered with filter paper and allowed to imbibe water with water, which was kept at room temperature until germination ceased in each Petri dish for 12 days. A seed is considered germinated when the radicle protrusion has attained approximately 1 mm. Then germination percentage was determined from counts of normal seedlings and the total seeds placed on petri dishes.

Seed vigor index I and II: After measuring the seedling shoot and root length as well as seedling dry weight, the seedling vigor index I and II were calculated according to the formula described by Abdul-Baki & Anderson (1973) as follows: Seed vigor index I was determined by multiplying seed germination percentage by sum of shoot and root length as Germination (%) × Seedling length [Seedling Root length + Shoot length (cm)]. Seed vigor index II was determined by multiplying seed germination percentage by seedling dry weight as Germination (%) × seedling dry weight (g).

Data analysis:

Growth, yield and quality parameters were subjected to analysis of variance using statistical analysis system software version 9.4 (SAS, 2008).

Means were compared by using Least Significant Difference test at 5% probability level.

Partial budget analysis:

Partial budget analysis of the treatments was carried out by following CIMMYT (1988) procedures by taking only fertilizer variable costs.

- Gross field benefit = Field price × Adjusted seed yield
- Net benefit = Total cost – Gross field benefits
- Total cost NPSB blended fertilizer cost of 14 ETB kg-1 and Urea fertilizer cost of 13.50 ETB kg-1 were considered in partial budget analysis.
- Marginal rate of return = Net benefits divided by total cost that vary
- The onion seed yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers expect from the same treatment. The average open market price of onion seed was 900 ETB kg-1 at the nearest market at Kobo and Libso in 2019.

RESULTS

Plant height:

Plant height was highly ($p < 0.0001$) affected by main effects of location, variety, NPSB blended fertilizer rate and interaction effects of variety by NPSB blended fertilizer rate. The maximum value of plant height (115 cm) was recorded from variety Nafis with the application of 61 kg NPSB blended fertilizer ha-1 planted at Kobo, whereas the lowest plant height (81.3 cm) was recorded from variety Bombay red at 122 kg NPSB blended fertilizer ha-1 planted at Libso (Table 2).

Flower stalks per plant:

Main effects of varieties, NPSB blended fertilizer rate and interaction effects of variety by fertilizer rate significantly ($p < 0.001$) affected flower stalks per plant. The maximum flower stalks per plant (9.6) was found from the variety Bombay red with the application of 183 kg NPSB blended fertilizer ha-1 planted at Libso. But the fewest flower stalks per plant (4) was recorded from variety Nafis at

Table 2: Effects of blended fertilizer rate and onion varieties on plant height, flower stalks per plant, 50% bolting date, number of umbels per plant and umbel diameter

		Variables					
Location	**Variety**	**FR**	**PH (cm)**	**FSP^{-1}**	**50%BD**	**NUP^{-1}**	**UD(cm)**
Kobo	Bombay red	0	83.3^{lmn}	7.6^{cde}	59.0^{g}	7.0^{defg}	6.4^{j}
		30.5	88.6^{j}	8.0^{bcd}	59.3^{g}	7.6^{cde}	6.5^{ij}
		61	88.0^{jk}	9.0^{ab}	57.3^{ghij}	9.0^{ab}	7.4^{a}
		91.5	84.6^{lm}	8.0^{bcd}	58.0^{ghij}	7.6^{cde}	6.9^{cdefgh}
		122	85.0^{kl}	6.6^{ef}	58.3^{ghi}	6.6^{efg}	6.9^{cdefgh}
		152.5	85.6^{jkl}	7.6^{cde}	58.6^{gh}	7.3^{cdef}	6.5^{ij}
		183	88.6^{j}	8.3^{bc}	58.6^{gh}	8.0^{bcd}	6.9^{cdefgh}
	Nafis	0	101.6^{efg}	4.6^{ij}	80.6^{a}	4.6^{jk}	7.0^{cdefg}
		30.5	107.3^{c}	4.0^{j}	80.0^{ab}	4.0^{k}	7.1^{abcd}
		61	115.0^{a}	6.6^{ef}	79.0^{abc}	6.6^{efg}	7.1^{abcd}
		91.5	106.6^{cd}	5.3^{ghi}	75.3^{de}	5.3^{hij}	7.4^{ab}
		122	104.3^{cde}	5.3^{ghi}	76.0^{de}	5.0^{ijk}	7.1^{abcd}
		152.5	98.0^{hi}	6.0^{fgh}	80.3^{ab}	6.0^{ghi}	7.0^{bcdef}
		183	100.3^{gh}	4.3^{ij}	80.6^{a}	4.3^{jk}	7.1^{abcde}
Libso	Bombay red	0	84.6^{lm}	7.0^{def}	58.3^{ghi}	7.0^{defg}	5.8^{k}
		30.5	83.6^{lmn}	8.3^{bc}	57.3^{ghij}	8.3^{bc}	6.0^{k}
		61	84.0^{lmn}	8.0^{bcd}	56.3^{ij}	8.0^{bcd}	6.9^{cdefg}
		91.5	83.6^{lmn}	8.0^{bcd}	56.6^{hij}	8.0^{bcd}	6.6^{hij}
		122	81.3^{n}	8.3^{bc}	57.6^{ghij}	8.3^{bc}	6.6^{hij}
		152.5	81.6^{mn}	8.0^{bcd}	56.0^{j}	8.0^{bcd}	6.5^{ij}
		183	86.3^{jkl}	9.6^{a}	56.6^{hij}	9.6^{a}	6.7^{efghij}
	Nafis	0	104.3^{cde}	5.0^{hij}	78.6^{abc}	5.0^{ijk}	7.0^{cdefg}
		30.5	101.6^{efg}	5.3^{ghi}	79.0^{abc}	5.3^{hij}	6.5^{ij}
		61	110.6^{b}	5.3^{ghi}	78.6^{abc}	5.3^{hij}	6.8^{defghi}
		91.5	103.6^{def}	5.0^{hij}	74.0^{ef}	5.0^{ijk}	7.2^{abc}
		122	99.6^{gh}	5.3^{ghi}	72.6^{f}	5.3^{hij}	6.7^{fghij}
		152.5	95.6^{i}	6.3^{fg}	77.3^{cd}	6.3^{fgh}	6.7^{ghhij}
		183	100.6^{fgh}	4.6^{ij}	78.3^{bc}	4.6^{jk}	7.1^{abcde}
LSD (5%)			3.0	1.1	2.2	1.04	0.35
CV (%)			2.0	10.5	2.0	9.6	3.1

FR: fertilizer rate, PH: plant height, FSP^{-1}: flower stalk per plant, 50% BD: fifty percent bolting date, NUP^{-1}: number of umbels per plant, UD: umbel diameter

Table 3: Effects of blended fertilizer rate and variety on number of seeds per umbel, seed weight per umbel, seed yield t ha^{-1}, seed vigor index I and II

		Variables					
Location	**Variety**	**FR**	**NSU^{-1}**	**SWU^{-1}**	**SY t ha^{-1}**	**SVI I**	**SVI II**
Kobo	Bombay red	0	822.3^{p}	3.2^{jk}	1.3^{jk}	708.4^{kl}	8.3^{fg}
		30.5	1365.3^{hgi}	5.4^{efgh}	1.7^{cde}	777.2^{ij}	8.3^{fg}
		61	1413.0^{fg}	5.5^{defgh}	1.8^{c}	926.7^{a}	17.6^{a}
		91.5	1318.3^{ijklm}	5.2^{fgh}	1.7^{def}	735.5^{jk}	8.2f^{g}
		122	1271.0^{m}	5.0^{h}	1.8^{cd}	790.9^{ghi}	17.1^{a}
		152.5	1403.0^{fgh}	5.5^{defgh}	1.8^{c}	843.5^{cdefg}	9.1^{efg}
		183	1413.3^{fg}	5.6^{cdef}	2.3^{a}	819.7^{defghi}	9.1^{efg}
	Nafis	0	1469.3^{de}	6.1^{abcd}	0.8^{m}	672.2^{l}	14.0^{bc}
		30.5	1345.6^{ijk}	5.3^{fgh}	1.2^{k}	862.4^{bcde}	17.2^{a}
		61	1531.6^{ab}	6.1^{abc}	1.5^{gh}	871.1^{bcd}	12.3^{cd}
		91.5	1129.3^{n}	4.5^{i}	1.5^{hi}	780.5^{ij}	16.2^{ab}
		122	1577.0^{a}	6.2^{ab}	1.6^{fgh}	692.5^{kl}	14.1^{bc}
		152.5	1553.0^{ab}	6.4^{a}	1.5^{hi}	821.5^{defghi}	8.8^{efg}
		183	1505.0^{bcd}	6.1^{abcd}	1.8^{cd}	808.8^{efghi}	16.7^{a}
Libso	Bombay red	0	917.3^{o}	3.6^{j}	1.4^{ij}	703.6^{kl}	8.0^{fg}
		30.5	1284.0^{lm}	5.1^{gh}	1.7^{def}	792.6^{fghi}	8.4^{fg}
		61	1352.6^{hij}	5.4^{efgh}	1.7^{cde}	814.0^{efghi}	8.6^{efg}
		91.5	1326.3^{ijkl}	5.2^{fgh}	1.6^{efg}	785.1^{hij}	10.8^{de}
		122	1295.0^{klm}	5.1^{fgh}	1.7^{cd}	844.9^{cdef}	8.9^{efg}
		152.5	1351.3^{hij}	5.3^{efgh}	1.7^{cde}	806.9^{fghi}	8.9^{efg}
		183	1403.6^{fgh}	5.6^{cdefg}	2.1^{b}	797.9^{fghi}	9.2^{ef}
	Nafis	0	1421.3^{ef}	2.8^{k}	0.5^{n}	618.0^{m}	6.7^{g}
		30.5	1307.3^{jklm}	5.1^{fgh}	0.9^{l}	835.5^{cdefgh}	8.5^{efg}
		61	1518.6^{bcd}	6.1^{abcd}	1.4^{ij}	878.9^{abc}	18.1^{a}
		91.5	1102.6^{n}	2.9^{k}	1.4^{ij}	721.7^{kl}	8.2^{fg}
		122	1525.3^{abc}	3.0^{k}	1.5^{gh}	710.9^{kl}	7.5^{fg}
		152.5	1473.3^{cde}	5.8^{bcde}	1.6^{fgh}	901.5^{ab}	8.8^{efg}
		183	1560.0^{ab}	3.1^{k}	1.6^{efg}	699.2^{kl}	7.7^{fg}
LSD (5%)			55.16	0.52	0.13	54.06	2.34
CV (%)			2.4	6.3	5.1	4.2	13.1

FR: fertilizer rate, NSU^{-1}: number of seeds per umbel, SWU^{-1}: seed weight per umbel, SY t ha^{-1}: seed yield tonne per hectare, SVI I: seed vigor index one, SVI II: seed vigor index two.

30.5 kg NPSB blended fertilizer planted at Kobo (Table 2).

Days to 50% bolting:

The main effects of location, variety, NPSB blended fertilizer rate, and interaction effects of variety by fertilizer rate are highly ($p < 0.0001$) influenced on 50% bolting date. The maximum 50% bolting date (81) was recorded from variety Nafis with the application of 183 kg NPSB blended fertilizer ha-1 planted at Kobo, while the shortest 50% bolting date (56) was recorded from variety Bombay red at 61 kg NPSB blended fertilizer planted at Libso (Table 2).

Number of umbels per plant:

The main effects of variety and interaction effects of variety by fertilizer rate were highly ($p < 0.0001$) affected by the number of umbels per plant. The highest number of umbels per plant (10) was recorded from variety Bombay red with the combination of 183 kg NPSB blended fertilizer ha-1 planted at Libso, but the lowest number of umbels per plant (4) was found from variety Nafis at 30.5 kg NPSB blended fertilizer ha-1 planted at Kobo (Table 2).

Umbel diameter:

Umbel diameter was highly ($P < 0.0001$) influenced by the main effects of location, variety, NPSB blended fertilizer rate, and interaction effects of variety by NPSB blended fertilizer rate. The maximum umbel diameter (7.4 cm) was recorded from both Bombay red and Nafis onion varieties with the application of 61 and 91.5 kg NPSB blended fertilizer ha-1, respectively, planted at Kobo. The lowest umbel diameter (6 cm) was recorded from the variety Bombay red at 30.5 kg NPSB blended fertilizer ha-1 planted at Libso (Table 2).

Number of seeds per umbel:

Number of seeds per umbel was highly significantly ($p < 0.01$) influenced by interaction effects of location by variety by NPSB blended fertilizer rate. The highest number of seeds per

umbel (1577) was recorded from variety Nafis with the combination of 122 kg NPSB blended fertilizer ha-1 planted at Kobo, whereas the lowest (822) was recorded from variety Bombay red without application of NPSB blended fertilizer planted in the same location (Table 3).

Seed weight per umbel:

Except main effects of variety, all other main and interaction effects significantly ($p < 0.0001$) affected seed weight per umbel. The maximum seed weight per umbel (6.4 g) was recorded from variety Nafis with the application of 152.5 kg NPSB blended fertilizer rate planted at Kobo while the least seed weight per umbel (2.8 g) was obtained from the variety Nafis without application of NPSB blended fertilizer planted at Libso (Table 3).

Seed yield:

The two-way interaction effects significantly ($p < 0.001$) influenced seed yield tonne ha-1. The highest seed yield 2.3 t ha-1 was recorded from variety Bombay red with the application of 183 kg ha-1 NPSB blended fertilizer rate planted at Kobo. However, the lowest seed yield 0.5 t ha-1 was obtained from variety Nafis without application of NPSB fertilizer planted at Libso (Table 3).

Germination percentage:

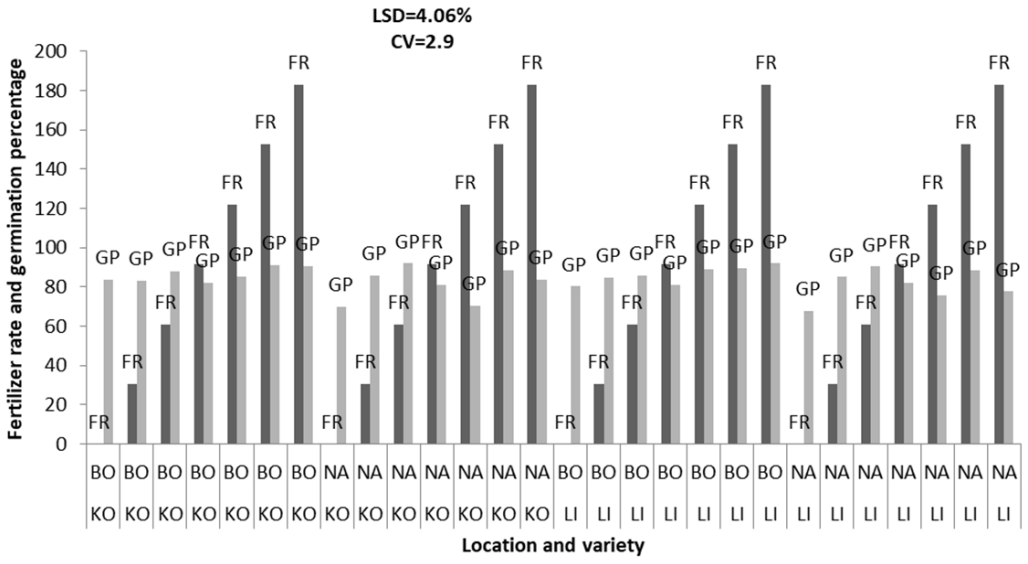
Main effects of variety, NPSB blended fertilizer rate and interaction effects of variety by NPSB blended fertilizer rate strongly ($p < 0.0001$) affected germination percentage. The maximum germination percentage (92%) was recorded from both Nafis and Bombay red varieties with the application of 61 and 183 kg NPSB blended fertilizer rates planted at Kobo and Libso, respectively while the lowest values of germination percentage (67.6%) were attained from variety Nafis without application of NPSB blended fertilizer planted at Libso (Fig. 1).

Seed vigor index I and II:

Main effects of NPSB blended fertilizer and interaction effects of variety by fertilizer rate strongly ($p < 0.001$) affected seed vigor index I. The maximum seed vigor index I (926.7) was recorded from variety Bombay red with the application rate of 61 kg NPSB blended fertilizer planted at Kobo and the lowest seed vigor index I (618) was recorded from variety Nafis without application of NPSB blended fertilizer planted at Libso (Table 3). Both main and interaction effects strongly($p < 0.0001$) influenced seed vigor index II. The highest value of seed vigor index (18.1) was recorded from variety Nafis with the application of 61 kg NPSB blended fertilizer rate planted at Libso while the lowest seed vigor index (7.5) was obtained from the same variety and location at 122 kg NPSB blended fertilizer rate (Table 3).

Partial budget analysis:

The partial budget analysis was executed using the CIMMYT (1988) description and guidelines for economic analysis of fertilizer application. As the rate of NPSB blended fertilizer application increased, each additional kilogram of the fertilizer had an effect on seed yield. To estimate the total costs, the mean current prices of NPSB blended



KO: Kobo, LI: Libso, BO:Bombay red, NA:Nafis, FR: fertilizer rate, GP: germination percentage

Fig. 1: Effects of blended fertilizer rate and varieties on onion seed germination percentage

Table 4: Partial budget analysis of the effects of location, blended fertilizer rate and onion varieties

Location	Variety	NPSB (kg h^{-1})	ASY (t ha^{-1})	GFB (birr ha^{-1})	TVC (birr ha^{-1})	NB (birr ha^{-1})	MRR%
Kobo	Bombay red	0	1.17	1053000	0	1053000	-
	Nafis	0	0.72	648000	0	648000	D
	Bombay red	30.5	1.53	1377000	838.75	1376161.25	38528.91
	Nafis	30.5	1.08	972000	838.75	971161.25	D
	Bombay red	61	1.62	1458000	1677.5	1456322.5	9557.23
	Nafis	61	1.35	1215000	1677.5	1213322.5	D
	Bombay red	91.5	1.53	1377000	2516.25	1374483.75	D
	Nafis	91.5	1.35	1215000	2516.25	1212483.75	D
	Bombay red	122	1.62	1458000	3355	1454645	D
	Nafis	122	1.44	1296000	3355	1292645	D
	Bombay red	152.5	1.62	1458000	4193.75	1453806.25	D
	Nafis	152.5	1.35	1215000	4193.75	1210806.25	D
	Bombay red	183	2.07	1863000	5032.5	1857967.5	11971.5
	Nafis	183	1.62	1458000	5032.5	1452967.5	D
Libso	Bombay red	0	1.26	1134000	0	1134000	-
	Nafis	0	0.45	405000	0	405000	D
	Bombay red	30.5	1.53	1377000	838.75	1376161.25	28871.68
	Nafis	30.5	0.81	729000	838.75	728161.25	D
	Bombay red	61	1.53	1377000	1677.5	1375322.5	D
	Nafis	61	1.26	1134000	1677.5	1132322.5	D
	Bombay red	91.5	1.44	1296000	2516.25	1293483.75	D
	Nafis	91.5	1.26	1134000	2516.25	1131483.75	D
	Bombay red	122	1.53	1377000	3355	1373645	D
	Nafis	122	1.35	1215000	3355	1211645	D
	Bombay red	152.5	1.53	1377000	4193.75	1372806.25	D
	Nafis	152.5	1.44	1296000	4193.75	1291806.25	D
	Bombay red	183	1.89	1701000	5032.5	1695967.5	7625.782
	Nafis	183	1.44	1296000	5032.5	1290967.5	D

ASY: Adjusted seed yield tonne ha^{-1}, GFB: Gross field benefit, TVC: Total variable cost, NB: Net benefit, MRR: marginal rate of return (%), D: dominated treatment

fertilizer and urea were collected at the time of planting and the market price of onion seed was taken at harvest. The partial budget analysis revealed that variety Bombay red planted at Kobo with the application of 183 kg NPSB ha-1 gave the maximum net benefit of 1,857,967.5 ETB ha-1 with a marginal rate of return of 11,971.5%. In the case of Libso, Bombay red planted with the application of 183 kg NPSB ha-1 gave the maximum net benefit of 1,695,967.5 ETB ha-1 with a marginal rate of return of 7,625.782% (Table 4).

DISCUSSION

The results of the present study indicated that onion varieties and NPSB blended fertilizer rates affected plant height. This might be due to genetic differences between the two onion varieties and the different application rates of NPSB blended fertilizer. Increasing fertilizer from zero to 61 NPSB kg ha-1 resulted in increased plant height on variety Nafis at both locations whereas, further increases in fertilizers above those described levels decreased the height of the plants. The current study is in line with the findings of Amare et al. (2020) who reported that application of fertilizer from zero to 115 P2O5 and 114 N kg ha-1 resulted in the increased height of plant. However, further increases in fertilizers above those described levels decrease the height of the plants. Birhanu (2016) reported that an increase in nitrogen fertilization from the control increased the height of the plant up to the certain stage at which the growth ceased or decreased due to the toxicity of the fertilizer.

The difference in flower stalks per plant was observed to be due to varietal differences rather than the application of NPSB blended fertilizer. This finding is in agreement with the report of Amare et al. (2020) 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.

The difference in days to fifty percent bolting might be due to variety and fertilizer rate differences. Increased NPSB fertilization prolongs the period of vegetative growth. The current finding is in line with Limeneh et al. (2019) who reported that the earliest bolting was after 50 days and the last was up to 56.67 days on average and the combination of higher rate of N with the lower rates of P fertilizers delayed days to bolting, but

the lower rates of N to the higher rates of P shortened bolting time. Sorensen & Grevsen (2010) also showed that too much nitrogen promoted excessive vegetative growth and delayed bolting and maturity of onion seed.

The number of umbels per plant was more dependent on the varietal differences than fertilizer rate differences. However, the combination of variety and fertilizer rate created the differences of umbel in diameter per plant. Debashis et al. (2017) reported that an increase in nitrogen fertilization increased the number of umbels and flower stalks per plant. Number of umbels was the most important trait for onion seed yield (Prats et al., 1996). The difference in umbel diameter might be due to the fact that flower setting and seed formation are highly controlled by phosphorous and the application of nitrogen increased the vegetative growth, produced good quality foliage and promotes carbohydrate synthesis, thereby producing larger umbel diameters. According to Ali et al. (2007), phosphorous and nitrogen fertilization had a significant effect on umbel diameter.

The highest number of seeds per umbel was obtained from optimum fertilization and the lowest number was from no application of fertilizer. This might be due to the role of nitrogen in the reduction of flower abortion and the effect of phosphorus on flower and seed production. Ali et al. (2007) also reported that the highest number of seeds per umbel was recorded from 150 N kg ha-1 and the lowest from the control.

Difference in seed weight per umbel might be due to the application rates of NPSB blended fertilizer rates and the environmental conditions of the two locations. Amare et al. (2020) found that the lowest seed weight per umbel was recorded from the plants that were grown under zero NP fertilizer application. High seed weight per umbel under high NP fertilizers might be due to the role of nitrogen in the buildup of carbohydrate and different metabolites and the role of phosphorus in seed formation and development (Marschner, 1995).

The seed yield difference might be due to the application of different rates of NPSB blended fertilizer and genetic differences of the onion varieties. According to Amare et al. (2020), the highest seed yield was obtained from the rate of fertilizer 115 P 2O5 and 114 N kg ha-1 and the lowest seed yield per hectare was recorded from plants that did not receive fertilizer.

The lowest germination percentage was recorded from seeds that did not receive the application of NPSB blended fertilizer. This indicates that fertilization application affects the quality of onion seeds. Ahmed & Abdella (1984) reported that phosphorus and nitrogen fertilization had a significant effect on seed germination percentage, in which higher germination percentage was most frequently recorded from the higher fertilizer application. Seed germination percentage of 90-94% is considered as highest and 70% as a minimum germination requirement for most onion cultivars under the Ethiopian condition (Lemma & Shimeles, 2003). Based on these criteria, the germination percentage of 92% recorded from Bombay red variety and 183 kg/ha NPSB rate in the current experiment is found to be highest.

The difference in seed vigor index I might be due to the fact that in large seeds, there is more food reserve in the cotyledon to sustain longer and more vigorous seedling growth than in smaller seeds, the smaller food reserve may be exhausted sooner. The present finding is in agreement with Amare et al. (2020) who reported that the highest seedling vigor index I (947.2) was obtained from 115 P2O5 and 114 N kg ha-1 and the lowest (102.3) seedling vigor index I was recorded for seeds that did not receive fertilizer. In addition, Ashenafi et al. (2014) indicated that the higher seed vigor index I was recorded from plants that were grown with optimum fertilization. Regarding seed vigor index II, the results of the current study agreed with Amare et al. (2020) who reported that the maximum seed vigor index II (46.73) was recorded from 115 P2O5 and 114 N kg ha-1 fertilizers. Whereas, the lowest vigor index II (9.2) was obtained from a lack of fertilizer application. Ashenafi et al. (2014) showed that optimum fertilizer application produced large sized seeds and a high seed vigor index II.

The highest economic benefit might be due to the highest seed yield produced by the Bombay red variety at the rate of 183 kg NPSB ha-1. The results revealed that the use of the Bombay red variety with the application of 183 kg NPSB blended fertilizer kg ha-1 was the most economically feasible treatment.

In conclusion, the investigation revealed that different parameters responded well to blended NPSB fertilizer rates on two onion varieties at the two locations. The application of 183 kg ha-1 NPSB blended fertilizer rate increased onion seed yield by 76.9% compared to the non-application of blended fertilizer on the variety Bombay red. Application of 183 kg ha-1 NPSB blended fertilizer rate also increased the germination percentage by 36% compared to the non-application of NPSB blended fertilizer. The partial budget analysis showed that variety Bombay red with the application of 183 kg NPSB ha-1 gave a maximum net benefit of 1,857,967.5 ETB ha-1 with a marginal rate of return of 11,971.5% at Kobo. In addition, at Libso a maximum net benefit of 1,695,967.5 ETB ha-1 with a marginal rate of

return of 7,625.782 % was recorded from the Bombay red variety with application of 183 kg NPSB ha-1. Therefore, for better yield and quality of onion seed production variety Bombay red with 183 kg NPSB fertilizer ha-1 is recommended in the study areas.

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