Effect of Blended Npsbzn Fertilizer Rates on Growth and Quality of Tomatoes (Solanumlycopersicum L) Varieties At Hawassa, Southern Ethiopia

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Abstract
Use of balanced fertilizer and appropriate varieties recommendation are important agronomic practices used to increase the growth and quality of tomato. Hence, field experiment was taken place to assess the effect of NPSBZn fertilizer rates on growth and quality of tomato varieties. The treatments consisted of seven levels of NPSBZn (0, 50, 100, 150, 200, 250, and 300 kg ha−1) and three tomato varieties (ARP tomato d2, Cochoro and melkashola). The experiment was laid out in randomized complete block design in factorial arrangement with three replications, all of the plots were supplemented uniformly with 46 kg N ha−1 in the form of urea. All phenological traits were significantly affected by the main effect of variety. However, only days to 50% fruiting and 50% maturity were affected by the main effect of NPSBZn rate. Variety and NPSBZn rate interacted to influence significantly only days to 50% flowering. Furthermore, the main effect of NPSBZn rate had significant influence on number of branches, plant height at different stage and number of clusters per plant. The main effect of variety had significant influence on all growth parameters. All fruit quality traits were influenced by the main effects variety but not main effect of NPSBZn rate. However, fruit pericarp thickness was influenced by the interaction effect of variety and NPSBZn rate. Therefore, study recommends that the experiment has to be repeated over seasons and locations by using other improved tomato varieties to make a convincing recommendation.

Keywords: ARP tomato d2; cochoro; melkashola; NPSBZn fertilizer; quality; tomato

1. Introduction
Tomato (SolanumlycopersicumL.) is Solanaceae family (Naika et al., 2005) it’s originated in the South American Andes now encompassed by part of Chile, Colombia, Bolivia, Ecuador and Peru (Salunkhe et al., 1987; Bai and Lindhout, 2007). The first domestication and cultivation of tomato was in Mexico (Tigchelaar et al., 1986). Tomato is ranking first in the world for vegetables, and it’s the fourth most economically important crop in the world: after rice, wheat, and soybean (FAO, 2015). The introduction of cultivated tomato into Ethiopian agriculture dates back to the period between 1935 and 1940 (Samuel et al., 2009; Gemechis, et al., 2012). But Tomato was recognized as a commodity crop starting 1966 when the establishment of Ethiopian Institute of Agricultural Research (EIAR) (Roseboom et al., 1994). The crop is grown between 700 and 2000 m as.1. with about 700 to over 1400 mm annual rain fall, in different areas, seasons, and soils under different weather conditions, and at different levels of technology (Ambbecha et al., 2006; Birhanu and Ketema, 2010).

Tomato production in Ethiopia was about 22,788 tons from harvested area of 3,677 ha (CSA, 2015). Tomatoes need about 84 to 112 kg N ha−1 and moderate to high levels of phosphorus (P) and potassium (K) for maximum yields (Ren et al., 2010). Nitrogen has significant effect on growth and quality of tomato (Bose and Som, 1990). Optimum level of phosphorus application increases the vegetative growth of tomato (Rahman et al., 1996). Boron is another important element for tomato as fruit vegetable. A positive correlation was observed between boron and flower bud, number of flowers and weight of fruit in tomato (Bose et al., 2002). Sulphur is also closely associated with N in the process of protein and enzyme synthesis (Hell K et al., 1997). Zinc is the only metal present in six enzyme classes that have important functions in plants (Auld, 2001).
Growers have been challenged by inconsistent production and low yields. Lack of appropriate management practices are among the major factors that influence productivity of tomato under farmer’s condition in Ethiopia; farmers get lower yield mainly due to inappropriate use of fertilizer (Tesfaye, 2008; Ambbecha et al., 2012). The national average tomato yield is very low as compared to the potential yield (43–49 t ha⁻¹) obtained under research conditions. This is due to narrow genetic basis of tomato varieties, poor seed quality, susceptibility to diseases and poor farmers” management practices including soil fertility and nutrient management problems (Haverkort et al., 2012).

In Ethiopia, however, only Di Ammonium Phosphate (DAP) and Urea fertilizers as source of 92 kg P₂O₅and46 kg N ha⁻¹, respectively (Lemma, 2002). Soil fertility status varies considerably with different ecological zones. In fact, even in the same zone, there are micro- differences in soil characteristics (Adekiy et al., 2009). Therefore, the types and rates of fertilizers for any crop production are determined for specific growing areas, because economically feasible fertilizer rate varies with soil type, fertility status, moisture content, other climatic variables, variety, crop rotation, and crop management practices (Smith et al., 1977).

Moreover, the soils around Hawassa were identified deficient not only nitrogen and phosphorous but also sulfur, boron and zinc (EthioSIS, 2016). Ministry of Agriculture of Ethiopia has recently introduced a new blended NPSBZn fertilizer as a substitute of DAP in crop production system around Hawassa (EthioSIS, 2013). However, the rate of blended NPSBZn fertilizer for growth and quality of tomato varieties has not been studied. This research, therefore, initiated to achieve the following objectives to assess the effect of blended NPSBZn fertilizer on growth and quality of tomato varieties.

2. Methodology:
2.1 Description of study area:

Field experiment was conducted at Hawasa, Sidama regional state of southern Ethiopia during main crop growing season (July–November) 2018. The site is located at Hawasa in SNNPR of Ethiopia about 273 km south of the capital Addis Ababa. Latitude 70 4’ N longitude 38 0 31’E at an altitude of 1700 m above sea level with an average rain fall of 900–1100 mm. Its annual minimum and maximum temperatures are 12 and 27°C, respectively. Hawassa area has sandy loam soil with a pH of 7.9 and according to FAO soil classification, its volcanic origin and described as fluvisol.

2.2 Experimental Materials:
2.2.1. Plant material:

Three tomato varieties (ARP tomato d2, Cochoro and melkashola) were used as planting material. The varieties were selected on the basis of their adaptation, better performance and resistance to disease such as yellow rust, stem rust and leaf rust in the study area.

2.2.2. Fertilizer materials:

Urea (46% N) and NPSBZn (16.9% N, 33.8% P₂O₅, 7.3% S, 0.67%B, and 2.23%Zn) were used as the sources of fertilizer.

2.3. Treatments and Experimental Design:

The treatments consisted of factorial combination of three tomato varieties (ARP tomato d2, Cochoro and melkashola) and seven levels of NPSBZn (0, 50, 100, 150, 200, 250, 300 kg ha⁻¹) fertilizer. In addition to the NPSBZn rates, 46 kg N ha⁻¹ was applied to all the plots uniformly. The experiment was laid out in a randomized complete block design (RCBD) with three replications in factorial arrangement of 7 × 3 = 21 treatment combinations. The gross size of each plot was 3.5 m × 1.5 m (5.25 m²) consisting of five rows and the distance between adjacent plots and blocks were 0.7 m and 1 m apart, respectively. The outermost one row on both sides of each plot and 0.21 cm on both sides of each row were considered as border plants, and not used for data collection to avoid border effects. Thus, the net plot was 2.1 m × 0.9 m (1.89 m²) consisted of three rows of 0.9 m length. The details of the treatment combinations and their nutrient contents are shown in (Table 1).

Table 1: Rate of blended fertilizer and nutrient content kg ha⁻¹

<table>
<thead>
<tr>
<th>Variety</th>
<th>Rate of blended fertilizer and nutrient content kg ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (kg ha⁻¹)</td>
</tr>
<tr>
<td>Melkashola</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>54.45</td>
</tr>
<tr>
<td>100</td>
<td>62.9</td>
</tr>
<tr>
<td>150</td>
<td>71.35</td>
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<tr>
<td>200</td>
<td>79.8</td>
</tr>
<tr>
<td>250</td>
<td>88.25</td>
</tr>
<tr>
<td>300</td>
<td>96.7</td>
</tr>
<tr>
<td>Cochoro</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>54.45</td>
</tr>
<tr>
<td>100</td>
<td>62.9</td>
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<tr>
<td>150</td>
<td>71.35</td>
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<tr>
<td>200</td>
<td>79.8</td>
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<tr>
<td>250</td>
<td>88.25</td>
</tr>
<tr>
<td>300</td>
<td>96.7</td>
</tr>
<tr>
<td>ARP Tomato d2</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>54.45</td>
</tr>
<tr>
<td>100</td>
<td>62.9</td>
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<tr>
<td>150</td>
<td>71.35</td>
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<tr>
<td>200</td>
<td>79.8</td>
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<tr>
<td>250</td>
<td>88.25</td>
</tr>
<tr>
<td>300</td>
<td>96.7</td>
</tr>
</tbody>
</table>

Table 1: Rate of blended fertilizer and nutrient content kg ha⁻¹

2.3. Experimental Procedures:

The experimental field was ploughed with tractor and the plots were prepared to avoid cobbles, leveled properly and furrows were made manually in such a way that it allows proper furrow irrigation. According to design a field layout was made and each treatment was assigned randomly to the experimental units
within block. Seedlings of three tomato varieties melkashola, Cochoro and ARP tomato d2 varieties was raised in well prepared seed bed nursery with a better management to facilitate the uprooting and subsequent good field establishment of seedling. Hence, seedlings were transplanted to the field experimental plots when they were about 35 days old. Irrigation was applied every two days to bring the soil moisture content to field capacity uniformly for all treatments during the whole growing season. All the rates of NPSBZn fertilizer as per the treatment was applied at planting time while the recommended 150 kg ha⁻¹ Urea was applied in split application (50% at planting and the remaining 50% 45 days after transplanting) uniformly on all plots. All other agronomic practices were followed as per the recommendation for the crop.

2.4. Cultural Practices:

Cultural practices such as weeding, hoeing, watering, staking, disease and pest control were applied uniformly for all treatments in order to produce healthy and strong seedlings. During the course of the study, fungicide (Ridomil MZ 68 WP) was applied at two weeks interval to control late blight, leaf blight, and bacterial disease since the incidence was observed.

2.5. Data Collected:

2.5.1. Crop phonology:

Days to 50% flowering: were recorded as the number of days from transplanting to the time when 50% of plants in each plot set flowers.

Days to 50% fruiting: were recorded as the number of days from the date of transplanting to date when 50% of plants in each plot bear fruit.

Days to 50% maturity: were recorded as the numbers of days from the date of transplanting to the date when 50% of the plants in each plot had physiologically mature fruits.

2.5.2. Growth parameters:

Plant height: The plant height was measured from the ground level to the tip of upper most part of the main stem at 50% flowering stage, at 50% fruiting stage

Number of primary branches: Number of branches extended from the main stem were counted and recorded on nine randomly selected plants at flowering stage from each plot.

Number of secondary branches: Number of branches extended from primary branches was counted and recorded nine randomly selected plants at flowering stages from each plot.

Number of clusters per plant: this was recorded by counting the total number of clusters per plant from nine randomly selected plants at full maturity.

Number of flowers per cluster (FIC): this was recorded by counting the total number of flowers per cluster from nine randomly selected clusters at bloom.

Number of fruits per cluster was recorded by counting the total number of fruits per cluster from nine randomly selected plants at red ripening stage of the fruit.

Fruit set percentage (FSP): this was determined by counting the number of mature fruits developed on flower clusters counted for number of flowers per cluster that is calculated as follows:

\[
FSP = \frac{FrC}{\#FlC} \times 100
\]

Where: FrP = Number of fruits per cluster and FlC = Number of flowers per cluster

2.6.3 Fruit Physical and Chemical Quality Attributes:

1. Physical quality attributes:

Mean pericarp thickness (mm): It was recorded from ten randomly selected fruits by cutting the cross section of a fruit and measuring the pericarp thickness using a caliper.

2. Chemical quality attributes:

Total soluble solids (TSS) (0Brix): The total soluble solid was determined following the procedure described by (Acedo et al., 2008). Aliquot of juice was extracted using High Performance Commercial Blender. A Palette digital refractometer ATAGO® PR-32α with a range of 0–32% was used to determine the TSS by placing two drops of clear juice on the prism. Between samples, the prism of the refractometer was washed with distilled water and dried with tissue paper before it is used for another reading. The refractometer was calibrated against distilled water at 0 percent TSS.

PH: Aliquot of clear juice filtered with cheesecloth was used for pH measurement and the pH value of each plot tomato juice was measured by a pH meter with a model of AD1020 pH/mv/ISE and to meter calibrated with standard pH buffer 4 and 7.

Titratable acidity: Extracted tomato juice was filtered through cheesecloth and decants clear juice were used for titration. Ten ml of the tomato juice sample was titrated gradually with 0.1N NaOH using burette to pink end point (persisted for 15 seconds). Titratable acidity was expressed as percent citric acid using the formula.

\[
TA(\%) = \frac{\text{Titre} \times 0.1 \text{N NaOH} \times 0.64}{1000} \times 100
\]

Where: titre is the volume of tomato juice and 0.1N is the amount of NaOH used to neutralize0.64 g of citric acid and 0.64 is the conversion factor.

Sugar to acid ratio (SAR): It was calculated by dividing the value of total soluble solids to the value of titratable acidity.
3. Result and Discussion:

3.1. Crop Phenology:

Results of analysis of variance revealed that variety had significant effect on days to 50% flowering, days to 50% fruiting, days to 50% maturity and number of harvest while blended NPSBZn fertilizer had significant effect on days to 50% flowering, days to 50% fruiting and days to 50% maturity. Blended NPSBZn fertilizer and variety interacted to influence significantly only days to 50% flowering (Appendix Table 1).

3.1.1. Days to 50% flowering:

The treatment combination of Melkashola variety and 300 kg ha$^{-1}$ NPSBZn fertilizer significantly delayed with delayed days to flowering (44.67 days) while combination of ARP tomato d2 and without fertilizer application showed significantly early flowering (31 days). The combination of Melkashola variety with 150, 200 and 250 kg ha$^{-1}$ NPSBZn fertilizer also had significantly longer days to flowering than other treatment combinations. All treatment combination of varieties and rates of NPSBZn fertilizer delayed days to flowering as compared to all varieties grown without fertilizer application. The delayed days to flowering intensified as the rates of NPSBZn fertilizer increased with all varieties combinations (Table 3). The increase in days to flowering of tomato varieties at the highest rate of NPSBZn might be attributed to the extension of the plants reproductive growth in response to the adequate and/or abundant supply of nutrients. The availability of N increased from 50 to 300 kg ha$^{-1}$ NPSBZn fertilizer and N promote vegetative growth and probably delayed reproductive growth by decreasing sink strength of flowers relative to vegetative tissues. Boron also plays perhaps an important role in flowering and fruit formation of tomato (Nonnecke, 1989, Nazet al., 2012). Sainjuet al. (2003) reported that high N level in the soil promoted excessive vegetative growth which delayed fruit setting and maturity in tomato. The earliness to flowering, fruiting and maturity in control plot might be that the plants were under stress and forced to complete their life cycle as shortest period of time for survival. Other workers also suggested that earliness in tomato might be due to nutrient stress (Naidu et al., 2002; Prativa and Bhattarai, 2011; Biramo, 2017). Higher rates of nitrogen and potash fertilizers delayed the fruiting development in tomatos (Jacques et al., 2013; Yeboahet al., 2014; Zhang et al., 2014).

Melkashola had significantly delayed 50% flowering of 69.52 days after planting and days to 50% maturity of 99.1 days after planting. Cochoro variety had significantly delayed flowering and maturity than the earliest variety ARP tomato d2 (Table 4). Melkashola had delayed 50% flowering and maturity by about 16 and 32.39 days than ARP tomato d2. The differences of fruit setting and maturity among varieties may be due to the inherent characteristic’s differences of varieties for maturity. The maturity of 75-80, 85-90 and 100-120 days were registered for the variety ARP tomato d2, Cochoro and Melkashola, respectively (MoA, 1998-2014). Other workers also observed significant differences among tomato varieties in Ethiopia (Jiregnaet al., 2017; Fisha, 2014; Habtamu et al., 2016). Lohar and Peat (1998) reported that the delay in flowering can correspondingly lead to the delay of fruit maturity in tomato. Furthermore, according to Fayazet al. (2007) the early or late maturity is attributed by genotypic character and in the extent influenced by the environmental factors of any particular growing area.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Variety</th>
<th>Days to 50% flowering</th>
<th>Days to 50% fruiting</th>
<th>Days to 50% maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPSBZn (kg ha$^{-1}$)</td>
<td>ARP tomato d2</td>
<td>Melkashola</td>
<td>AR</td>
<td>Cochoro</td>
</tr>
<tr>
<td>0</td>
<td>33$^{n}$</td>
<td>33.67&lt;sub&gt;$^{mn}$&lt;/sub&gt;</td>
<td>36.67&lt;sub&gt;$^{gh}$&lt;/sub&gt;</td>
<td>44.67&lt;sub&gt;$^{+}$&lt;/sub&gt;</td>
</tr>
<tr>
<td>50</td>
<td>33.67&lt;sub&gt;$^{mn}$&lt;/sub&gt;</td>
<td>36.67&lt;sub&gt;$^{gh}$&lt;/sub&gt;</td>
<td>40.33&lt;sub&gt;$^{d}$&lt;/sub&gt;</td>
<td>42&lt;sub&gt;$^{e}$&lt;/sub&gt;</td>
</tr>
<tr>
<td>100</td>
<td>33.67&lt;sub&gt;$^{mn}$&lt;/sub&gt;</td>
<td>36.67&lt;sub&gt;$^{gh}$&lt;/sub&gt;</td>
<td>40.33&lt;sub&gt;$^{d}$&lt;/sub&gt;</td>
<td>42&lt;sub&gt;$^{e}$&lt;/sub&gt;</td>
</tr>
<tr>
<td>150</td>
<td>33.67&lt;sub&gt;$^{mn}$&lt;/sub&gt;</td>
<td>36.67&lt;sub&gt;$^{gh}$&lt;/sub&gt;</td>
<td>40.33&lt;sub&gt;$^{d}$&lt;/sub&gt;</td>
<td>42&lt;sub&gt;$^{e}$&lt;/sub&gt;</td>
</tr>
<tr>
<td>200</td>
<td>33.67&lt;sub&gt;$^{mn}$&lt;/sub&gt;</td>
<td>36.67&lt;sub&gt;$^{gh}$&lt;/sub&gt;</td>
<td>40.33&lt;sub&gt;$^{d}$&lt;/sub&gt;</td>
<td>42&lt;sub&gt;$^{e}$&lt;/sub&gt;</td>
</tr>
<tr>
<td>250</td>
<td>33.67&lt;sub&gt;$^{mn}$&lt;/sub&gt;</td>
<td>36.67&lt;sub&gt;$^{gh}$&lt;/sub&gt;</td>
<td>40.33&lt;sub&gt;$^{d}$&lt;/sub&gt;</td>
<td>42&lt;sub&gt;$^{e}$&lt;/sub&gt;</td>
</tr>
<tr>
<td>300</td>
<td>33.67&lt;sub&gt;$^{mn}$&lt;/sub&gt;</td>
<td>36.67&lt;sub&gt;$^{gh}$&lt;/sub&gt;</td>
<td>40.33&lt;sub&gt;$^{d}$&lt;/sub&gt;</td>
<td>42&lt;sub&gt;$^{e}$&lt;/sub&gt;</td>
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<tr>
<td>LSD (0.05)</td>
<td>1.29</td>
<td>1.29</td>
<td>1.29</td>
<td>1.29</td>
</tr>
</tbody>
</table>

Table 2: Interaction effect of NPSBZn fertilizer and variety on days to 50% flowering of tomato at Hawassa in 2018/2019.
3.1. Growth of Tomato Varieties:

Numbers of primary and secondary branches were significantly influenced by the application of blended NPSBZn fertilizer while plant height at different stages was significantly influenced by the application of blended NPSBZn fertilizer and varieties. However, the interaction of blended NPSBZn fertilizer and variety had non-significant effect on difference number of branches and height of plants at different stages of the crop (Appendix Table 1).

3.1.1. Number of branches and plant height:

The tomato varieties had the highest number of primary (6.597) and secondary (23.38) branches in a plot which received 300 kg ha⁻¹ NPSBZn fertilizer and the application of 250 kg ha⁻¹ NPSBZn fertilizer also produced higher number of primary and secondary branches than the application of 50 to 200 kg ha⁻¹ NPSBZn fertilizer. The tomato varieties produced lowest number of primary and secondary branches when grown without fertilizer (Table 5). The higher number of branches produced due to the application of fertilizer might attributed to possible supplies of balanced plant nutrients to the soil from combination of inorganic fertilizers that might promoted the lateral shoot growing of the plant. The superiority observed due to the combined application of inorganic nutrient sources compared to the control may be due to direct promotion of root growth (Glala et al., 2010) and the release of the fixed nutrients, hence increasing the concentration and availability of nutrients in the root zone and increase plant growth and development (Okon and Vanderleyden, 1997). Alabi (2006) also observed significantly increased number of branches in response to increasing the levels of both P₂O₅ and poultry droppings when compared to the control plots. Abdalla et al. (2001), Glala et al. (2010) and Glala et al. (2012) also reported similar results in pepper plants.

Table 3: Effects of NPSBZn fertilizer and variety on days to flowering and maturity of tomato at Hawassa in 2018/2019.

<table>
<thead>
<tr>
<th>Variety</th>
<th>LSD (0.05)</th>
<th>2.61</th>
<th>2.572</th>
</tr>
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<tbody>
<tr>
<td>ARP tomato d2</td>
<td>53.33③</td>
<td>66.71③</td>
<td></td>
</tr>
<tr>
<td>Cochoro</td>
<td>57.33③</td>
<td>80.52③</td>
<td></td>
</tr>
<tr>
<td>Melkashola</td>
<td>69.52③</td>
<td>99.1③</td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>1.709</td>
<td>1.684</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>4.6</td>
<td>3.3</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Mean squares of ANOVA for phenological, growth yield components and quality traits of three tomato varieties as influenced by rates of blended NPSBZn fertilizer at Hawassa in 2018/2019 cropping season.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Growthtrait</th>
<th>NPSBZnrate(kg ha⁻¹)</th>
<th>NPB</th>
<th>NSB</th>
<th>PHFl (cm)</th>
<th>PHFr (cm)</th>
<th>PHFst H (cm)</th>
<th>PHFnIH (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.43 6c</td>
<td>35.8 2e</td>
<td>48.12f</td>
<td>53.76e</td>
<td>60.43f</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>5.79 6c</td>
<td>37.4 5e</td>
<td>49.54ef</td>
<td>55.82d</td>
<td>62ef</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>5.74 2b</td>
<td>38.9 9c</td>
<td>51.12e</td>
<td>57.07c</td>
<td>63.11de</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>5.84 7b</td>
<td>40.6 3bc</td>
<td>53.37ed</td>
<td>59.26c</td>
<td>64.65cd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>5.80 6b</td>
<td>41.4 1b</td>
<td>57.25ab</td>
<td>61.96a</td>
<td>67.91ab</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>6.08 7a</td>
<td>44.5 7a</td>
<td>57.7a</td>
<td>63.56a</td>
<td>68.84a</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>300</td>
<td>6.59 7a</td>
<td>42.8 2c</td>
<td>5.12</td>
<td>60.74a</td>
<td>66.49bc</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means with the same letter (s) in each column and each treatment had nonsignificant difference at 5% level of probability, NS= nonsignificant, CV (%) = Coefficient of variation, LSD (0.05) = Least Significant Difference at 5% level of probability.
Means with the same letter (s) in each column and each treatment had nonsignificant difference at 5% level of probability, NS= nonsignificant, CV (%) = Coefficient of variation, LSD (0.05) = Least Significant Difference at 5% level of probability. NPSBZn= number of primary branches, NSB= number of secondary branches, PHF= plant height at flowering, PHFr= plant height at fruiting, PHFstH= plant height at first harvest, PHFinH= plant height at final harvest. The tomato varieties supplied with 300kg ha⁻¹ NPSBZn fertilizer had tallest plants at flowering (44.57cm), fruiting (57.7cm), first harvest (63.56cm) and at final harvest (68.84 cm), however, the tomato varieties also had tall plants at the application of 250kg ha⁻¹ NPSBZn fertilizer with nonsignificant difference with the application of the highest rate of fertilizer. The shortest plants at all stages were observed in plots that did not receive fertilizer followed by in plots that received 50 kg ha⁻¹ NPSBZn fertilizer. It was observed that the height of plants increased as the rates of NPSBZn fertilizer increased (Table 5).

The observed improvement of plant height due to the application of organic and inorganic soil amendments might be by improving the soil physical, chemical and biological properties and leading to the adequate supply of nutrients to the plants which might have promoted the maximum vegetative growth. This might be because of the ability of nutrient to supply numerous plant nutrients and in creating suitable plant growing environment by improving moisture and nutrient condition of the soil which enhance growth and general performance of the plants. Due to the fact that nitrogen is an essential component of protein therefore a fundamental building material of the cells, as a constituent of all enzymes, which are specialized protein, nitrogen is involved in metabolic processes throughout the plant, as the result the plant grow vegetatively very well with added N fertilizer. In support of this, Gomez-Lepe and Ulrich (1974) and Atherton and Rudich (1986) indicated that plant vigor and growth generally increases with the supply of high amount of nutrients like nitrogen fertilizer.

The result of this experiment is in conformity with the findings of Gonzalez et al. (2001) who reported that organic manure and inorganic fertilizer supplied most of the essential nutrients at growth stage resulting in increase of growth variables including plant height. Corroborating the results of this study, Ojeniyiet al. (2007) also observed that NPK and animal manure significantly increased plant height in tomato compared to the control treatment. Plant height increment in response to the fertilization treatment may be attributed to stem elongation. Various studies conducted in Ethiopia reported that plant height increased as the amount of applied nutrients increased to the soil (Zewdu et. al., 1992; Mekonen, 1999). Samuel (1981) also reported that plant height measured increased significantly with increasing levels of nitrogen in wheat. Similarly, Johannes (1994) reported a significant increment in the height of Enset crops as the rates of N and P applications were increased. Melkashola had significantly tallest plant at flowering 48.9cm, fruiting 60.43cm, first harvest 64.91 cm and final harvest 69.85 cm and flowed by Cochoro and ARP tomato d2 (Table 3). The possible reason for this result could be due to the variation in genetic makeup or cell division rate that result in change in plant height of different varieties. The results of Abdul et al. (2014) who reported that tallness in wheat plants is mostly associated with the genetic makeup of the variety.

### 3.1.1. Number of cluster plant and fruit set percentage:

Number of clusters per plant was significantly influenced by NPSBZn fertilizer and variety but not the interaction of the two main factors, the fruit set percentage was significantly influenced by variety but not by NPSBZn fertilizer and the interaction of the two main factors whereas number of flowers per cluster neither influenced by the main factors nor the interaction of the two main factors (Appendix Table 1).

The application of 300 kg ha⁻¹ followed by 250 kg ha⁻¹ NPSBZn fertilizer significantly maximum number of cluster plant. The number of cluster plant in tomato increased as the rates of NPSBZn fertilizer increased and the plants in plots which did not receive fertilizer showed minimum number of cluster plant (Table 6).

The maximum number of clusters per plant might be due to the effects of P in promoting flower bud formation. The result supports the findings of Solaiman and Rabbani (2006) who found that number of clusters per plant ranged from 13.55 recorded in the control, to 23.48 recorded in treatment (200kg N + 35kg P₂O₅ +80kg K+ 15kg S ha⁻¹), which received the full dose of NPKS. Increase in the number of fruit clusters per plant led to increased total fruit yield of tomato due to positive correlation between the number of fruit cluster, and growth and yield parameters of tomato.

The application of boron in tomato increased the number of flower buds per plant and total number of fruits per plant than that of control (Suganiya et al., 2015). Similar results were reported by Meseret et al. (2012) that significant mean number of fruit cluster per plant was observed between varieties at Jimma. ARP tomato d2 variety had significantly maximum number of clusters per plant 20.73 and followed by Cochoro and melkashola variety 18.88, 18.2 respectively, statistically similar (Table 6). ARP tomato d2 had highest number of clusters per plant than Cochoro and melkashola. The observed difference in the production of clusters is probably due to the inherent potential of the varieties which was also indicated by the research results of Mohanty et al. (2001). The production of clusters is one of the major criteria in selecting tomato varieties and it determines the yielding potential of a variety (Pandey, 2006). Highest number of clusters per plant led to give highest total yield due to positive relationships between the number of cluster and yield traits. Similar results were reported by Meseret et al. (2012) that significant mean number of fruit cluster per plant was observed between varieties at Jimma.

Cochorohad highest fruit set percentage of 48.56% and followed by melkashola and ARP tomato d2 had 46.69 and 46.67 fruit set percentage respectively (Table 6). This is may be due to genetic makeup of varieties.
Table 6: Effects of NPSBZn fertilizer and variety on number of clusters, number of flower per cluster and fruit set of tomato at Hawassa in 2018/2019.

Means with the same letter(s) in the columns and rows are not significantly different at 5% level of significance, CV (%) = Coefficient of variation, LSD = Least Significant Difference at 5% level.

Summary and conclusion:

The study was carried out considering the Blended fertilizer on growth and quality of selected varieties of tomato in Hawassa of Ethiopia. The experiment field was conducted with three varieties namely (ARP tomato d2, Cochoro and melkashola). The treatments consisted of factorial combination of three tomato varieties (ARP tomato d2, Cochoro and melkashola). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The analysis of variance revealed that significant interaction of NPSBZn and variety on days to 50% flowering, while all other phenological traits were found to be non-significantly affected by the interaction effect of NPSBZn and variety.

The main effect of NPSBZn and variety was significant on days to 50% fruiting, days to 50% maturity, plant height at different stage and number of clusters per plant. Furthermore, the main effect of NPSBZn rate had significant influence on number of branches, plant height at different stage and number of clusters per plant. The main effect of variety had significant influence on number of flowers per cluster and number of clusters per plant. The variety had significant influence on plant height at different stage and number of clusters per plant. Furthermore, the main effect of NPSBZn rate had significant influence on number of clusters per plant. However, number of flower per cluster was influenced neither by the main effects of NPSBZn rate and variety nor by their interactions. Therefore it is recommended that the experiment has to be repeated over seasons and locations by using other improved tomato varieties to make a convincing recommendation.

References:


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