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Effect of Blended Npsbzn Fertilizer Rates on Growth and Quality of Tomatoes (SolanumLycopersicum L) VarietiesAt Hawassa, Southern Ethiopia

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Abstract

Use of balanced fertilizer and appropriate verities 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 lo cations by using other imprved tomato varieties to make a convincing recommendation.

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

1. Introduction

Tomato (SolanumlycopersicumL.) is Solanaceae family (Naikaet al., 2005) it"s originated in the South American Andes now encompassed by part of Chile, Colombia, Boliva, Ecuador and Peru (Salunkheet al., 1987; Bai and Lindhout, 2007). The first domestication and cultivation of tomato was in Mexico (Tigchelaaret 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) (Rose boom et al., 1994). The crop is grown between 700 and 2000 m.a.s.l. 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 (Ambechaet 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 (Renet 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 (Rahmanet 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 (Boseet 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; Ambechaet 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 (Haverkortet al., 2012).

In Ethiopia, however, only Di Ammonium Phosphate (DAP) and Urea fertilizers as source of 92 kg P_2O_5and46 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 (Adekiyaet 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 amount, 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 phosphorus but also sulfur, boron and zinc (EthioSIS, 2016). Ministry of Agriculture of Ethiopia has been 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.Methdology:

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 380 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 27ºC, 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% P_2O_5, 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 x 3 = 21 treatment combinations. The gross size of each plot was 3.5 m × 1.5 m (5.25 m^2) 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 m^2) consisted of three rows of 0.9 m length. The details of the treatment combinations and their nutrient contents are shown in (Table 1).

Variety	Rate of blended fertilizer and nutrient content kg ha-1					
	NPSB Zn	N (kg ha 1)	P2O5 (kg ha 1)	S (kg ha 1)	B (kg ha 1)	Zn (kg ha 1)
Melkashola	0	46	0	0	0	0
	50	54.45	16.9	3.65	0.335	1.115
	100	62.9	33.8	7.3	0.67	2.23
	150	71.35	50.7	10.95	1.005	3.345
	200	79.8	67.6	14.6	1.34	4.46
	250	88.25	84.5	18.25	1.675	5.575
	300	96.7	101.4	21.9	2.01	6.69
Cochoro	0	46	0	0	0	0
	50	54.45	16.9	3.65	0.335	1.115
	100	62.9	33.8	7.3	0.67	2.23
	150	71.35	50.7	10.95	1.005	3.345
	200	79.8	67.6	14.6	1.34	4.46
	250	88.25	84.5	18.25	1.675	5.575
	300	96.7	101.4	21.9	2.01	6.69
ARP Tomato d2	0	46	0	0	0	0
	50	54.45	16.9	3.65	0.335	1.115
	100	62.9	33.8	7.3	0.67	2.23
	150	71.35	50.7	10.95	1.005	3.345
	200	79.8	67.6	14.6	1.34	4.46
	250	88.25	84.5	18.25	1.675	5.575
	300	96.7	101.4	21.9	2.01	6.69

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 (FlC): 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:

$$FSP = \frac{FrC}{FlC} X100$$

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 (Acedoet al., 2008). Aliquot of juice was extracted using High Performance Commercial Blender. A Palette digital refractometer ATAGO® PR-32α with a range of °Brix 0 to 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.

$$TA (\%) = \frac{\text{Titre x 0. 1N NaOH x 0. 64}}{1000} X\ 100$$

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.

$$SAR = \frac{\begin{matrix}TS\\ S\end{matrix}}{TA}$$

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 (44.67days) while combination of ARP tomato d2 variety 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 flowering fruit setting and maturity in tomato. Farzaneh, et al. (2014) also observed higher fertilizer levels delayed the flowering of tomato, and Mercado et al. (2014) and Yeboahet al. (2014) reported that as the rates of nitrogen and potash proportionately increased the days to flowering.

Treatment		Variety	
NPSBZn(kg ha^{-1})	ARP tomato d2	Cochoro	Melkashola
0	31^{o}	33.67^{mn}	36ijk
50	33^{n}	35.33^{jkl}	37.67^{fg}
100	33.67^{mn}	35.67^{ijkl}	39.33^{de}
150	34.67^{lm}	36.67^{ghi}	40.33^{d}
200	35kl	37.33^{fgh}	42^{c}
250	36.33^{hij}	38.33^{ef}	43.33^{b}
300	36.67^{ghi}	39^{e}	44.67^{a}
LSD (0.05)	1.29		
CV (%)	2.1		

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

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

3.1.1. Days to fruiting, maturity and number of harvests:

The application of 300 kg ha^{-1} followed by 250 kg ha^{-1}NPSBZn fertilizer significantly delayed Days to50% fruiting and Days to50% maturity. The delayed fruiting and maturity in tomato increased as the rates of NPSBZn fertilizer and the plants in plots which did not receive fertilizer showed earliness 50% fruiting and maturity (Table 4). The delayed fruit setting and maturity may be due to the N in the blend plus from urea because N is known to extend vegetative growth and enhance photosynthetic activity of plants but delayed reproductive stage and maturity. Boand and Votava (2000) stated that excess application of nitrogen stimulates secondary growth and delays maturity.

Sainjuet al. (2003) who 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 tomatoes (Jacques et al., 2013; Yeboahet al., 2014; Zhang et al., 2014).

Melkashola had significantly delayed 50% fruiting of 69.52 days after planting and days to 50% maturity of 99.1days after planting. Cochoro variety had significantly delayed fruiting and maturity than the earliest variety ARP tomato d2 (Table 4). Melkashola had delayed50% fruiting 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 100-120days 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; Habtamuet 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.

Treatment		
NPSBZn rate (kg ha^{-1})	Days to50% fruiting	Days to50% maturity
0	55.11^{e}	75.22^{f}
50	56.67^{de}	78.67^{e}
100	58^{d}	80.67^{de}
150	61^{c}	81.67^{cd}
200	61.4^{4bc}	84.11^{bc}
250	64^{a}	85.78^{b}
300	64.22^{a}	88.67^{a}

LSD (0.05)	2.61	2.572
Variety		
ARP tomato d2	53.33^{c}	66.71^{c}
Cochoro	57.33^{b}	80.52^{b}
Melkashola	69.52^{a}	99.1^{a}
LSD (0.05)	1.709	1.684
CV (%)	4.6	3.3

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

Trait	Rep (2)	Variety (2)	Blended NPSBZn (6)	V x NPSBZn (12)	Error (40)	CV (%)
Days to 50% flowering	8.7778	202.9683**	47.3122**	1.5979**	0.6111	2.1
Days to 50% fruit setting	5.921	1493.587**	113.847**	12.624^{ns}	7.504	4.6
Days to 50% maturity	10.206	5544.4**	183.04**	9.926^{ns}	7.29	3.3
Number of primary branches	1.6503	0.5142^{ns}	1.1715**	0.2634^{ns}	0.2613	8.7
Number of secondary branches	1.5855	3.5363^{ns}	0.4613**	0.1822^{ns}	0.2995	2.5
Plant height at flowering (cm)	2.468	1143.519**	93.673**	3.864^{ns}	5.739	5.9
Plant height at fruiting (cm)	26.646	834.303**	125.201**	4.462^{ns}	6.45	4.8
Plant height at first harvest (cm)	30.95	589.81**	110.86**	2.21^{ns}	10.71	5.8
Plant height at final harvest (cm)	66.043	549.637**	88.102**	6.4^{ns}	4.845	3.4
Number of clusters per plant	6.136	36.14**	43.453**	1.132^{ns}	2.363	8
Number of flowers cluster[1]	3.484	0.2593^{ns}	0.9642^{ns}	0.3532^{ns}	0.4632	12.9
Fruit set percentage	18.618	26.810*	12.370^{ns}	7.472^{ns}	6.803	5.4
Fruit pericarp thickness	0.1227	1.3536*	0.7241*	0.416*	0.2034	7.4
Power of acidity (pH)	0.33343	6.52995**	0.00183^{ns}	0.00052^{ns}	0.0309	4.4
Titrable acidity (%)	0.0066742	0.002813*	0.0013^{ns}	0.0001^{ns}	0.0007	7.2
Total soluble solid (^{0}Brix)	0.01742	2.21421**	0.09743^{ns}	0.01499^{ns}	0.0726	6.8
Sugar to acid ratio	5.026	11.6617**	0.8980^{ns}	0.1998^{ns}	0.6567	7.8

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

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.

3.1. Growth of Tomato Varieties:

Numbers of primary and secondary branches were significantly influenced by the application of blended NPSBZn fertilizerwhile plant height at different stages was significantly influenced by the application of blendedNPSBZn 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 (Glalaet 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 P_2O_5 and poultry droppings when compared to the control plots. Abdallaet al. (2001), Glalaet al. (2010) and Glalaet al. (2012) also reported similar results in pepper plants.

Treatment	Growthtrait					
NPSBZnrate(kg ha^{-1})	NPB	NSB	PHFl (cm)	PHFr (cm)	PHFstH (cm)	PHFnlH (cm)
0	5.436c	21.42d	35.82e	48.12f	53.76e	60.43f
50	5.796bc	21.95c	37.43de	49.54ef	55.82de	62ef
100	5.742bc	21.97c	38.99cd	51.12de	57.07cd	63.11de
150	5.847bc	22.1c	40.63bc	53.33cd	59.26bc	64.65cd
200	5.806bc	22.19bc	41.41b	55.02bc	60.74ab	66.49bc
250	6.08b	22.71b	43.9a	57.25ab	61.96ab	67.91ab
300	6.597a	23.38a	44.57a	57.7a	63.56a	68.84a
LSD (0.05)	0.487	0.3414	2.282	2.42	3.118	2.097
Variety						

ARP tomato d2	5.846	22.102	35.7b	49.32b	56.79b	64.86b
Cochoro	6.077	22.398	36.58b	49.71b	54.95b	59.62c
Melkashola	5.778	22.232	48.9a	60.43a	64.91a	69.85a
LSD (0.05)	NS	NS	1.494	1.584	2.041	1.373
CV (%)	8.7	2.5	5.9	4.8	5.6	3.4

Table 5: Effects of NPSBZn fertilizer and variety on growth of tomato at Hawassa in 2018/2019.

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. NPB= number of primary branches, NSB= number of secondary branches, PHFl= plant height at flowering, PHFr= plant height at fruiting, PHFstH= plant height at first harvest, PHfnlH=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 (Zewiduet. 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 $plant^{-1}$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 $plant^{-1}$.The number of cluster $plant^{-1}$ 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 $plant^{-1}$ **(**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 (Suganiyaet al., 2015). Similar results were reported by Meseratet al. (2012) that significant mean number of fruit cluster per plant was observed between varietiesat 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 Mohantyet 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 Meseratet al. (2012) that significant mean number of fruit cluster per plant was observed between varietiesat Jimma.

Cochorohad highest fruit set percentage of 48.56% andfollowed 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.

Treatment	Number of Flower		
NPSBZn (kg ha-1)	NCPP	NFlPC	FSP
0	15.7e	5.064	47.39
50	17.59d	4.86	45.78
100	18.7cd	5.187	49.47
150	19.37c	5.183	47.09
200	20.05bc	5.388	47.12
250	21.38ab	5.286	47.88
300	22.09a	5.906	46.4
LSD (0.05)	1.464	NS	NS
Variety			
ARP tomato d2	20.73a	5.346	46.67b
Cochoro	18.88b	5.316	48.56a
Melkashola	18.2b	5.14	46.69b
LSD (0.05)	0.959	NS	1.627
CV (%)	8	12.9	5.5

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 ofselected 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 all growth parameters. 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 ot her improved tomato varieties to make a convincing recommendation.

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