COLLAGE OF AGRICULTURE AND NATURAL RESOURCE DEPARTMENT OF HORTICULTURE

EFFECT OF NPSB FERTILIZER AND VARIETIES ON GROWTH AND YIELD PERFORMANCE OF TOMATO (*Lycopersicon esculentum Mill*) IN MINI GREEN HOUSE

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
FAO	Food Agricultural Organization
CRD	Randomize Complete Block Design
SAS	Statistical Analysis Software

ABSTRACTS

*Tomato (Lycopersicon esculentum Mill) is a seasonal plant and one of economically important and widely grown vegetable crop as annual both in the rainy and dry seasons for their fruits by smallholder farmers and commercial state farms in Ethiopia. The productivity of tomato in Ethiopia is much lower than other countries due to many problems including lack of well adapted and productive varieties at farmer's hand and poor agronomic practices/recommendation for sustainable production and productivity of those high value crops. Therefore, this field experiment was conducted with the objectives to investigate the response of tomato varieties to chemical (NPSB) fertilizer for growth and yield performance. The treatment consists of 3 tomato varieties (*Flindndo, Melka shola and Melka Salsa*) and 4 level of NPSB (0, 50,100,150 kg NPS/ha) triplicated in, completely randomized design. Data on growth and yield performance were collected and main effects of varieties and fertilizer had showed significant differences for the data recorded except fruit length for NPSB rates. Interaction between fertilizer and variety had also significantly influenced the data collected and based on the current result, it can be concluded that Melka Salsa responded more for the fertilizer treatment yielding* 200gm and 156.7gm at 50 and 100 kg $NPSB^{-1}$ *(that equivalent to 0.24g and 0.48gm applied to single plant per pot) and this variety can potentially selected for further investigation and recommendation for the farming community.*

Key Words: Tomato, growth. Yield and variety

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L) is one of the most popular and widely grown vegetable crops in the world. It is one of the most commonly grown fresh market vegetable crop in the world. The present leading tomato producing countries of the worlds are china, the United States of America, India, Egypt, Turkey, Iran and Italy (FAO, 2000). Tomato contains the chemical composition and nutrients that are important for the human diet**.** Tomatoes are especially important for the human diet because of their content of vitamin C, carotenes and phenolic compounds (Kumar, 2006). Tomatoes are an excellent source of vitamin A and K-mineral. It is cultivated in different part of the country. Tomato is cultivated in Ethiopia in most parts of the country throughout the year. However, incidences of pests and diseases, moisture stress, improper rates of fertilizer application and too high and/or too low temperatures significantly constrain production and productivity of the crop (Getachew and Mohammed, 2012). Among different nutrients that were required for tomato cultivation nitrogen and phosphorous is the most important nutrients. Similarly, application of phosphorus is an important nutrient for tomato growth and development, a deficiency of P leads to reduced growth and yields (Hochmuth *et al.*, 2009). Sulfur in plants helps form important enzymes and assists in the formation of plant proteins. It is needed in very low amounts, but deficiencies can cause serious plant health problems and loss of vitality. It is essential constituent of sulphur containing amino acids cystine, cysteine and methionine and plays vital role in regulating the metabolic and enzymatic process including photosynthesis, respiration and symbiotic N fixation, besides being responsible for the synthesis of vitamins such as biotine, thiamine, vitamin B and certain coenzymes (Kumar and Singh, 2013). NPS promotes vegetative growth and fruit yield of tomato, and later application in the growing stages favors fruit development, thus NPS has a dramatic effect on tomato growth and development in soils with limited NPS supplies (Hokum *et al*., 2011).

Tomatoes have the greatest demand for phosphorus at the early stages of development (Csizinszky, 2005). However, the availability of P is largely dependent on the soil pH (Brady and Weil, 2002). Increasing productivity of the crop has a great role to strengthen the growing vegetable in the country. Tomato is becoming an important vegetable crop in small garden and commercial production in Ethiopia, however, production majorly affected by low soil fertility status, erratic rainfall, luck of high yielding variety, soil moisture content, disease, insect pests and recommended fertilizer application. Among these existing problems, blended fertilizer application is one of the major factors in Ethiopia, which can reduce yield and yield components of tomato in the growing area of the country. Application of blended fertilizer rate is not well researched and document b for this commercially important and local consumed crop in Ethiopia. Tomato production in greenhouses has attracted attention in recent years, based on the perception that greenhouse tomatoes can be more profitable than agronomic crops or horticultural crops in the open field (Snyder, 2006;

1.1. OBJECTIVE

1.1.1. General Objective

- To investigate the response of tomato varieties to chemical (NPSB) fertilizers for growth, yield and yield attributes in mini green house.

1.1.2 Specific Objective

- To identify appropriate fertilizer rate for high tomato yield response in mini green house.
- To identify comparative responses of tomato varieties to NPSB fertilizer in mini green house.
- To observe the interaction effect of tomato varieties and NPSB fertilizer in mini green house.

2. LITERETURE REVIEW

2.1. Origin, Description and Growth requirement of Tomato

Tomato is one of the most consumed and widely grown vegetable crops in the world. Wild-type tomato species are thought to be native of western South America, specifically in the dry coastal desert of Peru. Tomato crop is valued at 5–6 billion dollars, with international trade amounting to 3–3.5 billion dollars annually (FAOSTAT, 2005). Based on the average world production from 1999 to 2005, the top 10 tomato-producing countries are: China, the United States, Turkey, India, Italy, Egypt, Spain, Iran, Brazil, and Mexico. China contributed over 25% (or 31.6 million metric tons) to the total world production during the year 2005 (FAOSTAT, 2006). Tomato plant belongs to the family Solanaceae and genius *solanum*. The fruit which for purely used for culinary purpose is often grouped under vegetable crops (FAO, 2000). The center of origin of tomatoes have been debated by many, some are suggesting the center to be the dry coastal desert of Peru (Preedy and Watson, 2008, Blanca *et al.,* 2012), while others have suggested a dual center with one part in the coastal region between the Andes (Blanca *et al.,* 2012) and the ocean and the second part from South Mexico to Guatemala (Bauchet and Mathilde, 2012).

The domestication is still unclear but linguistic evidence has postulated Peru and Mexico as the major regions of domestication for tomatoes and it is known to be used in cooking in Mexico by the Aztecs already 500 BC and were transferred to the rest of the world by the conquistadors after the capture of the Aztecs territory (Bergougnoux, 2014).

A range of other wild tomato relatives are available for instance, *Solanum chmiewelskii, Solanum neorickii, Solanum chilense, Solanum habrochaites, Solanum penile, Solanum juglandifolium, Solanum ochranthum, Solanum lycopersicoides, Solanum sitiens, Solanume corneliomuelleri, Solanum arranum* and *Solanum galapagense* (Peralta *et al*., 2006).

Despite the fact that wild tomato relatives have contributed limitedly with desirable phenotypic traits to current cultivated tomatoes, interesting alleles for future tomato breeding may still be available in uninvestigated tomato collections (Rendón-Anaya *et al.,* 2017) and large variation has been described to the tomatoes as related to differences in shape, color, flavor and other parameters (Bai and Lindhout, 2007).

2.2. Effect of NPSB fertilizer on tomato plant

Nitrogen is a vital nutrient and a major yield-limiting factor; it is very essential for plant growth and makes up one to four percent of dry matter of the plants. Its availability in sufficient quantity throughout the growing season is essential for optimum tomato growth. It also has characteristics constitutes element of proteins and an integral component of many other compounds essential for plant growth processes including chlorophyll and many enzymes. It also mediates the utilization of phosphorus, potassium and other elements in plant (Onasanya *et al.,* 2009). Nitrogen and Phosphors are essential macronutrients for crop growth (Chen YF., *et al* 2008). Both considered as a skeleton for organic compounds, including proteins, amino acids, and enzymes responsible for growth and development.

Optimum level of P throughout root zone is essential for root development and improves nutrients and water utilization by the plant (Manjurul *et al.,* 2017). The balance combination of both N and P applications has significant impact on growth and yield parameters of tomato (Nawaz *et al*., 2012).

Orman and Kaplan (2017) conducted an experiment and evaluated the effects of elemental Sulfur and farmyard manure on agronomic biofortification within the parameters of N, P, S and N:S ratio in green bean. Staugaitis *et al.* (2017) conducted five years experiment in wheat to establish how different foliar fertilizers affect spring wheat when the optimum nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) rates had been applied during the main fertilization and reported that ammonium sulphate (15.0 kg ha-1) and urea (6.7 kg ha-1) increased grain yield. It was also indicated that the foliar fertilizers used did not increase grain and straw yield significantly. Woods *et al.* (2000) in their experiment showed that effects of potassium and phosphorus fertilizers on the growth of tomatoes significantly influenced growth and yield performances

2.3. Role of Nitrogen fertilizer in tomato

Tomato plant has a moderately high requirement for nitrogen which promotes better growth, flowering and fruit set. A minimum of 250kg per ha of nitrogen is recommended in high rain fall areas for high production. Approximately a quarter of nitrogen is applied at planting while the remainder is applied in the first six to eight weeks of growth at two to three-week interval (George, 2013). Nitrogen is an important nutrient for plant growth and yield but is difficult to optimize because it is susceptible to leaching, immobilization, gentrification and volatilization. Tomato yields are highly responsive to the application of N and growers have a tendency to apply excess N fertilizer rather than risk under-fertilization and reduced yields. Nitrogen has largest effect on yield and quality of tomato. It also promotes vegetation growth, flower and fruit set of tomato. It significantly increases the growth and yield of tomato. Nitrogen has a pronounced effect on growth and development of tomato. It promotes both vegetative and reproductive growth and impacts the characteristic deep green color of leaves. Nitrogen application resulted in greater values of plant height, leaf area, number of leaves and stem diameter of fodder maize, fresh and dry forage yield were increased due to addition of nitrogen. Leaf to stem ratio was found also to be increased by nitrogen that the increase in leaf to stem ratio with nitrogen application is probably due to the increase in number of leaves and leaf area under nitrogen treatments, producing more and heavy leaves (Gasim, 2001).

2.4. Influence of Blended NPS on the Growth of Tomato

The optimal amount of the elements in the soil cannot be utilized efficiently if nitrogen is deficient for plants. Increase plant height with respect to increased nitrogen rate indicates maximum vegetative growth of the plant under higher nitrogen availability (Cheng-WL *et al.,* 2014).

Nitrogen and Phosphors are essential macronutrients for crop growth (Chen YF., *et al* 2008). Both considered as a skeleton for organic compounds, including proteins, amino acids, and enzymes responsible for growth and development. N deficiency in the soil can decrease the production of number of fruits, fruit size, storage quality, color, and taste of tomato On the other hand; high N application can promote excessive vegetative growth which can delay the setting and maturity of tomato fruits, thereby reducing tomato production. Optimum level of P throughout root zone is essential for root development and improves nutrients and water utilization by the plant (Manjurul *et al.,* 2017). The balance combination of both N and P applications has significant impact on growth and yield parameters of tomato (Nawaz *et al*., 2012). Hence, a sandy textured soil with very low organic matter content is predominate in the UAE it is important to target N and P fertilizer to meet plant demand, prevent nutrient deficiencies, reduce the risk of soil and water pollution and decrease production costs (Abu-Alrub *et al*., 2014).

Gopal *et al.* (2003) studied the effects of P (sodium dihydrogen orthophosphate) at deficient (0.01 mM), subnormal (0.33 mM) and normal (2.0 mM) levels, and S (sodium sulfate) at deficient (0.02 mM) and normal (2.0 mM) levels on the performance of tomato cv. Pusa Ruby were studied under greenhouse conditions. At 55 days after sowing, the colour of old leaves changed from green to bluish- green, and the diameter of the main stem and the number of leaves were reduced under P deficiency. Under S deficiency, intense chlorosis of young leaves and inhibition of plant growth were observed. P deficiency reduced biomass production, fruit yield, and contents of chlorophyll a and b, reducing sugar, nonreducing sugar, total sugar, starch, organic P, phospholipid, nucleic acid and phosphorylated protein; delayed fruit maturation; and increased peroxidase, ribonuclease and acid phosphatase activities in leaves. These effects were aggravated by S deficiency, suggesting the synergistic role of both nutrients.

Woods *et al.* (2000) concluded the effects of potassium and phosphorus fertilizers on the growth of tomatoes in moss peat over three years. Additions of sulphate of potash ranged from 0 to 200g per bushel and super phosphate from 0 to 150g in two factorial trials. Additional superphosphate or sulphate of potash reduced the fresh and dry weight of early plants in January in two years but not in February. Sulphate of potash or superphosphate had no effect on fresh weight, dry weight or flower number in autumn tomatoes. Sulphate of potash had no effect on flower number in any year, but additional phosphate increased flower number on the first truss in one year. Satisfactory early and autumn plants were obtained by adding 25 and 50g sulphate of potash per bushel and 50 and 100g superphosphate. The effects of fertilizer treatment on the nutrient content of plants and peat are given.

3. MATERIAL AND METHOD

3.1. Experiment site

The experiment was conducted at Wolkite University under mini greenhouse condition. Wolkite University is geographically located in between 7.8-8.5N latitude and 37.5-38.7 E longitude which is 158 km away from Addis Ababa to south west direction in Guraghe zone which comprise an altitude ranging from 1,001 to 3500 above sea level and the zone has three agro-climatic zones of which 28.3% Dega (2500-3662 m.a.s), 64.9% Woina dega (1500-2500 m.a.s.l) and 6.8% kola (1000-1500 m.a.s). The mean annual temperature ranges from 14 to 24 °Cwith an average of 20.5°C.The soil type of the area heavy vertisol around 80% which is rich in organic matter while less capability to drain water. The rain fall of Wolkite is bimodal in which 80% of rain falls in Kremt period of June to August where as 20% in the belg period of February to May (GZADD, 2011).

3.2. Experimental design and Treatment

The experiment was conducted using 12 treatments, combination of three tomato varieties (Flindndo,Melka shola and Melka Salsa) and four NPSB fertilizer rates (0, 50,100 and 150kg /ha) which were planted in prepared pots and triplicated in completely randomized design (CRD)

3.3. Experimental procedures

Tomato seeds were sown on nursery beds prepared for the three varieties (Flindndo,Melka shola and Melka Salsa) and were transplanted on prepared pots filled with soil in the mini-green house. During transplanting, the proposed fertilizer rate in combination with the varieties was applied and the necessary cultural practices (weeding, irrigation and protection) for tomato production were applied uniformly as necessary. After maturation and at harvesting, three uniform size tomato fruits were selected and oven dried at 105^{0}C in horticulture pathology laboratory and biomass measured using sensitive balance.

3.4. Data collected

Branch number: Total branch number per plant was counted from each treatment and the counted values taken as branch number per treatment

Number of clusters per plant: Number of clusters has been counted from the first harvest to last harvest and fruits per cluster had also counted.

Fruit diameter (cm): Three fruits per treatments were selected randomly and the average value has recorded as a diameter of a fruit

Individual fruit fresh weight (g): Three fruits per treatments were selected randomly and the average value has been recorded as a weight of a single fruit.

Fruit length (cm):- Three fruits per treatments were selected randomly and the average value has recorded as a length of a fruit

Fruit yield (kg/plant): Total fruit yield was recorded at each harvest and then added to get the final yield per treatment and reported as kilogram of fruits per treatment

3.5. Data Analysis

The collected data were subjected to analysis of variance (ANOVA) using SAS 9.3. The treatment showing significant difference has been separated using least significant difference (LSD) test at 5% level.

4. RESULT AND DISCUSSION

4.1 Branch Number per plant

The result revealed that tomato varieties showed very highly ($p \leq 0.001$) significant variation for branch formation and the main effect for NPSB had also showed highly significant difference for the dependent variable (appendix 1).

The maximum (5.33) branch per plant was produced at 100 kg NPSB per hectare and least mean number of 4.11 at 50 kg per hectare which is statically similar with the value produced with control (table 1)

The interaction between variety and NPSB had a highly significant ($p \leq 0.001$) effect on the mean branch number of tomato (Appendix 1). Treatment combinations (50, Flidndo), (50,Melka Sholla),(100,Melka Sholla) (100,Melka Salsa), (150, Flidndo),150,Melka Salsa) and (150, Melka Salsa) all produced higher mean branch number per plant than the control and the highest mean value of 6.33 was produced from tomato variety Flindndo treated with100kg of NPSB fertilizer per hectare which followed by Melka Salsa with fertilizer rate similar rate for the Flindndo variety producing 5.33 branch per plant (Fig 1). The increment in branch number in response to NPSB and variety interaction may be synergetic physiological effects in plants.

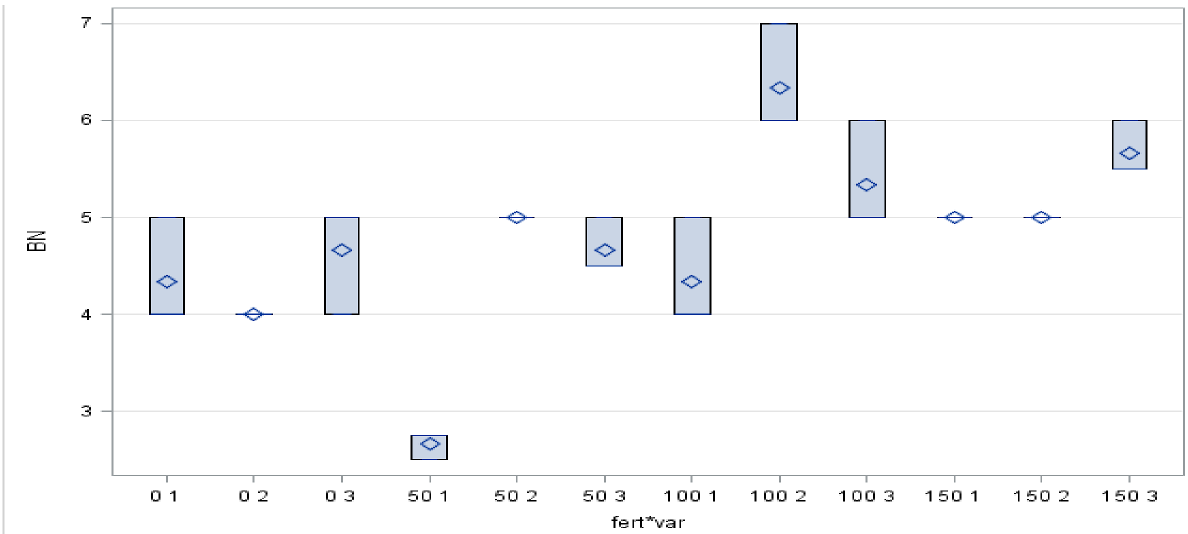


Figure 1. Interaction effect of NPSB and variety on tomato branch number formation

Fruit per culture

There was a highly significant variation ($p \leq 0.001$) between the varieties in mean fruit number per cluster (Appendix 1) and the main effects of NPBS fertilizer had also significantly ($p<0.001$) affected the mean tomato fruits per cluster (Appendix 1). From the varieties considered for this particular experiment, Melka Salsa produced maximum (2.35) fruits and lowest mean value (1.89) was recorded for MelkaSholla (table 1).

The observed differences among the experimental varieties could be due to the genetic variability that can contribute for the growth and yield attributes. Regarding mean values for fertilizer main effect, the highest (2.41) and lowest (1.95) number of fruits per cluster were recorded from 150 and 0 kg NPSB ha^{-1} respectively (table 1).These results are in agreement with the findings of Abdelmageed and Gruda (2009) and Chernet*et al.* (2013) who reported the presence of variation among tomato varieties in terms of the number of fruits per cluster and per plant, and suggested that such differences could be attributed to genotypic variability between varieties.

Fruits per plant

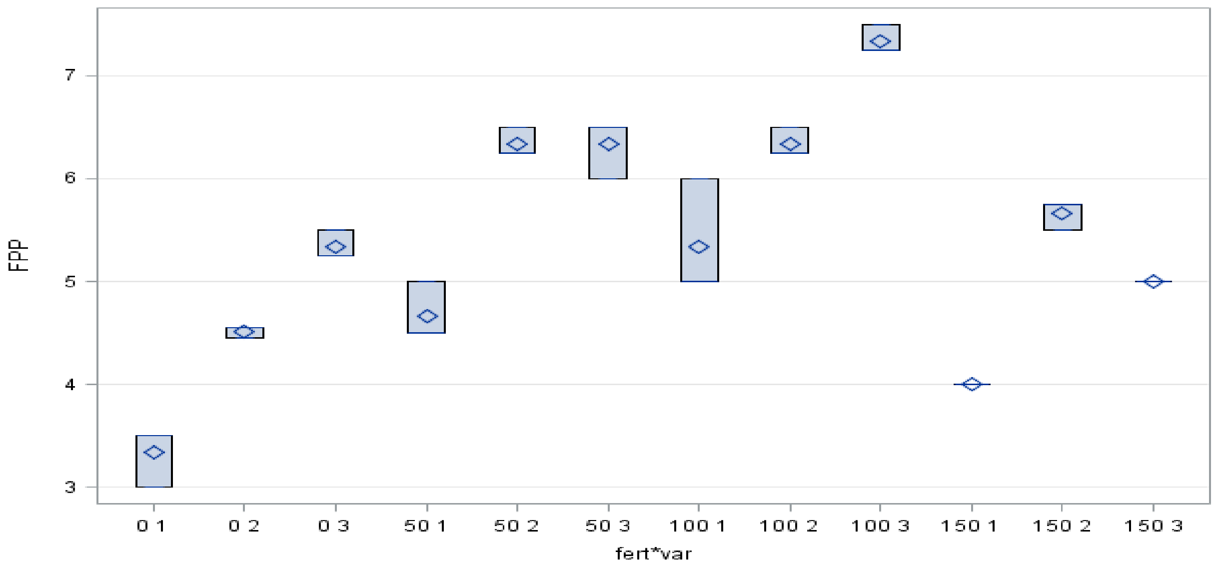
Tomato variety showed highly ($p \leq 0.001$) significant variations for number of fruits per plant and main effect of NPSB fertilizer had also revealed highly ($p \leq 0.001$) significant difference among the treatments (appendix 1). Highest (6.00) and least (4.33) mean fruit number per plant were recorded from Melka Salsa and Melka Sholla respectively among the varieties, and mean values in response to NPSB fertilizer application indicated the least number (4.39) of fruits produced from control treatment and maximum number (6.33) from 100kg ha^{-1}(table 1).

Table 1. Main effects of NPSB and varieties on tomato growth and yield attributes

Treatment	**Parameters**						
Variety	BN	FPC	FPP	FD	FL	IFW	YLD
V1 (MelkaSholla)	4.08b	1.89b	4.33c	2.99b	4.2b	26.42c	103.33c
V2 (Flidndo)	5.08a	2.24a	4.71b	3.55a	3.7c	34.17a	113.5b
V3 (Melka Salsa)	5.08a	2.35a	6.00a	2.83c	4.8a	27.58b	145.42a
	NPSB (kg/ha)						
0	4.33b	1.95b	4.39d	3.01b	4.41a	28.44b	93.00d
50	4.11b	2.18ab	5.78b	3.09b	4.28a	30.11a	141.11a
100	5.33a	2.05b	6.33a	3.35a	4.24a	30.33a	133.89b
150	5.22a	2.41a	4.89c	3.26a	4.00a	28.68b	115c
CV%	8.27	**11.35**	**4.48**	**4. 34**	**10.90**	**4.01**	**5.94**
LSD	0.38	**0.24**	**0.23**	**0.13**	**0.45**	**1.14**	**6.98**

The interaction between NPSB and variety indicated significantly ($p \leq 0.001$) increased mean fruit number per plant (Appendix 1). Although most of the combinations (Figure 2) seem to have similar trend of increment in average fruit number, least mean value of 3.33 was produced from unfertilized plot whereas the largest number of 7.33 had produced from treatment combination of 100 $kgha^{-1}$ NPSB and Melka Salsa implying that varietal and fertilizer combination increased the number of fruit produced per single plant 39.9 to 120%.

Figure 02. Interaction effect of NPSB and variety on tomato fruit numbers per plant



Fruit diameter

A significant variation was observed among tested varieties in fruit diameter and fertilizer effect had also showed significant ($p<0.05$) differnce for tomato fruit diameter (Appendix 1).

According to the mean values for the main effects, variety Flidndo had produced largest (3.55cm) mean diameter while the least (2.83cm) was observed in Melka Salsa (table 1). The result in this particular work for fruit diameter is in line with the work of (Abreham*et al*., 2019) who reported the existences of variation among genotypes studied in their experiment

Interaction between NPSB and variety revealed significant ($p\leq0.001$) differences for fruit diameter (appendix 2). It has observed that combined effect of variety and fertilizer had produced higher mean values than main effects as well plots with no fertilizer. Accordingly, treatment combination (100kg NPSB ha-1 and Flidndo) resulted with highest (4.08cm) of fruit diameter, contributing up to 46.23 % increment for fruit size.

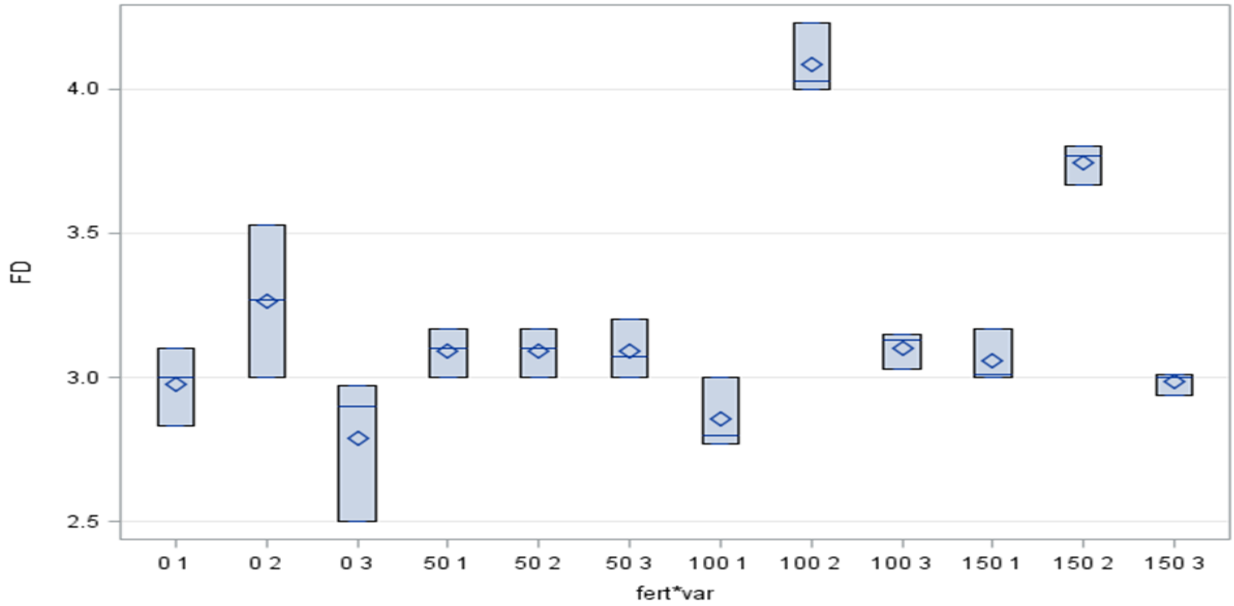


Figure 3. Interaction effect of NPSB and tomato varieties on fruit diameter

Fruit length

Fruit length has showed significant ($p \leq 0.001$) variations among the experimental varieties (appendix 2) and from the mean values, longest (4.8cm) and shortest (3.7cm) fruit were recorded for Melka Salsa and Flidndo respectively (table 1). NPSB fertilizer main effect and interaction between the varieties and fertilizer had revealed non-significant responses (appendix 2)

Individual Fruit weight (gm)

There was a great variation in the average individual fruit weight values of the varieties ($p \leq 0.001$) (appendix 2) and the highest value (34.17 g) was recorded in Flidndo and the lowest (26.42 g) in Melka Sholla variety (Table 1).The presence of the variability in fruit weight of tomato could be due to the presence of multiple allelic series for the major gene associated with fruit weight determination (Illa-Berenguer*et al.*, 2015).

Main effect of NPSB fertilizer application revealed that highly ($p \leq 0.001$) significant in the average fruit weight (appendix2) and statistically significant mean values were observed among the fertilizer rate, producing highest (30.11gm) and lowest (28.44gm) at 50 and 0kg NPSBha-1 (table 1).

Yield (gm/plant)

Varieties significantly varied in tomato fruit yield (Appendix 2).The main effects of NPSB was also significantly ($p \leq 0.001$) affected the yield of tomato (Appendix 2). Similarly, the interactive effects of NPSB and varieties had influenced the yield.

The mean tomato yield due to interactive effect among variety and NPSB fertilizer has indicated that more productivity than it would be in the main effects for varieties as well for fertilizer. Accordingly, Melka Salsa treated with 50kg and 100 kg ha-1 of NPSB produced 200gm and 156.7gm respectively (Figure 4). The existed response to interaction effect could be associated to genetic and applied nutrient synergy and physiological activities undertaking with in the plant system.

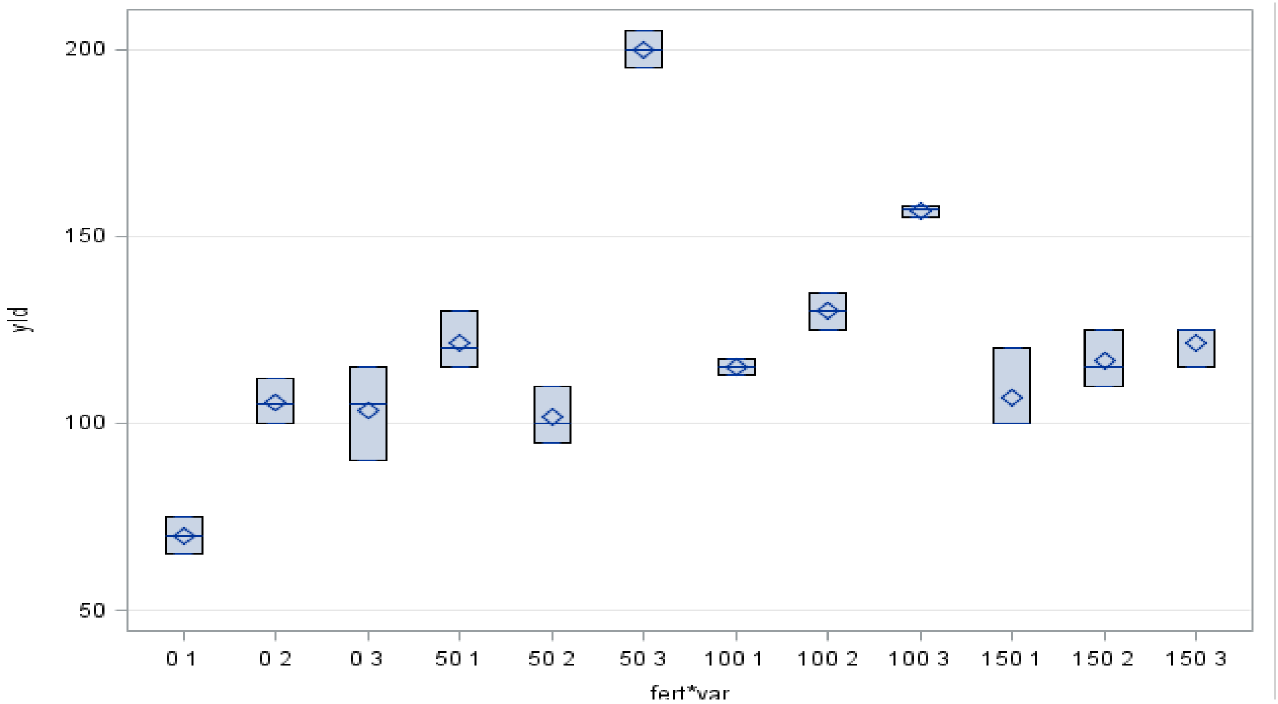


Fig 4. Interaction effect of Variety and NPSB fertilizer on tomato Yield

5. SUMMERY AND RECOMMENDATION

An experiment was conducted at Wolkite University Biotechnology mini greenhouse with irrigation. The experiment was conducted to assess the effect of tomato varieties and NPSB fertilizer on growth and yield performance.

The experiment was conducted with three varieties of tomato (Melka Sholla, Melka Salsa and Flidndo) and four NPS levels (0, 50, 100 and 150 kg ha^{-1}). The seedlings were raised in horticulture field experimental site and transplanted on the arranged pots in the mini green house. The experimental treatments was laid out in factorial arrangement using completely randomized design (CRD) replicating the treatments three times.

The results showed that varieties significantly differed for Tomato parameters data recorded and main effects of NPSB fertilizer application influenced the growth and yield attributes positively except the fruit length of tomato. The experiment, interaction effects of variety and NPSB had also significantly influenced both the growth, yield and yield attributes with an exception for fruit length.

This study is one season experiment, considering only yield and growth attributes with limited number of varieties. Therefore, such types of investigations need to be repeated by including storability and quality aspects of tomato

6. REFERENCES

Abdelmageed, A. H. and Gruda, N. (2009). Performance of different tomato genotypes in the arid tropics of Sudan during the summer season. II. Generative development. *J. Agric. Rural Dev. Trop.* **110** : 145-54.

Abu-Alrub, I.,Aran, A.Hamad, O. and Awaga, A. 2014.Yield and quality of Cenchrus ciliaris (L.) affected by nitrogen and phosphorus fertilization. *Journal of Food, Agriculture and Environment*, 12(3): 139-142.

AOAC (1990). Official methods of analysis, 15th Edn. Association of Official Analytical Chemists, Washington D.C.

Bai, Y. and Indhout, P.L. 2007. Domestication and Breeding of Tomatoes: What have We Gained and What Can We Gain in the Future. *Annals of Botany*, 100: 1085-1094. doi:10.1093/aob/mcm150, available online at www.aob.oxfordjournals.org

Baker AV.Mills, 1980.Ammonium and nitrate nutrition of horticultural crops.

Bauchet, G. and Mathilde, C. 2012. Genetic Diversity in Tomato (Solanum lycopersicum) and Its Wild Relatives. https://www.semanticscholar.org/paper/Genetic-Diversity-in-Tomato-(Solanum-lycopersicum)-Bauchet-ausse/45c634d1d6eab562755fbf23b096750fb0e9e759.

Bergougnoux ,V. 2014. The history of tomato: From domestication to biopharming. *Plant Biotechnology 2013: "Green for Good II"*. 32, 170-189.

Blanca, J., Izares, J. N. C., Cordero, L., Pascual, L., Diez, M. J. and Nuez, F. 2012. Variation Revealed by SNP Genotyping and Morphology Provides Insight into the Origin of the Tomato. *PLoS ONE* , 7(10): e48198. doi:10.1371/journal.pone.0048198.

Brady, N. C., and Weill, R .R. 2002. *Elements of the Nature and Properties of Soils*: 14th ed. Prentice-Hall, Inc., Upper Saddle River, New Jersey, USA.

Chen, Y.F., Wang, Y. and Wu W.H. 2008. Membrane transporters for nitrogen, phosphate and potassium uptake in plants. *Journal of Integrative Plant* Biology, 50 (7): 835-848.

Cheng-WL. , Yu S. , Bo-Ching, C. and Hung-Yu L. 2014.Effects of Nitrogen Fertilizers on the Growth and Nitrate Content of Lettuce (*Lactuca sativa* L.). International Journal of Environmental Research and Public Health, 11: 4427-4440. doi:10.3390/ijerph110404427.

Chernet, S., Belew, D. and Abay, F. (2013). Genetic variability and association of characters in tomato (*Solanum lycopersicum* L.) genotypes in Northern Ethiopia. *Int. J. Agric. Res.* **8** : 67-76.

Csizinszky, A. A. 2005. Production of Tomato in Open Field. Pp 257-256. (In): Ep

FAO, 2008.Deficit irrigation scheduling based on plant growth stages showing water stress tolerance.

FAO.2000, AO production year book,Basic Data unit, statistics Division, FAO, Italy, 54; 139-141, 2000.

FAOSTAT (2005) Food and Agricultural Organization of the United Nations. Statistical Databases, at http://www.fao.org.

FAOSTAT (2006) Food and Agricultural Organization of the United Nations. Statistical Databases, at http://www.fao.org.

Gasim, S. H. 2001. Effect of nitrogen, phosphorus and seed rate on growth, yield and quality of forage maize (*Zea mays* L.). M.Sc. Thesis, Faculty of Agricultural University of Khartoum.

George,2013. Commercial Tomato production Guide Hand book.

Getachew Tabor and Mohammed Yesuf. 2012. Mapping the Current Knowledge of Carrot Cultivation in Ethiopia. Denmark.

Gopal, R., Sinha, P., Dube, B. K. and Chatterjee, C. 2003. Phosphorus-sulphur interaction in tomato *(Lycopersicon esculentum* L.) metabolism. *Indian Journal of Horticulture*, 60(3): 244-250.

GZADD (Gurage zone Agricultural Development Department 2011: Documented report on socio-economic study of zone.

Hochmuth, G., Ron, R. and Eric, S. 2009. Phosphorus Management for Vegetable Production in Florida, Publication # HS105, University of Florida IFAS (Institute of Food and Agricultural Sciences) Extension.

Hokam ,E. M., El-Hendawy, S. E. and Schmidhalter, U.. 2011. Drip Irrigation Frequency: The Effects and Their Interaction with Nitrogen Fertilization on Maize Growth and Nitrogen Use Efficiency under Arid Conditions. *Journal of Agronomy and Crop Sciences*, 197:186-201.

Kumar V. 2006. Influence of nitrogen fertilizer on nutritional quantity of tomato.Indian College of Agricultural Sciences, 76,465-8.

Kumar, M., Meena, M.L., Kumar, S., Maji, S. and Kumar, D. 2013. Effect of nitrogen, phosphorus and potassium fertilizers on the growth, yield and quality of tomato var. Azad T-6. *Asian Journal of. Horticulture,* 8(2): 616-619.

Kumar, V. 2006. Influence of nitrogen fertilizer on nutritional quantity of tomato. *Bulletin of Environmental Contamination and Toxicology*, 92 (1): 103-108.

Manjurul, A., Masum, B., Mahamud, K. M. and Mehedi, H.M. 2017. Effect of Nitrogen and Phosphorous Fertilizer Application on the Growth and Yield of Tomato: A Mini-Review. *International Journal of Advances in Agriculture Science*s, 2(12):1-5.

Nawaz,H., Zubair, M. and Derawadan, H. 2012. Interactive effects of nitrogen, phosphorus and zinc on growth and yield of tomato (Solanum lycopersicm). African Journal of Agricultural Research, 7(26):3792-3769

Onasanya, A., Basso. A., Somado, E., Gasore, E.R. and Nwilene, F.E. 2009. Effect of Different Levels of Nitrogen and Phosphorus Fertilizers on the Growth and Yield of Maize (Zea mays L.) in Southwest Nigeria. I*nternational Journal of Agricultural Research,* 4(6):193-203.DOI: 10.3923/ijar.2009.193.203.

Orman, S. and Kaplan, M. 2017. Agronomic biofortification of green bean (*Phaselous vulgaris* L.) with elemental sulphur and farmyard manure. *Applied Ecology and Environmental Research*, 15(4):2061-2069.

Peralta, I., Knapp, S. and Spooner, D. 2006. Nomenclature for wild and cultivated tomatoes. Tomato Genetics Cooperative Report. AGRIS.

.

Rendón-Anaya, M., Montero-Vargas, J., Saburido-Álvarez, S., Vlasova, A., Capella-Gutiérrez, S., Ordaz-Ortiz, J.J., Aguilar, M., VianelloBrondani, R., Santalla, M., Delaye, L., Gabaldón, T., Gepts, P., Winkler, R., Guigó, R., Delgado-Salinas, A. and Herrera-Estrella, A. (2017) Genomic history of the origin and domestication of common bean unveils its closest sister species. Genome Biology 18: 60. https://doi.org/10.1186/s13059-017-1190-6.

Snyder, R. Guía del cultivo del tomate en invernadero. Mississippi State University, 2006. Available from: . Accessed: Sept. 09, 2015.

Staugaitis, G., Aleknavičienė, L., Brazienė, Z., Marcinkevičius, A. and Paltanavičius, V. 2017. The influence of foliar fertilization with nitrogen, sulphur, amino acids and microelements on spring wheat. *Zemdirbyste-Agriculture*, 104(2):123–130.

Woods, M. J., J. J. O’Hare and C. G. Nolan. 2000. The effect of potassium and phosphorus fertilizer on tomatoes propagated in peat. *Acta Horticulture*, 2(1): 201 - 203.

7. APPENDICES

Appendix 1.Analysis of variances for Fruit diameter, branch number/plant and fruit number per capsule and fruits number per plant
.

Source of variation		Mean square		
		Parameters		
	DF	BN	FPC	FPP
Variety	2	4.00***	0.79***	9.52***
Fertilizer	3	3.43***	0.35**	2.95***
V*NPSB	6	1.52***	0.3ns	5.92***
Error	24	0.154	0.06	0.057

, * indicate significance at $p \leq 0.01$, $p \leq 0.001$, respectively, 'ns' not significant.
FD, Fruit diameter, BN: branch number, FPC: Fruits per capsule, FPP, Fruits per plant

Appendix 2.Analysis of variances for Fruit diameter, Fruit length, Individual fruit weight & yield

Source of variation	Mean square				
	Parameters				
	DF	FD	FL	IFW	YLD
Variety	2	1.702***	3.64***	209.53***	7057.75***
Fertilizer	3	0.102*	0.264ns	8.48**	673.21***
V*NPSB	6	0.389***	0.502ns	90.79***	3054.60***
Error	24	0.03	0.213	1.39	37.58

, * indicate significance at $p \leq 0.01$, $p \leq 0.001$, respectively, 'ns' not significant.

8. APPROVAL SHEET

WOLKITE UNIVERSITY
DEPARTMENT OF HORTICULTURE

EFFECT OF TOMATO (*Lycopesicon escuentum mill*) VARIETIES AND NPS FERTILIZER ON GROWTH, YIELD AND STORABILITY

Submitted by:

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