Effect of Blended NPS Fertilizer Rates and Intra-row Spacing on Growth and Yield of Maize (*Zea mays* L.) in East Showa Zone, Oromia Regional, Ethiopia

[1]Melka Janbo, [2]Diriba-Shiferaw G. and [3]Feyera Merga

[1]Awash Melkassa Farmers Union coordinator, Adama District, East Showa Zone, Oromia, Ethiopia

[2]Department of Horticulture and Plant Sciences, College of Agriculture and Environmental Science, Arsi University, P.O. Box 193 Asella, Ethiopia

[3]Sinior Researcher in Agronomy, Melkassa Agricultural Research Center, EIAR, Ethiopia

***Corresponding Author:** Diriba-Shiferaw G., **Email**: dsphd2010@gmail.com

ABSTRACT

Maize is one of most important food crop grown in Ethiopia and is produced in different agro-ecologies in the country. However, its productivity is constrained by a number of problems out of which is inappropriate fertilizers applications and undetermined planting space utilization. Therefore, the field experiment was conducted at Melkassa Agricultural Research Center in East Showa Zone, Oromia Regional State with the aim of identifying the effect of blended NPS fertilizer rates and intra-row spacing on growth and yields of maize during 2019 cropping season. The experiment was arranged in a factorial combination of five rates of blended NPS fertilizer (0, 75, 150, 225, 300 kg ha^{-1}) and three intra row spacing (15, 25, 35cm) in a randomized complete block design in three replications. The result revealed that leaf width and grain yield was significantly ($p<0.05$) influenced by the interaction of NPS rates and plant spacing. The results showed that the above ground biomass and cob weight significantly affected by the main effect of spacing; while, cob length, stem diameter and leaf length were significantly influenced by both main effect of NPS fertilizer rates and plant spacing. Highest (13.67kg) above ground dry matter was recorded from the application of 300 kg NPS ha^{-1} at 35cm intra row spacing; while, the lowest (7.33 kg) was obtained from the control at 15 cm intra row spacing. Also highest grain yield (7400 kgha^{-1}) was obtained from 300 kg NPS ha^{-1} applied at 15cm intra-row spacing and lowest (3833.30 kg ha^{-1}) from control at 35cm intra-row spacing. The highest (17.07%) and lowest (13.93%) moisture contents were obtained from control at 35cm and 15cm intra-row spacing, respectively. Thus, it can be concluded that application of 300 kg NPS ha^{-1} at 15cm intra-row spacing was better for maize growth and yields under rain-fed cropping system in the study area. However, to give concrete *recommendation similar experiments should be done to confirm the obtained results across locations and years in the same cropping system and the like.*

Keywords: Intra-row spacing, maize growth, NPS Fertilizer, Yield

INTRODUCTION

Maize (*Zea mays* L.) is an important grain crop of the world and it ranks second, after wheat in hectarage (177,379,567 ha) and first in total production (872,066,770 MT) and productivity (4.9 t ha^{-1}) (FAOSTAT, 2013). It is the world's widely grown highland cereal and primary staple food crop in many developing countries (Kandil, 2013). World production of white maize is currently estimated to be around 65 to 70 million tons. Achieving food security for a progressive number of inhabitants is a great challenge, especially when there are important segments of the urban and rural population living temporarily or permanently in poverty (Menéndez and Palacio, 2015).

Africa produces around 7% of the total world production. Two-thirds of all African maize comes from Eastern and Southern Africa (Verheye, 2010; FAOSTAT, 2014). Among the individual geographical regions of the developing countries, white maize production has a paramount importance in Africa (Suri, 2011). The main white maize producers in Africa include Kenya, Tanzania, Zambia and Zimbabwe (Kidist, 2013). Although production has increased over the years, productivity has not increased as much as the area cultivated. For example, in the 50 years between 1961 and 2010, the maize area in SSA tripled; however, excluding South Africa, maize yields in SSA increased only by about 40% over this period (Shiferaw *et al.,* 2011).

Maize cultivation is largely a smallholder phenomenon; comprising about 80% of Ethiopia's population are both the primary producers and consumers of maize in Ethiopia (Alemu *et al.,* 2008). In order to improve maize production and productivity, an efficient use of production inputs and full packages has to be adopted by smallholder farmers. However, maize production is constrained by many biotic and abiotic factors like nutrients deficiency in type and amount, cultural practices like spacing/population, varieties, pests (diseases and insects) and other agronomic practices.

Declining soil fertility from time to time due to natural and human made factors are serious bottle necks for crop production in Ethiopia. Besides, lack of appropriate fertilizer blends and lack of micronutrients in fertilizer blends are the national problem which is major constraints to crop productivity (Fufa *et al*., 2011). Supplying nutrients at an appropriate amount is always imperative for better growth and development of a crop (Ali and Anjum, 2017). In fact, response of maize plant to application of nitrogen and phosphorus fertilizers varies from variety to variety, location to location, plant population, and also depends on the availability of the nutrients (Onasanya *et al*., 2009). Hybrid maize varieties are more responsive and efficient than cultivars to fertilizers (Taye, 2009). Hybrid maize varieties respond well to nutrient applications, particularly nitrogen and phosphorus and produce high and uniform yield than local varieties if the environment is conducive and better management practices followed. Application of essential plant nutrients in optimum quantity and right proportion, through correct method and time of application, is the key to increased and sustained crop production (Cisse and Amar, 2000). Chimdessa (2016) also reported that blended fertilizers increased maize productivity compared to the previously existing NP. Therefore, application of actual balanced recommended fertilizer rates based on soil and crop type is one of the best agronomic practices to maximize production. Still, most research works focus on N and P requirements of crops, limited information is available on various sources of nutrients such as K, S, Zn, B, and other micronutrients. Specifically, inappropriate type and rate of fertilizers utilization and plant spacing is the most problems of maize cultivation. Therefore, the main aim of this study was to identify the effect of blended NPS fertilizer rates and intra-row spacing on growth and yield of maize (*Zea mays* L.) in East Showa Zone, Oromia Regional, Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

This research was conducted at East Showa Zone Adama Woreda specifically in Melkassa Agricultural Research Center (MARC) in 2019 main cropping season. It is located at 118 km from Addis Ababa to South-East direction. Soil type of the study area is more favorable for maize production, which includes 35%, 55% and 10% sandy, silt and clay respectively. Highest and low rainfall was 1050 and 700 mm annual, respectively. There is great variation of temperature lies within 15 to 31^0C. The coldest month is October whereas May is the hottest month. The length of growing period is about 90-110 days. This area is familiar with broadcasting sowing cereal crops especially maize (MARC, 2018).

2.2. Treatments and Experimental Design

The experiment has two factors namely five rates of newly introduced blended NPS fertilizer (0, 75, 150, 225 and 300 kg ha^{-1}) and three intra-rows spacing (15, 25 and 35 cm). The experimental design used for this experiment was Randomized Complete Block Design (RCBD) consisting of fifteen (15) treatments in three replications. All fertilizer rates were applied at planting at their specific rate.

2.3. Experimental Materials and Procedures

The blended NPS fertilizer that obtained from Melkassa farmers` association was used for this study; NPS nutrients composition (N=19%, P=38% and S=7% per quintal). NPS was used by farmers at 200 kg ha^{-1} around the study areas; thus, based on this farmer's rate the various rates were set for the experiment. Maize seed (Melkassa-4 variety) at 8kg was utilized in this experiment. It was released before 10 years ago from Melkassa Agricultural Research Center. The size of each plot was 11.25m^2 (3mx3.75m). Hence, the gross plot area was 11.25m^2 and total plot area was 506.25m^2 (11.25m^{2}x45) plots. Between each plot there was 1m and between block 1.5m width remained for the purpose of traveling during supervision. Spacing used between rows was 75 cm. To avoid boarder effect, an extra land was required (277m^2). Therefore, 1002.25m^2 land was used during conducting this experiment. All data were taken from six plants of middle three rows.

2.4. Management of the Experiment

The land was ploughed two times by tractor. The seed rate was 8 kg ha^{-1} and was sown in row of 5cm depth by using manually in the rows on July 08, 2019. All the necessary field management practices were carried out as per the practices followed by Melkassa Agricultural Research Center. These practices were including plough two times, planting two seeds per hole, applying fertilizer at planting time, removing an extra seedling germinated, applying two-third of fertilizer and start weeding from 15th days of planting. Finally, the crop was harvested on the basis of maturity stage of each treatment after physiological maturity from the net plot area (NPA) and was threshed manually.

2.5. Soil Sampling and Analysis

The pre-planting soil samples were collected from six spots at depth of 0-30cm diagonally from the experimental site; the soil was composited, bagged, labeled then taken to the laboratory and processed for soil analysis. Soil analysis for specific parameters relevant to the study was carried out at the soil laboratory of Melkassa Agricultural Research Center.

2.6. Data Collected

2.6.1. Soil physicochemical parameters

Surface soil samples were collected from six pots at depth of 0- 30 cm diagonally from the experimental site for pre-planting and made one representative soil sample per the experimental site for analysis. These samples were preserved for chemical and physical analysis after drying under shade. Collected soil samples were dried under shade, powdered using pestle and mortar, passed through 2 mm sieve. Then samples were bagged, labeled then taken to the laboratory and processed for soil analysis for the following soil physico-chemical properties: - Soil pH was measured in 1:2.5 soil: water suspension using digital pH meter (Systronics make) having glass electrode as described by Jackson (1973). Organic matter was determined using traditional wet digestion with acid-dichrome and heat modified Walkely-Black (Nelson and Sommers, 1982). Total N was determined by using Kjeldahl method (Dewis and Freitas, 1970). Available sulphur was determined by using Available sulphur in the form of sulphate and determined by using 0.15% $CaCl_2$ as extractant and measured turbidometrically using spectrophotometer at 420nm (Jackson, 1973). Available P it was using extracting solution for extracted a sample from the soil using Bray II methods and using procedures described by Bary and Kurtz (1945). Cation Exchangeable Capacity (CEC) was determined by used the NH4AC pH 7.0 method. It is measuring the total amount of a given cation equilibrating the charge of the exchanger (Page, 1982). Texture or particle size was determined by Hydro meter method. Bulk density was determined by Core sampler method.

2.6.2. Phonological and growth attributes

Days to 50% emergence was recorded from the time of sowing until 50% germination of the total population. Ear length and stem diameter was measured using cent meter at physiological maturity. Plant height (m) was recorded when the crop reached maturity by measuring from the middle three rows from the base of the land to the top of plans and the average was calculated per plant. It was taken from representative six plants per plot, which two from short, two from medium and two from long plants. Then, the average was calculated by dividing the obtained result to six. This activity was done by skilled workers using hand meter.

2.6.3 Yield and yield components

Thousand Kernel weight (g) was weighted from one thousand grains at random and weight in grams for each experimental unit; grain yield (kg ha^{-1}) was determined by weighing the grain harvested from the three middle rows of each plot; and harvest index was recorded at ratio of economical yield to biological yield times 100. Moisture content of grain was determined by Near Infra Red Spectroscopy (AACC, 2000).

2.7. Statistical Analysis

All the data collected were analyzed using analysis of variance (ANOVA) procedure by statistical software package (SAS 9.2 Version). Significant differences between the treatments were delineated to LSD (Least Significance Difference) test at 5% level of significance difference.

3. RESULTS AND DISCUSSION

3.1. Soil Physical and Chemical Properties of the Experimental Site

The results indicated that textural class of the experimental site was 40%, 6.67% and 53.33% silty loam, loam and sandy loam, respectively. According to Rao *et al*. (1995) maize is best adapted to well drain sandy loam to clay loam soil. Thus, from the above result, the soil texture is more suitable for maize production. The texture indicated the degree of weathering, nutrient, and water holding capacity of the soil. The result of cation exchange capacity of the experimental soil was 16 cmol (+)/kg which rated as moderate according to Landon (1991) classified CEC between 12-25 cmol (+)/kg moderate. Total nitrogen percentage was 0.09% which is rated by Tekalign (1991) less than 0.1% as very low. Therefore, the result indicated that the soil required additional nitrogen to achieve desirable maize production. The result had pH of 7.0. The available P level in the experimental soil was 9.40 mg/kg soil which is low (P < 10 ppm) according to Tekalign (1991). The soil available sulfur was 5.1 ppm; therefore, the result showed that the available sulfur level was medium according to Olsen (1954) reported that soils with Sulfur content of 5–10 ppm as medium. Similarly, Tisdale *et al*. (2002) reported that concentration of 3 to 5 ppm or more SO_4^{-2} in the soil solution is adequate for the growth of many plant species.

3.2. Effect of NPS Fertilizer Rates and Intra-row Spacing on Phonology and Growth Parameters of Maize

The effects of NPS fertilizer rates and plant spacing studied showed that stem diameter, leaf length, leaf width, cob length and grain yield were significantly affected by the main effects of fertilizer rates and plant spacing (Table 1). In addition, spacing was showed significance variation on the above ground biological yield and cob weight. However, interaction effects of NPS fertilizer rates and plant spacing were showed significant differences only on leaf width and grain yield (Table 1). However, as the result revealed that there was no significant variation regarding to both main and interaction effects on days to 50% emergence, plant height, thousand grain weight, harvest index and moisture content of maize (Table 1).

Table 1. Mean square values for growth and yield components as influenced by the main and interaction effects of NPS rates and spacing of maize

Parameters	**Fertilizer**	**Spacing**	**Fertilizer x Spacing**
50%Days emergency	0.017ns	0.032ns	0.022ns
Plant height	20.77ns	11.65ns	1.98ns
Stem diameter	7.55***	18.50***	0.24ns
Leaf length	50.60**	146.70***	2.65ns
Leaf width	6.20***	17.70***	0.52*
Cobe length	23.85*	39.48*	0.50ns

Above ground biological yield	4.37ns	39.49*	4.93ns
Grain Yield	3950333.33***	9088222.22***	480166.67*
1000 Grain weight	1074.44ns	1975.56ns	1547.78ns
Harvest index	3.50ns	11.01ns	8.06ns
Moisture content	1.09ns	2.89ns	3.32ns
Cob weight	0.085ns	1.18*	0.21ns

Where, ns =non-significant, and *, **, ***, significant at P<0.05, 0.01 and 0.001 LSD tests, respectively.

3.2.1. Stem diameter (cm)

Stem diameter is one of the most important parameters of maize production. The result showed that there was significant (p<0.01) variation due to the main effect of both fertilizer rates and plant spacing (Table 2). The highest (12.62cm) and lowest (10.32cm) stem diameters were obtained from an application of 300 kg NPS ha^{-1} and from the control plot, respectively with significant improvement by 18%. Highest (12.61cm) and lowest (10.47cm) stem diameters were obtained at 35 and 15cm of plant spacing, respectively with significant improvement by 17%. In line with this result, Sangakkara *et al*. (2004) observed that as the number of plants increased in a given area, the competition among the plants for nutrients uptake and sunlight interception also increased which causes retarded growth.

3.2.2. Leaf length (cm)

The analysis of data showed that there were significant (p<0.01) differences among treatments regarding to leaf length due to the main effect of different blended NPS rates and intra-row spacing. Higher (101.95cm and 102.77cm) leaf lengths were recorded at an application of 225 and 300 kg NPS ha^{-1}; while the lower (97.28cm, 98.21cm and 99.31 cm at par to each other) leaf lengths were obtained from the control plot, at an application of 75 and 150 kg NPS ha^{-1}, respectively (Table 2). Higher (103.51cm) and lower (98.02cm and 98.18cm at par) leaf lengths were obtained at 35cm, and 15cm and 25cm plant spacing, respectively.

3.2.3. Cob length (cm)

Cobe length of maize was significantly ($p<0.05$) influenced by the main effects of blended NPS fertilizer rates and intra-row spacing, but their interaction did not influence cobe length. Highest (38.11 and 37.63 cm) cob lengths were obtained at an application of 300 and 225 kg NPS ha^{-1}, respectively without statistical differences from other rates of NPS applied; and lowest (34.17cm) cob length from control plot (Table 2). Generally, the result indicated that there was consistent increment in ear length with increasing of blended NPS fertilizer rates from control treatment to 300 kg NPS ha^{-1}; even though those fertilized with all levels of NPS were at par to each other. Maize planted at 35cm intra plant spacing was significantly increased cob length (38.28cm) as compared to those planted at 15 cm and 25cm plant spacing (35.26cm and 35.75cm at par), respectively (Table 2). In agreement with this result, Kena (2015) reported that the highest ear length (21.20cm) was recorded by highest fertilizer rate applied (180 kg ha^{-1}); while lowest ear length (16.73 cm) was recorded from zero fertilizer application. Similar to the current result, Zamir *et al*. (2011) reported that the cob length significantly decreased as the plant population became increased and there was a positive relationship between plant spacing and cob length of maize, probably due to variable plant competition.

Table 2. Main effect of different rates of NPS fertilizer and plant spacing on growth parameters of maize crop

	Parameters				
	Days to 50% emergency	**Plant height(cm)**	**Stem Diameter (cm)**	**Leaf length (cm)**	**Cobe Length (cm)**
NPS Rate (kg ha^{-1})					
0	4.85^{a}	192.72^{a}	10.32^{d}	97.28^{b}	34.17^{b}
75	4.81^{a}	193.73^{a}	10.76^{cd}	98.21^{b}	35.40^{ab}
150	4.84^{a}	194.88^{a}	11.20^{c}	99.31^{b}	36.84^{ab}
225	4.93^{a}	195.00^{a}	11.91^{b}	101.95^{a}	37.63^{a}
300	4.83^{a}	196.77^{a}	12.62^{a}	102.77^{a}	38.11^{a}
SE	0.054	2.28	0.256	1.439	1.545
LSD (0.05)	0.11ns	4.68ns	0.52**	2.947**	3.165*

Spacing (cm)					
15	4.89^{a}	195.56^{a}	10.47^{c}	98.02^{b}	35.26^{b}
25	4.80^{a}	194.49^{a}	11.01^{b}	98.18^{b}	35.75^{b}
35	4.87^{a}	193.81^{a}	12.61^{a}	103.51^{a}	38.28^{a}
SE	0.042	1.77	0.198	1.114	1.197
LSD (0.05)	0.085ns	3.63ns	0.41**	2.283**	2.452*
CV (%)	**2.85**	**2.52**	**4.39**	**2.54**	**7.53**

SE-Standard error; LSD-Least Significant Differences; CV-Coefficient of Variation; NS-Non significant

3.2.4. Leaf width (cm)

Analysis of variance indicated that both main and interaction effects of blended NPS rates and plant spacing had significant ($p<0.01$) effect on leaf width of maize (Tables 1 and 3). Thus, highest (12.83cm and 13.46cm at par) leaf width was recorded at the application of 225 and 300 kg NPS ha^{-1} at 35cm plant spacing, and lowest (9.42cm) from without external NPS application at 15cm spacing, respectively. This indicated that application beyond 225 kg NPS ha^{-1} to maize has no significant increment on leaf width; but this was significantly improved by 26.58% as compared to the lowest leaf width obtained from the control at 15cm plant spacing. Valadabadi and Farahani (2010) investigated that leaf width is influenced by genotype, plant population, climate and soil fertility. They further reported that highest physiological growth indices are achieved under high plant density, because photosynthesis increases by development of leaf width. In this research, the increase in leaf width explains the general crop trends that increasing plant density increased leaf width. Previous research findings also indicated that in high maize density, leaf width increased than low maize density throughout crop growth season (Saberali, 2007).

Table 3. Interaction effect of fertilizer rates and plant spacing on leaf width of maize crop

	NPS Fertilizer rate (kg ha^{-1})				
Spacing (cm)	0	75	150	225	300
15	9.42^{e}	9.50^{e}	9.63^{de}	9.90^{de}	10.97^{bc}
25	9.61^{e}	9.71^{de}	9.47^{e}	10.09^{cde}	11.18^{b}

35	10.61[bcd]	11.07[bc]	11.17[b]	12.83[a]	13.46[a]
SE=	0.51;	**LSD(0.05)=**	1.04*;	**CV (%) =**	5.90

3.3. Effect of NPS Rates and Intra-Row Spacing on Yield and Yield Components

3.3.1. Above ground biomass yield

The result showed that there was significant ($p<0.05$) effect by the main effect of spacing on above ground biomass yield of maize; but the main effect of NPS rate and the interaction effect of the two factors did not statistically influence maize biomass (Tables 1 and 4). The highest (11.93kg) and lowest (8.73kg) biomass was obtained at 35 and 15cm plant spacing, respectively; however, the biomass obtained at 15 and 25cm plant spacing were statistically at par. The higher biomass was significantly improved by 17.27% and 26.82% as compared to the biomass obtained at 25cm and 15cm plant spacing, respectively. The increased yield of above ground biomass of the present experiment was also similar to that reported by many other authors (Khan *et al*., 2014) who indicated that the above ground biomass yield increased significantly with an increased plant density.

3.3.2. Harvest index, moisture content, thousand grain weight and cob weight

The result revealed that there was no significant variation on thousand grain weight, harvest index and moisture contents mean due both main and interaction effects of NPS fertilizer rates and plant spacing (Tables 1 and 4). But, the analysis of variance showed that plant spacing significantly ($p<0.05$) influenced cob weight; whereas, the main effect of NPS fertilizer rates and their interaction did not significantly influence cob weight of maize (Tables 1 and 4). Thus, heaviest cob weight (2.44kg) was recorded from the crop planted at 35cm spacing (2.09kg) followed by 25cm spacing, and lightest cob weight (1.89kg) from 15cm spacing planted. This heaviest cob weight was improved by 14% and 22.5% as compared to the cob weight recorded from those planted at 25cm and 15cm spacing, respectively; which might be due to the less competition for resources between more spaced plants.

Table 4. Main effect of different rates of NPS fertilizer and plant spacing on yields and quality parameters of maize crop

Treatments	Parameters				
	Aboveground Dry matter(kg)	1000 Grain weight (gm)	Harvest Index (HI)	Moisture content (%)	Cobe Weight (kg)
NPS rate (kg ha^{-1})					
0	9.22[a]	325.56[a]	14.91[a]	15.63[a]	2.02[a]
75	10.22[a]	313.33[a]	14.51[a]	15.30[a]	2.19[a]
150	10.44[a]	307.78[a]	14.16[a]	14.84[a]	2.27[a]
225	9.89[a]	300.00[a]	15.24[a]	14.86[a]	2.07[a]
300	11.11[a]	298.89[a]	13.65[a]	15.40[a]	2.14[a]
SE	1.02	14.53	1.41	0.53	0.24
LSD (0.05)	NS	NS	NS	NS	NS
Spacing(cm)					
15	8.73[b]	296.00[a]	15.20[a]	14.71[a]	1.89[b]
25	9.87[b]	317.33[a]	14.74[a]	15.35[a]	2.09[ab]
35	11.93[a]	314.00[a]	13.54[a]	15.55[a]	2.44[a]
SE	0.79	11.26	1.09	0.41	0.19
LSD (0.05)	1.62*	NS	NS	NS	0.38*
CV (%)	**15.38**	**9.65**	**18.02**	**8.65**	**26.33**

SE-Standard error; LSD-Least Significant Differences; CV-Coefficient of Variation; NS- Non significant

3.3.3. Grain yield

The result obtained revealed that the grain yield was significantly ($p<0.05$) influenced due both main and interaction effects of NPS rates and plant spacing (Tables 1 and 5). Highest (7400 kg ha^{-1}) grain yield of maize was recorded from the plot fertilized with 300 kg NPS

ha^{-1} at 15cm plant spacing and lowest (3833.3 $kgha^{-1}$) was from plot without external NPS application at 35cm plant spacing, respectively. The highest grain yield was increased by 48% as compared to the lowest grain yield obtained from control at 35cm plant spacing; indicating that optimum rate and type of fertilizer application improved yields of maize even in the less plant spacing. In the study area under rain fed cropping yields of 7000 to 9000 kg ha^{-1} was expected on research farms and 4000 to 5000 $kgha^{-1}$ was expected from farmers` land. So, the result attained was in the range of expected yield in the research farms. This result agreed with the previous finding of Klikocka *et al*. (2016) whose found that a positive reaction of N and S fertilization on grain yield, which was highest grain yield (5.40 t ha^{-1}) obtained due to application of 80 N kg ha^{-1} by 13.1% increasing as compared to lowest yield (1.30 t ha^{-1}) in the control plot and S fertilization increased grain yield by 3.58%. Besides, Khan *et al*. (2014) reported 43% raise in grain yield with the addition of 90 kg P and 60 kg S ha^{-1}.

Table 5. Interaction effect of NPS rates and plant spacing on grain yield (kg ha^{-1}) of maize

	NPS Fertilizer rate (kg ha^{-1})				
Spacing (cm)	0	75	150	225	300
15	4566.70^{fgh}	5166.70^{de}	5833.30^{c}	6566.70^{b}	7400.00^{a}
25	4366.70^{ghi}	4766.70^{efg}	4966.70^{ef}	5233.30^{de}	5566.70^{cd}
35	3833.30^{i}	4066.70^{hi}	4366.70^{ghi}	4700.00^{efg}	4833.30^{efg}
SE=	280.50	**LSD(0.05)=**	574.5*	**CV (%) =**	6.80

4. CONCLUSION AND RECOMMENDATIONS

The results revealed that the highest leaf width (13.46cm) and grain yield (7400$kgha^{-1}$) were attained in the application of 300 kg NPS ha^{-1} at 35cm and 15cm plant spacing, respectively. Highest biomass yield (13.67kg/ha) was recorded in plot applied with 300 kg NPS ha $^{-1}$ at 35 cm plant spacing; while, lowest (7.33 kg) was obtained from control plot at 15 cm plant spacing. However, highest grain yield (7400 kg ha^{-1}) was obtained from an application of 300 kg NPS ha $^{-1}$ at 15 cm plant spacing and lowest (3833.30 kg ha^{-1}) was recorded from control plot at 35 cm plant spacing. Highest (17.07%) and lowest (13.93%) moisture content were obtained from control at 35cm and 15cm plant spacing, respectively. Therefore, based on the result of the study, it can be concluded that application of 300 kg NPS ha^{-1}at 15cm plant spacing was found to be superior in maize growth and yields. Thus, it is recommended that these studies had showed that further study is required to confirm the NPS fertilizer rates and plant spacing effects; and to identify and recommend the best rate of NPS for that plant spacing in the study areas and the like. Studies on different plant spacing of maize crop at different areas of the rift valley areas and the country is very important for recommendation of the exact rate along the different plant spacing is also an important issue to be considered in the future.

5. REFERENCES

AfDB (African Development Bank). 2011. Malawi Interim Country Strategy paper 2011-2012. Tunis: African Development Bank.

Alemu D., Wilfred M., Mandefro N. and David J.S. 2008. The maize seed system in Ethiopia: challenges and opportunities in drought prone areas. *African Journal of Agricultural Research*, 3 (4): 305-314.

Ali N.A. and Anjum M.M. 2017. Effect of different nitrogen rates on growth, yield and quality of maize. *Middle East Journal of Agriculture Research*, 6: 107- 112.

Anonymous. 2013. http://www.krishijagran.com/farm-data/ farm-statistics/2014/11/State-wise-Area-productionyield-crops-2011-12-and-2012-13/Area-Production-and Yield-of-Maize-during-2011-12-and-2012-13.

Anonymous. 2016. Package of practices for kharif crops of Punjab. Punjab Agricultural University, Ludhiana.

CSA (Central Statistical Agency). 2017. Federal Democratic Republic of Ethiopia Agricultural Sample Survey 2010/2011 (2003E.C.) (September-December, 2010) Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season), April 2011, Vol. I, Addis Ababa.

Cisse L. and Amar B. 2000. The importance of Phosphatic fertilizer for increased crop production in developing countries. *In Proceedings of the AFA 6th international annual conference Helon 31 January – 2 February.*

Dewis J. and Freitas P. 1970. Physical and chemical methods of soil and water analysis. FAO Bull. No. 10, Rome. 271p.

FAOSTAT (Food and Agriculture Organization of the United Nations). 2013. Online database, FAO, Rome.

FAOSTAT. 2014. Africa maize production-2012/13. http://faostat 3. fao. org/browse /Q/QC/E. Accessed on November 10, 2014.

Fufa B., Behute B., Simons R. and Berhe T. 2011. Strengthening the tef value chain in Ethiopia (Unpublished Report). pp. 12. Agricultural Transformation Agency.

Kandil E.E. 2013. Response of Some Maize Hybrids (*Zea mays* L.) to Different Levels of Nitrogenous Fertilization. *Journal of Applied Sciences Research*, 9(3): 1902-1908.

Kidist. 2013. Growth and productivity of maize as influenced by rate and time of nitrogen. *Journal of Applied Sciences Research*, 9(4): 1920-1928.

Khan F., S. Khan, S. Fahad et al., "Effect of different levels of nitrogen and phosphorus on the phenology and yield of maize varieties," *American Journal of Plant Sciences*, vol. 05, no. 17, pp. 2582–2590, 2014.

Landon J.R. 1991. Booker Tropical Soil Manual: A hand book for soil survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman Scientific and Technical, Essex, New York. 474p

National Bank of Ethiopia. 2011. Annual report VII. Addis Ababa, Ethiopia.

Olsen S.R., Cole C.V., Watenabe F.S. and Dean L.A. 1954. Estimation of the valuable phosphorus in soil by extraction with sodium bicarbonate United States Department of Agriculture Circ., 939.USA.

Onasanya R.O., Aiyelari O.P., Onasanya A.S., Oikeh F.E. and Oyelakin O.O. 2009. Growth and yield response of maize (*Zea mays* L.) to different rates of nitrogen and phosphorus fertilizers in Southern Nigeria. IDOSI Publications, 5(4): 400–407

Rao I., Friesen D. and Osaki M. 1995. Plant adaptation to P-limited tropical soils. *Handbook of Plant and Crop Physiology*, pp 61 – 95. New York, USA

Rosegrant M.W., Msangi S., Ringler C., Sulser T.B., Zhu T. and Cline S.A. 2010. International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model Description. International Food Policy Research Institute: Washington, D.C.

Saberali S.F. 2007. Influence of plant density and planting pattern of corn on its growth and yield under competition with common Lambes quarters (*Chenopodium album* L.). *Pajouhesh and Sazandegi*. 74: 143-152.

Sangakkara S.F., Bandaranayake, P.S.R.D., Gajanayake, J.N. and Stamp. 2004. Plant populations and yield of rain fed maize grown in wet and dry seasons of the tropics. Maydica, 49: 83-88.

Shiferaw B., Prasanna B., Hellin J. and Banziger M. 2011. Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. *Food Security*, 3(3): 307-327.

Suri T. 2011. "Selection and Comparative Advantage in Technology Adoption". *Econometrica*, 79(1): 159–209.

Taye, G. 2009. Effects of nitrogen and phosphorus fertilizers on the growth, yield and yield components of maize (*Zea mays* L.) at Nedjo, West Wollega, Ethiopia [MSc. Thesis]. Haramaya University.

Tekalign T. 1991. Working Document: Soil, Plant, Water Fertilizer, Animal Manure and Compost Analysis Manual. International Livestock center for Africa, No. B13, Addis Ababa, Ethiopia.

Tisdale S.L., Nelson W.L., Beaton J.D. and Havlin J.L. 2002. Soil Fertility and Fertilizers. 5th ed., Macmillan, New York.

Valadabadi S.A. and Farahani H.A. 2010. Effects of planting density and pattern on physiological growth indices in maize (*Zea mays* L.) under nitrogenous fertilizer application. *J. Agric. Ext. and Rural Dev*. 2(3): 40-47.

Verheye W. 2010. Growth and Production of Maize: Traditional Low-Input Cultivation. In: Land Use, Land Cover and Soil Sciences. Encyclopedia of Life Support Systems (EOLSS), UNESCO-EOLSS Publishers, Oxford, UK. Online available at: http://www.eolss.net. Accessed on October 28, 2014.

World Bank. 2013. World Development Report: Ethiopia at a glance. [http://devdata.worldbank.org/AAG/eth_aag.pdf] site visited on 10/12/2013.

Zamir MSI, Ahmad AH, Javeed HMR, Latif T. 2011. Growth and yield behaviour of two maize hybrids (*Zea mays* L.) towards different plant spacing. *Cercetari Agronomice in Moldova*, 44(2):33-40.