Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.5, No.13, 2015

Effects of Nitrogen and Phosphorus Fertilizers on the Yield of Maize (*Zea mays* L.) at Nedjo, West Wollega, Ethiopia

Geremew Taye

EIAR, Holetta agricultural research center PO.box 2003 Addis Ababa, Ethiopia

Kindie Tesfaye,

IRLI Project, Addis Ababa Ethiopia

Tolessa Debele

EIAR, SARD- SC wheat project

Abstract

This experiment was conducted to determine the optimum levels of nitrogen (N) and phosphorus (P) fertilizer for maize production; and to see the interaction between different levels of N and P fertilizer on the growth and performance of maize (*Zea mays* L.) BH-660 variety at Nedjo. The experiment had two factor: 5 levels of N (0, 46, 92, 138, and 184 kg ha^{-1}) and 5 levels of P (0, 23, 46, 69 and 92 kg ha^{-1}) arranged in Randomized Complete Block Design (RCBD) with three replications. The sources of N and P were urea (46% N) and triple super phosphate (TSP) (46% P_2O_5), respectively. The main effects of N and P brought significant effect on thousand grain weight. The interactions of N and P also significantly affected grain, and biomass yield; and harvest index. The highest grain yield (5497.5 kg ha^{-1}) and biomass yield (16521 kg ha^{-1}) were recorded at the highest rates of N/P (184/92 kg ha^{-1}).

Key words: nitrogen, phosphorus, maize NP interaction, Nedjo.

1. Introduction

Poor soil fertility is one of the bottlenecks for sustaining maize production and productivity in Ethiopia in general and in western Oromia in particular (Tolessa et al*.,* 2002). In most regions of Ethiopia, soils are deficient in nitrogen (N) and phosphorus (P). In some places of western Ethiopia, adverse soil conditions prevail, and frequently a combination of these limit crop production. The situation has been further aggravated by the long history of cultivation without any NP replenishment, which led to low soil fertility and low crop yields.

Maize is heavy nutrient feeder and has high demand for N and P which are often the limiting nutrients for maize production. The western part of Ethiopia is dominated by nitisols, which are inherently low in N and P where maize is mainly grown on these soil types by resource poor farmers who cannot afford to apply fertilizers at optimum rates. Although the use of fertilizers is increasing recently, the quantity of fertilizer applied to maize by small scale farmers is still very low.

Increasing levels of nitrogen and phosphorus in the soil under different soil and management condition showed increased grain yield, above ground biomass, number of kernels per ear and plant height of maize (Ayub et al., 2002; Muhammad et al. 2004; Hani et al. 2006). An important problem associated with phosphorus whether it is derived from the soil or applied as fertilizers is its fixation in the soil and the amount of inherent P is very low in the soils, most of which present in the soil in unavailable form, and added soluble forms of P are quickly fixed by many soils (Brady, 1990). Muhammad et al. (2004) reported that in soils which are deficient or marginal in available P, application of higher dose of P enhances emergence of seedlings through its effect on development of root, and thereby enhances days to flowering and maturity and also increases the grain yield of maize.
Above ground biomass and grain yields of maize increased with application of increasing levels of P fertilizer (Ayub et al., 2002). They also reported that increased P application enhanced uptake of soil nitrate and K by maize plant. It was also indicated that application of nitrogen fertilizer helps to increase phosphorus uptake from the soil (Onasanya et al., 2009). Wilkinson and Grunes (2000) confirmed the generalization that the response to one nutrient depends on the sufficiency level of other nutrients. Nitrogen can increase P concentrations in plants

by increasing root growth, increasing the ability of roots to absorb and translocate P, and by decreasing soil pH as a result of absorption of NH_4^+ and thus increasing solubility of fertilizer P (Havlin et al., 2003).

According to Demissew et al. (2002), 150 kg ha^{-1} DAP and 200 kg ha^{-1} of urea is recommended for Gimbi, Guliso, Jarso and similar areas. Significant response of maize grain yield up to the rate of 75 kg ha^{-1} N and 75 kg ha^{-1} P_2O_5 in west Wollega (Tolessa et al., 2002).

In the perspective of ever increasing human and livestock population, the practice of bringing new land under cultivation is no longer possible. Therefore, further increases in production of maize must largely come from higher productivity per unit area per unit time which necessitates better management of scarce fertilizer nutrients at farmer's level. This experiment was initiated to determine the optimum levels of N and P fertilizer for maize production; and to see the interaction between different levels of N and P fertilizer on the growth and performance of maize.

2. Materials and Methods

2.1 Experimental site

The experiment was conducted at Nedjo woreda in West Wollega zone of the Oromia National Regional State, Western Ethiopia, during the main crop growing season (June- December) 2008. Nedjo town is located at 515 km West of Addis Ababa on the main road to Assosa. The study site is situated at 9^0 30' 00" N latitude, 30^0 30' 00" E longitude, and 1735 meter above sea level (masl) in a sub-humid agro-ecology. The minimum, maximum and average annual rain fall were 1200, 1900 and 1400 mm respectively in a unimodal pattern, extending from April to October with a peak in July and August. The average minimum, maximum and mean temperatures of the area were 12, 26 and 19^0 C, respectively (Gauchan et al*.,* 1998). According to FAO/UNESCO soil classification system, the soils in southwest and western Ethiopia in general are nitisols (Fikru, 1988).

2.2 Experimental design and treatments

The experiment comprised of a factorial combination of 5 levels of N (0, 46, 92, 138, and 184 kg ha^{-1}) and 5 levels of P (0, 23, 46, 69 and 92 kg ha^{-1}) arranged in Randomized Complete Block Design (RCBD) with three replications. The sources of N and P were urea (46% N) and triple super phosphate (TSP) (46% P_2O_5), respectively. Maize variety BH-660 was used as a test crop.

A spacing of 75 cm and 30 cm were used for sowing. Half dose of N and full dose of P fertilizer, as per the treatments, were applied at planting and the remaining half dose of N was applied 35 days after sowing. All pertinent data were collected from net plot area of 2.25 x 3.6 m excluding plants from either end of the rows.

2.3 Data collection

Soil samples were collected from a depth of 30 cm before planting at random, and one complete composite sample was prepared to determine the particle size distribution and chemical properties of the soil. Soil texture was determined by Bouyoucos hydrometer method (Day, 1965), Organic matter determined based on the oxidation of organic carbon with acid dichromate medium following the Walkley and Black method And total N determined by Kjeldahl method (Dewis and Freitas, 1970) and available soil P determined using Olsen and Dean (1965) method. Soil pH determined in 1:2.5 soil: water ratio using a glass electrode attached to a digital pH meter.

2.4 Data analysis

All data were subjected to analysis of variance (ANOVA) using Statistical Analysis Software (SAS, 2002). The difference among significant treatment means was tested using least significant difference (LSD) at 5% level of significance.

3. Results and Discussion

3.1 Major Physico-Chemical Properties of the Soil

The result of the physical and chemical analysis of experimental soil revealed that the textural class of the surface soil (0-20cm) was sandy clay loam with a particle size distribution of 48% sand, 26% silt and 26% clay. According to Tekalign (1991) and Landon (1991) the chemical analysis showed that the soil was strongly acidic with relatively medium nitrogen, low organic matter, and low organic carbon (Table 1).

The available P total N and organic carbon of the soil was 16.4 mg kg-1, .02 and 3.05 respectively. Such soil often responds to P and N application according to Amar (1999) and Landon (1991) respectively.

Table 3. Major soil physico-chemical properties of the experimental field

parametrs	Values
A. particle size distributions	
textural class	
Sand (%)	48
Silt (%)	26
Clay (%)	26
B. chemical analysis	
soil pH	5.04
OC (%)	3.05
OM (%)	5.26
N (%)	0.28
P mg kg^{-1}	16.4

3.2 Grain yield

As indicated on table 2, grain yield was significantly affected by the main and interaction effects of the treatments. Application of 184/92 kg ha^{-1} N/P followed by application of 184/69 kg ha^{-1} N/P and 138/92 kg ha^{-1} N/P ($p<0.05$) gave significantly higher grain yield compared to the rest of the treatment combinations. The application of 0-92 kg ha^{-1} N in the absence of P and application of 0-23 kg ha^{-1} P in the absence of N fertilization gave significantly lower grain yield as compared to the rest of the treatments but increased with an increase in the level of both N and P applications.

Table 2. Grain yield of maize as affected by the interaction effects of different levels of N and P fertilizer application on hybrid maize variety grown at Nedjo

P rate	N rate (kg ha^{-1})					
(kg ha^{-1})	0	46	92	138	184	Mean
0	1797.8^{m}	1806.0^{m}	2078.3^{lm}	2373.3^{kl}	3510.4^{gh}	2313.1
23	1983.3^{lm}	3069.2^{hij}	3001.5^{ij}	3860.9^{fg}	3977.5^{efg}	3178.5
46	2817.2_{jk}	3864.9^{fg}	3948.8^{efg}	4177.0^{def}	4470.5^{cd}	3855.7
69	3324.4^{hi}	$4190.^{9c-f}$	$4181.^{2c-f}$	4408.1^{cde}	5137.4^{ab}	4248.4
92	3218.6^{hij}	4963.1^{b}	4664.5^{bc}	5103.6^{ab}	5497.5^{a}	4689.5
Mean	2628.2	3578.8	3574.8	3984.6	4518.7	
CV (%)	6.06					

Means followed by the same letter with in row or column are not significantly ($p < 0.05$) different

Application of 184/92 kg ha^{-1} N/P fertilizer increased the grain yield of maize by 206% as compared to the non-fertilized treatments. In fact, the average yield recorded from the control treatment (1797.8 kg ha^{-1}) was fairly higher than the average maize grain yield from local and non-fertilized farmers fields where average maize grain yield is about 1000 kg ha^{-1}. Similarly, Kelsa et al. (1992) reported an average maize grain yield of 2475 kg ha^{-1} from control plots of 253 trials from major maize growing, which is by far higher than the national average yield (2112 kg ha^{-1}). The use of improved varieties, row planting and better management practices of the trial plots might have contributed to this difference.

Increased application of N fertilizer was accompanied with increased grain yield of maize. This was reported by many other researchers such as Tenaw (2000) Tolessa et al. (2002), Jehan et al. (2006) and Kolawole and Joce (2009). Similarly Tolessa (1999) found progressive increases in maize grain yield with an increase in the levels of N and P fertilizers.

3.3 Biomass yield

Biomass yield of maize, as affected by interaction effects of different levels of nitrogen and phosphorous is presented in Table 3. The analysis of variance for biomass yield indicated significant ($P < 0.05$) biomass yield differences due to the interactions of N, P fertilizers and their main effects. Similar to the results for grain yield, application of 184/92 kg ha^{-1} NP fertilizers gave significantly the higher above ground biomass compared to rest of the treatment combinations and 126% as compared to non-fertilized treatments. Application of either of N or

P fertilizers alone did not have significant difference in biomass production from the non-fertilized treatments but increased with an increase in the application of N or P fertilizers.

This is in agreement with the findings of Kolawole and Joce (2009) indicted that application of NPK fertilizer increase the total dry matter of maize. In addition, inconformity to this finding, Ayub et al. (2002) and Hani et al. (2006) indicated that application of N had significantly increased the biomass yield of forage maize.

Table 3. Biomass yield (kg ha^{-1}) of maize as influenced by interaction effects of different levels of N and P fertilizers on hybrid maize variety grown at Nedjo.

P rate (kg ha^{-1})	N rate (kg ha^{-1})					Mean
	0	46	92	138	184	
0	7292.0^{kl}	6195.3^{l}	8148.3^{i-l}	7301.7^{kl}	8064.0^{jkl}	7400.3
23	7341.7^{kl}	9839.0^{f-j}	10077.3^{f-i}	11502.3^{ef}	9405.$^{4g-j}$	9633.1
46	8517.3^{ijk}	11175.7^{efg}	11282.3^{efg}	11844.0^{def}	10575.7^{fgh}	10679.0
69	8819.3^{h-k}	13816.3^{bcd}	13550.0^{bcd}	13077.7^{cde}	14155.7^{bc}	12683.8
92	11060.0^{fg}	14643.3^{abc}	13952.3^{bc}	15098.7^{ab}	16521.3^{a}	14295.1
Mean	8606.0	11173.9	11402.1	11764.9	11744.4	
CV (%)	8.37					

Means followed by the same letter with in a row or column are not significantly (p< 0.05) different.

3.4 Harvest index

Harvest index was significantly ($P < 0.05$) affected by the main and interaction effects of the treatments (Table 4). Application of 0-46 kg ha^{-1} P in combination with 184 kg ha^{-1} N gave significantly higher harvest index than the rest of the treatments except 0/69 kg ha^{-1} N/P fertilizer rates. On average harvest index consistently increased with an increase in N rate whereas significantly higher harvest index was recorded when 46 kg ha^{-1} P combined with 184 kg ha^{-1} N applied. This result is in agreement with findings of Tolessa (1999) and Sharar et al. (2003) who reported higher harvest index under higher level of N and P than application of lower levels the fertilizers. This could be due to an increase in grain yield more than the increase in biomass which resulted in higher harvest index.

Table 4. Harvest index (%) of maize as affected by the interaction of N and P fertilizer applications on hybrid maize variety grown at Nedjo.

Phosphorus (kg ha^{-1})	N rate (kg ha^{-1})					Mean
	0	46	92	138	184	
0	24.7^{f}	30.0^{def}	25.6^{f}	32.8^{cde}	43.6^{a}	31.3
23	27.1^{ef}	31.3^{c-f}	29.8^{def}	33.6^{cde}	42.5^{ab}	32.9
46	33.1^{cde}	34.9^{cd}	35.1^{cd}	35.4^{cd}	42.3^{ab}	36.2
69	37.7^{abc}	30.3^{def}	39.9^{c-f}	33.8^{cde}	36.3^{bcd}	33.8
92	30.6^{def}	33.4^{cde}	33.5^{cde}	33.8^{cde}	33.3^{cde}	32.9
Mean	30.7	32.1b	31.0	33.9	39.6	
CV (%)	11.19					

Means followed by the same within a row or column letter are not significantly ($p < 0.05$) different.

3.5 Thousand grain weight

Increasing N levels from 46 to 138 kg ha^{-1} significantly ($P < 0.05$) increased thousand grain weight and showed linear and consistent increment. Similarly, increasing P levels from 0 to 92 kg ha^{-1} significantly ($P < 0.05$) increased thousand grains weight. Application of 138 kg ha^{-1} N and 92 kg ha^{-1} P gave significantly higher thousand grain weight when compared to the rest of the N and P levels studied (Table 5). This result agrees with the findings of Tolessa (1999) and Sharar et al. (2003) who found that application of higher levels of N and P fertilizers significantly increased thousand grain weight; and Kolawole and Joce (2009) indicted that application of NPK fertilizer increase thousand grain weight of maize. Muhammad et al. (2004) and Zeidan et al. (2006) documented an increase in N fertilization resulted in an increase in thousand grain weight.

Table 5. Main effects of N and P levels on thousand grain weight of hybrid maize variety grown at Nedjo

Treatments	TGW	Treatments	TGW
N rates (kg ha^{-1})		P rates (kg ha^{-1})	
0	371.3^{bc}	0	325.1^{e}
46	359.9^{c}	23	357.7^{d}
92	366.5^{bc}	46	359.0^{c}
138	399.6^{a}	69	396.4^{b}
184	381.8^{b}	92	420.9^{a}
CV (%)	5.987		

TGW= Thousand grain weight, Means followed by the same letters within column are not statistically ($p < 0.05$) different.

6. Summary and Conclusions

It was observed that, application of N and P significantly affected grain yield, biomass yield and harvest index. Application of 184 kg ha^{-1} N and 92 kg ha^{-1} P gave the highest grain yield (5497.5 kg ha^{-1}). However, further analysis indicate that application of 184/69 and 138/92 kg ha^{-1} N/P fertilizers could give similar grain yield of maize to the 184/92 kg ha^{-1} N/P combinations. This indicates that application of N/P fertilizer above higher NP rates used in the current study does not have significant increase in the grain yield of maize in the study area.

The highest biomass yield (16521 kg ha^{-1}) was obtained at the highest rates of NP (184/ 92 kg ha^{-1} N and P). The mean separation for the main and interaction effects showed the possibility for increasing maize biomass yield beyond the application of 92 kg ha^{-1} P while application of N beyond 138 kg ha^{-1} did not significantly increase biomass yield. From this the farmers around Nedjo area better use NP fertilizers at the rate of 138/92 to get highest significant yield. Even though the result obtained show good result with high amount of fertilizer rate gave high yield it is necessary to see the effect with soil acidity amendment as the area is seriously acidic.

References

Amar, B., 1999. Diagnosis and prescription of phosphate fertilization with in the Mediterranean region countries. *In*: *African Crop Science Society Proceedings*. Casablanca, 10-14 October 1999. Pp.99-106.

Ayub, M., M.A. Nadeem, M.S. Sharar and N. Mahmood, 2002. Response of maize (*Zea mays* L.) fodder to different levels of nitrogen and phosphorus. *Asian J. plant sci*., 1: 352-254.

Brady, N.C., 1990. The Nature and Properties of Soil. 10th Ed. Macmillan Publications, Co Ltd New York. 364 p.

Day, P.R., 1965. Hydrometer method of particle size analysis. In: C.A. Black (ed.). Methods of soil analysis. *American Society of Agronomy*, Wisconsin Argon. No.9. Part 2. Pp. 562-563.

Demissew Aba Kemal, Tolessa Debele, Dange Wagari, Haji Tuna, Koste Abdissa and Germa Demisei. Bako National Maize Research Project, west Showa. *In* Oromia Agricultural Research Institute (OARI), 2002. *Recommended Research Results for Improving Crop, Livestock, and Natural Resources Productivity in Western Oromia: Users' Manual*. OARI, Bako Agriculteral Research Center, Oromia, Ethiopia.

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

Fikru Abebe, 1988. Need for Soil Survey Studiers *In* Desta Beyene (Ed). Proceedings of Soil Science Research Review in Ethiopia. Institute of Agricultural Research (IAR). 11-14 February 1986. Addis Ababa, Ethiopia. 15-20p.

Gauchan, D., J. Ayo-Odongo, K. Vaughan, L. Gizachew and M. Negeri, 1998. Participatory Systems Analysis of the Termite Situation in West Wollega, Oromia Region, Ethiopia. Working Document Series 68, ICRA, Netherlands. 158p.

Hani.A. E., A. H. Muna, and E.A. Eltom, 2006. The Effect of Nitrogen and Phosphorus Fertilizatoin on Growth, yield and Quality of Forage Maize. Department of agriculture, alzaiem Alazhari University and Department of agronomy, faculty of agriculture, university of kartoum, sahambat 13314, sudan.

Havlin J. L., J.D. Beaton, S.L. Tisdale, W.L. Nelson, 2003. Soil Fertility Fertilizers, An introduction to nutrient Manageme nt 6th edition Pearson Education, Inc.

Jehan B., S. Ahmad, M. Tariq, H. Akber and M. Shafi, 2006. Response of Maize to Planting Methods and Fertilizer N. Asian Research Publishing Network. Vol. 1, No 3.

Kelsa Kena, Tadesse Yoannes and Tesfa Bogale, 1992. Influence of fertilizer and its management practices on maize grain yields in major maize producing areas of Ethiopia. *In: proceedings of the first national maize work shop of Ethiopia*. CIMMYT (International Maize and Wheat Improvement Center) and IAR (Institute of Agricultural Research).

Kolawole Edomwonyi LAW-OGBOMO, Joyce Egberanwen LAW-OGBOMO. 2009. The Performance of *Zea mays* as Influenced by NPK Fertilizer Application. Print ISSN 2067-3205; Electronic ISSN 2067-3264 Not Sci Biol 1 (1) 2009, 59-62.

Landon, J.R. (Ed), 1991. Booker Tropical Soil Manual. A handbook for soil survey and agricultural land evolution in the tropics and subtropics. Longman Scientific and Technical.Essex,New York. 474p.

Muhammad R., K. Javaid and H. Muhammad, 2004. Biological Response of Maize (*Zea mays* L.) to Variable Grades of Phosphorus and Planting Geometry. *International Journal of Agriculture & Biology.* pp. 462-464.

Olsen, S.R. and L.A. Dean, 1965. Phosphorus. In: Methods of soil analysis. Agronomy No 9. American Society of Agronomy. Madison, USA

Onasanya R..O., O.P. Aiyelari, A. Onasanya, S. Oikeh, F.E. Nwilene and O.O. Oyelakin, 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.

SAS, 2002 version 9.0 Institute inc., Cary, NC, USA

Sharar. M.S. M. Ayub, M.A. Nadeem and N. Ahmad, 2003. Effect of Different Nitrogen and Phosphorus on Growth and grain yield of Maize. *Asian Jornal of Plant Sciences*.2 (3); 347-349.

Tekalign Tadesse, 1991. Soil, plant, water, fertilizer, animal manure and compost analysis working document. No 13. International Livestock Research Center for Africa (ILCA). Addis Ababa.

Tenaw Workayehu, 2000. Effect of nitrogen fertilizer rates and plant densities on grain yield of maize. *African Crop Sci. J*. 8: 273-282.

Tolessa Debelle, 1999. Evaluation of Maize Yield Response to Nitrogen and Phosphorus Fertilizer in Western Ethiopia. *African crop science conference proceeding*, vol.4 pp291-294.

Tolessa Debelle, Tesfa Bogale, Wakene Negassa, Tenaw Worayenu, Minale Liben, Tewoddros Mesfin, Burtukan Mekonen and Waga Mazeengia, 2002. A Review of Fertilizer Management Research on Maize in Ethiopia. *In* Mandefro Nigussie, D. Tanner, and S. Twumasi-Afriyie (*Eds*.) 2002. *Enahancing the Contribution of Maize to Food Security in Ethiopia, Proceeding of the 2nd National maize workshop Ethiopia 12-16 November 2001. Addis Ababa, Ethiopia*. Addis Ababa, Ethiopia: *Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improvement Center* (CIMMYT). 46-54p.

Zeidan, M.S., A. Amany, M.F. Baher El-kramany, 2006. Effect of N-fertilizer and Plant Density on Yield and Quality of Maize in Sandy Soil. INSInet Publication. 2(4): 156-161.