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RESEARCH PAPER

Effects Blended and Urea Fertilizer rate on Yield and yield Components of Maize in Ultisols of Liben Jawi district

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Abstract

Maize is a major staple crop grown and widely consumed in western Ethiopia but it is low due to declining soil fertility and requires application of high fertilizer for optimum production. A field experiment was carried out on farmers' field to study the effect of blended NPSB and urea fertilizer rate on yield and yield components, and economics of highland maize for two consecutive cropping seasons on Ultisol of Liben Jawi district. Three rates of nitrogen (150 250 and 350 kg urea ha-1) and four rates of blended NPSB (150, 200, 250 and 300 kg NPSB ha-1) were combined in factorial arrangement forming 12 treatments and tested with negative control and recommended (119/69 kg NP ha-1). The experiment was laid out in randomized complete block design with three replications. Combined application of blended NPSB and Urea was significantly affected mean yield and yield components of maize. Significantly higher biomass and grain yield of maize were obtained with application of higher nitrogen and blended NPSB fertilizer rate. Higher mean dry biomass yield of 21333 kg ha-1 and grain yield of 6975 kg ha-1 of maize was obtained with application of 350/300 kg urea/NPSB ha-1 fertilizer rate. Application of 250/250 kg urea/NPSB ha-1 gave net return of EB 44216 and higher marginal rate return of 2036 % for highland maize production. Therefore, application of 250/250 kg urea/NPSB ha-1 fertilizer rate was recommended for highland maize production and economic return in Ultisol of Liben Jawi and similar agroecologies.
Keywords: Blended fertilizer, maize, grain yield, nitrogen

Introduction

Globally maize (Zea mays L) is one of the most versatile and multi utility crops, having wider adaptability in diverse ecologies and queen of cereals because of its highest genetic potential (Kumar et al., 2013) and it is true in Ethiopia. Maize is the most staple food and most cultivated cereal in Africa and Ethiopia in terms of land area, production and is inevitable in achieving food security in Ethiopia (Buchaillot et al. 2019; CSA, 2018, CSA, 2019; Fufa et al., 2019). It is the major source of food, feed, fodder and industrial raw material and provides enormous opportunity for crop diversification, value addition and employment generation (Kumar et al., 2013). Maize is among the most important food source for human consumption in the world and sub Sharan Africa (FAO, 2018). Maize is widely grown by farmers of rural households and some private investors in western Ethiopia and constitutes 16.79 and 18.60 % of the country total 80.71 and 81.39% grain cereal production next to teff (CSA, 2018; CSA, 2019). However, the current national maize grain yield was (3.99 t ha-1) (CSA, 2019) in Ethiopia is very low by international standards, indicating growth potential as compared to the world average (5.75 t ha-1) and southern Africa average (5.79 t ha-1) (FAOstat, 2017). The major reasons for low yield of maize in in western Ethiopia are; low soil fertility (under optimum fertilizer application, soil acidity), and use of nonoptimum agronomic practices, diseases, pests and weeds. The use of chemical fertilizers particularly nitrogen for maize production is by far below the recommended rate (Aman and Tewodros, 2019). Maize grain yield can be improved by taking adaptive cultivation practices (fertilizer application, maize varieties, sowing time, sowing density and row and plant spacing) (Sileshi et al., 2010; Pasuquin et al., 2014). Furthermore, increased use of improved maize varieties and mineral fertilizers, coupled with increased extension services are the key factors promoting the accelerated growth in maize productivity in Ethiopia (Tsedeke et al., 2015).

Use of inputs is at a low level, suggesting substantial scope for raising productivity through improved seeds, and fertilizers (Alemayehu et al., 2012). Low soil fertility related mainly to continuous cropping without replenishment of depleted nutrients in SSA is the major constraints to higher crop productivity in smallholder farmers (Rusinamhodzi et al., 2011; Sanchez, 2015). Most countries in SSA applying less than 10 kg of nutrients per ha-1 sum of nitrogen, phosphorus and potassium inputs in organic and chemical fertilizers (Masso et al., 2017; Rurinda et al., 2013). Agricultural sector is expected to produce 60% more food by 2050 (Alexandratos and Bruinsma, 2012) for 9.8 billion world population. The use of fertilizers by farmers in Sub Saharan African countries has less than 10 kg ha-1 and globally the lowest fertilizer uses as compared to countries (Bationo et al., 2012). This is mainly due to high prices associated with acquiring fertilizers (Epule et al., 2015). Mismanagement of plant nutrition is considered to be the major one among different reasons for low productivity of maize production (Paramasivan et al., 2014).

Low crop yields in Sub-Saharan Africa are associated with low fertilizer use (Bonilla et al., 2020). Soil fertility varies throughout the growing season each year due to alteration in the quantity and availability of mineral nutrients by the addition of fertilizers, manure, compost, mulch, and lime or sulfur, in addition to leaching (Ravikumar and Somashekar, 2014). Low soil nitrogen and phosphorus as well as other unpredictable environmental factors have reduced yields at farm level (Gasura et al. 2015). Plants can take only up 30 to 40% of the applied N but over 60% of the N in the soil generally is lost by leaching, surface runoff, denitrification, volatilization, and microbial consumption (Santos et al., 2019).

Soil fertility improvement is one of the most important soil management practices determining better grain yield of maize. But the use of fertilizer could lead to an increase in crop yield in Sab Sharan Africa of about 30-50% in the next 30 years (Ciceri and Allanore, 2019). Identifying site-specific combinations of management practices that are conducive to high yields and low-risk input recommendations was crucial (Grassini et al., 2015).

Use of fertilizer has the greatest influence among all improved production technologies (Ványiné Széles et al., 2012; Crista et al., 2014) on maize yield, as its effect on yield was determined to be 31% (Berzsenyi and Győrffy, 1997) and 48% (Nagy, 2008). Application of nitrogen and phosphorus fertilizer was significantly increased mean grain and biomass yield of maize from 6.21 to 7.11 t ha-1 and 8.39 to 9.54 t ha-1 as compared to control (Muhidin et al., 2019). Application of 175-80-60 kg NPK ha-1 was produced significantly optimum yield and is appropriate and economical rate of for obtaining maximum grain yield of maize (Asghar et al., 2010). Nitrogen application significantly affected and improved mean grain yield of maize by over 57% when compared to the 0-N (Oyebiyi et al., 2019).

Currently, detailed maps of soil nutrients (including micro-nutrients) for SSA, in order to support agricultural development, intensification and monitoring of the soil resource has done for different countries including Ethiopia (Kamau and Shepherd 2012; Shepherd et al. 2015; Wild, 2016). Spatial predictions of soil macro and micro-nutrient content for Ethiopia at 250 m spatial resolution and for 0-30 cm depth was producing (Hengl et al., 2017) showed variation in deficiency different nutrient could help for blending fertilizers for each district in the region.

Currently based on map of Ethiopian Soil Information System (EthioSIS) has confirmed that several nutrients (N, P, K, S, Zn, Fe and B) other than the common (nitrogen and phosphorus) (ATA, 2013). Thus, compound fertilizer (NPS) and three blended fertilizers (NPSB, NPSZnB, and NPSZn) plus or minus potash fertilizer are needed to address the key nutrient deficiencies in the tested soils in Ethiopia (ATA, 2014). Application of 150 kg NPSB ha-1 fertilizer rate was found to be superior and economically viable for maze production in Bako area (Fufa et al., 2019).

Except the Ethio SIS map, so far there is no information or research finding on the differential of newly blended fertilizer responses to high yielding newly released maize varieties in Liben Jawi district. Knowing the contribution blended (NPSB) fertilizer rate in maximizing maize yield in the area are needed to be investigated to explore the yield potential of maize. In addition, asserting the Ethio SIS map of nutrient deficiency is very crucial for sustainable soil fertility management and maize production. Therefore, the objectives were to determine optimum blended (NPSB) and urea fertilizer rate for maize crop in Ultisol of Liben Jawi district and to assess economic benefit of blended (NPSB) and Urea fertilizers rates for maize production in Ultisol of Liben Jawi district.

Materials and Methods

The experiment was conducted on two and one farmers field in 2018/2019 and 2019/20 cropping seasons of humid highland agroecosystems of Chanchudina Masara and Liban Gamo Peasant association, Liben Jawi district, Oromia National Regional State, western Ethiopia. Farm 1, 2 and 3 lies between 8°52'0.57"N, 8°56'40.43"N and 8°52'3.36"N latitude and 37°28'8.76"E, 37°31'47.58"E and 37°28'5.43"E longitude and at an altitude of 1977, 2313 and 1983 meter above sea level in 2018/2019 and 20192020 cropping seasons. The mean annual rainfall of 1040 mm with unimodal distribution (MAARC, 2019). It has a medium cool sub-humid climate with the mean minimum, mean maximum and average air temperatures of 8.9, 27.4 and 18.1oC, respectively (MAARC, 2019). The soil type is brown clay loam Ultisol (Tolera et al., 2016).

The treatment used was three rates of urea (150 250 and 350 kg N ha-1) and four rates of blended NPSB (150, 200, 250 and 300 kg NPSB ha-1) were combined in factorial arrangement forming 12 treatments and tested with negative control and recommended (119/69 kg NP ha-1). The experiment was laid out in randomized complete block design with three replications. Maize variety (Jibat) was used. The plot size was 4.5 x 3m= 13.5m2. The spacing used was 75 x 25 cm between rows and plants. The nitrogen rates from blended fertilizer was applied at the time of planting and the remaining nitrogen rates from urea was applied in split application first at knee height of maize and the remaining half at early tasseling of maize. All other agronomic management practices were applied as per recommendation for the maize production.

Pre soil sampling was collected before planting and treatment application and analyzed for some physicochemical properties of the soil at Kulumsa and Holetta Agricultural Research Center Soil and Plant Laboratory. Determination of soil particle size distribution was carried out using the hydrometer method (Dewis and Freitas, 1984). Soil pH was measured using digital pH meter in 1:2.5 soil to solution ratio with H2O. Exchangeable basis was extracted with 1.0 Molar ammonium acetate at pH 7. Ca and Mg in the extract were measured by atomic absorption spectrophotometer while Na and K were determined using flame photometry (Van Reeuwijk, 1992).

Cation exchange capacity of the soil was determined following the modified Kjeldahl procedure (Chapman, 1965) and reported as CEC of the soil. Percent base saturation was calculated from the sum of exchangeable basis as a percent of the CEC of the soil. Exchangeable acidity was determined by extracting the soil samples with M KCL solution and titrating with sodium hydroxide as described by McLean (1965). Organic carbon was determined following wet digestion methods as described by Walkley and Black

(1934) whereas kjeldahl procedure was used for the determination of total N as described by Jackson (1958). The available P was measured by Bray II method (Bray and Kurtz, 1945).

Grain yield, dry biomass and harvest index of maize were collected at physiological maturity and harvesting. The harvested grain yield was adjusted to 12.5 % moisture level (Birru, 1979 and Nelson et al., 1985). The adjusted seed yield at 12.5 % moisture level per plot was converted to grain yield as kilogram per hectare. The collected data were analyzed using SAS 9.4 software (SAS, 2012). Mean separation was done using least significance difference (LSD) at 5 % probability level (Steel et al., 1997). The economic (partial budget) analysis was used following CIMMYT (1988). The maize grain valued at an average open market price of EB 900 per 100 kg. Labour cost for field operation was EB 60 per man-day. The yield was adjusted down by 10 % to reflect actual production conditions (CIMMYT, 1988). The cost of fertilizer Urea and Blended (NPSB) were EB 14.04 and 14.48 per 100 kg with current market price.

Results and Discussions

Soil physicochemical properties of the experimental site before planting

The soil of the experimental site was sandy clay loam for farm 1 and clay loam for farm 2 and 3 in textural distribution (Table 1). The pH of soil was 5.36, 5.64 and 5.85 found in strongly acidic in farm 1 and medium acidic in farm 2 and 3 (Table 1) (London 1991, Msanya et al., 200). The available phosphorus was ranged between 7.76 to 10.97 mg kg-1 found in medium range (London, 199; Tekalegn, 1991). The total nitrogen content was 0.18 % in farm 1, 0.26 and 0.28 % in farm 2 and farm 3 found in low and medium range (London, 199; Tekalegn, 1991). The organic carbon content of the soil range between 2.9 to 3.34 % found in high range (London, 1991; Tekalegn, 1991). The cation exchange capacity of the soil ranged between 7.98 to 12.76 cmol+ kg-1 soil found in low to medium range (London 1991; Tekalegn, 1991; Msanya et al., 200).

Table 1. Selected soil physicochemical characterization of the experimental field before planting in Liben Jawi District

Farms	pH (1:2.5 H_2O)	Available P (mg kg^{-1})	Total N (%)	OC	OM	Cation exchange capacity	Clay	Silt	Sand	Texture
				(%)		(cmol (+) kg^{-1})		%		
Farm-1	5.36	7.76	0.18	2.9	5	7.98	45	27.55	27.5	Sand clay loam
Farm-2	5.64	9.83	0.26	3.27	5.63	9.18	48	32.5	24.3	Clay loam
Farm-3	5.85	10.97	0.28	3.34	5.74	12.76	54	34.3	21.3	Clay loam

Dry biomass, Grain yield and Harvest index

Combined analysis over years and farms revealed that dry biomass yield of maize was significantly affected by application of urea and NPSB fertilize rates (Table 2). The average dry biomass of farm 2 was greater by 35.31 and 44.71 % as compared to farm 1 and 3. Higher dry biomass yield of maize was obtained with application of higher urea and blended NPSB fertilizer rate as compared to control and recommended fertilizer rate. Similarly, Asghar et al. (2010) reported that the mean biological yield of maize was significantly affected by NPK application and higher mean biological yield (16.83 t ha-1) recorded with application of 250-110-85 kg NPK ha-1 and the minimum (10.80 t ha-1) produced from control. Also, application of 100% of recommended dose of NPK fertilizer was produced higher maize biological yield (17.79 t ha-1) while lowest was observed where no NPK fertilizers was not applied (Sarwar et al. 2017). Azra et al. (2012) reported that application of NPK fertilizers increased the mean grain yield in maize. Likewise, Bakala (2018) reported that. biological yield of maize was significantly influenced by application of Blended NPSB and N fertilizer.

The mean grain yield of maize was significantly affected by application of urea and NPSB fertilize rate in three farms in 2018, 2019 cropping seasons and combined mean of three farms over years (Table 2). The average yield of farm 3 was greater by 14.99 and 3.04 % than farm 1 and 2 respectively. This might be due to variation in field management history of different farmers field for crop production in addition to management practices in the cropping season. Similarly, Fufa et al. (2019) found that maize grain yield was significantly affected by application of blended NPSB fertilizer rate and economically profitable yield was obtained with application of 150 kg NPSB ha-1 at Bako. Asghar et al. (2010) reported that the mean maize grain yield was greatly affected by different levels of NPK application and application of 250-110-85 kg NPK ha-1 produced maximum grain yield 6.03 t ha-1 and minimum from without fertilizer application. Application of 100% of recommended dose of NPK fertilizer was produced higher grain yield (6.99 t ha-1) and grain protein content (8.78%) of maize (Sarwar et al. 2017). Similarly, Sisay (2018) reported that mean grain yield of maize was highly significantly affected due to application of blended NPS fertilizer and N fertilizer rate.

The application of 350/300 kg urea/NPSB ha-1 gave significantly higher mean grain yield of maize and greater by 35.37, 13.41, 42.21 and 29.67 % as compared to recommended NP fertilizer rate in farm 1, 2, 3 and combined mean over years (Table 2). This result confirmed that the old recommended fertilizer rate before a decade should be checked and site-specific recommendation is indeed needed for better production of maize. The higher mean grain yield of maize with application of higher (350/300 kg urea/NPSB ha-1) was greater by 427, 262, 222 and 283 % in farm 1, 2, 3 and combined mean over years as compared to control (Table 2). This result suggested that farmers should apply any sources of fertilizer to produce maize. But if maize planted without any fertilizer sources it is simple loss of his labour and other inputs. Application of N fertilizer significantly increased maize yields between 0.25 and 1.6 t ha-1 (Gotosa et al., 2019). Cai et al. (2012) reported that application of higher N fertilizer is crucial to the better development of maize plant and grain yield.

Higher mean grain yield of maize was related higher rates of nitrogen fertilizer application. Likewise, Onasanya et al. (2009) also reported higher maize grain yield with increase in N rates. Mupangwa et al. (2019) found that application of 90 kg N ha-1 had produced higher mean grain yield of maize as compared with 0 and 30 kg N ha-1 in all three cropping seasons in conservation agriculture-based cropping systems of Southern Africa.

Application of increasing rate of N fertilizer could increase the mean grain yield and higher grain yield of (8.8 t ha-1) obtained with 240 kg N ha-1 as compared to rates between 120-200 kg N ha-1 (Sapkota et al., 2017). Tesfaye et al. (2019) reported that the mean grain yield response for nitrogen fertilizer application of maize was ranged from 2657 to 4266 kg ha-1 in 2015 and from 3648 to 5454 kg ha-1 in 2016 in high rainfall areas, while it ranged from 383 to 1513 kg ha-1 in 2015 and from 1500 to 3310 kg ha-1 in 2016 in moisture stress areas.

The harvest index of maize was significantly ($P<0.05$) affected by application of urea and blended NPSB fertilizer rates (Table 2). Significantly higher harvest index of maize 57.92, 31.24, and 43.10 % were obtained from application recommended 200/150 kg urea/DAP ha-1 in farm 1, 2 and combined over three farms while for farm 3 harvest index of 41.49 % was obtained from application 350/300 Urea/NPSB ha-1. The harvest index of maize was markedly influenced by NPK application and application of 175-80-60 kg NPK ha-1 resulted in higher harvest index of (36.47 %) as compared other treatments and minimum (30.25 %) obtained from control due to subnormal growth and development of the other yield parameters due to shortage of N (Asghar et al., 2010).

Table 2. Effects of nitrogen and blended (NPSB) fertilizer rate on dry biomass and grain yield of maize in Ultisol of Liben Jawi in 2018 and 2019 cropping season

Urea	NPSB	Dry biomass (kg ha^{-1})				Grain yield (kg ha^{-1})				Harvest Index (%)			
(kg ha^{-1})	(kg ha^{-1})	Farm 1	Farm 2	Farm3	Mean	Farm 1	Farm 2	Farm3	Mean	Farm 1	Farm 2	Farm3	Mean
		2018		2019		2018		2019		2018		2019	
150	150	13476de	20067c	13457f	15666d	4371e	5266c	5109f	4915f	32.59b	26.30bc	37.94bcd	32.28bc
150	200	17640abc	21196bc	15286cdef	18041c	5233cde	5505bc	5981cdef	5573e	29.74b	25.91bc	39.10abc	31.58bc
150	250	16716bcd	23502ab	14558def	18259c	4967de	5790abc	5432def	5396ef	29.73b	24.81c	38.28cde	30.61c
150	300	16231cd	23742ab	15563cdef	18512c	5071de	5923abc	5448def	5481ef	31.38b	25.07c	34.96e	30.47c
250	150	17809abc	21844bc	15951bcde	18535c	5687bcd	5697abc	6254bcde	5879cde	31.91b	26.11bc	39.30abc	32.44bc
250	200	18513abc	23520ab	13960ef	18665bc	5578bcd	6114abc	5481def	5724ed	30.08b	25.97bc	39.35abc	31.80bc
250	250	19529abc	25436a	17509abc	20824ab	5709bcd	6360abc	6947abc	6339bc	29.43b	25.08c	39.65abc	31.39bc
250	300	20382ab	25356a	18889a	21542a	6227ab	6201abc	6859abc	6429abc	30.81b	24.40	36.28de	30.50c
350	150	18276abc	24053ab	17143abc	19824abc	5595bcd	6437ab	6637abc	6223bcd	30.58b	26.86abc	38.73abcd	32.06bc
350	200	16533bcd	25680a	16958abcd	19724abc	4963de	6454ab	6468bcd	5962bcde	30.02b	25.16c	38.17bcd	31.12bc
350	250	19531abc	25938a	17551abc	21007a	5992abc	6473ab	7057ab	6507ab	30.52b	25.00c	40.18ab	31.90bc
350	300	20920a	24653ab	18425ab	21333a	6644a	6655a	7624a	6975a	31.76b	27.09abc	41.49a	33.44bc
200	150	10142e	19156c	13338f	14212d	4908de	5868abc	5361ef	5379ef	57.92a	31.24a	40.15ab	43.10a
0	0	3502f	5996d	5733g	5077e	1260f	1839d	2371g	1823g	35.06b	30.71ab	41.39a	35.72b
LSD (5%)		3936	3055.5	2478	2187.8	920.61	972.48	1028	595.27	13.89	4.3942	2.87	5.084
CV (%)		14.33	8.22	9.65	13.05	10.64	10.07	10.33	11.35	25.11	9.91	4.26	16.62

Means followed by different letter(s) in a column and rows are significant at 5% level of Probability

Table 3. Effects of Urea and blended NPSB fertilizer rate on economic profitability of highland of maize production in Ultisol of Liben Jawi

Urea (kg ha^{-1})	NPSB (kg ha^{-1})	Grain yield (kg ha^{-1})	Adjusted Grain yield (kg ha^{-1})	Gross field benefit (EB ha^{-1})	Urea cost (EB ha^{-1})	NPSB cost (EB ha^{-1})	TCV (EB ha-1)	Net benefit (EB ha^{-1})	Value to cost ratio	MRR (%)
0	0	1823	1641	14766	0	0	0	14766		
150	150	4915	4424	39812	2106	2172	4278	35534	8.31	485
200	150	5379	4841	43570	2808	2172	4980	38590	7.75	435
150	200	5573	5016	45141	2106	2896	5002	40139	8.02	7041
250	150	5879	5291	47620	3510	2172	5682	41938	7.38	265
150	250	5396	4856	43708	2106	3620	5726	37982D	6.63	
250	200	5724	5152	46364	3510	2896	6406	39958D	6.24	
150	300	5481	4933	44396	2106	4344	6450	37946D	5.88	
350	150	6223	5601	50406	4914	2172	7086	43320	6.11	98
250	250	6339	5705	51346	3510	3620	7130	44216	6.20	2036
350	200	5962	5366	48292	4914	2896	7810	40482D	5.18	
250	300	6429	5786	52075	3510	4344	7854	44221	5.63	1
350	250	6507	5856	52707	4914	3620	8534	44173D	5.18	
350	300	6975	6278	56498	4914	4344	9258	47240	5.10	215

D = Dominated and Price of urea and NPSB 14.004 and 14.48 EB kg-1 grain price = 9 EB kg-1

Similarly, Sarwar et al. (2017) reported that application of 100% of recommended dose of NPK fertilizer was produced maximum harvest index (39.37%) of maize. Likewise, Anwar et al. (2017) reported that significant increments in harvest index of maize 33.70 to 36.80 and 40.20 with increasing N rate from 0 to 75 and 150 kg N ha-1 respectively.

Higher harvest index from application of maximum N fertilizer rate and minimum from minimum N application rates (Aghdam et al., 2014; Sharifi and Namvar, 2016). Similarly, Jat et al. (2010) reported that higher mean harvest index of 42.40% and 42.60% were obtained with application of 120 kg N ha-1 as compared to 60 kg N ha-1 (41.80 and 41.90%) and control (40.60 and 40.60%) in 2006 and 2007 cropping seasons. Also, Also, Sisay (2018) found that harvest index of maize was significantly affected by application of blended NPS and N fertilizer rates and significantly higher highest harvest index (54.12%) was recorded from application of blended 182 kg NPS ha-1 and 124.8 kg N ha-1 fertilizer rates and lowest from control.

Economic viability of urea and blended fertilizer application on highland maize production

The partial budget analysis due to integrated use of Urea and blended NPSB fertilizer rate is indicated in Table 3. The highest net return of EB 47240 ha-1 with marginal rate return of 215 % and values to cost ratio of EB 5.10 profit per unit investment for maize production in Ultisol of Liben Jawi was recorded from application of 350/300 kg urea/NPSB ha-1, followed by net return of EB 44216 and marginal rate return of 2036 % with values to cost ratio of EB 6.28 from application of 250/250 kg urea/NPSB ha-1 fertilizer rate (Table 3). Similarly, Tamado and Moges (2015) reported that higher net benefit was obtained from higher N rate application. Begizew (2018) also reported that the highest net return EB 46592 ha-1 was obtained from application of 115 kg N ha-1 followed by 92 kg N ha-1. Likewise, Bakala (2018) reported that application of 150 kg NPSB + 110.8N kg ha-1 had the highest net benefit of EB 32321 ha-1. Muhidin et al. (2019) reported that application 138/104 NP kg ha-1 fertilizer rates gave the highest net benefit EB 21,445 ha-1 with marginal rate of return 120% was recommended for maize production in Omonada. The value to cost ratio was ranged from 5.10 to 8.31 profit per unit investment for maize production in Liben Jawi distirct with application urea and blended NPSB fertilizer rate. The highest marginal rate of return of 7041 % was obtained with application of 150/200 kg urea/NPSB ha-1 fertilizer rate. Therefore, application of 250/250 kg urea/NPSB ha-1 fertilizer rate was recommended for better highland maize production and economic return in Ultisol of Liben Jawi, West Showa.

Conclusion

Application of integrated use of urea and blended NPSB fertilizer rate were significantly affected yield and yield components of highland maize. Significantly higher maize grain yield of 6975 kg ha-1 was obtained with application of 350/300 kg urea/NPSB ha-1 followed by 350/250 kg urea/NPSB ha-1 application with grain yield of 6507 kg ha-1. Application of 350/300 kg urea/NPSBha-1 gave the highest net return of EB 47240 ha-1 with marginal rate return of 215 % and values to cost ratio of EB 5.10 profit per unit investment for maize production in Ultisol of Liben Jawi district. Therefore, application of 250/250 kg urea/NPSB ha-1 was produced better grain yield and economical feasible and recommended for highland maize production in Ultisol of Liben Jawi and similar agro-ecologies in western Oromia.

References

Aghdam, S.M., Yeganehpoor, F., Kahrariyan, B. and Shabani, E. (2014). Effect of different urea levels on yield and yield components of corn 704. I. J. Adv. Biol. Biomedical Res., 2(2):.300-305.

Alemayehu Seyoum, Dorosh, P. and Sinafikeh Asrat. (2012). Crop Production in Ethiopia: Regional Patterns and Trends. Ethiopia Strategy Support Program (ESSP II). International Food Policy Research

Institute. Ethiopian Development Research Institute. Research Note 11. Summary of ESSP II Working Paper 16. 2pp.

Alexandratos, N. and Bruinsma, J. (2012). World agriculture towards 2030/2050: the 2012 revision. ESA Working paper Rome, FAO.

Aman Tufa and Tewodros Tefera. (2019). Exploring the Drivers of Maize Technologies Adoption Intensity: Empirical Evidence of Smallholders in SNNRP Region, Ethiopia". EC Agri., 5 (2): 113-118.

Anwar, S., Ullah, W., Islam, M., Shafi, M., Iqbal, A. and Alamzeb, M. (2017). Effect of nitrogen rates and application times on growth and yield of maize (Zea mays L.). Pure and Applied Biol., 6(3): 908-916.

Asghar, A., Ali, A., Syed, W.H., Asif, M., Khaliq, T. and Abid, A. A. (2010). Growth and Yield of Maize (Zea mays L.) Cultivars Affected by NPK Application in Different Proportion, Pakistan J. of Sci., 62 (4): 211-216.

ATA. (2013). Survey of NARS researchers conducted in 2012

ATA. (2014). Soil Fertility Status and Fertilizer Recommendation Atlas for Tigray Regional State, Ethiopia. Ethiopian Agricultural Transformation Agency (ATA), A.A., Ethiopia.

Bakala Anbessa. (2018). Soil Characterization and Response of Maize (Zea mays L.) to Application of Blended Fertilizer Types and Rates in Asossa District, Western Ethiopia. M.Sc Thesis. Hawassa University. 117 pp.

Bationo, A., Hartemink, A., Lungu, O., Naimi, M., Okoth, P., Smaling, E., Thiombiano, L. and Waswa, B. (2012). Knowing the African soils to improve fertilizer recommendations. pp. 19-42. In: Improving Soil Fertility Recommendations in Africa Using the Decision Support System for Agrotechnology Transfer (DSSAT), Springer: Dordrecht, The Netherlands.

Begizew Golla. (2018). Effect of Nitrogen Rate and Intra-Row Spacing on Yield and Yield Components of Maize (Zea mays L.) at Bako, Western Ethiopia. M.Sc Thesis. Jimma University. 88pp.

Berzsenyi, Z. and Győrffy, B. (1997). Effect of crop rotation and fertilization on maize and wheat yields and yield stability in long-term experiments. Agrokémia és Talajtan., 46: 77-98.

Bonilla C. C., Chamberlin, J., Guo, Z. and Hijmans, R.J. (2020). Spatial variation in fertilizer prices in Sub-Saharan Africa. PLoSONE. 15(1): e0227764.

Birru, A. (1979). Agricultural Field Experiment Management Manual Part III. IAR (Institute of Agricultural Research). Addis Ababa, Ethiopia. pp. 35-42.

Bray, H.R. and Kurtz, L.T. (1945). Determination of organic and available forms of phosphorus in soils. Soil Sci., 9: 39-46.

Buchaillot, Ma. L., Gracia-Romero, A., Vergara-Diaz, O. Zaman-Allah, M. A., Tarekegne, A. Cairns, J. E., Prasanna, B. M., Araus, J. L. and Kefauver S. C. (2019). Evaluating Maize Genotype Performance under Low Nitrogen Conditions Using RGB UAV Phenotyping Techniques. Sensors., 19(1815): 2-27.

Cai, H., Chu, Q., Gu, R., Yuan, L., Liu, J., Zhang, X., Chen, F., Mi, G. and Zhang, F. (2012). Identification of QTLs for plant height, ear height and grain yield in maize (Zea mays L.) in response to nitrogen and phosphorus supply. Plant Breeding., 131: 502-510.

Chapman, H.D. (1965). Cation exchange capacity by ammonium saturation. pp. 891- 901. In: Black, CA. (Ed.) Methods of Soil Analysis. Agronomy part II, No. 9, American Society of Agronomy, Madison, Wisconsin, USA.

Ciceri, D. and Allanore, A. (2019). Local fertilizers to achieve food self-sufficiency in Africa. Sci. Total Environ., 648: 669-680.

Crista, F.M., Boldea, M., Radulov, I., Lato, A., Crista, L., Dragomir, C., Berbecea, A., Nita, L. and Okros, A. (2014). The impact of chemical fertilization on maize yield. Res. J. Agri. Sci., 46: 172-177.

CIMMYT. (1988). From agronomic Data to Farmer Recommendations: Economics

Training Manual. Completely Revised Edition. Mexico, D. F.81pp.

CSA. (2018). Agricultural Sample Survey 2017/18 (2010 E.C.). Report on Area and Production of Major Crops Volume I. Statistical Bulletin 586. Addis Ababa, Ethiopia.

CSA. (2019). Area and production of major crops. Agricultural Sample Survey 2018/19 (2011 E.C.). V1. Statistical Bulletin. 589. Addis Ababa, Ethiopia.

Dewis, J. and Freitas, F. (1984). Physical and chemical methods of soil and water analysis. FAO Soil Bulletin No. 10. FAO, Rome. 275 pp.

Epule, E.T. Bryant, C.R., Akkari, C. and Daouda, O. (2015). Can organic fertilizers set the pace for a greener arable agricultural revolution in Africa? Analysis, synthesis and way forward. Land Use Policy., 47: 179-187.

FAOstat. (2017). Food and Agriculture Organization Statistics Data Base, Agricultural production indices. FAO, Rome, Italy.

FAO. (2018). World Food and Agriculture: Statistical Pocketbook 2018. Rome. Licence: CC BY-NC-SA 3.0 IGO. 254 pp.

Fufa Anbessa, Thomas Abraham and Habtamu Ashagre. (2019). Influence of Plant Population and NPSB Blended Fertilizer Rates on Yield Parameters and Yield of Maize (Zea mays L.) in Bako, Ethiopia. I. J. of Agri. Envi. and Biote., 12(4): 345-349.

Gasura, E., Setimela, P.S. and Souta, C. M. (2015). Evaluation of the performance of sorghum genotypes using GGE biplot. Canadian J. Plant Sci., 95(6):1205-1214.

Gotosa, J., Kodzwa, J., Nyamangara, J. and Gwenzi, W. (2019). Effect of Nitrogen Fertiliser Application on Maize Yield Across Agro Ecological Regions and Soil Types in Zimbabwe: A Meta analysis Approach. I. J. of Plant Production, https://doi.org/10.1007/ s42106-019-00045-9.

Grassini, P., van Bussel, L.G.J., Van Wart, J., Wolf, J., Claessens, L., Yang, H., Boogaard, H., de Groote, H., van Ittersum, M.K. and Cassman, K.G. (2015). How good is good enough? Data requirements for reliable crop yield simulations and yield-gap analysis. Field Crops Res., 177: 49-63.

Hengl, T., Leenaars. J. G. B. Shepherd. K. D., Walsh, M. G... Heuvelink, G. B. M., Tekalign Mamo. Helina Tilahun. Ezra Berkhout, Cooper, M., Fegraus, E., Wheeler, I. and Kwabena, N.A. (2017). Soil nutrient maps of Sub-Saharan Africa: assessment of soil nutrient content at 250 m spatial resolution using machine learning. Nut. Cycl. Agroecosy. 109:77-102. DOI 10.1007/s10705-017-9870-x.

Jackson, M.L. (1958). Soil chemical analysis. pp. 183-204. Prentice Hall, Inc., Engle Wood Cliffs. New Jersey.

Jat, N.K., Kumar, A. and Dhar, S. (2010). Influence of Sesbania green manure with or without wheat residues and N fertilization on maize-wheat cropping system. Indian J. of Agron., 55 (4): 253-258.

Kamau, M. and Shepherd, K. (2012). Mineralogy of Africa’s soils as a predictor of soil fertility. In: RUFORUM third biennial conference, 24–28 September 2012, Entebbe, Uganda.

Kumar, A., Jat, S. L., Kumar, R. and Yadav, O. P. (2013). Directorate of Maize Research, Pusa Campus, New Delhi- 110 012, 123p.

Landon, J.R. (Ed) (1991) Booker Tropical soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. John Wiley and Sons, Inc., New York. 474pp.

MAARC. (2019). Meteorological data of Ambo area for 1975-2019. Ambo, Oromia, Ethiopia.

Masso, C., Baijukya, F., Ebanyat, P., Bouaziz, S., Wendt, J., Bekunda, M. and Vanlauwe, B. (2017). Dilemma of nitrogen management for future food security in sub-Saharan Africa–a review. Soil Res., 55: 425-434.

McLean, E.O. (1965). Aluminum. pp. 978-998. In Black, CA. (Ed.). Methods of Soil Analysis. Agronomy No. 9. Part II. American Society of Agronomy Madison, Wisconsin. USA.

Msanya B.M., Kimaro, D.N., Mbogoni, J.D.J and Kimbi, G.G. (2000). Soils and Land

Resources Report of Morogoro Urban District, Tanzania. Sokoine University of Agriculture, Faculty of Agriculture, Department of Soil Science, Morogoro, Tanzania. Ministry of Agriculture, ARI-Mlingano, National Soil Service, Tanga, Tanzania.

Muhidin Biya, Sisay Gurmu and Eshetu Yadete. (2019). Determination of NP Fertilizer Requirement for Newly Released Medium Maturing Maize Varieties at Jimma Zone, Southwestern Ethiopia. I. J. of Res. Studies in Sci. Engin. and Tech., 6 (12): 13-19.

Mupangwa, W, Thierfelder, C., Cheesman, S., Nyagumbo, I., Muoni, T., Mhlanga, B., Mwila, M., Sida, T.S. and Ngwira, A. (2019). Effects of maize residue and mineral nitrogen applications on maize yield in conservation agriculture- based cropping systems of Southern Africa. Renewable Agri. and Food Syst., 1–14.

Nagy, J. (2008). Maize production: Food, bioenergy, forage. Akadémiai Kiadó, Budapest.

Nelson, L.A., Voss, R.D. and Pesek, J. (1985). Agronomic and statistical evaluation of fertilizer response. 89 pp.

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. World J. of Agri. Sci., 5(4): 400-407.

Oyebiyi F.B., Aula, L., Omara, P., Nambi, E. Dhillon, J.S. and Raun, W.R. (2019). Maize (Zea mays L.) Grain Yield Response to Methods of Nitrogen Fertilization. Commun. Soil Sci. and Plant Analysis., 50(21):2694-2700.

Paramasivan, M., Kumaresan, K. R. Malarvizhi, P. and Velayudham, K. (2014). Effect of different levels of NPK and Zn on yield and nutrient uptake by hybrid maize (COHM%) in Pilamedu and Aplaviduthi series of Tamil Nadu. Madras Agri. J., 98 (10-12): 334-338.

Pasuquin, J.M., Pampolino, M.F., Witt, C., Dobermann, A., Oberthur, T., Fisher, M.J. and Inubushi, K. (2014). Closing yield gaps in maize production in Southeast Asia through site-specific nutrient management. Field Crops Res., 156: 219-230.

Ravikumar, P. and Somashekar, R. K. (2014). Spatial distribution of macronutrients in soils of Markandeya river basin, Belgaum (d), Karnataka(s), India. Proceedings of the I. Academy of Ecology and Environ., 4(2): 81-94.

Rurinda, J., Mapfumo, P., van Wijk, M.T., Mtambanengwe, F., Rufino, M.C., Chikowo, R. and Giller, K.E. (2013). Managing soil fertility to adapt to rainfall variability in smallholder cropping systems in Zimbabwe. Field Crop Res., 154: 211-225.

Rusinamhodzi, L., Corbeels, M., van Wijk, M.T., Rufino, M.C., Nyamangara, J. and Giller, K.E. (2011). A meta-analysis of long-term effects of conservation agriculture on maize grain yield under rain-fed conditions. Agron. Sust. Devel., 31(4):657-673.

Sanchez, P.A. (2015). En route to plentiful food production in Africa. Native Plants, 1: 14014.

Santos, Ad., Amaral Ju´ nior, A.Td., Fritsche-Neto, R., Kamphorst,I S. H., Ferreira, F.R.A., IFrancisco, J., Amaral3, Td., Vivas, J.M.S., Diniz Santos, P. H.A., Lima, V.J., Khan, S., Schmitt, K.F.M., Leite, J. T., Junior, D. Rd. S., Bispo, R. B., Santos,Td. O., Oliveira, U.Ad., uimarães, ID L. J.M. and Rodriguez, R. (2019). Relative importance of gene effects for nitrogen-use efficiency in popcorn. PLoSONE. 14 (9): e0222726.

Sapkota, A., Shrestha, R. K. and Chalise, D. (2017). Response of Maize to the Soil Application of Nitrogen and Phosphorous Fertilizers. I.J. of Applied sci. and Biot., 5(4): 537-541.

Sarwar, M.A., Tahir, M., Ali, A., Hussain, M., Anwar, M.W., Abuzar, M.K. and Ahmad, I. 2017. Evaluating green manuring of moringa and Jantar along with inorganic fertilizers to enhance the yield and quality attributes of autumn maize (Zea mays L.). Pakistan J. of Agri. Res, 30(4): 356-362.

SAS. (2012). SAS/STAT Software Syntax, Version 9.4. SAS Institute, Cary, NC. USA.

Sharifi, R.S. and Namvar, A. (2016). Effects of time and rate of nitrogen application on phenology and some agronomical traits of maize (Zea mays L.). Biologija, 62(1):10-18.

Shepherd, K.D., Shepherd, G. and Walsh, M.G. (2015). Land health surveillance and response: a framework for evidence-informed land management. Agric Syst 132:93-106.

Sileshi, G., Akinnifesi, F.K., Debusho, L.K., Beedy, T., Ajayi, O.C. and Mong, O.S. (2010). Variation in maize yield gaps with plant nutrient inputs, soil type and climate across sub-Saharan Africa. Field Crops Res. 116: 1-13.

Sisay Gurmu. (2018). Effect of Blended NPS Fertilizer and Compost on Growth and Yield of Quality Protein Maize (Zea mays L.) at Jimma, Southwestern Ethiopia. M.Sc Thesis. Jimma University. 115pp.

Steel, R.G.D., Torrie, J.H. and Dicky, D.A. (1997). Principles and Procedures of Statistics, A Biometrical Approach. 3rd Edition, McGraw Hill, Inc. Book Co., New York, 352-358.

Tamado Tana and Moges Assefa. (2015). Effect of Nitrogen Fertilizer Rates and Plant Densities on Yield and Yield Related Traits of Maize (Zea maize L.) Under Irrigation in Southern Tigray, Ethiopia.

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

Tsedeke Abate, Bekele Shiferaw, Abebe Menkir, DagneWegary, Yilma Kebede, Kindie T., Menale K., Gezahegn B., Berhanu T. and Tolera K. (2015). Factors that transformed maize productivity in Ethiopia. Food Sci. 7: 965-981.

Tesfaye B., Jairos Rurinda, Mesfin Kebede, James Mutegi, Gebresilasie Hailu, Tolcha Tufa, Tolera Abera and Tesfaye Shiferaw. (2019). Yield Response and Nutrient Use Efficiencies under Different Fertilizer Applications in Maize (Zea mays L.) In Contrasting Agro Ecosystems. I. J. of Plant and Soil Sci, 29(3): 1-19.

Tolera A., Dagne W., Ernest Semu, Msanya, B.M., Tolessa Debele and Haekoo Kim. (2016). Pedological Characterization, Fertility Status and Classification of the Soils under Maize Production of Bako Tibe and Toke Kutaye Districts of Western Showa, Ethiopia. Ethiopian J. of Applied Sci. Techn., 7 (1): 1-17.

Ványiné Széles, A., Megyes, A. and Nagy, J. (2012). Irrigation and nitrogen effects on the leaf chlorophyll content and grain yield of maize in different crop years. Agri. Water Management., 107:133-144.

Van Reeuwijk, L.P. (Ed.) (2002). Procedures for Soil Analysis. 6th Edition. Technical Paper: International Soil Reference and Information Centre, Wageningen, The Netherlands.

Walkley, A. and Black, C.A. (1934). An examination of Degtjareff method for determining soil organic matter and the proposed modification of the chromic acid titration method. Soil Sci. 37: 29-38.

Wild, S. (2016). Mapping Africa's soil microbiome. Nature, 539:152.