Vol 4 | Issue 1 | Pages 28-38

Insights of Agricultural Technologies

Original Article

DOI: 10.36959/339/360

Determination of NPSB Fertilizer Type Rate and Nutrient Use Efficiency of Maize (Zea Mays L.) at Yeki District, Southwest of Ethiopia

Mulisa Wedajo[1], Selamyihun Kidanu[2] and Alemaheyu Reggasa[3]*

[1]*Ethiopian Institute of Agricultural Research, Teppi Agricultural Research Center, Ethiopia*

[2]*OCP society Anonyme Commercial Representative Offices, Addis, Ababa, Ethiopia*

[3]*Jimma University Colleges of Agriculture and Veterinary Medicine, Ethiopia*

Abstract

In Sheka Zone, including Yeki District, maize (Zea mays L) yields are low because of low soil fertility, little and blanket fertilizer use. This field experiment conducted to evaluate NPSB fertilizer during 2018. The treatments laid out in a randomized complete block design with four replications. The treatments consisted of three NPSB levels (150, 200, and 250) combined with two-urea levels (100 and 150) kg ha^{-1} and two controls (200 urea + 150 TSP kg ha^{-1} and no fertilizer as control). Plant height and the number of ears per plant were not significantly (p 0.05) influenced as compared to the control and blanket recommended NP fertilizer. Whereas ear height, ear length, and cob length influenced as compared to the control and thousand-grain weight, grain yield, and biomass yield were significantly (p 0.05) influenced as compared to the control and recommended NP fertilizer. The highest maize grain yield (8828.2 kg ha^{-1}) was obtained from the application of 250 NPSB + 100 Urea + 100 KCl, while the lowest grain yield (2968.90 kg ha^{-1}) was from the control plot. Application of NPSB and urea improved the nutrient use efficiency of maize, except for physiological nitrogen and phosphorus use efficiency. Economically, the highest net benefit (13445.3 EB) obtained under the application of 150 NPSB + 100 urea + 100 KCl kg ha^{-1}. Therefore, application of NPSB at a rate of 150NPSB + 100 urea + 100 KCl kg ha^{-1} recommended for maize production in Yeki District.

Keywords

Grain yield, Biological yield, Blanket fertilize use, Nutrient use efficiency

Introduction

Maize (*Zea mays* L.) is one of the most important stable food crops in Ethiopia. It is among the cereal crop wider production and consumption in widely across different agro-ecologies. However, the current maize average productivity is 3.67 tons per hectare [1]. Yet, the national crop productivity remained low compared to the 4.7 t ha^{-1} reported from on-farm trials [2] and lower than the world average yield which is about 5.21 t ha^{-1} [3]. Poor soil fertility is one of the bottlenecks for sustaining maize production and productivity in Ethiopia in general [4,5].

Ethiopian smallholder farmers in the past four decades used urea and DAP for their crop production [6]. Continuous cultivation without appropriate farming practices has resulted in severe depletion of nutrients and soil organic matter, seriously threatening agricultural production [7,8]. In case lower biomass production and increasing demand of local organic matter for fuel and fodder accelerate the declining of soil fertility [9,10]. Plants require a specific amount of certain nutrients in some specific form at appropriate times, for their growth and development. The roles of both macro and micronutrients are crucial in crop nutrition and thus important for achieving higher yields [11,12].

Ethiopian Agricultural Transformation Agency (ATA) in 2012 was launched Ethiopian Soil Information System (EthoSIS) project which provided detailed soil map up-to-date soil fertility data. The result informs revealed that in addition to nitrogen and phosphorus, potassium sulfur, boron, copper,

***Corresponding author:** Mulisa Wedajo, Ethiopian Institute of Agricultural Research, Teppi Agricultural Research Center, Teppi 34, Ethiopia

Accepted: March 28, 2023

Published online: March 30, 2023

Citation: Wedajo M, Kidanu S, Reggasa A (2023) Determination of NPSB Fertilizer Type Rate and Nutrient Use Efficiency of Maize (Zea Mays L.) at Yeki District, Southwest of Ethiopia. Insights Agric Technol 4(1):28-38

manganese, iron and zinc deficiencies are widespread in Ethiopian soils [13-15].

According to the EthioSIS [2015] map; NPS, NPSB, NPSBCa and NPSCa fertilizer types are recommended for crop production in Yeki District Southwest of Ethiopia. However, the map was suggested only fertilizer type to a specific location but, the right rate in respect to crop type was not studied in the Yeki district at Beko village. Therefore, the objective of this study was initiated to determine the optimum, economic feasibility of NPSB and urea fertilizer and nutrient use efficiency of maize in Yeki District, Southwest of Ethiopia.

Materials and Methods

Study area

The field experiment was conductied in Yeki District at Beko village during 2018 the main cropping season. Yeki District located in Southwest of Ethiopia in South Nations Nationalities and People's Regional State (SNNPR's) at an elevation of 1200 m.a.s.l and it is located at latitude of 7°10'54.5'' and longitude of 35°25'04.3'' East of Ethiopia and approximately 611 km from capital city of Addis Ababa. The mean annual maximum and minimum temperatures was 29.7 °C and 15.5 °C respectively. The total annual rainfall in the area was uni-modal distribution with average of 1559 mm. The soils of the study area are dominated by Nitisols [16].

Experimental materials

A high yielding medium maturing hybrid maize variety (BH140) was used as a test crop. It can give (7.5-8.5 and 4.7-6) t ha^{-1} grain yields on-station and on-farm experiments respectively with maturity date of 145 and 25 kg ha^{-1} seed rate. The source of N from Urea and P from TSP fertilizer were used.

Fertilizers' TSP and NPS were applied at planting and while urea was applied in twice equal split half at knee height and the remaining half at flag leaf emergence following time of urea application recommended by Tolessa, et al. [4]. The first side dressing was 30 days after emergence (knee height stage) just after the first weeding and again 60 days after emergence just after the second weeding or before tasseling and Potassium (100 kg ha^{-1}) fertilizer was applied at the intermediate of the first and second nitrogen application.

Experimental design

The treatments were laid out in factorial randomized complete block design with four replications. Fertilizer type; NPSB in three rate (150, 200 and 250) kg ha^{-1} combined with two rates of urea (100 and 150) kg ha^{-1} and in each block two check treatments were added (Control and recommended 200 kg N ha^{-1} + 150 kg TSP ha^{-1}). A total of eight treatments per replication. The area of each plot was 3.5m × 3.75 m (13.125 m^2) length and width respectively and the total experimental area of 18m × 55.5m (999 m^2) then the eight treatments were randomly assigned to each experimental unity followed, so as to allocate in each block and plant space 75 cm × 25 cm between row and between plants were used for plating of the maize respectively. A footpath of 1m and 0.5m were left between blocks and plots respectively.

Experimental procedures and field management

The land was plowed two times by ox and leveled by hand. Maize seed-sowing was done by hand on the 25th of April 2018 after rainfall to provide moisture for better germination. Two seeds were planted per hill to ensure the desired stand in each treatment and thinned to one plant with a plant population of 53,333 plants per hector. Thinning was done at two to three leave stages after germination. The outermost rows at both sides of plots were considered as borders. Then after, all the remaining necessary agronomic practices and crop management activities were undertaken as recommended and in line with the practices followed by the Tepi Agricultural Research Center. At physiological maturity of maize harvesting and shelling were done by hand.

Data collection and measurements

Soil sampling and analysis: Composite surface soil samples were collected before planting from the plough layer (0-20 cm) during the study period to understand soil fertility status.

Soil samples were analyzed for Soil texture by Bouyoucos hydrometer method [17], pH in a 1:2.5 soil water suspension using a glass electrode pH meter [18], available Phosphorus was determined in Olsen methods [19], available Potassium was determined by ammonium acetate extracts flame photometer [20]. Total Nitrogen was determined by the modified Kjeldahl method [21].

Available sulfur and Boron were determined by Mehlich-3 method by shaking the soil samples with an extracting solution of 0.2 M CH_3COOH (acetic acid) + 0.25 M NH_4NO_3 (ammonium nitrate) + 0.015 M NH4F (ammonium fluoride) + 0.013 M HNO_3 (nitric acid) + 0.001 M EDTA (ethylene-diamine-tetra-acetic acid) [22].

Cation exchange capacity (CEC) of the soil was determined with the ammonium acetate saturated samples using sodium (Na) from percolating sodium chloride (NaCl) solution to replace the ammonium ions. The displaced ammonium was measured using the modified Kjeldahl procedure [23]. Organic carbon with acid dichromate medium following the Walkley and Black method [24], dichromate was used to destroy the organic matter. Organic matter was estimated as organic carbon multiplied by 1.724 assuming average Carbon concentration of organic matter of 58%.

Maize agronomic data: Plant height (cm): It was measured as the height from the soil surface to the base of the tassel of six randomly taken maize plants from the net plot area (3.5m × 3.75m) at plant physiological maturity.

Ear height (cm): It was measured from ground level to the node bearing the top useful ear.

Ear length (cm): It was measured from the point where the ear attaches to the stem to the tip of the year before the husk removed.

Cob length (cm): It was measured from the point where the grain rows start to the tip of the grain rows end after the husk removed.

Thousand grain weight (g): It was determined from 1000 randomly taken grains from each plot and weighed using sensitive balance.

Grain yield (kg ha^{-1}): Maize crop harvesting was done after the crop had reached physiological maturity. From each internal three rows of net plot, four maize plants were randomly harvested by hand. Then, husk was removed and the grains were shelled manually and their weights were recorded by electronic balance. The grain was sun-dried until it had constant weight and reweighed to determine moisture content. After drying the grain yield adjusted to 12.5% moisture content, the final dry weight was determined and recorded and then convert to a hector basis.

Biological yield (kg ha^{-1}): Total above ground of four maize plants from each internal three rows of net plot were randomly harvested at physiological maturity by hand. It was measured from a plant harvested from the net plot and weighed after uniformly sun-dried until it had constant weight and then weighed and converted to a hector basis.

Harvest index: Harvest index is the physiological ability of maize to convert total dry matter into grain yield. It was calculated as the ratio of grain yield to total aboveground biomass;

$$Harvest\ Index\ (\%) = \frac{Grain\ yield}{Bio\log ical\ yield} \times 100$$

Shelling percentage: it was measured as the ratio of the weights of shelled grain and unshelled ear expressed in percentage.

Plant tissue data: The measurement of N was carried out according to the Kjeldahl procedure by transform inorganic N into ammonium N by digesting with H_2SO_4 and a catalyst [23].

The measurement of P concentration of grain was carried out through calcinations of both grain and straw separately at 450 °C. After calcination, wet destruction of plant substances with strong acids was carried out and then P were measured using dry ashing and Black (flame Photometer) as described by Chapman [23]. The measurements of K and S in grain were carried out through dry ashing.

The grain and straw concentrations of N, P, K and Swere used to estimate the N, P, K, S and B uptake which was calculated by multiplying grain and straw yields on hector basis with the respective N, P, K, S and B percentage. Apparent fertilizer N and P recovery were calculated by following the formula as [(UN - UO)/N] × 100; where UN stands for nutrient uptake (grain + straw) of fertilized plot, UO stands for nutrient uptake (grain + straw) of control (no fertilized plot) and N stands for amount of nutrient applied. Agronomic and physiological N and P use efficiencies were calculated by using procedures described by Fageria and Baligar, (2005a) as: (GN – GO)/N for agronomic efficiency and (YN - YO/(UN - UO) for physiological efficiency; where GN and GO stand for grain yield of fertilized plot and grain yield of unfertilized plot respectively, YN - YO stand for grain yield of fertilized plot and unfertilized plot respectively and UN and UN stand for nutrient uptake (grain + straw) of fertilized plot and nutrient uptake (grain + straw) of control (no fertilized plot), respectively.

Economic data: Partial budget averaged of the fourteen (8) treatment calculated from income and expenses based on variable cost. Net benefit was calculated by subtracting the Total Variable Cost (TVC) from the gross field benefit (GFB) for each treatment. All variable costs were calculated excluding the price of other agronomic practices such as cost of seed, land plowing, sowing, weeding, protection of the farm and harvesting because it was uniform for all treatments.

Cost of NPSB fertilizer was Ethiopian birr (ETB 13.75 kg^{-1}, TSP was ETB 12.75 kg^{-1}, KCl was ETB 14.50 kg^{-1} and urea was ETB 10 kg^{-1}). The cost of fertilizer transportation was considered as ETB 15 per 100 kg fertilizer and labor cost of fertilizer application ETB 18 per day for 8 hours for 100 kg fertilizer. The Local market selling price of one-kilogram maize in Ethiopia birr at the Teppi area was five birr. The variable costs were summed up and subtracted from gross field benefits which were taken as net benefit.

The average yield was adjusted downward by 10% which was used to reflect the difference between the experimental field and the expected yield from farmers' fields with farmers' practices from the same treatments [24,25].

Dominance analysis led to the selection of treatments ranked in increasing order of total variable costs. For each pair of ranked treatments, the percent marginal rate of return (MRR) was calculated. The MRR (%) between any pair of un-dominated treatments was the return per unit of investment in fertilizer. It was calculated by dividing the change in net benefit to the change in variable costs.

Analysis of marginal rate of return (MRR) was carried out for non-dominated treatments and the MRRs were compared to a minimum acceptable rate of return (MARR) of 100% to select the optimum treatment [26].

Statistical data analysis

Data were subjected to Analysis of Variance (ANOVA) [27] by SAS version 9.3. The mean differences were separated using the list significant difference (LSD) to signify the treatment differences at a 5% level of probability.

Results and Discussion

Soil physical properties

Soil particle: the soil of experimental site was dominated by clay soil textural class having an average proportion of clay (60%), Silt (26%) and sand (14%) (Table 1). According to Kochhar [28] soil clay to clay loam texture is optimum for maize. Hence, soil texture of site was suitable for growing of maize.

Soil chemical properties

Soil reaction (pH): The experimental site was 6.27 (Table 1). According to Landon [29] the pH range of the experimental site rated as slightly acidic. According to Havlin [30] the

Table 1: Pre-plant-soil physicochemical properties of experimental site.

Soil properties	Values	Rating	Reference(s)
pH	6.27	Slightly acid	Landon, 1991 [29]
TN (%)	0.24	Moderate	Tekalign, 1991 [31]
Av. P (mg kg^{-1})	5.00	Low	Landon, 1991 [29]
Av. K (ppm)	550.80	High	Horneck, et al. (2011) [32]
Av. S (ppm)	13.14	Medium	Horneck, et al. (2011) [32]
Av. B (ppm)	0.99	Moderate	Horneck, et al. (2011) [32]
CEC cmol (+) kg^{-1} of soil	30.89	High	Landon, 1991 [29]
OC (%)	2.64	High	Hazelton and Murphy, 2007 [34]
Clay (%)	60		
Silt (%)	26		
Sand (%)	14		FAO, 1977
Textural class	Clay		

Where: pH = power of hydrogen, TN = Total Nitrogen, av.P = available Phosphorus, av.K = available Potassium, av.S = available Sulfur, av.B = available Boron, ECC = Cation Exchangeable Capacity, OC = Organic Carbon

soil pH range of 5.5-7 is optimum for maize production. Therefore, the soil pH of the experimental site was ideal for maize production.

The soil total N of the exponential area was 0.24% (Table 1). According to Tekalign, [31] soil total N availability rate of 0.2-0.5% as moderate. Hence the soil of the experimental site has moderate and requires nitrogen application as maize is a highly exhaustive crop for nitrogen and the production potential of it is highly affected by N deficiency.

Available soil phosphorous of the experimental area was 5 mg kg^{-1} (Table 1). According to Landon [29], available (Olsen extractable) soil P level of less than 5 mg kg^{-1} is rated as low. According to this worker, the available (Olsen extractable) P in the experimental site was low. Therefore, P content fertilizer is important to obtain optimum maize production in the experimental site.

Available soil Potassium of the experimental area was 550.80 ppm (Table 1). Horneck [32] reported that a soil with potassium content of 250-800 ppm is high. Thus, the soil of the experimental site has rated as high.

The soil available sulfur of the experimental area was 13.14 ppm (Table 1). Horneck [32] reported that a soil with Sulfur content of 5-20 ppm is medium. Thus, the soil of the experimental site has rated as medium.

The soil available boron of the exponential site was 0.99 ppm. According to Horneck [32] rate soil availability of 0.5-1 ppm is moderate. Thus, the soil of the experimental site has moderate (Table 1).

The Cation exchangeable capacity of the exponential area was 30.89 cmol (+) kg^{-1} (Table 1). According to Landon [29], CEC of the soils 25-40 cmol (+) kg^{-1} is high. Therefore the CEC soil of the experimental area was high. This high CEC may be due to the relatively high organic matter in the experimental site. The cation exchange capacity of soil could then relate to the organic matter content of a soil [33].

The results of the soil analysis of the experimental site showed the soil organic carbon content was 2.64% (Table 1). Hazelton and Murphy [34] rate soil organic carbon percentage of 1.80-3 is high. Therefore the amounts of organic carbon content of the experimental area rated as high. The high organic carbon content of surface soil could be related to organic matter content due to litter fall and crop residue of the soil surface.

Soil organic carbon was determined to estimate the amount of organic matter in the soil. Organic matter has an important influence on soil physical and chemical properties, soil fertility status, plant nutrient and biological activity in the soil [33]. The organic matter content (4.55%) was estimated from soil organic carbon of the experimental area. On the other hand; the higher the clay content a soil has, the higher the % OC it contains due to the stability of clay colloids. Results in the work of Feller and Beare, [35] support the argument and reported that organic carbon generally increased with the clay content.

Effect of NPSB and urea Fertilizer on Growth, yield and yield components of Maize

The difference in plant height, number of ear per plant among treatments that received application of NPSB and urea or recommended NP was none significantly (P > 0.05) different (Table 2). Ear height, ear length and cob length were significantly (p < 0.05) different from the control. On the other hand, compared to the recommended NP, the mean value of ear height, ear length and cob length were statically none significant from the application of NPSB, urea and K fertilizer.

Numerically the longest ear height (144.95 cm) was recorded from the application of 250 NPSB + 150 urea + 100KCl kg ha^{-1}; while the shortest ear height (126.70 cm) was recorded from the control treatment. Application of 250 NPSB + 150 urea + 100 KCl kg ha^{-1} increased ear height by 6.72% compared to the control treatment (Table 2).

Table 2: Effects of balanced fertilizer on plant height, Ear height and Ear length of maize.

Treatments (Fertilizer rates kg ha^{-1})	Plant height cm	Ear height cm	Ear length cm	Cob length cm	Number of ear per plant
Control	244.45	126.7b	30d	13.55c	1
200 urea + 150 kg TSP	256.55	141.7ab	32.95c	15.65b	1.05
150 NPSB + 100 Urea + 100 KCl	254.9	137.55ab	33.3bc	16.8ab	1.05
200 NPSB + 100 Urea + 100 KCl	263.3	138.5ab	34.4bc	17ab	1
250 NPSB + 100 Urea + 100 KCl	268.55	140.25ab	37.55a	17.3a	1.05
150 NPSB + 150 Urea + 100 KCl	262.3	138.75ab	35.8ab	16.45ab	1
200 NPSB + 150 Urea + 100 KCl	258.4	136.45ab	34.6bc	16.95ab	1
250 NPSB + 150 Urea + 100 KCl	266.2	144.95a	35.85ab	17ab	1
LSD	ns	15.269	2.7989	1.4492	ns
CV%	6.34857	7.5183	5.54807	6.03207	5.91484

LSD = Least Significant Difference ($p < 0.05$), cm = centimeter, CV = Coefficient of Variation, Means values followed by the same letter(s) within the column were not significantly different at 0.05 probability level.

Table 3: Effect of balanced fertilizer on yield and yield component parameters of maize.

Treatments (Fertilizer rates kg ha^{-1})	Thousand seed weight (gm)	Grain yield (kg ha^{-1})	Biomass t ha^{-1}	Harvest index	Shelling percentage %
T1= control	300.78b	2968.9f	7.67e	38.61d	73.79d
200 urea + 150 TSP	364.8a	5166.6e	11.76d	43.90b	80.55c
150 NPSB + 100 Urea + 100 KCl	385.24a	7033.4d	15.51c	45.31ab	84.01b
200 NPSB + 100 Urea + 100 KCl	407.5a	8291.2ab	18.30a	45.28ab	84.95b
250 NPSB + 100 Urea + 100 KCl	406.46a	8828.2a	18.52a	47.65a	88.51a
150 NPSB + 150 Urea + 100 KCl	384.42a	8082.9bc	17.80ab	45.46ab	84.55b
200 NPSB + 150 Urea + 100 KCl	395.62a	7547.1cd	16.93b	44.53b	83.92bc
250 NPSB + 150 Urea + 100 KCl	387.41a	7605.3cd	16.92b	44.91b	83.98b
LSD	47.4	592.6	0.9166	2.5852	3.3857
CV%	8.5043	5.80637	4.03952	3.95416	2.77276

LSD = List Significant Difference, CV% = Coefficient Variation, Means values followed by the same letter(s) within the column are not significantly different at 0.05 probability level.

Numerically the maximum ear length (37.55 cm) was recorded on plots received 250 NPSB + 100 urea + 100 KCl kg ha^{-1} fertilizer; while the minimum ear length (30 cm) was recorded on the control plots. Application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} fertilizer increased ear length by 11.20% and 6.53% when compared with the control plot and recommended NP fertilizer respectively. The ear length development might be due to the application of balanced fertilizer (NPSB, urea and KCl). An increase in ear length at higher N and P could be due to good photo-assimilates supply which facilitates photosynthesis and S aids in seed formation.

Dagne [36] reported that the application of blended fertilizer was showed significant differences in ear length when compared to the control treatment. Increase in photosynthesis activities account for plant growth under an adequate supply of nitrogen and phosphorous [37]. The maximum assimilate supply should be available during maize grain filling with a split application of Nitrogen [38]. Study by Moraditochaee, et al. [39] also indicated nitrogen significantly increased the ear length of maize.

The Application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} increased cob length by 5.01% respectively when compared to the recommended NP, though these differences were statically none significantly ($p > 0.05$) different under the application of other treatment (Table 4) when compared with the recommended NP fertilizer.

This result disagrees with the Shifera, et al. [40] finding which showed that the application of NPS and NPSB fertilizer had no significant effect on cob length comparing with the control treatment, but the study by Ahmad, et al. [41] reported increase in nitrogen levels positively influence cob length of maize. Also Derby, et al. [42] reported at a favorable environmental optimum utilization of solar light, higher assimilated production and its conversion to starches resulted in higher cob length.

Effect of NPSB and urea Fertilizer on Yield and Yield Component of Maize

Thousand grain weight, grain yield, biomass yield and shelling percentage were significantly ($P < 0.05$) affected by the application of NPSB and urea fertilizer as compared to the recommended NP fertilizer except shelling percentage was none significantly affected under the application of 200 NPSB + 150 urea +100 KCl (Table 3).

The heavier thousand grain weight (407.5 gm) was recorded from the application of 200 NPSB + 100 Urea + 100 KCl kg ha^{-1}; while the lighter (300.78 gm) from the control treatment. An increase in thousand grain weights were due to the effects of N for grain filling and increases the plumpness of grains, P for cell division, seed formation and development, S for seed production helps for heavier grain weight of maize. Availability of sufficient light and moisture to an individual plant at higher nutrient proportion leads to enhanced plant growth and might have led to better grain development which ultimately increased grain weight. At sufficient NPSB fertilizer grains providing sufficient development of an individual grain, leading to higher thousand grain weight.

The weight of grains depends on the flabbiness of grains and the transport of assimilates to the seed [43]. Also, the sufficient availability of nutrients from inorganic source at critical growth stages; especially at grain filling and development [44] and thus resulted in properly filled grains.

The highest grain yield (8828.20 kg ha^{-1}) was recorded from the application of 250 NPSB + 100 urea +100 KCl kg ha^{-1}, while the lowest grain yield (2968.90 kg ha^{-1}) was recorded from the control plot (Table 3). The application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} fertilizers improved maize grain yield by 49.66% and 26.16% when compared with the control treatment and recommended NP fertilizer respectively. The low yield of maize under the application of recommended NP might be due to the absence of macronutrients like K and S and other micronutrients (B). The more grain yield increment from the plot that treated with balanced fertilizer might be the contribution of balanced nutrient (macro and micronutrient) present in NPSB fertilizer as compared to recommended NP and control.

Ali, et al. [45] reported combined application of nitrogen and phosphorous increase maize yield (3424.95 kg ha^{-1}) by 112.05% as compared to the control plot when applied at the rate of 150 + 120 N and P_2O_5 kg ha^{-1} respectively. Muhammad, et al. [46] reported application of 120 kg K ha^{-1} fertilizer to improve maize yield by 24.21% as compared to the control. A similar study indicated that maximum grain yield was obtained by applying blended fertilizer, whereas the lowest grain yield was recorded from the control treatments [36,40]. Asfa, et al. [47] and Ayalew and Habte [48] reported blended fertilize with the recommended amount of N and P increased teff yield as compared to the control. Similar achievements from the application of blended fertilizer increased bread wheat yield [46] reported combination application of macronutrient and micronutrients increases dry matter, grain yield, yield component and straw of wheat over control.

The maximum biological yield (18.52 t ha^{-1}) was obtained under the application of 250 NPSB + 100 kg urea + 100 KCl kg ha^{-1} and the minimum biological yield (7675.4 kg ha^{-1}) was obtained from control treatment (Table 3). Application of 250 NPSB + 100 urea + 100 KCl kgha^{-1} resulted in 41.40% and 22.30% more biological yield compared to the control treatment and recommended NP fertilizer respectively. This biological yield increment of maize with the application of balanced fertilizer over the control and recommended NP might be due to the balanced nutrient of NPSB with urea fertilizer. Split application of nitrogen fertilizer in addition to the balanced fertilizers and also it might be attributed to the additional availability of nutrients.

These results conformed to the found of Sharma, et al. [49] those stated that the application of micronutrients combinations with macronutrients gave the highest biological yield and grain yield.

The maximum harvest index (47%) was obtained at the application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} and the minimum harvest index (38%) were recorded under control treatment. The application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} resulted in 10.48% and 4.10% more harvest index as compared to the control treatment and recommended NP fertilizer respectively. This increment of harvest index due to the micronutrients might be attributed to its influences in enhancing the photosynthesis process and translocation of photosynthetic products to the economic part. The higher harvest index expressed the physiological potential for converting dry matter into grain yield.

The highest shelling percentage (88%) was obtained from the application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} and the lowest (73%) from the control treatment (Table 3). Application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} resulted in 9.10% and 4.71% more shelling percentage when compared to the control treatment and recommended NP fertilizer respectively (Table 3).

Application of N and P alone or in various combinations had increase shelling percentage of maize [45]. Similarly, a positive correlation was observed between shelling percentage and various levels of N.

Effect of NPSB and urea fertilizer on maize nutrient uptake

Nitrogen uptake of maize: The maximum grain N uptake (126.83 kg ha^{-1}), straw N uptake (104.16 kg ha^{-1}) and total biomass N uptake (230.99 kgha^{-1}) were obtained from the application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1}, while the minimum N in grain (12.37 kg ha^{-1}), straw (13.35 kgha^{-1}) and total biomass uptake (25.72 kgha^{-1}) were recorded from the control treatment (Table 4). The application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} grain N uptakes increased by 82.23% and 52.72% as compared to the control treatment and recommended NP respectively. The improvement of N uptake and concentration of maize over the control and the recommended NP could be due to improved efficiency of N attributed to macro and micronutrient present in types of fertilizer applied and split application of N application also increases the nitrogen uptake through the growing season. The application of NPSB and urea along with K and recommended NP had influenced the grain and straw N uptake.

These results conformed to the finding of Dagne [36] that stated that the application of micronutrients combinations with macronutrients gave the highest N uptake both in grain and straw. N uptake in grain has positive significant associations with grain yield (Fageria and Baligar, 2005a). Hence, improving N uptake in grain may lead to improved grain yield. Also, combine the application of nitrogen and phosphorus to increase the N uptake of maize was reported by Ali, et al. [45] as the level of phosphorous increase the N uptake increased.

Phosphorous nutrient uptake of maize: The maximum P grain uptake (64.45 kg ha^{-1}) and total biomass uptake (88.75 kg ha^{-1}) were obtained under the application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1}, while the minimum P grain uptake (8.02) kg ha^{-1} was obtained under control treatment (Table 4). The application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} improved grain P uptake by 77.88% as compared to control treatment. Similarly, it improved grain P uptake by 55.21% as compared to recommended NP fertilizer. This improvement might be the synergic effect of micronutrient combined with macronutrient fertilizer improved uptake of phosphorous over recommended NP fertilizer. Also, the positive strong and highly significant association of P uptake with K grain uptake, N grain uptake, P recovery and S grain uptake were observed; consequently improve the grain P uptake over recommended NP.

This result was agreed with Dagne [36], who reported blended fertilizer with Cu and Zn the highest grain uptake and contents of P were observed. The nutrient uptake increased through the application of lime and compost with blended macronutrients and micronutrients in the appropriate form of fertilizer to nutrient-deficient soil [50].

Potassium nutrient uptake of maize: The highest K uptake in grain, straw and total biomass kg ha^{-1} (97.01, 239.15

Table 4: Maize grain and straw nitrogen concentration and uptake.

Treatments (Fertilizer rates kg ha^{-1})	Nutrient uptake kg ha^{-1}					
	N			P		
	Grain	Straw	Biomass	Grain	Straw	Biomass
Control	12.37	13.35	25.72	8.02	4.58	12.59
200 urea + 150 TSP	39.27	33.04	72.31	18.6	11.76	30.36
150 NPSB + 100 Urea + 100 KCl	70.1	66.25	136.35	37.98	18.2	56.18
200 NPSB + 100 Urea + 100 KCl	112.76	68.33	181.09	50.58	21.9	72.48
250 NPSB +100 Urea + 100 KCl	126.83	104.16	230.99	64.45	24.3	88.75
150 NPSB + 150 Urea + 100 KCl	85.95	88.76	174.71	43.65	21.13	64.78
200 NPSB + 150 Urea + 100 KCl	105.66	67.35	173.01	50.57	23	73.56
250 NPSB + 150 Urea + 100 KCl	94.31	78.63	172.94	57.8	26.75	84.55

Total biomass = Grain + straw uptake

Table 5: Maize grain and straw potassium (K), Sulfur (S), and boron (B) concentration and uptake.

Treatments (Fertilizer rates kg ha^{-1})	Nutrient uptake kg ha^{-1}								
	K			S			B		
	Grain	Straw	Biomass	Grain	Straw	Biomass	Grain	Straw	Biomass
Control	16.33	58.72	75.05	3.27	2.67	5.94	0.89	0.76	1.65
200 urea + 150 TSP	34.1	104.72	138.82	6.72	5.6	12.32	1.55	2.8	4.35
150 NPSB + 100 Urea + 100 KCl	80.18	171.81	251.99	11.25	8.01	19.26	2.81	4.37	7.18
200 NPSB + 100 Urea +100 KCl	97.01	239.15	336.16	13.27	11.39	24.65	3.32	5.25	8.57
250 NPSB + 100 Urea +100 KCl	90.05	233.49	323.54	12.36	10.42	22.78	3.53	5.2	8.74
150 NPSB + 150 Urea + 100 KCl	92.15	189.35	281.5	13.74	9.3	23.04	3.23	5.08	8.31
200 NPSB + 150 Urea +100 KCl	71.7	220.94	292.64	13.58	9.86	23.44	3.02	4.11	7.13
250 NPSB + 150 Urea + 100 KCl	68.45	211.58	280.03	12.93	8.92	21.85	3.04	4.05	7.1

K = potassium, S = Sulfur, B = boron, biomass (Grain + straw uptake), and 336.16) were obtained from the application of 200 NPSB + 100 urea + 100 KCl kg ha^{-1} (Table 5). These increments might be the optimum supply of nitrogen with NPSB fertilizer ensures optimum uptake of potassium as well as phosphorus. Generally application of 200 NPSB + 100 urea + 100 KCl kg ha^{-1} had improved K uptake in grain and total biomass of maize plants by 71.19% and 64.50% as compared to the control respectively. Similarly, it had increased K uptake in grain and total biomass maize plant by 49.99% and 41.55% as compared to the recommended NP fertilizer respectively.

Malkouti [51] and Asefa, et al. [47] who reported fertilizer use efficiency for different crops increased by the application of suitable micronutrients combination with NPK fertilizer. Maize takes up to 38% of the total K for the whole growing season, from 38 to 52 days after sowing [52].

Sulfur nutrient uptake of maize: The maximum S uptake by grain (13.74 kg ha^{-1}) was recorded from treatment that received 150 NPS + 150 urea + 100 KCl. The minimum S uptakes by grain, straw and total biomass (3.27, 2.67 and 5.94) kg ha^{-1} were recorded from control treatment respectively (Table 5).

Jones, et al. [53] stated matching appropriate essential macro and micronutrients with crop nutrient uptake could optimize nutrient use efficiency and crop yield. The amount of S in a cereal crop at harvest can range between 7 and 30 kg ha^{-1}, depending on both S supply and yield level, although most crops contain nearer to 15 kg ha^{-1} [54]. Nitrogen fertilizer application increased the grain sulfur concentration at high, but not at low S and increased grain nitrogen concentration in S fertilizer applications [55]. The S nutrient content and uptake were the contribution of both macro and micronutrients present in blended fertilizer. Therefore, in this study total biomass S uptakes were ranged between (5.94 and 24.55) kg ha^{-1} from control to fertilizer applied respectively.

Boron nutrient uptake of maize: The maximum B uptake in grain (3.53) kg ha^{-1} was obtained under the application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} (Table 5). Application of 250 NPSB + 100 urea + 100 KCl kg ha^{-1} had improved B uptake in grain of maize plants by 59.72% as compared to the control treatment.

Fayera, et al. [56] reported the application of NPK fertilizer with Zn and B improves nutrient concentration and uptake and enhanced teff yield.

Effect of NPSB and Urea Fertilizer on Maize Apparent N and P fertilizer recovery

The highest apparent fertilize recovery of N recorded was 230.47% from 250 NPSB + 100 urea + 100 KCl kg ha^{-1} and P was 96.38% from 150 NPSB + 150 urea + 100 KCl kg ha^{-1} (Table 6). The apparent N and P recovery decreased with increasing rate of fertilizer application were inconsistently. The fertilizer had improved the N and P recovery over recommended N and P might be the contribution of macronutrient (S) and micronutrient (B) present in NPSB fertilizer increased the availability of macronutrients.

Effect of NPSB and Urea Fertilizer on Maize Agronomic N and P use efficiency of maize

Agronomic N use efficiency of maize: The highest agronomic fertilizer N use efficiency (64.75 kg ha^{-1}) was obtained from the application of 200 NPSB + 100 urea + 100 KCl kg ha^{-1}, while lowest agronomic fertilizer N use efficiency (23.89 kg ha^{-1}) was recorded from recommended NP fertilizer (Table 6). A balanced 200 NPSB + 100 urea + 100 KCl kg ha^{-1} fertilizer improved agronomic N fertilizer use efficiency by 46.10% as compared to the recommended NP fertilizers.

Karim and Ramasamy [57] suggested that higher fertilizer use efficiency which was always associated with low fertilizer rate, cultural practices means promoting integrated nutrient management will help to effect saving in the amount of fertilizer applied to the crops and there to improve fertilizer use efficiency. Agronomic fertilizer use efficiency of any nutrient can be increased by increasing plant uptake and the use of nutrients and by decreasing nutrient losses from the soil plant system. Mengel, et al. [58] agronomic fertilizer use efficiency value for a nutrient should not be less than 5 kg ha^{-1}. The results of the studied area were ranged from 23.89 to 64.75 kg ha^{-1} which was the optimum standard of agronomic use efficiency according to Mengel, et al. [58], Dobermann [59] reported that agronomic fertilizer use efficiency should be within the ranges of 10 to 30 kg ha^{-1} and if the value of agronomic N fertilizer use efficiency above 30 kg ha^{-1} in well

Table 6: Apparent fertilizer recovery, agronomic and physiological use efficiency of maize.

Treatments (Fertilizer rates kg ha^{-1})	AR %		AE kg ha^{-1}		PE kg ha^{-1}	
	N	P	N	P	N	P
Control	-	-	-	-	-	-
200 urea + 150 TSP	50.89	25.75	23.89	31.85	46.94	230.23
150 NPSB + 100 Urea + 100 KCl	152.53	80.50	55.56	75.06	36.43	179.81
200 NPSB + 100 Urea + 100 KCl	187.83	82.95	64.75	73.72	34.47	177.49
250 NPSB + 100 Urea + 100 KCl	230.47	84.39	64.21	64.92	27.86	142.41
150 NPSB + 150 Urea + 100 KCl	154.13	96.38	53.14	94.44	34.48	194.05
200 NPSB + 150 Urea + 100 KCl	137.86	84.45	43.52	63.41	31.57	151.84
250 NPSB + 150 Urea + 100 KCl	126.91	79.74	40.58	51.37	31.96	128.54

AR = Apparent Recovery, AE = Agronomic use Efficiency, PE = Physiological use Efficiency managed system or at lower levels of N use or low soil N supply.

Agronomic P use efficiency of maize: The highest agronomic fertilizer P use efficiency (94.44 kg ha^{-1}) was obtained under the application of 150 NPSB + 150 urea + 100 KCl kg ha^{-1}, while lowest agronomic fertilizer P use efficiency (31.85 kg ha^{-1}) was recorded from recommended NP fertilizer (Table 6). Application of 150 NPSB + 150 urea +100 KCl kg ha^{-1} improved agronomic P fertilizer use efficiency by 49.56% as compared to recommended NP fertilizers.

Physiological N and P use efficiency of maize

The physiological efficiency of N and P were not influenced by the application NPSB fertilizer along with urea and K fertilizer application as compared to the recommended NP fertilizer (Table 6), but the physiological efficiency of this study was at the range of N and P physiological use efficiency.

According to Dobermann [59], physiological efficiency values should commonly range from 30 to 60 kg kg^{-1}. If the obtained results are above these common values, it could be concluded that the farm was under a well-managed system and the reverse is true, if the results obtained are below the common values.

Economic analysis

Marginal analysis: Economic analysis revealed that the maximum marginal rate of return was recorded with the application of 150 NPSB + 100 Urea + 100 KCl with MRR 4.35 (Table 7). The marginal rates of those treatments were well above the minimum acceptable return.

According to CIMMYT [26] experience and empirical evidence, for the majority of situations indicated that the minimum rates of return acceptable to farmers were between 50 and 100%. In the present study, the treatments that had between 50 and 100% marginal rate of return was recommended for the farmers, with treatments that had the small number of variable cost. Therefore, 150 NPSB + 100 urea + 100 KCl kg ha^{-1} treatment was recommended to the study area.

The best recommendation for treatments subjected to marginal rate of return was not necessarily based on the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the highest net benefit, relatively low variable cost together with an acceptable MRR becomes the recommendation [26].

The result indicated that the net benefit was decreased as the total cost that varies increased beyond un-dominated fertilizer treatment application. Therefore, no farmer may choose other dominated treatments in comparison with the un-dominated treatments. This also helps to avoid the dominated treatment in further estimate of marginal rates of return (Table 7).

Dominance analysis: The highest net benefits from the application of inputs for the production of the crop might not be sufficient for the farmers to accept as good practices. In most cases, farmers prefer the highest profit (with low cost and high income). For this purpose, it is necessary to conduct dominated treatment analysis [26]. The MRR% between any pair of un-dominated treatments denotes the return per unit of investment in fertilizer expressed as a percentage. A dominated treatment is any treatment that has net benefits that are less than those of a treatment with lower costs that vary.

Conclusion

Application of NPSB and urea along KCl was none significantly (P > 0.05) influenced plant height, number of ear per plant among treatments that received application of NPSB and urea or recommended NP was none significantly (P > 0.05) different. Ear height, ear length and cob length were significantly (p < 0.05) different from the control. On the other hand, compared to the recommended NP, the mean value of ear height, ear length and cob length were statically none significant from the application of NPSB, urea and K fertilizer. Thousand grain weight, grain yield and biomass yield were significantly (P < 0.05) affected by the application of NPSB and urea fertilizer as compared to the control and recommended NP fertilizer. The highest maize grain yield (8828.2 kg ha^{-1}) was obtained from the application of 250 NPSB + 100 Urea + 100 KCl; while the lowest grains yield (2968.90 kg ha^{-1}) was from the control plot.

Table 7: Partial budget analysis of fertilizer application rate and types on maize.

Treatments	Grain yield Kg ha^{-1}	Adj. grain yield	GFB	TVC	NB	MRR
Control	2968.9	2672.01	13360.05	0	13360.05	
200 urea + 150 TSP	5166.6	4649.94	23249.7	16635	6614.7	D
150 NPSB + 100 Urea + 100 KCl	7033.4	6330.06	31650.3	18205	13445.3	4.35
150 NPSB + 150 Urea + 100 KCl	8082.9	7274.61	36373.05	20395	15978.05	1.15
200 NPSB +100 Urea + 100 KCl	8291.2	7462.08	37310.4	21230	16080.4	0.12
250 NPSB + 100 Urea + 100 KCl	8828.2	7945.38	39726.9	22780	16946.9	0.55
200 NPSB + 150 Urea + 100 KCl	7547.1	6792.39	33961.95	23420	10541.95	D
250 NPSB + 150 Urea + 100 KCl	7605.3	6844.77	34223.85	23510	10713.85	1.91

Adj = Adjusted grain yield to 10%, GFB = Growth field benefit, TVC = Totalcost that varies, NB = Net benefit, MRR = Marginal rate of return

Application of NPSB and urea improved nutrient uptake, apparent recovery, and agronomic use efficiency, except Physiological Nitrogen and Phosphorus use efficiency as compared with the blanket recommended NP fertilizer. The maximum grain N uptake (126.76 kg ha^{-1}) was obtained from the application of 250 NPSB + 100 Urea + 100 KCl kg ha^{-1}.

Economically the highest net benefit (13445.3 EB) was obtained under the application of 150 NPSB + 100 Urea + 100 KCl $ha^{-1}$and lowest net benefit (6614.7 EB) was obtained under the recommended (200 urea + 150 TSP). Therefore, application of 150 NPSB + 100 urea along with 100 KCl kg ha^{-1} fertilizers is recommended for maize production in Yeki District.

Acknowledgements

We would like acknowledge EIAR for budget funded for the experiment input. We also express our thanks to Teppi Agricultural Research Center for resource allocation during field work. Also Very special thanks to Mr. Tesfaney Ejegu for his support of this work from field experiment to completion.

Conflicts of Interest

We declare no conflict of interest.

References

1. CSA (central statistical agency) (2017) Agricultural Sample Survey: Report on area and production of major crops. Statistical Bulletin Vol-I: 269-278.
2. IFPRI (International Food Policy Research Institute) (2010) Maize value chain potential in Ethiopia: Constraints and opportunities for enhancing the system, Washington DC.
3. FAO (Food and Agriculture Organization of the United Nations) (2011) The State of the World's Land and Water Resources for Food and Agriculture (SOLAW) Managing Systems at Risk: Food and Agriculture Organization of the United Nations: Earthscan.
4. Debele T, Gedeno G, Leul M (1994) In 6 Annual Conference of the Crop Science Society of Ethiopia, 3-4 May 1994: Response of maize to split application of nitrogen fertilizer at Bako. Addis Abeba (Ethiopia).
5. Abebayehu A, Elias E, Diels J (2011) Comparative analysis of soil nutrient balance at farm level: A case study in Jimma Zone, Ethiopia. International Journal of Soil Science 6: 259-266.
6. IFDC (International Fertilizer Development Center) (2015) Assessment of Fertilizer Consumption and Use by Crop in Ethiopia.
7. Zingore S (2011) Maize productivity and response to fertilizer use as affected by soil fertility variability, manure application, and cropping system. Better Crops 95: 4-6.
8. ATA (Agricultural Transformation Agency) (2016) Soil fertility status and fertilizer recommendation atlas for SNNPRS, Ethiopia. Ethiopian Agricultural Transformation Agency (ATA), A.A, Ethiopia.
9. Selamyihun K, Mamo T, Stroosnijder L (2005) Biomass production of Eucalyptus boundary plantations and their effect on crop productivity on Ethiopian highland Vertisols. Agroforestry Systems 63: 281-290.
10. Nigussie H, Poesen J, Paridaens K, et al. (2007) Nutrient export and associated costs from micro-dam catchments in Tigray. 27-28.
11. Arif M, Ali S, Khan A, et al. (2006) Influence of farmyard manure application on various wheat cultivars. Sarhad J Agric 22: 27-29.
12. Lelago AB, Mamo TA, Haile WW, et al. (2016) Soil micronutrients status assessment, mapping and spatial distribution of Damboya, Kedida Gamela and Kecha Bira Districts, Kambata Tambaro zone, southern Ethiopia. African Journal of Agricultural Research 11: 4504-4516.
13. EthioSIS (Ethiopian Soils Information System) (2013) Status of soil resources in Ethiopia and priorities for sustainable management, GSP for eastern and southern Africa, Nairobi, Kenya, March 25-27.
14. EthioSIS (Ethiopia Soil Information System) (2014) Soil fertility status and fertilizer recommendation atlas for Tigray regional state _ July 2014, Addis Ababa, Ethiopia.
15. EthioSIS (Ethiopia Soil Information System) (2015) Ethiopian Agricultural Transformation Agency. et/highlighted deliverables/ Ethiopian soil information system ethiosis.
16. FAO UNESCO ISRIC (1988) Soil Map of World. Revised legend, Reprinted with corrections; world soil Resources report no.60. FAO, Rome.
17. Day PR (1965) Particle fractionation and particle-size analysis. Methods of Soil Analysis: Part 1 Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling, 9.1, 545-567.
18. Van Reeuwijk LP (1992) Procedures for Soil Analyses. Int. Soil Reference and Information Centre, (ISRIC), (3rd edition), Wageningen, Netherlands, 34.
19. Olsen SR (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate, Washington, D.C: US Department of Agriculture, 939: 18-19.
20. Morgan MF (1941) Chemical diagnosis by the universal soil testing system: conn. agr. exp. Sta , New Haven bull, 450.
21. Bremner JM (1965) Total Nitrogen, methods of soil analysis, part 2: Chemical and microbiological properties (methods of soilanb), American Society of Agronomy, Wisconsin, 1149-1178.
22. Mehlich A (1984) Mehlich 3 soil test extractant, a modification of Mehlich 2 extractant. Commun. Soil Sci Plant Anal 15: 1409-1416.
23. Chapman HD (1965) Cation exchange capacity methods of soil analysis, part 2, chemical and microbiological properties, (methods of soil analysis). American Society of Agronomy, Madison, 891-901.
24. Walkley A, Black IA (1934) An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science 37: 29-38.
25. Getachew A, Rezene F (2006) Response of faba bean to phosphate fertilizer and weed control on nitisols of Ethiopian highlands. Italian Journal of Agronomy 281-290.
26. CIMMYT (1998) Economics Program, International Maize and Wheat Improvement Center, from agronomic data to farmer recommendations: An economics training manual. 27.
27. SAS Institute Inc (2011) SAS/STAT® 9.3 User's Guide. SAS Institute Inc: Cary, NC, USA.

28. Kochhar SL (1986) Tropical crops: a textbook of economic botany, McMillian Publisher Ltd., London and Basingtone, 152-156.
29. Landon JR (1991) Booker Tropical soil manual, a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Longman Scientific & Technical Publ., Harlon, Booker 474.
30. Havlin JL, Beaton JD, Tisdale SL, et al. (1999) Soil Fertility and Fertilizers: an introduction to nutrient management, 6th edition, Prentice-Hall, Upper Saddle River, N.J, 499.
31. Tekalign M, Haque I (1991) Phosphorus status of some Ethiopian soils: III, Evaluation of soil test methods for available phosphorus. Tropical Agriculture (Trinidad) 68: 51-56.
32. Horneck DA, Sullivan DM, Owen JS, et al. (2011) Soil test interpretation guide.
33. Brady NC, Weil RR (2002) The Nature and Properties of Soils. (13th edn), Prentice-Hall, New Jersey.
34. Hazelton P, Murphy B (2007) Interpreting soil test results: what do all the numbers mean. (2nd edn). Department of natural resources. CSIRO publishing, Australia.
35. Feller C, Beare MH (1997) Physical control of soil organic matter dynamics in the tropics. Geoderma 79: 69-116.
36. Chimdessa D (2016) Blended fertilizers effects on Maize yield and yield components of Western Oromia, Ethiopia. Agriculture, Forestry and Fisheries 5: 151-162.
37. Jan A, Naveed K, Jan T (2002) Residual effect of groundnut and soil amendments on the Performance of gram under rainfed conditions. Asian Journal of Plant Science 1: 625-627.
38. Arif M, Amin I, Jan MT, et al. (2010) Effect of plant population and nitrogen levels and methods of application on-ear characters and yield of maize. Pak J Bot 42: 1959-1967.
39. Moraditochaee M, Motamed MK, Azarpour E, et al. (2012) Effects of nitrogen fertilizer and plant density management in corn farming. ARPN Journal of Agricultural and Biological Science 7: 133-137.
40. Boke S, Habte M, Asefa A, et al. (2018) Macro and Micronutrients for optimizing maize production at Hawassa Zuria District, Southern Ethiopia. Journal of Biology, Agriculture and Healthcare 8.
41. Ahmad S, Khan AA, Kamran M, et al. (2018) Response of Maize cultivar to Various Nitrogen Levels. Eur Exp Biol 8.
42. Derbay N, Casey FX, Kinghton RE, et al. (2004) Midseason nitrogen fertilizer management for corn-based on weather and yield prediction. Agron J 96: 494-502.
43. Siam H S, Abd-El Kader M G, El-Alia H I (2008) Yield and yield components of maize as affected by different sources and application rates of nitrogen fertilizer. Research Journal of Agriculture and Biological Sciences 4: 399-412.
44. Mohsin AU, Ahmad J, Ahmad AUH, et al. (2012) Effect of nitrogen application through different combinations of urea and farmyard manure on the performance of spring maize. J Anim Plant Sci 22: 195-198.
45. Ali J, Bakht J, Shafi M, et al. (2002) Effect of various levels of N and P on yield and yield components of Maize. Pakistan Journal of Agronomy 1: 12-14.
46. Mulugeta H, Abay A (2017) Blended fertilizers as sources of balanced nutrients for growth and yield of Wheat at Hulla District in Southern Ethiopia. Journal of Natural Sciences Research 7.
47. Asefa F, Mohammed M, Debela A (2014) Effects of different rates of NPK and blended fertilizers on nutrient uptake and use efficiency of Teff [*Eragrostistef* (*Zuccagni*) Trotter] in Dedessa District, Southwestern Ethiopia. Journal of Biology, Agriculture and Healthcare 4: 25.
48. Ayalew A, Habte M (2017) Use of balanced nutrients for better production of Teff (Eragrostistef (zucc.) at Bensa in Southern Ethiopia. Journal of Resources Development and Management 32.
49. Sharma SK, Jain NK, Upadhyay B (2012) Effect of balanced fertilization on productivity and soil fertility status of maize. Research on Crops 13: 95-99.
50. Demissie W, Kidanu S, Tolera A, et al. (2017) Effects of lime, blended fertilizer (NPSB) and compost on yield and yield attributes of Barley (Hordium vulgare L.) on acid soils of Wolmera District, West Showa, Ethiopia. Ethiopia Journal of Applied Science & Technol 8: 84-100.
51. Malakouti MJ (2008) The effect of micronutrients in ensuring efficient use of macronutrients. Turkish Journal of Agriculture and Forestry 32: 215-220.
52. Rehman SU, Ahma Alias M, Bukhsh HA, et al. (2008) Comparative performance and profitability of two corn hybrids with organic and inorganic fertilizers. Pakistan Journal of Agricultural Science 45: 8-12.
53. Jones C, Olson-Rutz K, Dinkins CP (2011) Nutrient uptake timing by crops, to assist with fertilizing decisions. 2-8.
54. Chalmers WP, A Hodgson I Kane R, Mcgrath S, et al. (1997) Diagnosis and prediction of sulfur deficiency in winter wheat and barley, Project report 142. London: Home-Grown Cereals Authority. 48.
55. Jarupula S, Dwivedi BS, Dwivedi AK, et al. (2018) Effect of long term application of nitrogen and sulfur nutrition on nitrogen assimilation in Soybean. Journal of Pharmacognosy and Phytochemistry 7: 2000-2004.
56. Fayera A, Muktar M, Adugna D (2014) Effects of different rates of NPK and blended fertilizers on nutrient uptake and use efficiency of Teff [Eragrostistef (Zuccagni) Trotter] in Dedessa District, Southwestern Ethiopia. Journal of Biology, Agriculture and Healthcare 4: 25.
57. Karim AA, Ramasamy C (2000) Expanding frontiers of agriculture: contemporary issues. Kalyani Publishers, Ludhiana, India.
58. Mengel K, Hutsch B, Kane Y (2006) Nitrogen fertilizer application rates on cereal crops according to available mineral and organic soil nitrogen. European Journal of Agronomy 24: 343-348.
59. Dobermann AR (2005) Nitrogen Use Efficiency State of the Art: Agronomy and horticulture faculty publications.

DOI: 10.36959/339/360