Vol. 10(2), pp. 54-63, July-December 2019
DOI: 10.5897/JCO2019.0193
Article Number: 120132A62366
ISSN 2141-6591

http://www.academicjournals.org/JCO

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Journal of Cereals and Oilseeds

*Full Length Research Paper*

# Evaluation of NPSZnB fertilizer levels on yield and yield component of maize (*Zea mays* L.) at Laelay Adiyabo and Medebay Zana districts, Western Tigray, Ethiopia

**Kinfe Tekulu, Tsadik Tadele, Tewolde Berhe, Weldegebreal Gebrehiwot, Gebresemaeti Kahsu, Solomon Mebrahtom and Goitom Aregawi**

Department of Soil Fertility Research, Tigray Agricultural Research Institute, Shire Soil Research Center, P. O. Box 40, Shire, Ethiopia.

Receive 25 April, 2019; Accepted 1 August, 2019

**The use of right amount of fertilizer based on crop requirement has a significant importance for sustainable crop production. Study was undertaken to investigate the effects of NPSZnB blended fertilizer for maize yield production at Laelay Adiyabo and Medebay Zana districts. Seven treatments were used for the field experiment. Treatments were without fertilizer, blanket recommended NP (64 kg N ha$^{-1}$+69 kg $P_2O_5$ ha$^{-1}$) and five treatments of blended fertilizer rates (150, 200, 250, 300, and 350 kg NPSZnB ha$^{-1}$). Treatments were laid out in RCBD design with three replications. The results revealed that among fertilizers rates significantly ($P \leq 0.05$) affected almost all the maize traits tested except tasseling, silking and maturity in Laelay Adiyabo district. However, in Medebay Zana district except tasseling, silking and maturity, plant height and thousand seeds weight, the rest parameters of above ground biomass yield, stover yield grain yield and harvest index were found significantly ($P<0.05$) affected by the fertilizer treatments. Highest stover yields (11.12 and 11.76 t ha$^{-1}$) were obtained from application of 150 and 250 kg NPSZnB ha$^{-1}$for Laelay Adiyabo and Medebay Zana districts, respectively. At both districts of Laelay Adiyabo and Medebay Zana areas the highest grain yields (3.20 and 2.97 t ha$^{-1}$) were obtained, respectively from application of NPSZnB fertilizer at the rate of 300 kg ha$^{-1}$, while the minimum grain yields of both districts were obtained from the control checks. The highest marginal rate of returns of 242 and 255% were obtained from application of 150 kg NPSZnB ha$^{-1}$in both Laelay Adiyabo and Medebay Zana districts, respectively. Therefore, based on the result obtained from this study 150 kg NPSZnB ha$^{-1}$ can be recommended as profitable for the production of maize at both districts of the study areas.**

**Key words:** Blended fertilizer, maize yield, profitability.

## INTRODUCTION

In Ethiopia agriculture, maize is one of the pillar cereal crops ranking first in total production and productivity, and second to tef in area coverage (FAOSTAT, 2017). In spite of the large area coverage under maize, the national (Ethiopia) and regional (Tigray) average grain yields were reached about 3.6 t ha$^{-1}$ FAOSTAT (2017)

*Corresponding author. E-mail: tekulukinfe@gmail.com. Tel: +251344440604.

and 2.48 t $ha^{-1}$ CSA (2015), respectively and these yields were certainly below the world's average yield which was about 5.6 t $ha^{-1}$ (FAOSTAT, 2017). Maize crop production in Tigray is particularly practicing in north western zone at the districts of Medebay Zana, Tahtay Koraro and Laelay Adiyabo (CSA, 2015).

However, the yield obtained by the farmers in the study areas is low mainly due to poor essential soil nutrient (ATA, 2014). Declining soil fertility, shallow soil depth, high run-off and low infiltration capacity of the soil are the major constraint for sustainable agricultural production in Tigray. Soil erosion and limited use of external nutrient inputs severely exhausted plant nutrients from the soil and declined soil fertility because of high nutrient losses, and are the major factors limiting crop production in rain-fed and irrigated farms of the different agro-ecological zones of Tigray (Virgo and Munro, 1978; Mitiku, 1996). Nutrient mining due to sub optimal fertilizer use coupled with unblended fertilizer use favored the emergence of multi nutrient deficiency in Ethiopian soils (Astatke et al., 2004; Wassie et al., 2010; Wassie and Shiferaw, 2011) and resulted in stagnant crop production.

To overcome this problem of nutrient deficiency balanced fertilizers containing N, P, S, B, Fe and Zn have been recommended for site specific nutrient deficiencies and thereby increase crop production and productivity, water and labor productivity. The major recently recommended blended fertilizers for Tigray region by MOA and ATA are NPS, NPSB, NPSZn, NPSZnB, NPSFeZn and NPSFeZnB (ATA, 2014).

Although the type of required blended fertilizers are identified for the region, optimum rates of the major recommended blended fertilizer types for different crops, agro ecologies and soil types is not yet determined for the region. Besides, it is quite essential to verify the soil fertility map for major crops grown in different agro ecologies and on different soil types to increase and to improve quality of major crops grown in Tigray region. Therefore, the main objective of the study was to evaluate the effects of NPSZNB fertilizer rates on yield, yield component of maize at Laelay Adiyabo and Medebay Zana districts.

## MATERIALS AND METHODS

### Area description

The field experiments were conducted at Laelay Adyabo and Medebay Zana districts (figure 1) , North western Zone of Tigray regional state located at 1783 and 2093 m above sea level, respectively for two consecutive main cropping seasons under rain fed conditions during 2017 and 2018. The soils of LaelayAdyabo and Medebay Zana districts were characterized with Cambisols and vertisols, respectively. Laelay Adyabo district received annual rainfall of 563.5 and 975.7 mm while Medebay Zana district received annual rainfall of 1013 and 1208 mm during growing years of 2017 and 2018, respectively (Figure 2a). The average monthly temperature of Laelay Adyabo district was 21.75°C, whereas the average monthly temperature of Medebay Zana district was 18.45 and 17.85°C, respectively during the years of 2017 and 2018. Both study areas are found in a semiarid climatic zone (Figure 2b).

### Experimental design and treatment

The experiments were laid out in randomized complete block design (RCBD) with three replications in two administrative places (kebeles) in Laelay Adyabo district with two farmers each and in Medebay Zana district it was done on one kebele in two farmers. The experiments were consisting total of seven treatments including recommended blanket NP fertilizer with an amount of 64 kg N $ha^{-1}$ and 69 kg $P_2O_5$ $ha^{-1}$. Urea was used as source of N and TSP was used as source $P_2O_5$ for the treatment of blanket recommendation. The blended fertilizer rates were consisted of six levels of NPSZnB (0, 150, 200, 250, 300 and 350 kg $ha^{-1}$) and were adjusted with N to N of the recommended NP since the N content of blended fertilizer of NPSZnB is smaller as compared to $P_2O_5$ which the N content of 100 kg NPSZnB is about 17 kg. This revealed that all treatments except control received 64 kg N $ha^{-1}$. A full dose of blended fertilizer was applied at planting time close to seed drilling line, while N fertilizer was applied half of the total at four leaf stage and the rest at knee height period for the N adjusted and the blanket recommended treatments. The plot size was 3.75 m × 4 m (15 $m^2$) and the net harvested plot size area was 9.375 $m^2$. The spacing between replications, plots, rows and plants were 1.5, 0.5, 0.75 and 0.4 m, respectively. For both study districts improved melkasa6Q variety with the recommended seed rate of 30 kg $ha^{-1}$ was used and sown using drilling method at depth of 10 cm. All recommended cultural practices (plowing, digging and weeding, pesticides) for the test crop was done as per the recommendation of the area.

### Soil sampling and analysis

A Disturbed composite soil sample of the study sites were collected from 0-20 cm depth before planting for physical and chemical soil characterization at laboratory of Shire Soil Research Center. Soil texture was determined using the Bouyoucos hydrometer method (Bouyoucos, 1962). The pH of the soil was measured in the supernatant suspension of a 1:2.5 soil to water ratio using a pH meter (Rhoades, 1982). And electrical conductivity (EC) 1:2.5 soil to water suspension was measured according to the method described by (Jackson 1967). Organic carbon (%) was determined by method as described by (Walkely and Black 1934). Available P (ppm) was analyzed by employing the Olsen method using ascorbic acid as the reducing agent (Olsen et al., 1954). Total nitrogen was measured using Kjedahl method as described by (Bremner and Mulvaney 1982). CEC in cmol (+) $kg^{-1}$ soil was determined by ammonium acetate method.

### Data collection and analysis

Data collected for the experiment were days to 50% taseling, days to 50% silking, days to 90% maturity, plant height (cm), biomass yield (kg $ha^{-1}$), stover yield (kg $ha^{-1}$), thousand seeds weight (g), grain yield (kg $ha^{-1}$) and harvest index(%). Data were collected for the experiment on yield and yield component related parameters on plot basis and converted to $ha^{-1}$.

The collected data were subjected to statistical analysis of variance (ANOVA) using SAS version of 9.0 (SAS, 2002). Significant difference between and among treatment means were assessed using the least significant difference (LSD) at 0.05 level of probability (Gomez and Gomez, 1984). To evaluate the feasibility of

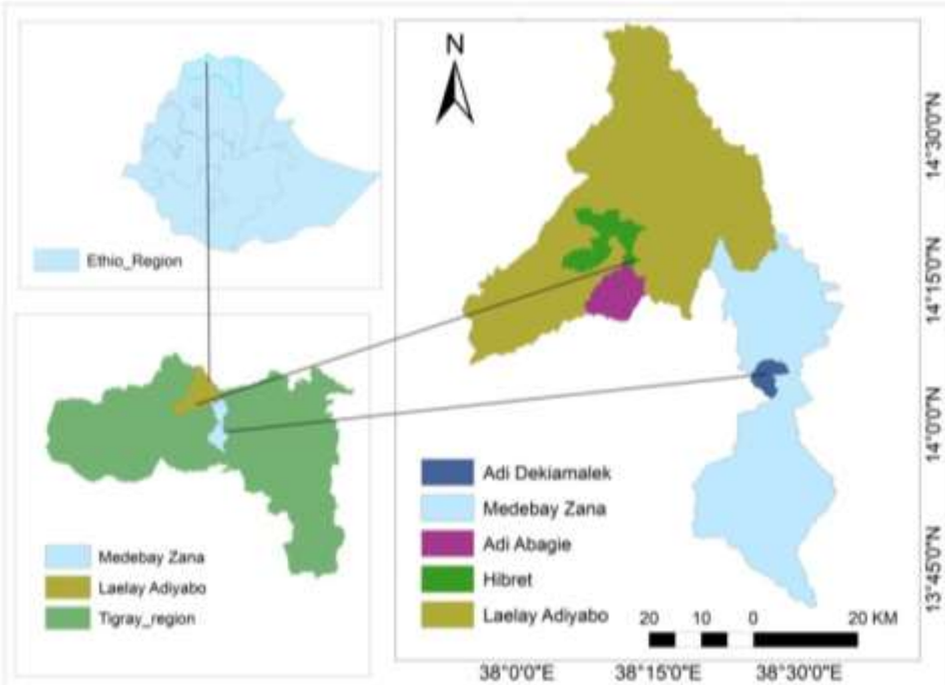


**Figure 1.** Location of the study areas.

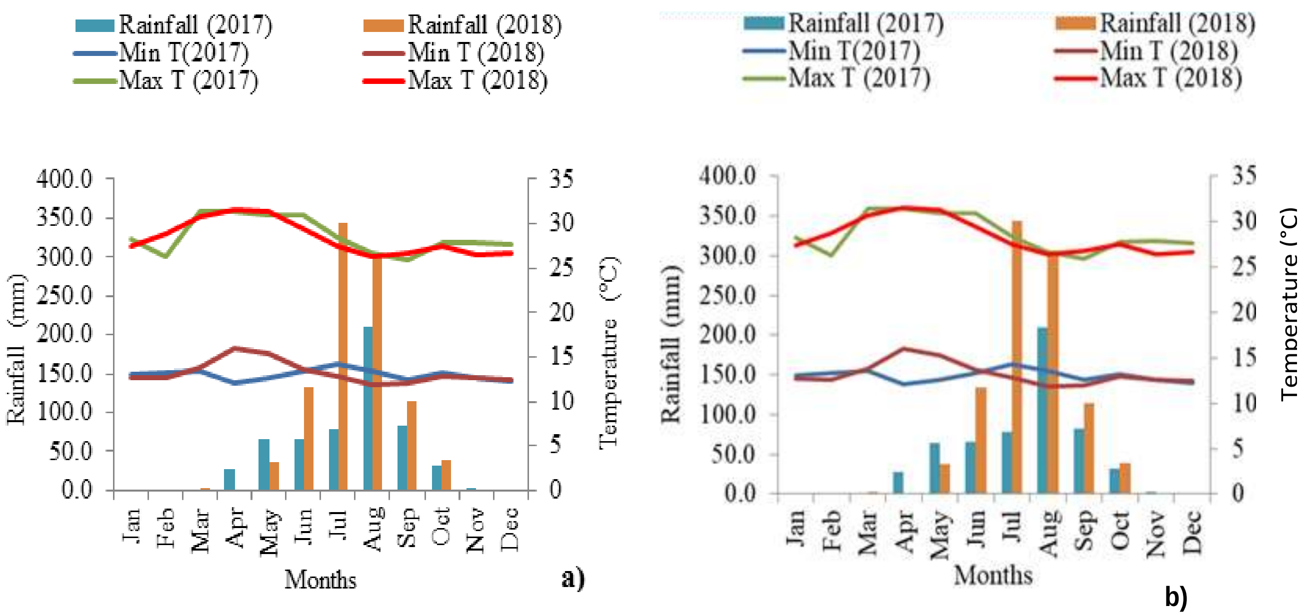


**Figure 2.** Monthly rainfall, maximum and minimum temperatures recorded in Laelay Adyabo (a) and Medebay Zana (b) districts during experimental years of 2017 and 2018 (Where; Max T= Maximum temperature and Min T= Minimum temperature).
**Source:** National Metrology Agency of Ethiopia, Tigray Mekelle branch (2019).

different treatments partial budget analysis technique of CIMMYT (1988) was applied to stover and grain yield. The partial budget analysis was performed based on the field price of the crop with prices of 0.35 and 0.014 *$* kg$^{-1}$ for grain and stover of maize, respectively. Based on the CIMMYT manuscript it is expected that experimental yields are often higher than the yields that farmers could expect using the same treatments. Hence, in economic calculations, the grain yield has been adjusted 10% lower than the actual yield obtained from the experimental plots to make the representative yield at the farmers' fields, (CIMMT, 1988). It also included all the variable costs such as application costs and prices of each fertilizer that vary for each treatment.

**Table 1.** Physico-chemical properties of soils in the experimental site before sowing.

| Laelay Adiyabo district | Soil texture (%) | | | Textural class | pH | ECe (dS $m^{-1}$) | Ava.P (ppm) | OC (%) | TN (%) | CEC [cmol(+)/kg] |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | | | | | | |
| S1Y1 | 40 | 43 | 17 | L | 5.41 | 3.23 | 21.04 | 1.81 | 0.13 | 30.20 |
| S2Y1 | 53 | 24 | 23 | SCL | 5 | 0.65 | 4.23 | 0.70 | 0.06 | 21.20 |
| S3Y1 | 18 | 33 | 49 | C | 5.23 | 0.90 | 23.24 | 1.45 | 0.14 | 63.21 |
| S4Y1 | 23 | 33 | 44 | C | 5.37 | 0.60 | 15.45 | 0.87 | 0.08 | 61.46 |
| S1Y2 | 46 | 42 | 12 | L | 6.04 | 2.57 | 17 | 1.60 | 0.15 | 45 |
| S2Y2 | 37 | 33 | 30 | CL | 5.70 | 1.46 | 20 | 1.74 | 0.16 | 57 |
| S3Y2 | 53 | 35 | 12 | SL | 5.00 | 4.27 | 12 | 0.91 | 0.09 | 20.43 |
| S4Y2 | 43 | 22 | 35 | CL | 6.05 | 1.85 | 24 | 2.01 | 0.19 | 56 |
| **Mean** | 39.3 | 33.13 | 27.75 | — | 5.48 | 1.94 | 17.12 | 1.39 | 0.13 | 44.31 |
| **Medebay Zana district** | | | | | | | | | | |
| S1Y1 | 44 | 38 | 18 | L | 6.13 | 0.52 | 8.68 | 0.51 | 0.05 | 47 |
| S2Y1 | 34 | 30 | 36 | CL | 6.83 | 0.82 | 3.86 | 0.62 | 0.06 | 46.5 |
| S1Y2 | 40 | 40 | 20 | L | 6.02 | 1.57 | 17.11 | 0.70 | 0.04 | 40 |
| S2Y2 | 29 | 22 | 49 | C | 5.43 | 0.71 | 4.66 | 1.16 | 0.06 | 31.4 |
| **Mean** | 36.5 | 32.5 | 30.75 | — | 6.1 | 0.90 | 8.58 | 0.75 | 0.05 | 41.23 |

Where, pH-power of hydrogen, ECe-paste extracts electrical conductivity, OC-organic carbon, TN-total nitrogen, Ava.P-available phosphorus, CEC-cation exchange capacity, Tex-texture, L-loam, SCL-sandy clay loam, C-clayey, CL-clay loam, SL-sandy loam, SY -denoting sampling sites of respective years in respective districts.

## RESULTS AND DISCUSSION

### Pre-Sowing soil physical and chemical properties of the experimental sites

#### *Physical properties of the soil*

**Soil particle size distribution:** The soils sampled from sites of Laelay Adiyabo and Medebay Zana districts were dominated by clay loam textural class having an approximately average proportion of sand (39.13%), silt (33.13%) and clay contents (27.75%), and sand (36.75%), silt (32.5%) and clay contents (30.75%), respectively (Table 1). McDonald et al. (1994) stated that soils ranged from 30 to 35% of clay content described as textural class of clay loam. Geeves et al. (2007*a*) recognized that water infiltration capacity of clay loam texture as moderate. Hence, soil texture of both districts was found suitable for growing of maize crop.

#### *Chemical properties of soils*

**Soil reaction (pH) and Soil electrical conductivity (ECe):** The average pH value of soils of the study sites were 5.48 and 6.1 for Laelay Adiyabo and Medebay Zana districts, respectively, with a higher pH in MedebayZana district (Table 1). According to Tekalign (1991) pH ranging from 5.3 to 5.9 rated as moderately acidic. Therefore, the average pH of sampled soil of Laelay Adiyabo sites was fall in the rating of moderately acidic. Whereas the average soil pH Medebay Zana district sites was rating as slightly acid according (Tekalign 1991). Both pH results were suitable for availability of plant nutrients thus the pH were appropriate for growing of maize crop without any addition of amendments. The surface soil of the study areas exhibited an average ECe of 1.94 and 0.9 dS $m^{-1}$ for Laelay Adiyabo and Medebay Zana districts, respectively. Average ECe of sites of Laelay Adiyabo district was found higher than the average ECe of sites of Medebay Zana district, this probably due to low rainfall and in return low leaching of cation in Laelay Adiyabo district. Soils having ECe less than 2 dS $m^{-1}$ has negligible salt effect on plant growth (Richards, 1954). Therefore, the sites were having optimum ECe for cultivating of maize crop.

**Soil organic carbon (OC) and total nitrogen contents:** Soil OC contents of the study sites were 1.39 and 0.75 %, respectively for Laelay Adiyabo and Medebay Zana districts (Table 1). Better soil OC was measured in Laelay Adiyabo district as contrasted to Medebay Zana district this may be due to farmers manuring practice of organic fertilizers in their field. However, both districts having low OC according to Tekalign (1991) rating scale of OC content of the soil between 0.5 - 1.5 is low. The average value of total N contents of the soils of the study sites of Laelay Adiyabo and Medebay Zana were 0.13 and 0.05%, respectively (Table 1). This low N content in MedebayZana district could be attributed to the low organic carbon content of the soil. Tekalign (1991) rated that soil total N content between 0.05 to 0.12% is considered as medium so that the soil of Medebay Zana district was found in a medium total N content. However, the soil of Laelay Adiyabo districts found having high total soil N content according to Tekalign (1991) ratings of soil total N.

## Available phosphorus

The average available P of soils of the study sites were measured with 17.12 and 8.58 ppm for the districts of Laelay Adiyabo and Medebay Zana, respectively (Table 1). When the two sites were compared higher available P was recorded from the district of LaelayAdiyabo. According Olsen et al. (1954) soils having available P from 5 to 10 ppm is considered medium, greater than 10 ppm regarded as high.

## Cation exchange capacity (CEC)

Table 1 presented the study sites of Laelay Adiyabo and Medebay Zana districts having approximately similar average CEC with values of 44.31 and 41.23 cmol(+)/kg, in that order. According to Metson (1961) and Landon (1991) soils having CEC greater than 40 cmol (+)/kg were considered as very high.

## Crop phenology and growth parameters

### *Crop phenology*

At both study locations tasseling, silking and maturity of maize crop was not significantly affected by fertilization of blended fertilizer doses (Table 3). It was known that blended fertilizers with different rates of N, P, S Zn and B might have encouraged early establishment, rapid growth and development of crop thus; shortening the days to tasseling silking and maturity but the current result were divergent in this respect. This may be due to effect of fertilizers on tasseling, silking and maturity of the single maize variety tested. The other probable reason could application of N fertilizer except on control treatment applied at the same rate to all treatment of levels of blended fertilizer and thus effect of N was insignificant. Dagne (2016) found that days to silking were significantly affected by the application of blended fertilizers. Meanwhile, Bakala (2018) found that 50% silking, tasseling and maturity to be significantly affected by the application of blended fertilizer rates.

## Plant height

Plant height of maize crop was significantly (P=0.014) affected by the application of blended fertilizer in Laelay Adiyabo district but this was not the case in Medebay Zana district (Table 2). Here the shortest plant height (177.62 cm) was measured in the control treatment. However, there were no significant differences amongst the plots treated with blended fertilizers at (150, 200, 250, 300 and 350 kg $ha^{-1}$) and the blanket recommendation of NP fertilizers. This increment in plant height might be due to increase in cell elongation and more vegetative growth attributed to different nutrient contents of NPSZnB blended fertilizer. On the other hand, the least plant height in unfertilized plots might have been due to the low soil fertility level in the study area. Plant growth and development may be retarded if any of nutrient elements is less than its critical value in the soil or not adequately balanced with fertilization. Plant growth and development may be retarded significantly if any of the nutrient elements is less than its threshold value in the soil or not adequately balanced with other nutrient elements (Landon, 1991). Tamene et al. (2018) found that effect of N rates under blended fertilizer of PKSZnB with highly significantly effect on plant height as compared to negative control and standard control (92 N, 69 $P_2O_5$) kg $ha^{-1}$ when N levels increased from 0, 46, 92, 138, 176 and 222 kg $ha^{-1}$. This result is also in agreement with that of Dagne (2016), and Tekle and Wassie (2018) who found that application of blended fertilizers and blanket NP recommendation which significantly increased plant height as compared to the control. Likewise, Bakala (2018) found that blended fertilizers had significantly influenced plant height.

## Yield and yield components

### *Biomass yield*

Biomass yields were significantly higher in all plots treated with blended fertilizers compared to untreated checks in all study sites (Table 3). In Laelay Adiyabo district the highest biomass yield (14146.7 kg $ha^{-1}$) was recorded in plots that received blended fertilizers at the rate of 300 kg $ha^{-1}$. However, in Laelay Adiyabo district amongst the five treatments of NPSZnB blended fertilizers of 150, 200, 250, 300 and 350 kg $ha^{-1}$there were no significant differences in biomass yield. On the other hand, these rates had higher yields compared to the control plots. In Medebay Zana district the highest biomass yield (14554.80 kg $ha^{-1}$) was recorded from fertilization of blended fertilizer at the rate of 250 kg $ha^{-1}$. Nevertheless, the other four levels of blended fertilizer rates of 200, 250, 300 and 350 kg $ha^{-1}$ and the recommended NP fertilizers was not significant except for the 150 kg NPSZnB $ha^{-1}$ and control treatments, respectively. The lowest yield (9692.90 kg) was recorded from the untreated checks. When the biomass yield of both districts compared higher biomass yield was measured at Medebay Zana district this was may be

**Table 2.** Days to 50% tasseling, days to 50% silking, days to 50% maturity and plant height of maize crop under the effect of different NPSZnB fertilizer rates.

| Treatments ($kg\ ha^{-1}$) | Two years combined result | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | DT (days) | DS (days) | DM (days) | PH (cm) | DT (days) | DS (days) | DM (days) | PH (cm) |
| | Laelay Adiyabo district | | | | Medebay Zana district | | | |
| 0 | 77.46 | 82.75 | 127.88 | 177.62$^{B}$ | 78.50 | 83.75 | 131.50 | 212.18 |
| 150NPSZnB | 75.67 | 79.71 | 127.33 | 207.18$^{A}$ | 75.75 | 82.17 | 130.42 | 221.12 |
| 200NPSZnB | 75.29 | 79.96 | 127.38 | 209.83$^{A}$ | 75.83 | 82.42 | 130.83 | 220.13 |
| 250NPSZnB | 75.83 | 79.92 | 127.42 | 215.10$^{A}$ | 75.25 | 81.25 | 130.17 | 225 |
| 300NPSZnB | 75.38 | 79.25 | 127.38 | 219.74$^{A}$ | 76.17 | 81.17 | 130.42 | 229.93 |
| 350NPSZnB | 75.79 | 80.25 | 127.83 | 215.32$^{A}$ | 75.42 | 81.25 | 130.50 | 222.68 |
| 64 N, 69 $P_2O_5$ | 75.92 | 80.54 | 127.58 | 200.29$^{AB}$ | 76.67 | 82.75 | 131 | 217.37 |
| **Mean** | 75.90 | 80.34 | 127.54 | 206.44 | 76.23 | 82.11 | 130.70 | 221.20 |
| **LSD** ($P \leq 0.05$) | NS | NS | NS | 23.82 | NS | NS | NS | NS |
| **CV** (%) | 11.64 | 13.90 | 7.49 | 20.24 | 6.47 | 5.73 | 6.57 | 14.22 |

Where, means followed by the same letters are not significantly different ($P \leq 0.05$). DT-Days to 50% tasseling, DS- days to 50%silking, DM-Days to 50% maturity, PH- plant height, NS-non-significance, CV-coefficient of variance.

**Table 3.** Biomass yield, straw yield and thousand seeds weight of maize crop under the effect of different NPSZnB fertilizer rates.

| Treatments ($kg\ ha^{-1}$) | Two years combined result | | | | | |
|---|---|---|---|---|---|---|
| | BY ($kg\ ha^{-1}$) | SY ($kg\ ha^{-1}$) | TSW (g) | BY ($kg\ ha^{-1}$) | SY ($kg\ ha^{-1}$) | TSW (g) |
| | Laelay Adiyabo district | | | Medebay Zana district | | |
| 0 | 8434.20$^{C}$ | 6339.60$^{C}$ | 210.48$^{B}$ | 9692.90$^{C}$ | 8171.50$^{C}$ | 205.18$^{B}$ |
| 150NPSZnB | 14146.70$^{A}$ | 11118.20$^{A}$ | 225.70$^{AB}$ | 12526.20$^{B}$ | 9759.20$^{BC}$ | 226.67$^{AB}$ |
| 200NPSZnB | 12945.10$^{A}$ | 9948.10$^{A}$ | 233.37$^{AB}$ | 13783.20$^{AB}$ | 11214.80$^{AB}$ | 220.67$^{AB}$ |
| 250NPSZnB | 12664.40$^{AB}$ | 9678$^{AB}$ | 229.61$^{AB}$ | 14554.80$^{A}$ | 11762.50$^{A}$ | 223.70$^{AB}$ |
| 300NPSZnB | 12917.30$^{A}$ | 9863.30$^{AB}$ | 241.81$^{A}$ | 14280.10$^{A}$ | 11307.10$^{AB}$ | 233.50$^{A}$ |
| 350NPSZnB | 12835.20$^{AB}$ | 10016.50$^{A}$ | 239.25$^{A}$ | 13659.70$^{AB}$ | 11223.30$^{AB}$ | 219.48$^{AB}$ |
| 64 N, 69 $P_2O_5$ | 11166.10$^{B}$ | 8426.10$^{B}$ | 223.46$^{AB}$ | 13059.40$^{AB}$ | 10352.60$^{AB}$ | 220.67$^{AB}$ |
| **Mean** | 12158.42 | 9341.42 | 229.10 | 13079.48 | 10541.58 | 221.41 |
| **LSD** ($P \leq 0.05$) | 1681.10 | 1510.80 | 24.57 | 1747.50 | 1642.80 | 28.23 |
| **CV** (%) | 24.25 | 28.37 | 18.81 | 16.43 | 19.17 | 15.68 |

Where, means followed by the same letters are not significantly different ($P \leq 0.05$), BY- biomass yield, SY- stover yield, TSW-thousand seeds weight, NS-non-significance, CV-coefficient of variance.

because of continuous vegetative growth of maize crop until the rainfall withdrew. However, in Laelay Adiyabo district low amount of rainfall was rained during the growing seasons as a result the vegetative growing of maize crop was proportionally gone with the received low amount of rainfall. Even though, lowest biomass yields were recorded from the unfertilized plots in both study districts there was no consistent increase in yield amongst the different blended fertilizer levels. This could be due to N effect since N levels were adjusted to the same amounts of 64 kg N $ha^{-1}$ in all except the control treatments. It is a known fact that plants require huge amounts of N nutrients compared to all other essential nutrients. Therefore, the low yields in unfertilized plots might have been due to reduced leaf area development resulting in smaller radiation interception which further translates to low efficiency in the conversion of solar radiation to maintain efficient photosynthesis. The current results are in agreement with that of Tamene et al. (2018) who obtained significantly highest biomass yield of maize crop at the rate of 46 kg N $ha^{-1}$ under blended fertilizer of PKSZnB as compared to negative control, standard control (92 N, 69 $P_2O_5$) kg $ha^{-1}$ and 222 kg N $ha^{-1}$ at N treatments under blended arranged from 0, 46, 92, 138, 176 and 222 kg N $ha^{-1}$.

### *Stover yield*

Stover yield was significantly (P<0.0001) and (P=0.0005) affected by the application of blended fertilizers in Laelay Adiyabo and Medebay Zana districts, respectively (Table 3). In Laelay Adiyabo district the higher yield (11118.2 kg $ha^{-1}$) was obtained from fertilization of maize plots with 150 kg NPSZnB $ha^{-1}$, there was however, no significant difference amongst the different rates of 200, 250, 300 and 350 kg NPSZnB $ha^{-1}$. The lowest yields (6339.6 kg $ha^{-1}$) were recorded from the negative and positive controls (standard checks). Meanwhile, in Medebay Zana the highest yields (11762.5 kg $ha^{-1}$) were recorded from plots that had 250 kg $ha^{-1}$ blended fertilizers. In this district there were no significant differences in stover yields among the other levels of blended fertilizer rates of 200, 250, 300 and 350 kg $ha^{-1}$ and the recommended NP fertilizers. The lowest yields (8171.5 kg $ha^{-1}$) were recorded in the control treatment. Comparably the two districts higher stover yield was recorded in Medebay Zana districts this perhaps due to improved vegetative growth coupled to the required higher amount of rainfall. Nevertheless, there was no consistent increase of stover yields in both districts from blended fertilizer applications and levels. This could be due to N effect since N in except control treatment in all treatments adjusted to the same amount of 64 kg N $ha^{-1}$. It is known that plants require huge amounts of N nutrient compared to all other essential nutrients. Therefore, low yield in unfertilized plots might have been due to reduced leaf area development resulting in reduced radiation interception and, consequently, low efficiency in the conversion of solar radiation. Related tendency observed with Bakala (2018) in maize crop who declared stover yield was significantly affected by blended fertilizer. These results were also in agreement with the findings of Tekle and Wassie (2018) who found that straw of tef (*Eragrotis tef*) was found to be highest in blended fertilizers compared to control treatments and recommended rate blanket NP applications.

### *Thousand seeds weight*

In the study of Laelay Adiyabo and Medebay Zana districts thousand seeds weight of maize crop were found to be significantly affected by blended fertilizer rates compared to the negative control (Table 3). The five NPSZnB blended fertilizer rates of 150, 200, 250, 300 and 350 kg $ha^{-1}$ did not show any significant variations amongst each other in thousand seeds weight of maize. The standard check was also in par with the positive rates of the blended fertilizer rates. This result is in harmony with Dagne (2016) and Tekle and Wassie (2018) who found that application of blended fertilizers significantly increased thousand seeds weight as compared to the control.

### *Grain yield*

The result of experiment indicated that grain yield of maize crop was highly significantly (<0.0001) affected by blended fertilizer rates in both districts (Table 4). In the district of Laelay Adiyabo plots treated with zero fertilizer had significantly lower yield (2058.4 kg $ha^{-1}$) as compared with the five rates of NPSZnB blended fertilizer of 150, 200, 250, 300, 350 kg $ha^{-1}$ and standard check. But, there was no significant variation amongst the four rates of 150, 200, 250 and 300 kg $ha^{-1}$NPSZnB blended fertilizer. Accordingly, the highest grain yield (3200 kg $ha^{-1}$) was obtained from application of 300 kg NPSZnB $ha^{-1}$. In Medebay Zana district significance highest yield (2973 kg $ha^{-1}$) was acquired from application of 300 kg NPSZnB $ha^{-1}$ as weighed against to NPSZnB fertilizer levels (200 and 350 kg $ha^{-1}$), recommended NP fertilizes and the control treatment. In both study districts the highest yield was obtained from the same treatment of blended fertilizer with an amount of 300 kg NPSZnB$ha^{-1}$. But, in both districts there was no increase of grain yield consistently amongst the blended fertilizer levels. This is probably due to N effect which was equally adjusted to 64 kg N $ha^{-1}$ in all treatments and was not sufficient enough since plants usually require huge amounts of N nutrients compared to all other essential nutrients. When both districts of Laelay Adiyabo and Medebay Zana compared each other the somewhat higher yield was exhibited in the district of Laelay Adiyabo this was may be due to improved soil result of available P and total N in this district. These results are in line with the findings of Benti (1993) who stated that, although adoption of new varieties especially maize hybrids is moving fast in Ethiopia, fertilizer management techniques need to supplement the existing potential of these varieties. This also tentatively showed that low soil fertility is amongst the greatest constraints to maize production in Ethiopia (Kelsa et al., 1992). The increase in grain yield could be attributed to beneficial effect of yield contributing characters and positive interaction of nutrients in the blended fertilizer. It was known that plants required huge amount of N nutrient as compared to all essential nutrients. The increase in grain yield could be attributed to beneficial effect of yield contributing characters and positive interaction of nutrients in the blended fertilizer. The association of grain yield with thousand seeds weight observed in this study agrees with the findings of Khatun et al. (1999) who concluded that increasing thousand seeds weight yield attributes is the most important component directly related to grain yield in maize. Similar trend observed with Bakala (2018) in maize crop who claimed that 200 Kg NPSZnB + 150.2 N gave best results

**Table 4.** Grain yield and harvest index of maize crop under the effect of different NPSZnB fertilizer rates.

| Treatments (kg ha$^{-1}$) | Two years combined result | | | |
|---|---|---|---|---|
| | GY (kg ha$^{-1}$) | HI (%) | GY (kg ha$^{-1}$) | HI (%) |
| | Laelay Adiyabo district | | Medebay Zana district | |
| 0 | 2058.40$^{D}$ | 24.52$^{ABC}$ | 1521.40$^{D}$ | 15.94$^{E}$ |
| 150 NPSZnB | 3021.40$^{AB}$ | 22.08$^{C}$ | 2767$^{AB}$ | 22.34$^{A}$ |
| 200NPSZnB | 3034.50$^{AB}$ | 24.26$^{ABC}$ | 2568.40$^{BC}$ | 18.81$^{CD}$ |
| 250NPSZnB | 2945.4$^{AB}$ | 24.25$^{ABC}$ | 2792.30$^{AB}$ | 19.56$^{BDC}$ |
| 300NPSZnB | 3200$^{A}$ | 26.52$^{A}$ | 2973$^{A}$ | 21.25$^{AB}$ |
| 350NPSZnB | 2922.30$^{B}$ | 23.45$^{BC}$ | 2436.40$^{C}$ | 18.20$^{DE}$ |
| 64 N, 69 $P_2O_5$ | 2751.20$^{C}$ | 25.81$^{AB}$ | 2706.90$^{B}$ | 21.04$^{ABC}$ |
| **Mean** | 2847.60 | 24.41 | 2537.91 | 19.59 |
| **LSD** (P≤0.05) | 255.65 | 3.10 | 249.4 | 2.44 |
| **CV** (%) | 15.75 | 21.98 | 12.09 | 15.33 |

Where, means followed by the same letters are not significantly different (P≤0.05), GY- grain yield, HI-harvest index, NS-non-significance, CV-coefficient of variance.

in comparison to 100 Kg TSP and 200 Kg Urea, 125 Kg TSP and 250 Kg Urea, 150 Kg TSP and 300 Kg Urea, and 100 Kg NPSB Kg +73.9 N. Similarly, Tamene et al. (2018) found that effect of N rate at the of 46 kg N ha$^{-1}$ under blended fertilizer of PKSZnB significantly highest grain yield maize crop as compared to negative control, standard control (92 N, 69 $P_2O_5$) kg ha$^{-1}$ and 222 kg N ha$^{-1}$ at N treatments arranged from 0, 46, 92, 138, 176 and 222 kg ha$^{-1}$. Dagne (2016) verified that application of blended fertilizer on maize crop as brought significantly highest grain yield as compared to negative control, standard control of NP and recommended NP + Cu +Zn. In agreement with the current findings Tekle and Wassie (2018) found that grain yield of tef was found highest in blended fertilizers as compared to control treatment and recommended NP fertilizers. Additionally, Jafer (2018) found better grain yield from application of blended fertilizer compare to recommended NP fertilizer and unfertilized plot.

## Harvest index

At both study locations the application of blended fertilizers had significant effects on harvest index of maize crop. In the Laelay Adiyabo district the highest harvest (26.52%) index was realized from the application of 300 kg NPSZnB ha$^{-1}$ as compared to blended fertilizer rates 150 and 350 kg NPSZnB ha$^{-1}$ but, this was significantly similar with control treatment, standard check and NPSZnB fertilizer rates of 200 and 250 kg ha$^{-1}$. This result agrees with the findings of Tekle and Wassie (2018) who reported that harvest index of tef was found to be highest in blended fertilizer treatments. Meanwhile, in the Medebay Zana district harvest index was found to be significantly higher in plots that received blended fertilizers at rate of 150 kg NPSZnB ha$^{-1}$ as contrasted to the control treatment and blended fertilizer levels of 200, 250 and 350 kg NPSZnB ha$^{-1}$ but, it was significantly in par with 300 kg NPSZnB ha$^{-1}$ and recommended NP fertilizers.

## Partial budget analysis

As it were presented in Tables 5 and 6, the net farm benefit was calculated taking possible field variable costs and all benefits (stover and grain yields) for Laelay Adiyabo and Medebay Zana districts. The maximum farm net benefits were 1076.04 and 1073.76 $ ha$^{-1}$with the application of 150 and 300 kg NPSZnB ha$^{-1}$ for Laelay Adiyabo and Medebay Zana districts, respectively. In both district the partial budget analysis revealed that application of 150 kg NPSZnB ha$^{-1}$ was resulted in highest MRR% with values of 242 and 255 for Laelay Adiyabo and Medebay Zana districts, respectively. These values imply that with one $ cost it was attained 2.42 and 2.55 $ profit. Therefore, in both districts 150 kg NPSZnB ha$^{-1}$ can be used for the production of maize.

## CONCLUSIONS AND RECOMMENDATION

According to the combined mean analysis fertilizer rates and types at both districts revealed significance difference on above ground biomass, stover and grain yield. In Laelay Adiyabo district significantly maximum maize stover 11.12 t ha$^{-1}$was recorded with fertilization of 150 kg NPSZnB ha$^{-1}$, whereas in Medebay Zana district the maximum stover yield was found from application of 250 kg ha$^{-1}$ with the stover yield of 14.55 t ha$^{-1}$, but in both districts the minimum stover yield was obtained from the control treatment. In both districts of Laelay Adiyabo and Medebay Zana maximum (3.2 and 2.97 t ha$^{-1}$) and

**Table 5.** Partial budget analysis of stover and grain yield of maize under the effect of different NPSZnB fertilizer rates for Laelay Adiyabo district.

| Treatments (kg $ha^{-1}$) | TVC | SY | ADSY | GY | ADGY | TSGR ($ $ha^{-1}$) | TGGR ($ $ha^{-1}$) | TSGGR ($ $ha^{-1}$) | NB ($ $ha^{-1}$) | MRR (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 6339.6 | 5705.64 | 2058.4 | 1852.56 | 79.4936 | 716.963 | 796.456 | 796.456 | |
| 150 NPSZnB | 115.757 | 11118.2 | 10006.4 | 3021.4 | 2719.26 | 139.413 | 1052.39 | 1191.8 | 1076.04 | 242 |
| 200 NPSZnB | 134.118 | 9948.1 | 8953.29 | 3034.5 | 2731.05 | 124.741 | 1056.95 | 1181.69 | 1047.57 | D |
| 250 NPSZnB | 152.479 | 9678 | 8710.2 | 2963 | 2666.7 | 121.354 | 1032.04 | 1153.4 | 1000.92 | D |
| 64 N, 69 $P_2O_5$ | 157.604 | 8426.1 | 7583.49 | 2751.2 | 2476.08 | 105.657 | 958.272 | 1063.93 | 906.325 | D |
| 300 NPSZnB | 170.84 | 9863.3 | 8876.97 | 3200 | 2880 | 123.678 | 1114.59 | 1238.27 | 1067.43 | D |
| 350 NPSZnB | 189.202 | 10016.5 | 9014.85 | 2922.3 | 2630.07 | 125.599 | 1017.87 | 1143.47 | 954.265 | D |

Where, TVC=total variable cost, SY=stover yield, ADSY= adjusted stover yield, GY=grain yield, ADGY= adjusted grain yield, TSGR=total stover yield gross return, TGGR, =total grain yield gross return, TSGGR=total stover and grain yield gross return, NB=net benefit, MRR=marginal rate of return, D=dominated.
**N.B.** TSP=0.65 $/1kg, urea=0.44 $/1kg, NPSZnB=0.53 $/1kg, maize grain=0.35 $/1kg, maize stover=0.01 $/1kg, one $=28.71 Ethiopian birr.

**Table 6.** Partial budget analysis of stover and grain yield of maize under the effect of different NPSZnB fertilizer rates for Medebay Zana district.

| Treatments (kg $ha^{-1}$) | TVC | SY | ADSY | GY | ADGY | TSGR ($ $ha^{-1}$) | TGGR ($ $ha^{-1}$) | TSGGR ($ $ha^{-1}$) | NB ($ $ha^{-1}$) | MRR (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 8171.5 | 7354.35 | 1521.4 | 1369.26 | 102.46 | 476.93 | 579.39 | 579.39 | - |
| 150 NPSZnB | 115.76 | 9759.2 | 8783.28 | 2767 | 2490.30 | 122.37 | 867.4 | 989.77 | 874.01 | 255 |
| 200 NPSZnB | 134.12 | 11214.8 | 10093.32 | 2568.4 | 2311.56 | 140.62 | 805.14 | 945.77 | 811.65 | D |
| 250 NPSZnB | 152.48 | 11762.5 | 10586.25 | 2792.3 | 2513.07 | 147.49 | 875.33 | 1022.82 | 870.34 | D |
| 64 N, 69 $P_2O_5$ | 157.60 | 10352.6 | 9317.34 | 2706.9 | 2436.21 | 129.81 | 848.56 | 978.37 | 820.77 | D |
| 300 NPSZnB | 170.84 | 11307.1 | 10176.39 | 2973 | 2675.7 | 141.78 | 931.97 | 1073.76 | 902.92 | 52 |
| 350 NPSZnB | 189.20 | 11223.3 | 10100.97 | 2436.4 | 2192.76 | 140.73 | 763.76 | 904.49 | 715.29 | D |

Where, TVC=total variable cost, SY=stover yield, ADSY= adjusted stover yield, GY=grain yield, ADGY= adjusted grain yield, TSGR=total stover yield gross return, TGGR, =total grain yield gross return, TSGGR=total stover and grain yield gross return, NB=net benefit, MRR=marginal rate of return, D=dominated.
**N.B.** TSP=0.65 $/1kg, urea=0.44 $/1kg, NPSZnB=0.53 $/1kg, maize grain=0.35 $/1kg, maize stover=0.01 $/1kg, one $=28.71 Ethiopian birr.

minimum (2.1 and 1.5 t $ha^{-1}$) grain yield was recorded with application of 300 kg NPSZnB $ha^{-1}$and control treatment, respectively. According to the partial budget analysis the highest marginal rate of return was attained from application of 150 kg NPSZnB $ha^{-1}$ as the best rates recommended for maize production at areas of Laelay Adiyabo and Medebay Zana districts. Therefore, NPSZnB fertilizer at a rate of 150 kg $ha^{-1}$ for improved maize production and can be used as a point of reference for additional study of NPSZnB fertilizer effect on maize (melkasa6Q) production.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

## ACKNOWLEDGEMENT

The authors are grateful for (Tigray Agricultural Research Institute- Agricultural Growth Program II (TARI-AGP II project) for giving financial support and their warmth assistance during the implementation of this work on the ground to produce this piece of output.

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