Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.13, No.18, 2022

# Evaluation of Different Blended Fertilizer Types and Rates for Better Production of Sorghum (Sorghum bicolor L.) at Yeki District, South Western Ethiopia

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**Abstract**
A field experiment was conducted to assess the effect of different blended fertilizer types and rates on the growth and yield of sorghum in Yeki woreda, Sheka zone, southwestern Ethiopia. Seven treatments: No fertilizer(control); three rates of NPS (69 N, 54 P205, 10 S; 92 N, 72 P2O5, 13 S; 115 N, 90 P2O5, 17 S kg ha-1) and three rates of NPSB (69 N, 54 P205, 10 S 1.07 B; 92 N, 72 P2O5, 13 S 1.4 B; 115 N, 90 P2O5, 17 S 1.7 B kg ha-1) were compared in randomized complete block design with three replications. The results revealed significant ($p \leq 0.05$) improvement in biomass and grain yield and yield components of sorghum except for panicle length due to the application of different types and rates. Both fertilizer types and the three rates of each fertilizer gave statistically similar grain yields. When rates of each blended fertilizer were compared the lowest rates gave the highest grain yield but all rates of NPS gave greater yield than their respective rates of NPSB. The highest (5592.6 kg ha-1) grain yield was obtained from the lowest NPS rate (69 N, 54 P205, 10 S) applied plots. Application of the lowest NPS rate increased grain yield of sorghum by 71.6% and 11.2% over control and NPSB ( at 69 N, 54 P205, 10 S 1.07 B rate ), suggesting that excluding B from NPSB blend will not affect the sorghum production. Partial budget analysis results also revealed that higher net benefit from application of lower rate of NPS. In conclusion, to improve sorghum production and to get better net benefit at the study and similar agro ecology, application of NPS at 69 N, 54 P205, 10 S (150 kg NPS + 90 kg urea top dressed) is recommended.
**Keywords**: NPSB, NPS, Net benefit, Sorghum, Yield
**DOI:** 10.7176/JNSR/13-18-01
**Publication date:**October 31st 2022

## 1 INTRODUCTION

Soil fertility decline is a key problem for sorghum production in sorghum growing areas of Ethiopia (Getachew and Wondimu, 2008). Nutrient mining due to sub-optimal fertilizer use coupled with agronomic unbalanced fertilizer uses has favored the emergence of multi-nutrient deficiency in Ethiopian soils (Wassie *et al.,* 2011; Asgelil *et al.,* 2007; Abyie *et al.,* 2003) which in part explain fertilizer factor productivity decline and stagnant crop productivity conditions encountered despite continued use of the blanket recommendation.

Sorghum (*Sorghum bicolor L.*) is considered as low input crop but reports indicated that recent sorghum varieties respond well for N and other nutrients elements. There had been relatively little recent experimental research on sorghum requirements for nutrients. Application of both FYM and mineral fertilizer application positively influences Stover yield and panicle weight in northern Ethiopia (Getachew and Wondimu, 2008). However, Tolera Abera (2012) reported that NP fertilizer rate did not significantly influence the mean grain yield of sorghum in western Ethiopia. The lack of significance in western Ethiopia might be due to unbalanced application of fertilizers. Balanced fertilizers containing N, P, K, S, B, and Zn in blend form have been recommended to ameliorate site-specific nutrient deficiencies and thereby increase land, water, and labor productivity. The work of Wassie and Shiferaw (2011) in southern Ethiopia provides a striking example of how fertilizer use efficiency of potato can be raised when NP fertilizers are combined with K on a location-specific basis. The recent national soil inventory data also revealed that S, B, and Zn deficiencies are widespread in Ethiopian soils, while some soils are also deficient in K, Cu, Mn, and Fe (ATA, 2016), which all potentially hold back crop productivity. However, fertilizer trials involving multi-nutrient blends that include micronutrients are rare. Very recently, soil test based fertilizer recommendation and calibration efforts have been made by EIAR and RARIs but only limited to a certain location and crop types.

According to EthioSIS fertilizer type recommendation map, eight types of fertilizer blends are identified for SNNPRS by woreda and kebele. Similarly, four types of fertilizers for the woreda and two types of fertilizer blends were identified for Shosha kebele. In addition, potassium was found to be deficient in the soils of the study area. But this needs validation for the fertilizer types and determination of rates for the identified fertilizer types for specific crops. Therefore, this study was initiated with the objectives (1) to evaluate the relative influences of NPS and NPSB on sorghum production and (2) to determine the optimum rate of the selected fertilizer type for sorghum production at shosha kebele, Yeki district.

 

## 2 MATERIALS AND METHODS

### 2.1. Description of the Experimental Area

Field experiment was carried out for two consecutive years (2017& 2018) on two Farmers at Shosha kebele, in Yeki woreda, Sheka Zone, Southwest Ethiopia. The altitude of the study area ranges from 1203 to 1800 m.a.s.l. with latitude of $7^0$ 12 725' N and longitude $35^0$ 28 376' E. The area receives average annual rainfall of 1898mm and minimum and maximum temperature of $12^0{}_C$ and $26^0{}_C$, respectively. It is known by undulating farmland with average slope of 5%. The study area has predominantly Nitosols, with a textural class of clay loam (FAO, 1998). Major crops grown in the study area include Sorghum, maize, wheat, inset coffee, tomatoes, potato, banana, ginger, avocado, mango, papaya, sugarcane, turmeric, and cabbage. From those Sorghum is extensively grown cereal in the study area. Ginger and coffee are used as cash crops; Sorghum wheat, maize, inset, and others are used for financials as well as household consumption purposes (Getachew et al., 2018).

### 2.2. Experimental Details and Treatment Set-Ups

The treatments were laid down in randomized complete block design (RCBD) and replicated three times. Seven treatments: (T1) control (No fertilizer), three rate of NPS: (69N, 54 $P_2O_5$, 10S (T2) 92N, 72 P2O5, 13S (T3), 115N, 90 P2O5, 17S (T4)) and Three rate of NPSB :( 69N, 54 P2O5, 10S, 1.07B (T5), 92N, 72 P2O5, 13S, 1.4B (T6), 115N, 90 P2O5, 17S, 1.7B (T7)) were tested. NPS compound and NPSB blends were used as sources of N, P, S, and B. NPS, NPSB, and KCl fertilizers were applied at planting whereas additional urea fertilizer (based on the rate) is top dressed after 45 days of planting the test crop (Table 1). 100 kg KCl was used as K source and applied for all treatments except absolute control. The plot size was 3x3 m (9 $m^2$) and the spacing between rows and within rows were 75 and 20 cm respectively. The improved sorghum variety ''Melkam'' was received from Melkasa Agricultural research center in 2009 (MoANR, 2016) and used as test crop. All field managements practice were carried out as per the recommendation of the area.

**Table 1. Treatment used in the study area**

| Treatment | Fertilizer type and rate | | | | |
|---|---|---|---|---|---|
| | Applied blended form fertilizer and Urea | Fertilizer in nutrient form | | | |
| | NPS,NPSB and Urea /ha | N | $P_2O_5$ | S | B |
| T1 | Control | 0 | 0 | 0 | 0 |
| T2 | 142 Kg NPS+91 Kg urea top dressed | 69 | 54 | 10 | - |
| T3 | 189 Kg NPS +122 Kg urea top dressed | 92 | 72 | 13 | - |
| T4 | 137 Kg NPS +124 Kg urea top dressed | 115 | 90 | 17 | - |
| T5 | 142 Kg NPSB+91 Kg urea top dressed | 69 | 54 | 10 | 1.07 |
| T6 | 189 Kg NPSB +122 Kg urea top dressed | 92 | 72 | 13 | 1.4 |
| T7 | 137 Kg NPSB+124 Kg urea top dressed | 115 | 90 | 17 | 1.7 |

N. ***B:** Blended NPSB fertilizer contain full nutrient PSB and nearly half N (fertilizer in nutrient form) in each treatment case. Nearly half N top-dressed from urea at knee stage.*

### 2.3. Soil Sampling and Analysis

Composite surface (0-20 cm depth) soil samples were collected from each experimental field before planting (one composite sample from 20 sampling points). After manual homogenization soil samples were composited, air dried, and ground to pass 2 mm sieve and 0.5 mm sieve (for total N) for analyses of the soil Physico-chemical properties (Table 2).

### 2.4. Agronomic Data Collection

The yield and yield components of agronomic data including plant height (cm), spike length (cm), thousand seed weight (gm), biomass (ton), and grain yield (Kg $ha^{-1}$) were collected and subjected to analysis of variance (ANOVA).

### 2.5. Economic Analyses

Partial budget analysis was carried out to determine the net benefit and marginal rate of return obtained from the application of specific fertilizer types and rates. Sorghum grain yield was valued at an average open market value of the local market price of Birr 600 per 100 kg whereas the average price of urea, NPS, and NPSB was Birr 10, 11.12, and 12.00 per kg, respectively. The cost of other production practices like seed and weeding was assumed to remain the same among the treatments. The grain yield was down adjusted by 10% to reflect the situation in actual production by farmers (CIMMYT, 1988).

### 2.6. Data analysis

The data obtained from the field were subjected to combined analysis of variance (ANOVA) over years after confirmation of homogeneity of error variance using SAS, version 9.3, using the general linear model (GLM) procedure (SAS Institute, 2011). A significant difference between and among treatment means was assessed using the least significant difference (LSD) test at 0.05 level of probability.

## 3 RESULTS AND DISCUSSION

### 3.1. Physico-chemical Properties of Experimental Soil before Planting

According to the laboratory analysis, the soil textural class of the experimental area is clay loam (Table 2). The soil texture influences water contents, water intake rates, aeration, root penetration, and soil fertility. Soil pH results were found to be slightly acidic according to EthioSIS (2014) with a pH value of 5.6. The pH of the soil (5.00-7.55) was found within the suitable range for crop production (Sahlemdhin, 1999). The organic carbon content of the soil was 2.16% which could be rated as low according to London (1991). The low estimated OC might be due to the complete removal of crop residues and no addition of external organic material inputs such as compost or manure. In conformity with this, complete removal of aboveground biomass, continuous tillage, insufficient application of organic inputs, and heavy grazing was reported as the major reasons for extremely low soil OC in Ethiopian soils (Iticha and Takele, 2019). On the other hand, the total N (0.15%) and available P (19.8 mg kg-1) contents of the soil were low in accordance with ratings by EthioSIS (2014).

The lower TN may be ascribed to complete removal of crop residues, less organic input application, and more intensive cultivation. Similarly, Gebrelibanos and Assen (2013), reported lower soil TN due to intensive cultivation, less input application, and higher mineralization rate in Ethiopian soils. The considerably low available P implies that P could be a limiting nutrient for crop production in the study area, and hence external application of P is required for optimum plant growth. The decline of P in most cultivated soils of Ethiopia resulted from the impacts of low P fertilizer application rate, massive nutrient depletion through complete crop harvest, low return of crop residues, and soil erosion (Iticha and Takele, 2019). The CEC of study soil was also rated as medium in accordance with London (1991).

**Table 2. Selected physico-chemical properties of the Study area soil before planting**

| | Physico-chemical Properties | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Material** | pH-$H_2O$ (1:2.5) | OC (%) | TN (%) | Ava. P (mg $kg^{-1}$) | CEC (cmol(+)kg-$^1$) | Clay (%) | Silt (%) | Sand (%) | Textural Class |
| **Surface soil (0-20cm)** | 5.8 | 2.16 | 0.15 | 19.8 | 24.6 | 35.00 | 39.17 | 25.83 | Clay loam |

### 3.2. Yield and Yield Components of Sorghum as influenced by Types and Rate of Blended Fertilizers

Data analysis indicated that treatment effects did not show by year, so data are averaged across years. Results of two years' mean biomass and grain yield data showed that there were significant differences ($p \leq 0.05$) between treatments (Table 3). Sorghum grain and biomass yields were significantly influenced by fertilizer types and applied rates when compared with that of the control. However, there were no significant differences between applied fertilizer types and their different rates. Though statistically no significant differences between the two fertilizer types and among all rates, the application of NPS better influenced the sorghum production in the study area, suggesting the importance of only NPS blend to the area. The highest grain yield (5592.59 kg $ha^{-1}$) was recorded from the application of NPS at the rate of 69 N, 54 P2O5,10 S (142 Kg NPS+91 Kg urea top dressed) when compared with control and other higher rates of NPS and all rates of NPSB fertilizer. This is because soil micronutrient deficiency in Yeki district is compensated by balanced fertilizer. The current finding was agreed with Weldegebriel *et al*., (2018) who reported as the plots treated by NPS fertilizer give the highest grain yield as that of NPKSZn and the lowest grain yield of sorghum was recorded from the control. Similarly, Gebrekirkos, et al., (2017) reported that the maximum grain yield was obtained from the balanced fertilizer type NPSZn, while the lowest yield was obtained in unfertilized plots.

Inclusion of B in NPS did not improve the production of sorghum. The application of two highest rates of NPSB gave statistically similar grain yield with control; but applications of 92 kg N, 72 kg P2O5, 13 kg S, and 1.07 kg B and 115 kg N, 90 kg P2O5, 17 kg S and 1.7 kg B $ha^{-1}$ increased yield by 35 and 41% over control.

**Table: 3- Combined mean grain and biomass yield of Sorghum as influenced by blended fertilizer types and rates at Yeki district**

| **Treatments** | Biomass yield (t ha$^{-1}$) | Grain yield (kg ha$^{-1}$) |
|---|---|---|
| 1. Control (No fertilizers) | 18.32b | 3259.6b |
| 2.NPS = 69N, 54 P2O5, 10S | 31.22a | 5592.6a |
| 3. NPS = 92N, 72 P2O5, 13S | 39.33a | 5500.0a |
| 4. NPS = 115N, 90 P2O5, 17S | 33.40a | 5120.4a |
| 5.NPSB = 69N, 54 P2O5, 10S, 1.07B | 33.27a | 5027.8a |
| 6. NPSB = 92N, 72 P2O5, 13S, 1.4B | 31.46a | 4407.4ab |
| 7. NPSB = 115N, 90P2O5, 17S, 1.7B | 35.67a | 4601.8ab |
| Mean | 31.81 | 4787.0 |
| LSD (0.05) | 8.91 | 1553.4 |
| CV% | 10.61 | 12.34 |

*LSD (0.05%): least significant difference at 5% level; CV: coefficient of variation; means in a column followed by the same letters are not significantly different at 5% level of significance.*

Application of 69 N, 54 P2O5, and 10 S (142 kg ha$^{-1}$ NPS plus 91 kg ha$^{-1}$ urea top dressing) fertilizer increased sorghum yield by 71.6% and 11.2% over untreated control and respective rate of NPSB, respectively. The removal of B from NPS blend did not affect the sorghum production rather increase yield over the application of NPSB. Reduced sorghum yield due to the inclusion of B with NPS might in part, be due to the use of NPSB fertilizer out of the place as micronutrients are toxic for crops at a higher level or in part be due to lack of proper identification on the farm.

**Table 4. Mean yield components of Sorghum as influenced by types and rates of blended fertilizer at Yeki district**

| Treatments | PH (cm) | SL (cm) | TSW (gm) |
|---|---|---|---|
| 1. control (No fertilizers) | 361.53b | 28.3 | 26.82c |
| 2.NPS = 69N, 54 P2O5, 10S | 368.92ab | 29.6 | 29.3abc |
| 3. NPS = 92N, 72 P2O5, 13S | 392.53a | 30.2 | 32.03a |
| 4. NPS = 115N, 90 P2O5, 17S | 379.9ab | 31.6 | 30.22ab |
| 5.NPSB = 69N, 54 P2O5, 10S, 1.07B | 368.1b | 28.47 | 29.32abc |
| 6. NPSB = 92N, 72 P2O5, 13S, 1.4B | 367.4b | 29.4 | 28.9bc |
| 7. NPSB = 115N, 90P2O5, 17S, 1.7B | 373.82ab | 29.67 | 27.98bc |
| Mean | 373.17 | 29.6 | 29.22 |
| LSD (0.05) | 24.05 | NS | 2.93 |
| CV% | 5.43 | 7.16 | 8.44 |

**N.B:** *LSD (0.05%): least significant difference at 5% level; CV: coefficient of Variation; PH: plant height; SL: spike length; TSW: thousand seed weight; Means in a column followed by the same letters are not significantly different at 5% level of Significance*

Plant height and thousands seed weight of sorghum were significantly affected by applied fertilizer types and rates. Panicle/spike length was not significantly affected by either type or rate of applied fertilizers. The highest plant height (392.53 cm) was recorded from treatment which receives 189 Kg NPS +122 Kg urea top dressed but this was statistical parity with rest treatments except for the control treatment, and the lowest plant height was measured from the control treatment. This finding is in agreement with the report of Kasaye *et al*., (2018) that plant height increases with the increment of fertilizer application from nil to balanced fertilizer type. In addition to this, it can be suggested the application of optimum fertilizer nutrients increased plant growth and biomass and the increased amounts of nutrient increases the production of sorghum (Bayu *et al*., 2006).

**Partial Economic Analysis**

Partial economic analysis also showed that a marginal rate of return (MRR) of 222% and the highest net benefit of ETB 26291.85 was obtained by applying 142 kg NPS blend and 91 kg urea/ha top dressing at a rate of 69:54:10 NPS. So, based on current economic and yield data results it can be recommended that the use of 142 kg NPS blend and 91 kg urea/ha is the best option for sorghum production in Yeki district and similar Agroecology.

**Table 5: - Partial budget and dominance analysis for NPS and NPSB fertilizers on Sorghum in Yeki district**

| NO. | Treatment | GY(Kg $ha^{-1}$) | Adjusted GY(Kg $ha^{-1}$) | FC (ETB $ha^{-1}$) | AC (ETB $ha^{-1}$) | TVC ETB $ha^{-1}$ | GB (ETB $ha^{-1}$) | NB(ETB $ha^{-1}$) | % MRR |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Control | 3259.3 | 2933.4 | 0 | 0 | 0 | 17600.2 | 17600.22 | |
| 2 | NPS=69,54,10 | 5592.6 | 5033.4 | 3708.2 | 200 | 3908.2 | 30200.0 | 26291.8 | 222% |
| 5 | NPSB=69,54,10,1.07 | 5027.8 | 4525.0 | 3918.2 | 200 | 4118.2 | 27150.1 | 23031.9 | D |
| 3 | NPS=92,72,13 | 5500 | 4950 | 4547.8 | 270 | 4817.8 | 29700 | 24882.2 | 264% |
| 6 | NPSB=92,72,13,1.4 | 4407.4 | 3966.7 | 4831 | 280 | 5111 | 23800 | 18689 | D |
| 4 | .NPS=115,90,17 | 5120.4 | 4608.4 | 5388.1 | 350 | 5738.1 | 27650.2 | 21912.1 | 514% |
| 7 | NPSB=115,90,17,1.7 | 4601.9 | 4141.7 | 5733.7 | 345 | 6078.7 | 24850.3 | 18771.6 | D |

*Price of sorghum = 6 birr/100kg*

**Table. 6. Analysis of net benefit and MRR% of NPS and NPSB fertilizers on Sorghum after removal of dominated treatments**

| No. | Treatment | GY(Kg $ha^{-1}$) | Adjusted GY(Kg $ha^{-1}$) | FC (ETB $ha^{-1}$) | AC (ETB $ha^{-1}$) | TVC (ETB $ha^{-1}$) | GB (ETB $ha^{-1}$) | NB(ETB $ha^{-1}$) | MRR % |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Control(no input) | 3259.3 | 2933.4 | 0 | 0 | 0 | 17600.2 | 17600.22 | |
| 4 | NPS=115,90,17 | 5120.4 | 4608.4 | 5388.1 | 350 | 5738.1 | 27650.2 | 21912.1 | 514% |
| 3 | NPS=92,72,13 | 5500 | 4950 | 4547.8 | 270 | 4817.8 | 29700 | 24882.2 | 264% |
| 2 | NPS=69,54,10 | 5592.6 | 5033.4 | 3708.2 | 200 | 3908.2 | 30200.0 | 26291.8 | 222% |

***N.B**: Yield adjustment: 10%, ETB: Ethiopian Birr, GY: grain yield, FC: fertilizer cost, AC: application cost, TVC: total variable cost, GB: gross benefit, NB: net benefit, D: dominated treatments that are rejected, MRR: marginal rate of return*

## 4 CONCLUSIONS AND RECOMMENDATION

NPS and NPSB fertilizers are the two fertilizer types identified for Shosha kebele and major fertilizer types recommended for Yeki woreda. The two fertilizer types were evaluated to compare their relative influence (because it was difficult to clearly identify the type of fertilizer blend on the ground) on sorghum production and determine the optimum rate of the selected fertilizer type. Current results show that mean sorghum yield was significantly affected by the application of NPS. The addition of B to NPS blend did not affect the sorghum production but a slight yield reduction was observed. Reduced sorghum yield due to the inclusion of B with NPS might in part, be due to the use of NPSB fertilizer out of the place as micronutrients are toxic for crops at a higher level or in part be due to lack of proper identification on the farm. Production of sorghum with NPS at a rate of 69:54:10 kg $ha^{-1}$ significantly improved sorghum yield and gave high net benefit and %MRR. So current study clearly indicated that NPS at a rate of 142 kg NPS and 91 kg $ha^{-1}$ can be the best option for sorghum production in the study area. However, the recommended rate should be further verified and demonstrated for wider use.

**Declarations**

**Funding statement**

This work was supported by Southern Agricultural Research Institute, Natural Resource Research Directorate.

**Declaration of interest statement**

The authors declare no conflict of interest.

**Acknowledgments**

The authors would like to thank the Southern Agricultural Research Institute, Natural Resource Research Directorate for the financial support to this study; and Bonga Agricultural Research Center (BARC) for valuable collaboration work, evaluation and monitoring of the activity in the field. The authors are also thankful to the smallholder farmers who voluntarily availed their lands for the experiments.

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