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International Journal of Plant Science and Agriculture (IJPSA)

Response of Sorghum (*Sorghum bicolor* (L.)Moench) Varieties to Blend NPSB Fertilizer Rates under Irrigation at DasenechWoreda, South Omo Zone, Southern Ethiopia

Research Article

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Abstract

Sorghum is an important small holder farmer's crop in Ethiopia. It plays the first role in the daily diet of the people used as food and local beverages in arid areas of Ethiopia However, yields are low due to low soil fertility, inadequate amount and type of fertilizer application and lack of improved sorghum varieties. A field experiment was conducted during 2019/2020 cropping season at Dansenechworeda to determine the effect of blended NPSB fertilizer rate on yield and yield components of sorghum varieties. The treatment consists of three varieties of sorghum (local, Melkam and Teshale) and five level of blended NPSB fertilizer rates (0, 50,100,150,200 kg ha^{-1}) and arranged in RCB design with three replications. All yield and yield component data were collected and subjected to statistical analysis. The results indicated that grain yield, panicle weight, plant height, days to flowering and days to maturity were significantly ($P< 0.05$) influenced by the interaction of variety and fertilizer rate. The highest grain yield (5023 kg ha^{-1}) was obtained from the combination of Melkam cultivar with 50 kg ha^{-1} fertilizer rate. Local cultivar without fertilizer recorded significantly the lowest grain yield (3797 kg ha^{-1}). The heaviest panicle weight (91g) was observed from the combination of Melkam cultivar with 200 kg ha-1 fertilizer rate. The highest 1000 kernel weights (41g), above grounded dry biomass (16095 kgha^{-1}) were recorded at local variety of Mana. The economic analysis also supported that the highest net benefit of (36483ETB ha^{-1}) with marginal return of 190 % was obtained from the blended fertilizer rate of 50 kg ha^{-1}. Confirmation of these results by carrying out the same experiment at multiple seasons, different soil types or through simulation modeling is recommended.

Keywords: Blended Fertilizers, Economic Analysis and Grain Yield.

Introduction

Sorghumis one of the most important cereal crops grown in arid and semi-arid parts of the world, evolved in semi-arid tropical Africa, India and China where it is still used as a major food grain [23]. Sorghum, because of its drought resistance and wide range of ecological adaptation, is the crop of choice for dry regions and areas with unreliable rainfall [23]. It is produced in many countries of the world and it is the fifth major cereal crop in the world in terms of production after maize, rice, wheat, and barley and third in Africa after maize and rice [9].

In Ethiopia, sorghum productivity is estimated at 2300 Kgha^{-1} [5], which is considerably lower than experimental yield that reaches up to 3500 Kgha^{-1} on farmers' fields in major sorghum growing regions of the country. This still is very low when compared with the yield of 7000Kg to 9000 Kgha^{-1} obtained under intensive management. According to central statistical authority [6], the average national yield of sorghum is 2525 kg ha^{-1} in Ethiopia, 2225 kg ha^{-1} in southern Ethiopia and 2140 kg ha^{-1} in the study area.

Application of balanced fertilizers is the basis to produce more crop output from existing land under cultivation [1, 4]. Previous fertilizer research work in Ethiopia has been focused on N and P fertilizers, soil types and various climatic conditions, while very limited work has been reported with other essential macro- and micro-nutrients (K, S, Fe, Zn, B, etc). Taking into account this gap, the Agricultural Transformation Agency (ATA) of Ethiopia suggested some blended fertilizers such as NPS, NPSB, NPSZnand NPSZnB fertilizers for crop production in DasenechWoreda area of Ethiopia [8]. However, specific blended fertilizers type and rate

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Received: July 14, 2022
Accepted: October 13, 2022
Published: October 19, 2022

Citation: Belay Yeb, ZekariasAnbese. Response of Sorghum (*Sorghum bicolor* (L.)Moench) Varieties to Blend NPSB Fertilizer Rates under Irrigation at DasenechWoreda, South Omo Zone, Southern Ethiopia. *Int J Plant Sci Agric.* 2022;5(2):180-185.

for sorghum production in western parts of Ethiopia were not well identified and recommended.

Therefore, encouraging sorghum producing farmers through the provision of appropriate agronomic practices, selecting drought tolerant varieties, applying required amount of fertilizer and remedial measures to alleviate production constraints of sorghum would serve as means for increased sorghum production. This becomes of paramount importance in view of the food insecurity prevailing in dry land areas, particularly in DasenechWoreda of the SouthOmo zone. Based on these facts, the general objective of this research was to determine the optimum rate of NPSB fertilizer rate on yield and yield components of sorghum varieties and toidentify sorghum genotypes well adapted to the study area.

Materials and Methods

Description of the Study Area

The study was conducted in South Omo zone, Dasenechworeda which is located at about 991mm from Addis Ababa and 755km from Hawassa. Geographically, it was located between 4°37'-4°48' Nlatitude and 35°56'-36°20' E longitude, with altitude of 353 to 606masl. The district has very small, erratic and variable rainfall, and high ambient temperature ranging in 32-42°C. According to the National Metrological Agency (2016) [19], the annual rainfall of the district ranges from 126 mm to 500 mm.

Experimental Materials

An improved variety of sorghum (Melkam, local [Mana] and Teshale)) was used as test crop for the study. According to Ethio-SIS (2016) [8], the nutrient content of NPS were (18.1% N, 36.1% P_2O_5, 6.7% S and0.1%B) was used as source of fertilizer materials.

Treatments, Design and Experimental Procedures

The factorial experiment consists of three sorghum varieties (Melkam, local [Mana]andTeshale) and five levels of NPSB (0, 50, 100, 150 and 200 kg ha^{-1}) which were arranged with randomized complete block design (RCBD) with three replications. Every plot except absolute control had received blanket dose of 100 kg of urea (46% N [CO $(NH_2)_2$]). The sorghum was planted at the rate of 8 kg ha-1on a plot size of 4.5 m x5m (22.5m^2) with inter and intra row spacing of 0.75m and 0.2 m respectively. Distance between plots and blocks were1m and 1.5m respectively.

Management of the Experiment

The experimental plots were prepared by oxen ploughing and harrowing. The land was manually leveled and divided into blocks and plots. The field layout was prepared and all the treatments were applied in the experimental plots and blocks according to the design prepared earlier. Rows were made by hand pulled rowmarker at the spacing of 0.75m between rows and 0.2m between plants. The seed was sown by hand drilling at the seed rate of 8 kg ha-1in 3 cm depth. Weeding was done manually as required.

Data Collection and Measurements

Crop Phenology and Growth Parameters: Days to heading after planting was recorded when the panicles were fully visible on 50% of the plants in each plot by visual observation.Days to physiological maturity after planting was also recorded when 90% of the plants in each plot reached maturity as judged by the time when grainsare difficult to divide by thumb nail. Plant height was recorded when the crop reached maturity by measurement made on 5 randomly selected plants from each net plot area. The selected plants were measured for plant height from ground level to the top of the panicles. The panicles length was recorded from the four central rows of each plot of 15 plants when the crop reached maturity. The selected plants were measured from the base of the panicles to the tip.

Yield and Yield Components: Weight of panicle per plant was determined from 15 randomly selected panicles per plot and averaged on per panicles basis.Thousand kernel weights were measured by weighing 1000 kernels sampled from the net plot of each plot using a sensitive balance. Biomass yield was recorded from the four central rows 3m X 3m (9m^2) areas after the samples were air dried.Grain yield was also recorded from four central rows [3m X 3m (9m^2) area] and itwas adjusted to 12.5% moisture level. Harvest index was derived as the ratio of grain yield to the above ground dry biomass yield

Statistical Analysis

Analysis of variance (ANOVA) for the yield, yield components and growth parameters of the sorghum varieties under the different treatments was analyzed using SAS (statistical analysis software) version 9.1.3 (SAS, 2004). Means was separated using least significance difference (LSD) test at a probability level of 5%.

Results and Discussions

Phenological Parameters of Common Bean

Plant Height: Analysis variance showed significant difference ($p<0.05$) due to the main effect of varieties and fertilizer rate. The highest plant height (276.7cm) was recorded by the local varieties of Mana. While the shortest plant height (157.7cm) was recorded in Melkam (Table 1). The possible reason for this result could be the variation in the genetic makeup and rate cell division in each genotype. This finding was in line with the finding of Tekleand Zemach(2014) [24]; Hussain (2011)and Mihretet al. (2015) [12, [17] that plant height was significantly affected by the different sorghum varieties.

As fertilizer application rate increased from0 to 200kgha^{-1}, the plant height increased from 192.3 to 196.8cm (Table 1). The tallest (196.8) and the shortest (192.3) plant height was found from 200kg ha^{-1} NPSB and at unfertilized plots respectively. This result was in agreement with findings by [25] that the application of different levels of blended (NPSB) fertilizer significantly affected plant height, the tallest plant height (145.4 cm) was observed in plots that were treated with 300 kg NPSB ha^{-1} and 150 kg NPSB ha^{-1}, respectively while the shortest plant height were found in unfertilized plots. In agreement with this result, Dagne (2016) [7] reported a significant variation in plant height of maize due to the effect of blended fertilizer. Melkamu et al (2019) [15] reported that macro and micro nutrients (N, P, S and B) application can increase plant height.

Panicle Length: Panicle length was significantly ($p<0.05$) affected due to the main effect of varieties and fertilizer rate (Table 1). The highest panicle length (27.7cm) was recorded for improved varieties of Melkam and statistically at par with local variety of Mana (27.1cm). The increase inpanicle lengthcould be due to the genetic makeup of the variety. In agreement with this result, Wodewosen and Tekle (2014) [26] reported that early maturing sorghum varieties typically have smaller panicle length than late maturing type. Similarly, Namoobe et al. (2014)[18] foundout thatvarieties hada significant effect on panicle length with the longest panicle length of 28.4 cm.

Increasing in blended fertilizer rate showed a corresponding increment of panicle length as compared with the control fertilizer plot. The longest (27.6 cm) and the shortest (23.7 cm) panicle length of were obtained from 50 kg ha^{-1} fertilizer and control plot respectively.

Number of Productive Tillers: Number of productive tillers were significantly ($p<0.05$) influenced by main effect of variety and fertilizer. The highest (21) number of productive tiller was recorded by Teshalecultivar. The highest number (17.9) of effective tiller was obtained from 50 kg ha^{-1} NPSB fertilizer. The number of tillers decreased with the increasing rate of fertilizer rate. The lowest number of tillers, which was obtained from the P control plots, was significantly lower than the other fertilized plots. Similar results were reported by Rut-Dugaet al., (2019) [20] on Wane and Kingbird varieties of wheat. The highest result of Wane and Kingbird verities of wheat were improved by 42.9% and 26.7% respectively as compared to the lowest number of productive tillers per plant at control.

Number of Total Tiller: Number of total tillers were significantly ($p<0.05$) affected by main effect of variety and fertilizer. The highest value (32) and the lowest (16) were recorded by Teshaleand local cultivars respectively. The highest (27) and the lowest (17) number of total tiller was obtained 200 kg ha-1NPSB and control respectively. Mesfin and Zemach (2015) reported similar findings that indicate NPSB increased the number of tillers per plant than convectional fertilizer DAP and Urea and also control plots. Whereas, application of blended fertilizer and row planting method has brought a significant effect in the Eragrostistefyield and yield components grown on Vertisol [13].

Days to Flowering: Days to flowering were significantly ($p<0.05$) influenced by main effects of variety and NPSB rates. Early(73.1 days)and late (95.3 days) flowered cultivars were Teshale and Melkam respectively. Significantly early (82 days) flowering was caused by maximum fertilizer rate 200 kg ha^{-1}. Days to flowering was also significantly ($p<0.05$) affected by the combination of variety with blended fertilizer rates. The earliest flowering (70 days) was observed from the combination of Teshale cultivar with 200 kg hafertilizer (Fig.1).

Days to Maturity: Days to maturity were significantly ($p<0.05$) influenced by main effects of variety. Early and late matured cultivars were Teshale (103.4 days) and Melkam (116.6 days) respectively (Table 1). Days to maturity was also significantly ($p<0.05$) affected by blended fertilizer rates. Significantly early (108 days) and late (113 days) maturing cultivars were caused by 200 kg ha^{-1} NPSB rate and control respectively (Table 1). This is in line with the findings reported by Tsadiket al., (2020) [25] that, application of blended fertilizer took the longest days to 90% physiological maturity (124 days) was recorded in control plots and plots that received 200 kg NPSB ha^{-1} and 250 kg NPSB ha^{-1} matured in 121, 1 day earlier than the other treatments.

Yield and Yield Components

Thousand Kernel Weight: Analysis of variance indicated thousand kernel weight was significantly ($p<0.05$) affected by the main effect of varieties and NPSB fertilizer rate. The maximum 1000 kernel weight (41g) was recorded for the local variety of Manaand the minimum 1000 kernel weight of (28 g) were recorded for the improved varieties of Melkam (Table 2). The higher thousand kernel weight could be due to the difference in genetic makeup of

Table 1. Main Effects of Varieties and Fertilizer on Yield Components of Sorghum.

	plant height (cm)	Panicle length (cm)	No of Effective tillers	No of total tiller	Days to flowering	Days to maturity
Varieties						
Melkam	149.1 c	27.7 a	13 b	18 b	95.3 a	116.6 a
Mana (local)	276.7 a	27.1 a	11 b	16 b	86.2 b	110.8 b
Teshale	157.7 b	23.5 b	21 a	32 a	73.1 c	103.4 c
LSD (5%)	0.4	0.7	2.4	3.4	1	0.5
NPSB fertilizer (kg ha^{-1})						
0	192.3 e	23.7 c	10.9 c	17 b	87 a	113 a
50	193.6 d	27.6 a	17.9 a	21 b	86 ab	111 b
100	194.6 c	26.9 a	15.1 ab	21 b	85 b	110 c
150	195.2 b	26.7 a	14.6 b	21 b	84 c	109 d
200	196.8 a	25.7 b	14.8 ab	27 a	82 d	108 d
LSD (5%)	0.5	0.9	3.1	4.4	1.3	0.6
Cv (%)	0.26	3.7	22.3	21.4	1.5	0.6

Means of the same category followed by different letters are significantly different at 5% level of probability using LSD test. Where ns = non-significant data the variety and environmental factor [24]. This finding is in line with finding of Wondewosen and Tekle (2014) [26] who reported that 1000 kernel weight was significantly different due to varieties. Similarly, Mihret et al. (2015) [17] found that the thousand kernel weight of Melkam and Meko were 30.9g and 33.3g, respectively.

The mean values of thousands kernel weight were increased by 17% in the blended fertilizer rate of 50kg ha^{-1} as compared with control, respectively. This result is in line with the finding of Dagne (2016) [7] that reported significance difference on thousands kernel weight of maize due to the effect of blended fertilizer.

Panicle Weight: Panicle weight of sorghum was significantly ($p<0.05$) affected due to the main affect variety and fertilizer. Mana (local) variety gave significantly the lowest panicle weight per plant as compared to Melkam and Teshale variety (Table 2). This result is in agreement with the report by Namoobe et al. (2014) [18] that panicle weight of sorghum was significantly affected by varieties.

The maximum (83 g) and the minimum (72g) panicle weight were recorded on 200 kg ha^{-1} NPSB and nil fertilizer application rates. This result is in line with the finding of Berhaneet al. (2015) [3] who reported that the panicle weight of sorghum was significantly affected by the application of high amount of blended fertilizer rate. Moreover, Gebrelibanos and Dereje (2015) [10] reported that application of high amount blended fertilizer rate has significance variation on yield per panicle of sorghum.

Grain Yield: Grain yield of sorghum was significantly ($p<0.05$) affected by the main and interaction effect of varieties and fertilizer (Table 2). The highest grain yield (5008 kg ha^{-1}) was obtained from Melkam variety while the lowest grain yield (4131 kg ha^{-1}) was obtained from the Teshale variety. This result was in line with Husain et al. (2011) and Melese (2016) [12, 16] that significance variation on performance of sorghum varieties on grain yield was noticed. The highest grain yield obtained from the improved sorghum varieties is associated with the increased number yield attributing parameters such as, panicle length and panicle weight,Tekle and Zemach 2014 [25].

The grain yield (4609 kg ha^{-1}) obtained from the maximum fertilizer application rate of 200 kg ha^{-1} was significantly higherthan the yield obtained from the control (4438kg) plot. This is in line with Sujathammaet al. (2015) who reported that application of blended fertilizer result in maximum grain yield of sorghum as compared with the unfertilized one. Tsadiket al. 2020 [25] reported that, application of different rates of NPSB fertilizer was statistically significant ($P< 0.05$) on the grain yield of sorghum. Plants that were treated with 300 kg NPSB ha^{-1} showed significantly higher grain yield as compared to control plot. In addition, Getachew (2018) [11] reported that,application of 159 kg ha^{-1} NPSB fertilizer rate is economical and recommended for cereal crop varieties production under Jimma.

Biomass Yield: There was significant ($p<0.05$) variationon theabove ground dry biomass due to the effect of variety of sorghum. The highest above ground dry biomass yield (16095 kgha^{-1}) was obtained from the local variety Mana and exceeds 31 % and 64.8 % over the other varieties of Melkamand Teshale, respectively (Table 2). This result is in agreement with Hussain et.al (2011) [12] who reported that varieties significantly affected the stalk yield of sorghum. Similarly, Wodoweson and Takle (2014) [26]and Mihretet al. (2015) [17] reported that like grain yieldsignificant difference among varieties of sorghum was also found in above ground biomass yield.

The biomass yield of sorghum in this trial was not affected significantlyby different blended fertilizer rates. The results of the present study substantiate that lack of adequate nutrient supply and poor soil structure are the principal constraints to crop production under low input agriculture systems [10]. In their report the highest biological yield was obtained from treatment of 200 kg ha^{-1} of P and the lowest belonged to 50 kg ha^{-1} of P that showed increment of 77.16 percent in the biological yield of sorghum as compared with the 50 kg ha^{-1} P treatment. Similarly, Berhaneet al. (2015) [3] reported that high amount of teff biomass yield was obtained from the plots that was treated with blended fertilizer compared to control.

Harvest Index: The analysis of variance showed that significance difference ($p>0.05$) in harvest index was observed only due to the main effect of variety. On the other hand, the fertilizer rate

Table 2. Main Effects of Varieties and Fertilizer on Yield and Yield Components of Sorghum.

Varieties	Thousand kernel weight(gm)	Panicle weight(kg/ha)	Grain yield(kg/ha)	Biomass yield(kg/ha)	Harvest index
Mana (local)	41a	71c	4279b	16095a	0.27b
Teshale	29b	81b	4131c	9767b	0.43a
Melkam	28b	85a	5008a	11102b	0.45a
LSD (5%)	2	0.4	4.1	773	0.02
Fertilizer (Kg ha^{-1})					
0	30c	72e	4305 d	12070	0.38
50	35a	78d	4609 a	11678	0.41
100	33ab	80c	4525 b	12190	0.39
150	34ab	82b	4526 b	12556	0.38
200	31 bc	83 a	4478 c	12931	0.37
LSD (5%)	3	0.5	5.2	NS	NS
CV (%)	8	0.6	0.1	8.2	7.2
Means of the same category followed by different letters are significantly different at 5% level of probability using LSD test. NS = non-significant data					

Figure 1. Interaction Effect of Varieties and Blend NPSB Fertilizer Rates on Sorghum Height.

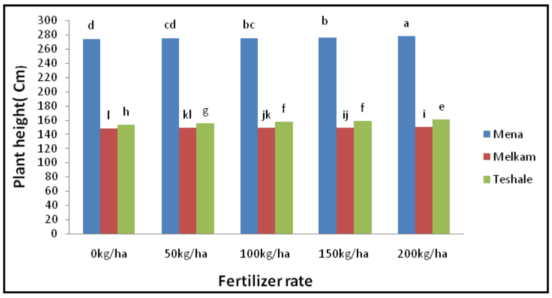


Figure 2. Interaction Effect of Varieties and Blend NPSB Fertilizer Rates on Sorghum Panicle Weight.

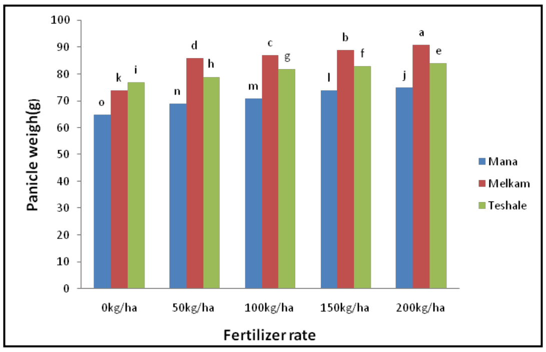


Figure 3. Interaction Effect of Varieties and Blend NPSB Fertilizer Rates on Days to Flowering.

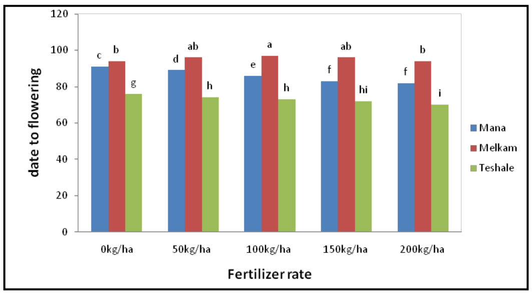


Figure 4. Interaction Effect of Varieties and Blend NPSB Fertilizer Rates on Days to Maturity.

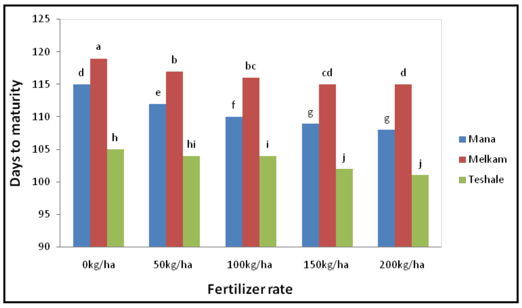
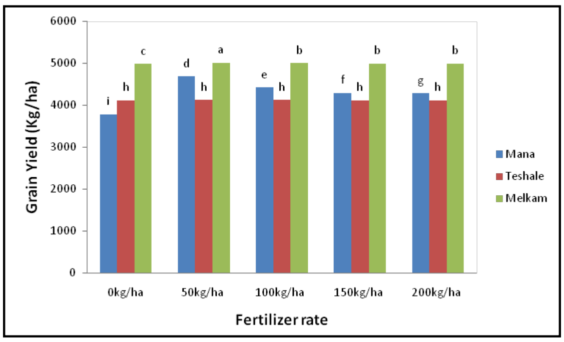


Figure 5. Interaction Effect of Varieties and Blend NPSB Fertilizer Rates on Grain Yield of Sorghum.



and the interaction effect of variety and fertilizer did not cause significance different on the harvest index (Table 3). The highest (0.45) and lowest (0.27) harvest index was recorded in Melkam and local variety respectively. Thus, according to the results, the high harvest index by the improved varieties implied that there is a good partitioning of dry matter to grain yield in the improved varieties of sorghum than the local variety. The possible reason for this could be due to less partitioning of biological yield to economical yield of the long maturing with a high plant height of the local variety due to high above ground dry biomass.

Fertilizer rate did not cause significance difference on the harvest index.In agreement to this, Tsadik et al (2020) [25] reported that application of NPSB fertilizer did not significantly affect the harvest index.

Summary, Conclusion And Recommendation

Summary and Conclusion

Providing food for the fast-increasing population is one of the major challenges of these days in developing countries. In Ethiopia, low soil fertility and lack of improved sorghum varieties are one of the factors limiting the productivity of crops, including sorghum. Therefore, supporting soil fertility in intensive cropping systems for higher yields can be attained through optimum and balanced levels of fertilizer applications. In line with this, experimental was conducted in Dasenech Woreda, in 2019/2020 cropping season to determine the effect of blended fertilizer rate on yield and economic performance of sorghum varieties. The analysis of variance results indicated that, sorghum grain yield, panicle weight, plant height, days to flowering and days to maturity were significantly ($P < 0.05$) influenced by the interaction of variety and fertilizer and also by the main effect of variety and fertilizer. Except for above ground biomass and harvest index all yield components were affected significantly ($P < 0.05$) by the main effects of variety and fertilizer.

The highest grain yield (5023 kg ha^{-1}) was observed from the combination of Melkam cultivar with 50 kg ha^{-1} fertilizer rate. Local cultivar with 50 kg ha^{-1} fertilizer rates are significantly the lowest grain yield (3797 kg ha^{-1}). The highest 1000 kernel weights (45.2 g), above grounded dry biomass (14385.6 kg ha^{-1}) were recorded at local variety. The economic analysis of this experiment indicated that a maximum net benefit (36,483ETB ha^{-1}) with the highest marginal rate of return (190%) was obtained from blended fertilizer rate of 50 kg ha^{-1}

Recommendation

Based on the economic analysis, statistical analysis and marginal rate of returns results, it can be recommended that, the combined application of 50 kg ha^{1} NPSB and with Melkam variety was recommended for superior production of sorghum in the study area. However, the result should be repeated under different agro ecologies in order to reach a conclusive recommendation.

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