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Evaluation of Different Blended Fertilizer Type on Yield and Yield Components Sorghum Crop at Fadis District of East Hararghe Zone

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Abstract

Sorghum is a drought tolerant and nutritious cereal crop usually cultivated for food, feed and fodder by subsistence farmers and its yield is constrained by declining soil fertility due to nutrient depletion, low level of fertilizer use and unblended application of fertilizer in Oromia region, district in East Hararghe Zone. Appropriate (economic and judicious use) of fertilization for a given crop is necessary for sustainable crop production. Experiment on effect of blended fertilizer type on yield and yield components of sorghum crop was conducted in Fadis district of East Hararghe zone at NegawoUmarkule peasant association in 2017/2018 cropping season. It was initiated to evaluate effect of different blended fertilizer type on yield and yield components of sorghum. Eight treatments compromising of different blended fertilizer type with different nutrient content which including NPS, NPSZnB, DAP, NPSB, NPKSB, NPSZn, UREA and control were laid out in a randomized complete block design with three replications. The result of the experiment indicate that there is significance difference among treatments and all blended fertilizer types were improve growth and yield components Of sorghum crop as compared to control. However, application of 100 kg/ha of NPS, NPKSB and NPSB were more increase the plant height, panicle length and grain yield of sorghum than nil fertilizer application and control in the growing year. The highest grain yield (3748.6 kg/ha) was recorded from treatment with application of 100 kg/ha NPS. These result were 45.8%, 70.7% and 75.3% more yield improvement over the control treatment, 100 kg/ha UREA treatment and 100 kg/ha NPSZn treatmentrespectively. In general, Blended fertilizer increase growth and yield component of sorghum due to the blend of different nutrient which are crucial for plant growth. Therefore, based on the result obtained from this study application of 100 kg/ha of blended NPS and NPSZnB are recommended for sorghum production in Fadis area of Eastern Hararghe zone.

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Keywords

Blended fertilizer, Blended fertilizer type, Yield, Yield component.

Introduction

Sorghum is produced in many countries of the world and it is the fifth major cereal crop in the world in terms of tonnage after maize, wheat, rice and barley (FAO, 2012). It is a staple food for more than half a billion people in the world, 60 percent of whom are in Africa. It is a highly versatile crop with many uses including human food and animal feed, for brewing and bio-fuels (Kumara *et al.*, 2011). Global sorghum production was 61.66 million tons; 63.99 estimated million tons could represent an increase of 2.33 million tons or a 3.78% in sorghum production around the world in year 2015/16 (USDA, 2016). It is the third most important cereal crop in Ethiopia and fourth in Oromia region in terms of area of production (CSA, 2018). In Ethiopia, it is adapted to a wide range of environments, and hence can be produced in the high lands, medium altitude and low lands. During 2016/17 cropping season (1,881,970.73 hectares) of land area was covered by sorghum with the average yield productivity of 2.5 ton ha-1 (CSA, 2017). It is known for its versatility and diversity, and is produced over a wide range of agroecological zones. Sorghum is widely produced more than any other crops in the areas where there is moisture stress (MoA, 2010). It is a staple food crop on which the lives of millions of poor Ethiopians depend. It has tremendous uses for the Ethiopian farmer and no part of this plant is ignored (Adugna, 2007). Because of its drought resistance and can be grown under conditions which are unfavorable for most of cereal crops and is the crop of choice for dry regions and areas with unreliable rainfall (Taye, 2013).

Sorghum productivity is estimated at 2300 Kgha-1 (CSA 2015), 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 9000Kgha-1 obtained under intensive management (Geremew *et al.*, 2004). Although the productivity of sorghum is low; in Oromia Region state, the average productivity of 22.22 Quintal ha^{-1} which is even below the national average yield and productivity of 27.26 Quintal ha^{-1} (CSA, 2016; CSA, 2018).

Soil fertility decline is the main issue in African agriculture in general and in Ethiopia in particular. In Ethiopia, large number of population is hardly satisfied by reliable production, instead a decline in their crop yield is letting them to suffer from poverty and malnutrition. Studies indicated that in some parts of Ethiopia farmer suffer from lack of what to eat particularly in months starting from June up to September (Abera, 2003). Ethiopian soils have been subjected to severe degradation caused by natural and man-made factors (IFDC, 2015). Low soil fertility and shortage of moisture is the major constraints in the reduction of growth and productivity of sorghum (Gebreyesus, 2012). The rate of soil fertility decline depends on soil erosion, nutrient removal in harvests, the rate at which nutrients are returned to the soil through the use of both inorganic fertilizer and organic manures, and the rate of mineralization of soil mineral and organic matter nutrients (Kaizzi *et al.*, 2017). The blunder with this agricultural problem is very intricate in nature, the complexity arises from various condition of the country such as the agro-climate, topography of the lands, the soil types and socio-economic status of the farming community and the combination of these; the overall effect of which is finally reflected by soil fertility decline and reduction in yield of crops. Since its start in the early 1970's, fertilizer use in Ethiopia has focused mainly on the use and application of nitrogen and phosphorous fertilizers in the form of Urea and DAP for almost all crops. Such unbalanced application of plant nutrients may aggravate the depletion of other important nutrient elements in soils (Fayera *et al.*, 2014). The appropriate use of nitrogen and phosphorous fertilizer for sorghum production could make an important contribution to optimize profit through increasing production and productivity of sorghum in areas, where there is low practice of using improved technologies such as optimum level of fertilizer (Abebe *et al.*, 2016). Even if, due to application of potassium, Sulfur and Zinc in different parts of the country sharply increase yield which leads the country started using fertilizers which can supply the deficient nutrients and will continue to use in the form of blends (IFDC, 2015).

Application of balanced fertilizer based on the actual limitation of nutrients in the soil is very crucial to increase production and productivity of crops. Balanced fertilizer amended with enough amount of Nitrogen and phosphorous on sorghum gave the highest yield, nutritional content and economic return (Gebrekorkos *et al.*, 2017). Moreover, application of macronutrients in combination with micronutrient increased sorghum yield and concomitantly improved N, P and K uptake and its nutrient use efficiency of sorghum varieties (Redai *et al.*, 2018). Now a day, agricultural transformation agency (ATA), has been conducted soil fertility survey and display it on the map. And also recommend different balanced fertilizer based on their map which is blanket recommendation.

Thus why, those balanced fertilizer has to be checked and validated before going for calibration. And also, Increasing yields through the application of nitrogen and phosphorus alone can deplete other nutrients.

Therefore, information on production practices to optimize the grain yield and quality of sorghum by applying the appropriate type of blended fertilizer and understanding the plant nutrients requirement of an area could help to implement demand-driven soil fertility management practices to sorghum production in Ethiopia in general and Fadis district specifically. Hence, the present study was planned to evaluate the effects of blended fertilizer type on yield and yield components of sorghum crop in smallholder based farming systems in Fadis district of East Hararghe zone, Oromia regional state.

Objectives

To evaluate effect of different blended fertilizer type on yield and yield components sorghum crop

To quantify the economic viability of blended fertilizer for sorghum production in the study area.

Materials and Methods

Description of the study Area

Location

The study was conducted at Umarkule peasant association of Fadis district in the eastern hararghe zone, Oromia regional state. It is located in the eastern part of the country at 550 km from Addis Ababa the capital city of Ethiopia and 24 km from Harar town in the southern direction. The geographical location of the district is 8^0 22’ 0” and 9^0 14’ 0” N and 42^0 62’ 0” and 42^0 19’ 0” E. The altitude of the area ranges from 500-2100 meter above sea level (FWANRDO, 2017/18).

Topography and land use

Topographic feature of the study area is 70% plain area, 28% plateau and 2% mountain or hill. Cultivable land/cropland (21.02%), pasture (2.80%), forest (11.2%), grass land(38.01%),communal land (10.5%) and remaining (14.04%) is considered as mountainous, valley and otherwise unusable (FWANRDO,2017/18).

Climate and rain fall

According to FWANRDO (2017/18) report, the district has two basic agro-climatic conditions, namely Midland (39%), and lowland (61%). The district experience mean annual maximum and minimum rainfall, mean annual maximum and minimum temperature in the area were 850 to 650mm, 30.4°C, and 10.0°C, respectively.

Accordingly, the district has a bimodal rainfall distribution pattern with heavy rains from April to June and long and erratic rains from August to October.

Soil type and vegetation

The soil of the study area was dominantly sand clay loam soils (moderately fine texture). The area of the district covered by forest, bushes and shrubs is 42,954 ha (FWANRDO, 2011). Fedsi district has few patches of natural vegetation cover and some of the area is occupied by plantation forests and farmers incorporating trees on farmlands, boundary plantings, trees in croplands and woodlots agroforestry etc (FWANRDO, 2011).

Population

The district consists of 19 rural PAs and two rural towns and the total human population of the area 149,664 of which 76,182 (50.9%) are males and 73,482(49.09%) are females (CSA, 2007).The average family size is estimated to be 6 and 4 per household in rural and urban areas respectively. The average landholding per farm family is 0.73 hectare and has a total area of 110,502 hectares (FWANRDO, 2017/18).

Agricultural activities

Agriculture in the district is characterized by small-scale subsistence mixed farming-system with livestock production as an integral part. The livelihood of the Fedis district is highly associated with agricultural activities for the fulfillment of household needs. Farmers are growing trees and /or shrubs in the agricultural landscape and also crop production is a leading economic activity of the area. Crop production is mainly rain-fed, practically all annual crops produced by this way for household consumption. Cereal crops including maize (*Zea mays* L.), sorghum (S*orghum biocolar*), and haricot beans (*Phaseolus vulgaris*) are grown on the study area. Haricot bean (*Phaseolus vulgaris*) is growing as an intercrop with maize and sorghum crops in the study area. A cash crop such as *Chat* (*Cataedulis*) is also grown predominantly in the study area. In addition to these different fruits, vegetables, cereal crops, and tuber crops are the most common agricultural products of the study area (FWANRDO, 2017/18).

Experimental Design and Treatments

The experiment was laid out in Randomized Complete Block Design (RCBD) following three replication. The experimental site was ploughed and harrowed before sowing. The improved and adapted Melkam sorghum variety was used for the experiment. Plot size was 3m x

4m. Furrow rows were made manually in spacing of 75 cm apart and sorghum seed was drilled manually and thinned by 20cm spacing between plants. The experiment consisting of eight treatments;

T_1 No fertilizer

$T_2$100 kg/ha NPS

$T_3$100 kg/ha NPSZnB

T4 100kg/ha DAP

$T_5$100 kg/ha NPSB

T_6 100 kg/ha NPKB

T7 100 kg/ha NPSZn

T8 100 kg/ha UREA

Data Collection and Soil Sampling

Treatment effects were determined using plant height, panicle length, panicle Diameter and grain yield. Composite soil sample was collected from (20-30 spots) before planting in zigzag movement with the sampling depth of (0-20) cm and analyzed for soil physico-chemical properties.

Data Analysis

Analysis of variance was performed using the GLM procedure of SAS Statistical Software Version 9.1. Effects were considered significant in all statistical calculations if the P-values were < 0.05. Means were separated using Least Significant Difference (LSD) test.

Economic Analysis

The economic evaluation comprising partial budget analysis with dominance, and marginal rate of return was carried out. To estimate economic parameters, the yield of sorghum was valued based on average market price collected from the local markets during two consecutive years of production. A wage rate of 50 birr a man per day was considered. Some of the concepts used in the partial budget analysis are gross field benefit (GFB), total variable cost (TVC) and the net benefit (NB) CIMMYT, 1988.

The dominance analysis procedure, which was used to select potentially profitable treatments, a dominance analysis is thus carried out by first listing the treatments in order of increasing costs that vary.

Any treatment that has net benefits that are less than or equal to those of a treatment with lower costs that vary is dominated. The selected treatments by using this technique were referred to as undominated treatments.

For each pair of ranked undominated treatments, a percentage marginal rate of return (% MRR) was calculated. The percent MRR between any pair of undominated treatments denoted the return per unit of investment in crop management practices expressed as percentage. The MRR (%) was calculated as follows (CIMMYT, 1988).For a treatment to be considered a worthwhile option to farmers, the marginal rate of return (MRR) needed to be at least 100%. Thus, the minimum acceptable rate of return was considered to be 100%.

GM = TR – TVC ---Equation 1

Where GM =Gross margin (ETB/ha), TR =Total revenue (ETB/ha) and TVC =Total variable cost (ETB/ha)

NR = GM – TFC; Where NR = Net return (ETB/ha) and TFC = Total fixed cost (ETB/ha)

TCP = TVC + TFC; Where TCP = Total cost of production.

Benefit-cost ratio = NR / TCP ---Equation 2 (CIMMYT, 1988).

Results and Discussion

Physico-chemical properties of Experimental Soil before planting

As it can be observed from the table below, soils of the experimental sites was dominated by clay fractions or moderate fine texture until 20 cm depth, and hence they consequently retain nutrients and have a high water holding capacity (Berry *et al.*, 2007).

In addition, as per the ratings by EthioSIS (2014), total nitrogen and available phosphors were found to be very low and organic carbon was found to be low in the study sites.

Therefore, this in general tells us that getting crop yields from the study locations would no more be easy without significant fertilization of the soil.

Effect of Blended Fertilizer Rate Type on Yield and Yield Components of Sorghum

Plant Height

Plant height of sorghum was highly significant different at p(0.05) due to different type of blended fertilizer. The highest plant height (170.9 cm) was recorded from treatment which receives 100 $kgha^{-1}$ of NPKSB, this was in statistical high parity with treatment of NPS and others except control and treatment with 100kg/ha of only Nitrogen fertilizer or Urea and the lowest plant height (136 cm) was recorded from the treatment with 100 kg/ha of UREA. This indicate application of blended fertilizers improve growth of sorghum due to different nutrient combination which are more essential for plant rather than control and sole nitrogen fertilizer.

This finding is in agreement with the report of Gebrekirkos *et al.,* (2017) that plant height increases with increment of fertilizer application from nil to blended fertilizer type including NPKSB and NPS. Furthermore, Redai *et al.,* 2018 reported that application of different blended fertilizer gives the highest plant height over the absolute control treatment. This result is also in agreement with that of Dagne (2016), and Tekle and Wassie (2018) who found that application of blended fertilizers and NP fertilizers which significantly increased plant height as compared to N fertilizers and the control. Likewise, Bakala (2018) found that blended fertilizers had significantly influenced plant height.

Yield components

Crops with highest panicle length and panicle diameter could have high grain yield. Application of different blended fertilizer type significantly affect the panicle length and panicle diameter of sorghum. The longest panicle length (19.9 cm) was recorded from treatment that receives 100 Kg ha^{-1} NPSB, this was in statistical parity with the rest treatment except control while the lowest panicle length (15.7 cm) was recorded from the control treatment and the highest panicle diameter (7.2 cm) was recorded from the treatment with 100 kg/ha of NPKSB, this was statistically parity with the rest treatment except sole Nitrogen treatment and control while, the lowest was recorded from control treatment. This indicate application of different blended fertilizer add micro nutrient which are essential for plant growth and improve yield of the crops. The result was in conformity with the finding reported that tallest panicle length was recorded from the plot treated by blend fertilizer and the shortest panicle length was recorded from the control (Redai *et al.,* 2018).). The current result was agree with increasing trend in blended fertilizer and amended with N and P in case of (NPSZn) fertilizer shows a corresponding increment of panicle length as compared with the nil fertilizers (Gebrekorkos *et al.,* 2017). The current finding was disagree with finding reported that panicle length of sorghum did not give significantly different response under fertilized and unfertilized conditions (Sibhatu *et al.,* 2017).

Grain Yield

The result shows that there is highly significant difference among treatment at 5% due to application of different blended fertilizers. The highest grain yield (3748.6 kg/ha) was obtained from the treatment with NPS, this was statistical parity with treatment wich receive NPSB,DAP and NPSZnB and the lowest grain yield was recorded from treatment with NPSzn and Urea (N) alone respectively. Application of blended fertilizers other than using no fertilizer increased the yield of sorghum. Application of NPKSZn increased sorghum grain yield over the control. This implies that the grain yield was low without application of either of the soil fertility amendments (Redai, 2020).The result was agreed with (Kasaye 2018) finding reported as sorghum yield increase with increase in the rate of nitrogen and application of blended fertilizer to the optimum rate. Additionally, the finding reported that increasing application of fertilizer nutrients such as N, P, B and Zn increases the grain yield and biomass weight of sorghum significantly (Regessa, 2005). This result is also in agreement with that of Dagne (2016) who found that application of blended fertilizers and NP fertilizers which significantly increased Grain yield as compared to N fertilizers and the control.

Economic Analysis

The interest of producers in applying fertilizer is not limited to increasing yield alone, but also to make profit out of it. Towards maximizing profit, the amount and type of fertilizer application as well as costs of fertilizer are determining factors. In the study area the demand and market price of sorghum is important. Due to this fact increasing both grain yield can increase farmers" income. As indicated in the below Table, the partial budget analysis showed that the highest net benefit of 36307.6 Birr/ha was obtained in the treatment that received 100 kg NPS per hectare.

Table.1 Selected physio-chemical properties of experimental soil before planting

No	Sample code	pH	OC%	OM %	Avail.p in ppm	TN	Texture
1	**Ame01**	**7.83**	**1.048**	**1.8**	**0.79**	**0.051**	**Clay loam**

Table.2 Effect of Different Blended Fertilizer Type on yield and yield components of Sorghum.

S N	Treatments	Plant height(cm)	Panicle length(cm)	Panicle diameter(cm)	Yield kg/ha
1	Control(no fertilizer)	143^{bc}	15.7^{b}	4.5c	2031.9^{cd}
2	100 kg/ha NPS	170.47^{a}	20^{a}	6.5^{a}	3748.6^{a}
3	100 kg/ha NPSZnB	156.7^{abc}	19^{ab}	6.1^{ab}	3318.1^{ab}
4	100 kg/ha DAP	166^{ab}	19.1^{ab}	6.6^{a}	3265.3^{ab}
5	100 kg/ha NPSB	159.2^{abc}	19.9^{a}	6.5a	3218.1^{ab}
6	100 kg/ha NPKSB	170.9^{a}	19.5^{a}	7.2^{a}	2288.9^{bc}
7	100 kg/ha NPSZn	168.7^{a}	19.8^{a}	6.9a	925.8^{d}
8	100 kg/ha UREA	136^{c}	16.3^{ab}	4.7^{bc}	1100^{d}
	LSD	23.87	3.8	1.5	1172.4
	CV (%)	8.58	11.57	13.87	26.92

Table.3 The economic (Dominance and MRR) advantages of different blended fertilizer on Yield and yield components of sorghum

Treatments	Variables							
	Yield (kg/ha)	Gross Filed Benefit (EB/ha)	Total Variable Cost (EB/ha)	Total Fixed Cost (EB/ha)	Total Cost (EB/ha)	Net Benefit (EB/ha)	Dominance	Marginal Rate of Return (%)
Control	2031.9	22350.9	1990	1500	3490	18860.9		
100 kg/ha NPS	3748.6	41234.6	3427	1500	4927	36307.6	ND	1310
100 kg/ha NPSZnB	3318.1	36499.1	3427	1500	4927	31572.1	D	-
100 kg/ha DAP	3265.3	35918.3	3427	1500	4927	30991.3	D	-
100 kg/ha NPSB	3218.1	35399.1	3427	1500	4927	30472.1	D	-
100 kg/ha NPKSB	2288.9	25177.9	3427	1500	4927	20250.9	D	-
100 kg/ha NPSZn	925.8	10183.8	3427	1500	4927	5256.8	D	-
100 kg/ha UREA	1100	12100	3427	1500	4927	7173	D	-

Fig.1 Map of the study area

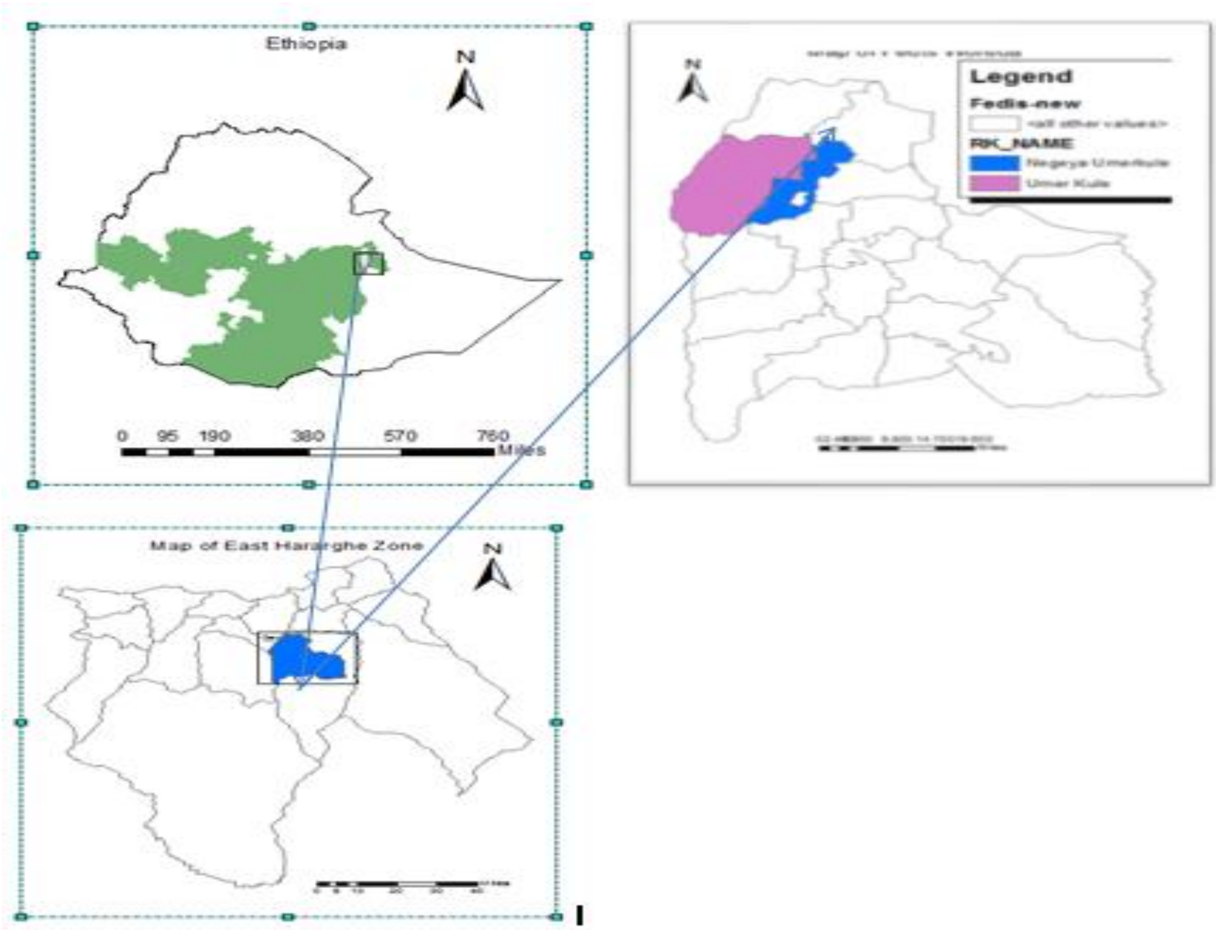
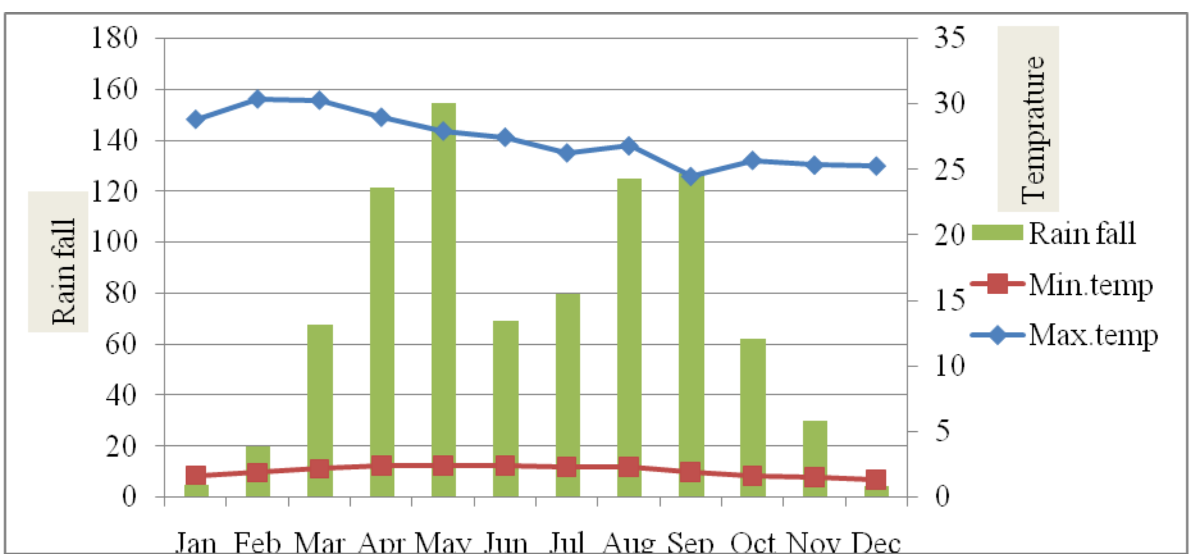


Fig.2 Rain fall and Temperature data of Fedis District, 2018 GC.



The highest marginal rate of return (1310%) was obtained from 100 kg/ha NPS treatment. However, the dominated treatment was rejected from further economic analysis to distinguish treatments with optimum return to farmer‟s practice; marginal analysis was performed on non-dominated treatment.

For treatment to be considered as advisable to farmers, between 50% and 100% marginal rate of return (MRR) was the minimum acceptable rate of return (CIMMYT, 1988). Therefore, highest net benefit and MRR is profitable and recommended for farmers in Fadis district area.

Recommendation

Rational fertilizer promotions and recommendations based on actual limiting nutrients for a given crop is not only revealed to supply adequate plant nutrients but also helped to understand the long-term ecological and economic benefits of the studied crop.

Fertilizer use in the study area has focused mainly on the application of N and P in the form of urea and di-ammonium phosphate (DAP) for almost all cultivated crops based on the blanket recommendation. Such unblended application of plant nutrients may aggravated the depletion of other important nutrient elements in soils such as K, S and micronutrients (Zn and B). This study found that inorganic blended fertilizers can improve sorghum yield and yield components significantly.

Therefore, field experiment was conducted during the 2017/18 main cropping season at Fadis district to evaluate the effect of different blended fertilizer type application on yield and yield components of sorghum; and to determine economically appropriate blended fertilizer type for sorghum production

The result obtained in this study shows that the sorghum yield and yield components are significantly affected by different blended fertilizer type in the study area. Thus blended fertilizers improve the growth and yield of sorghum with increase in plant height, panicle length, panicle diameter and grain yield frequently improves orghum productivity and farmers livelihood.

More over blended NPS and NPSZnB are promising in increasing sorghum production and productivity in the study area. Generally, it is necessary more or repeated research for validity and confirmity as well as economic rate of those blended fertilizer.

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