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Research Article

Response of Sorghum (*Sorghum bicolor* (L.) Moench) Varieties to Blended Fertilizer on yield, yield component and nutritional content under Irrigation in Raya Valley, Northern Ethiopia

Gebremeskel Gebrekorkos[1*], Yemane G. Egziabher[2] and Solomon Habtu[3]

[1]Ethiopian Institution of Agricultural Research, Mehoni Research Center, Maichew, Ethiopia; [2]Department of Dry Land Crop and Horticultural Science, College of Dryland Agriculture and Natural Resource, Mekelle University, Mekelle, Ethiopia; [3]Deparetement of Land Resource Management and Environmental Protection, College of Dryland Agriculture and Natural Resource, Mekelle University, Mekelle, Ethiopia

***Corresponding author:** gebremeskel12@gmail.com

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ABSTRACT

Sorghum productivity has been limited mainly by declining soil fertility and shortage of rain fall in the study area. Appropriate (economic and judicious use) of fertilization for a given crop is necessary for sustainable crop production. A field experiment was thus conducted in Mehoni Agricultural Research center (MhARC) test station in 2016/2017cropping season to investigate the effect of blended fertilizer on yield components, yield and nutritional content of sorghum varieties under irrigation. The treatments consisted of one local sorghum variety (Kodom) and two improved varieties (MekoI and Melkam) as well as six fertilizer types (control, 100 kg ha $^{-1}$ DAP and 100 kg ha^{-1} urea, blended NPS fertilizer, Blended NPSZn, Blended NPSZn + N + P and blended fertilizer NPSKZn) laid out in split plot design that the three sorghum varieties was assigned in the main plot and six fertilizer types in the sub plot with three replications. The analysis of variance result indicated that the growth, yield components and yield were significantly influenced by the main effect of variety and fertilizer except the panicle length in the fertilizers. The highest plant height (281.3cm), leaf area (7392cm^2), LAI (4.93), 1000 kernel weight(46.28g) and above ground dry biomass(15984kg ha^{-1}) were recorded at the late maturing and local variety of Kodom .On the other hand, the highest panicle length(30.98cm), panicle weight(100.84 g), harvest index(0.46), water productivity(1.23 kgm^{-3}), grain yield (4962 kg ha $^{-1}$) and nutritional value were obtained under Melkam. With regards to the blended fertilizer, the maximum plant growth parameter, yield component, nutritional value and grain yield (5107 kg ha^{-1}) were obtained from the treatment that received blended fertilizer amended with N and P fertilizers (F5).The highest grain yield (5530.86 kg ha^{-1}) were achieved in Melkam variety and blended fertilizer amended with N and P, and this can thus be recommended for the study area.The maximum net benefit (44601.62 ETB ha^{-1}) also obtained from the combination treatment of Melkam with blended fertilizer amended with N and P.

Key words: Blended fertilizer, Economic analysis, Irrigation, Nutritional quality, Sorghum yield

INTRODUCTION

Sorghum is produced in many countries of the world and it is the fifth major cereal crop in the world in terms of tonnageafter maize, wheat, rice and barley (FAO, 2012). More than 35% of world sorghum is grown directly for human consumption. In the year 2015/16, global sorghum production was 61.66 million tons; in this year's 63.99 estimated million tons could represent an increase of 2.33 million tons or a 3.78% in sorghum production around the world (USDA, 2016). The major sorghum producing countries of Africa takes places across the continent, with the northern African countries of Nigeria, Sudan, Ethiopia and Burkina Faso accounting for nearly 70% of Africa's production. According to Taylor (2003) sorghum is the major food and nutritional security crop to more than 100 million people in horn of Africa, owing to its flexibility to drought and other production constrains. Sorghum remains as an important food sources crop in sub Saharan Africa (SSA) and especially in the

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marginal areas where other crops do not do grow due to low rain fall, hot and dry to other cereals because it have drought and hot tolerant characteristics (AATF, 2011).

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. Sorghum is widely produced more than any other crops in the areas where there is moisture stress (MoA, 2010). Sorghum grain plays the first role in the daily diet of the people used as food and local beverages in Ethiopia. It is used for making, *"injera", "Kitta", "Nifro",* and local beverages such as "*Tella*", and "*Areke.* In Ethiopia, during 2014/15, sorghum covered 14.58 % (1,831,600.45 hectares) of the total of 80.78 %(10,144,252.30 hectares) area fixed to cereal crop production (*tef*, maize, sorghum, and wheat). Similarly, during the same year, sorghum contributed to 16.05% (43,391,342.61 quintals) of the total production 87.31% (about 236,076,624.39 quintals) allocated for major cereals (maize, *tef*, wheat, and sorghum). In that year, sorghum was ranked 3rd and 4th in area coverage and total production, respectively (CSA, 2015).

Low soil fertility and shortage of moisture is the major constraints in the reduction of growth and productivity of sorghum (Gebreyesus, 2012). Low soil fertility, particularly N and P deficiencies are among the major biophysical constraints affecting agriculture in Sub-Saharan Africa. According to Sanchez *et al*. (1997), soil fertility depletion in smallholder farmers' holdings is the basic root cause for declining per capita food production in the region.

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).Application of blended fertilizer based on the actual limitation of nutrients in the soil is very crucial to increase production and productivity of crops.

Rainfall is spatially and temporally variable and has poor distribution particularly during the main cropping season (June-September), which is the most important factor affecting the productivity of the crops. Shortage of soil moisture in the dry rain fed areas often occurs during the most sensitive growth stages (flowering and grain filling) and, rain fed crop growth is poor and yield is consequently low(EIAR and TARI, 2011). Therefore, application of supplementary irrigation (SI) at times of dry spells of crops is an effective response to alleviate the adverse impact of soil moisture stress during dry spells on the yield of rained crops. Moreover, supplemental irrigation, using a limited amount of water, is applied during the critical crop growth stages, which can result in substantial improvement in yield and water productivity (Oweis and Hachum, 2012).

Thus, information on production practices to optimize the grain yield and quality of sorghum by applying the appropriate rate of blended fertilizer at the correct time will be important to sorghum production in Ethiopia. Accordingly, this study was aimed to investigate the Effect of blended fertilizer on yield, nutritional content, and economic performance of sorghum varieties under irrigation.

MATERIALS AND METHODS

Description of the experimental site

The experiment was carried out at Mehoni Agricultural Research center (MhARC) test station under supplementary irrigation conditions in 2016/2017 cropping season. It is located 668 Km from Addis Ababa, the capital of Ethiopia. Geographically the experimental site is located at 12.70° North latitude and 39.70° East longitude with an altitude of 1578 m.a.s.l. The site receives a mean annual rainfall of 539 mm with an average minimum and maximum temperature of 12.81 and 23.24°C, respectively (MhARC, 2016). The total rain fall during the five months growing season in the year 2016 was 185 mm. The soil textural class of the experimental site was clay with pH of 6.89.

Treatment and Experimental design

The experimental design was laid out in split plot design with three replications. Three sorghum varieties assigned in the main plot and six blended fertilizer types in the sub plot.

The sorghum varieties were V1=Kodom, V2 = MekoI and V3= Melkam

In the sub plots blended fertilizers were assigned as follows:

F1= no fertilizer

F2= 100kg of DAP and 100kg UREA

F3= 100kg of 19 N **-** 38 P_2O_5 – 0.0 k_2O + 7 S + 0.0 Zn

F4= 100 kg of 17.7N +35.3 P2O5 + 6.5S +2.5 Zn

F5=100 kg of 17.7N +35.3 P2O5 + 6.5S +2.5 Zn + 61.5kg Urea + 25kg TSP

F6**=**100kg of15.2 N – 30.4 P_2O_5 – 8k_2O + 6.5 S + 2.2Zn

The gross size of experimental plot was 3.75 x 3 m (11.25 m^2) with five rows of sorghum planted at a spacing of 75 cm between rows and 20 cm between plants. Net sampling plot size was 2.25 m * 3 m in all experimental plots, in which the two outer most rows at both ends were considered as borders.

The full dose of blended fertilizer and triple super phosphate (TSP) was applied as band application at sowing. Nitrogen fertilizer in the form of urea (46% N) was applied in two doses, i.e., half of the quantity applied as band application at planting and the remaining half was top-dressed at knee height growth stages of sorghum.

Crop water and irrigation requirement of sorghum

Long term climate data consisting of rainfall, minimum and maximum temperature, relative humidity, wind speed and sunshine hours was collected and CROPWAT software over 8 was used to work out the crop water and supplementary irrigation requirement. Rain gauge was also installed to monitor the daily rainfall during the experimental season in order to account it into the supplementary irrigation. The effective rain fall was calculated by using the dependable rain (FAO/AGLW) procedure. Water from the nearby ground water well was pumped, metered and conveyed through plastic pipes for supplying the required irrigation amount to each furrow. Crop water productivity was determined as follows:

Crop water productivity = grain yield (kg/ha)/water consumed use (m^3/ha) (Abdel-motagally, 2010).

Table 1: Irrigation water requirement for each sorghum variety

Kodom variety							Melkam and Meko I						
Month	Dec	Stage	Kc	ETc	Eff rain	Irr. Req.	Month	Dec	Stage	Kc	ETc	Eff rain	Irr.req.
			coeff	mm/dec	mm/dec	mm/dec				coeff	mm/dec	mm/dec	mm/dec
Jul	3	Init	0.4	16.3	48.8	-32.5	Jul	3	Init	0.4	16.3	48.8	-32.5
Aug	1	Init	0.4	16.1	20.4	-4.3	Aug	1	Init	0.4	16.1	20.4	-4.3
Aug	2	Deve	0.43	16.9	0	16.9	Aug	2	Deve	0.52	20.5	0	20.5
Aug	3	Deve	0.6	26.1	0	26.1	Aug	3	Deve	0.75	32.4	0	32.4
Sep	1	Deve	0.79	31.3	34.2	-2.9	Sep	1	Mid	0.97	38.2	34.2	4
Sep	2	Deve	0.98	38.4	0	38.4	Sep	2	Mid	1.05	41.2	0	41.2
Sep	3	Mid	1.12	45.8	0	45.8	Sep	3	Mid	1.05	42.7	0	42.7
Oct	1	Mid	1.13	48.7	0	48.7	Oct	1	Mid	1.05	45	0	45
Oct	2	Mid	1.13	50.8	0	50.8	Oct	2	Late	1.05	46.9	0	46.9
Oct	3	Mid	1.13	52.9	0	52.9	Oct	3	Late	0.97	45.5	0	45.5
Nov	1	Late	1.13	44.9	0	44.9	Nov	1	Late	0.86	34.3	0	34.3
Nov	2	Late	1.04	39.4	0	39.4	Nov	2	Late	0.77	23.2	0	23.2
Nov	3	Late	0.93	33.9	0	33.9	-				-		
Dec	1	Late	0.82	23.3	0	23.3	-				-		
							-				-		
				484.6	103.4	381.2	-				402.3	103.4	298.9

Where Dec = decade; Init = inicial; Deve = development; Mid = middle; Late = late stag; ETc = Crop Evapotranspiration; Eff rain = Effective rain fall; Irr.Req = irrigation requirement.

Data collection

Soil sample at a depth of 0-30 cm was taken from five random spots diagonally across the experimental field using auger before planting. The collected soil samples were composite to one sample. The bulked soil samples were air dried, thoroughly mixed and ground to pass 2 mm sieve size before laboratory analysis. Then the samples were properly labeled, packed and transported to the laboratory for the analysis of major physical and chemical properties.

Five random plants from each net plot area (2.25 m * 3 m) were taken to measure plant height (cm) when the plants reached 90% physiological matured. Five randomly taken plants per plot from the net area were taken to measure leaf area (cm ^{2}). Physiologically well performed three leaves per plant were considered. It was determined at 50% heading using the method described by Sticker *et al.* (1961) as:

Leaf area = leaf length of the leaves x maximum width of leaf x 0.75. Where, 0.75= correction factor for sorghum. The unit leaf area of sorghum was calculated as leaf area = leaf area x number of leaves per plant. Similarly, leaf area index (LAI) was measured from five random plants per plot in which it was calculated as the ratio of unit leaf area per unit ground area from the net plot (Watson,1958)

Panicles of five sorghum plants, where data for sorghum growth parameters were taken, were bulked and mixed together at 12.5% adjusted moisture level (using Digital Grain Moisture Meter, Moistexss7satake) to determine head weight per plant (g plant^{-1}). From the bulked seed of the five plants that were tagged adjusted at 12.5% moisture level, 1000 kernels were counted using manually counting by daily man power to determine 1000 seed weight(g).

Grain yield were obtained by harvesting from all plants of net plot area. It was determined using sensitive balance after the grain had been dried, threshed and cleaned. After that it was converted to kg ha^{-1} basis. Correspondingly, the above ground biomass (kg) was measured after the plants from the net plot area were harvested and sun dried till constant dry weight was attained. Harvest index was also computed as ratio of grain dry weight to above ground dry biomass.

Data analysis

The collected data were subjected to statistically analysis. The analysis of variance (ANOVA) was carried out using Gen State version14 computer soft ware. Mean separation was carried out using least significance difference (LSD) test at 5% probability level as described in Gomez and Gomez (1984).

Nutritional analysis

The nutritional analysis of the sorghum grain was done at Melkassa Agricultural Research Center (MARC) using the grain Analyzer IM 9500 NIRS (Near Infra Red Spectroscopy) instrument. By using the IM 9500 NIRS instrument protein content (%), Ash content (%), Iron (mg kg^{-1}) and Zinc (mg kg^{-1}) content were determined. A sample of 300 gram sorghum grain of each experimental unit was prepared for the analysis. The prepared grain sorghum was filled simply to the loading part of the NIRS machine. Then; nutritional content of sorghum (Protein content, Iron content, Zinc content and Ash content) was recorded from the display part.

Economic analysis

Economic analysis was performed to investigate the economic feasibility of the treatments by using partial and marginal analyses. Marginal rate of return (MRR) was calculated as the change in net benefit (NB) divided by the change in total variable cost (TVC) of the successive net benefit and total variable cost levels (CIMMYT, 1988). Net benefit = Gross income - total variable cost. The average open market price (Birr kg^{-1}) for sorghum crops, the official prices of fertilizers and labor costs to apply fertilizer were used for analysis.

RESULTS AND DISCUSSION

Soil analysis

Analysis of soil samples before planting was done for the major physical and chemical properties at soil laboratory of Mekelle soil research center (Table 2). The soil of the experimental site has a proportion of 15% sand, 27% silt and 58% clay and it is classified as clay soil according to the soil triangle texturally (Table 2). The organic matter content of the soil was 1.95%, which is rated under low, in agreement with the finding of Tekalign (1991).

Moreover, the soil pH at the experimental site was 6.89. According to Tekalign (1991), soils having pH value in the range of 6.73 to 7.3 are considered neutral soils. The cation exchange capacity was 34 cmol (+) Kg^{-1} which is categorized as high(Hazelton and Murphy ,2007) .

As described in Table 2 the soil ECe at the experimental site was 0.12. According to Hazelton and Murphy (2007) soils having ECe less than 4 are considered as non saline and suitable for cereal production.

The results in Table 2 indicated that the soil comprised total N of 0.1008% and thus the composite soil sample of the experimental area was rated as low (London, 1991). The experimental soil contains available P of 6.6 mg kg^{-1}. According to Olson *et al* (1954), it has medium level of available P in the experimental site.

Table 2: Major soil characteristics of the experimental field before planting

Soil parameters	Unit	Value
Particle size distribution		
Sand	%	15
Silt	%	27
Clay	%	58
Textural class		Class
Organic matter	%	1.95
pH	-	6.89
ECe	ds m^{-1}	0.12
CEC	%	34
Total N	%	0.1008
Available P	mg kg^{-1}	6.6

Yield component, yield and water productivity

Plant height of sorghum was highly significant different (P<0.01) due to the effect of both varieties and fertilizer types.

The tallest plant height (281.3cm) of sorghum was recorded in the local variety of Kodem. While, the shortest plant height (152.2cm) was recorded in Melkam and was statistically similar with the plant height (159.0 cm) obtained in Meko variety (Table 3). The possible reason for this result could be due to the variation in genetic makeup or cell division rate that result in change in plant height of different varieties. This finding was in line with the finding of Tekle and Zemach (2014) that plant height were significantly affected by varieties of sorghum. Hussain *et al.* (2011) also reported significant variation among sorghum varieties in plant height. Consistent with this result, Mihret *et al*. (2015) reported that highly significance variation due to the effect of varieties in sorghum.

As fertilizer application rate increases from nil to the blended fertilizer type F5, the plant height also increased from 192.2 cm to 201.7 cm (table 3). This increment might be due to high amount of nitrogen level and high level of phosphorus as nitrogen and phosphorus are the major nutrients that affect cell elongation and vegetative growth of plant parts. In agreement with this result, Dagne (2016) reported that a significant variation was obtained in plant height of maize due to the effect of blended fertilizer types.

Panicle length of sorghum was significantly affected due to the effect of varieties (Table 3). The highest panicle length (30.98cm) was recorded for the improved varieties of Melkam and statistically as par with local variety of Kodom (30.29cm). The minimum panicle length (24.52 cm) was recorded in the case of MekoI variety (Table 3). The increase in panicle length could be due to the genetic make of the variety. In agreement with this result, Wondewosen and Tekle (2014) reported that early maturing sorghum varieties typically have smaller panicle length than late maturing type. Similarly, Namoobe *et al*. (2014) found out that varieties had a significant effect on panicle length with longest panicle length of 28.4 cm and shortest length of 17.6 cm.

The panicle length of sorghum was not significantly different (P>0.05) due to the application of fertilizers (Table 3). Increasing trend in blended fertilizer and amended with N and P (F5) fertilizer shows a corresponding increment of panicle length as compared with the nil fertilizers.

As described in Table 3, leaf area was highly significantly varied (P<0.01) due to the main effect of variety and fertilizer. The maximum leaf area was obtained in the local variety of Kodom which have late maturity and have large number of leaves as compared to the improved varieties (Table 3). On the other hand the least leaf area was recorded on MekoI variety of sorghum. The main reason for this result could be due to presence of large number of leaves, maximum leaf length and width of the varieties because of genetic makeup difference. These results indicated that sorghum varieties with higher leaf area can produce more food through photosynthesis as leaf is responsible part for preparation of food and may have higher biomass or grain yield. In line with this result, Bahar *et al.* (2015) reported that significance variation in leaf area among five varieties of sorghum.

As indicated in Tables 3 application of blended fertilizer and recommended DAP and urea highly significantly affected the leaf area as compared to control. The highest leaf area (6103 cm^2) was obtained under the application of recommended blended fertilizer amended with N and P fertilizers and was statistically similar with recommended Urea and DAP (F2), recommended NPSZn (F4) and NPKSzn (F6) fertilizers. But, the lowest leaf area (5510 cm^2) was obtained from the plots without fertilizer application. This finding complement to the work of Dagne (2016) who reported that application of blended fertilizer with Cu and Zn affects the leaf area of maize. Berhane *et al.* (2015) similarly reported that application of high N fertilizer increases leaf area of sorghum.

Likewise the leaf area, variety and fertilizers showed highly significance variation on the leaf area index but non- significance effect due to the interaction of variety and fertilizer (table 3). Difference in genetic make of the variety may cause variation in leaf area index. Accordingly, the highest LAI (4.93) was recorded in the Kodom variety and the smallest LAI (2.60) obtained from the Meko I variety (Table 3). This result is due to the fact that leaf area index depends on the number of leaves per plant and the stage of the growth. This current result was in line with Addai and Alimiyawo (2015) who found thatvarieties of sorghum significantly affect the LAI of sorghum.

Addition of the major nutrients of N and P in the blended fertilizer NPSZn increases the leaf area index. Accordingly, the largest leaf area index (4.07) was recorded due to the application of blended fertilizer amended with N and P and statistically at par with other blended fertilizers that produced 10.9% LAI increase over the unfertilized treatments (Table 3).Gebrelibanos and Dereje (2015) similarly reported that application of high fertilizer increases leaf area index of sorghum. Similar to this result, Addai and Alimiyawo (2015) reported that the application of NPK fertilizers to the Sorghum variety called Dorado significantly increased leaf number, seed weight, grain yield and LAI.

Panicle weight of sorghum was significantly affected due to the main effect of variety and fertilizers. Meko variety gave significantly the lowest panicle weight per plant as compared to Melkam and Kodem varieties (Table 3). The highest panicle weight (100.84gram) was recorded at the case of Melkam variety due to the presence of high panicle length. In agreement with this result, Namoobe *et al.* (2014) reported that panicle weight of sorghum was significance affected by varieties.

Application of blended fertilizer resulted in increase in panicle weight of sorghum (Table 3). The maximum panicle weight (102.88 gram) of sorghum was recorded on the highest fertilizer application rate (F5) and statistically as par with the recommended blended fertilizer of F4 when compared with the minimum panicle weight (83.44 gram) in nil fertilizer application. This could be due to the role of the essential nutrients in enhancing the seed holding capacity of the panicle. This result is in line with the finding of Berhane *et al.* (2015) who reported that panicle weight of sorghum was significantly affected by the application of high amount of nitrogen. Similarly, Brhan (2012) found that application of blended fertilizers have significance effect on seed weight per panicle on teff. Moreover, Gebrelibanos and Dereje (2015) reported that application of high amount of fertilizer have significance variation on yield per panicle of sorghum.

As indicated in Table 3 the analysis of variance showed that there was significance difference ($p<0.5$) due to the main effect of varieties and fertilizers on the 1000kernel weight of sorghum. The interaction of variety and fertilizer did not show any significance difference on the thousands kernel weight of sorghum. The maximum 1000 kernels weight of 46.28 gram was recorded for the local variety Kodem and the minimum 1000 kernel weight of 32.17 gram and 30.83gram were recorded for the improved variety of Melkam and Meko, respectively (Table 3).

The more thousands grain weight could be due to the difference in genetic makeup of the variety and environmental factor. This finding is in line with finding of Wondewoson and Tekle (2014) who reported that1000 kernel weight was significantly different due to varieties. Similarly, Mihret *et al.* (2015) found that the thousand kernel weight of Melkam and Meko were 30.9 gram and 33.3 gram, respectively. Similarly, Tekle and Zemach (2014) found that maximum thousands seeds weights of 28.7 gm, 27.667 gm and 27.000 gm were recorded for the improved sorghum varieties of Meko-1, Teshale and Gambella 1107, respectively while, the minimum 1000 seeds weight of 20.33 gm was recorded for the local check.

The highest (37.89g) and the lowest (34.44g) average thousands kernel weight were obtained with application of blended fertilizer amended with N and P, and control respectively (table 3). However, there was no significance difference between the recommended DAP and urea, blended fertilizers NPS and blended fertilizer NPKSZn. The mean values of thousands kernel weight were increased by 7.4 and 8.5 % in the blended fertilizer (F4) and blended fertilizer amended with N and P(F5) as compared with control, respectively.The more grain weight could be due to positive interaction of nutrients in the blended fertilizers. This might be also as a result of the contribution of nutrients in photosynthesis process and movement of its products to storage organs (seeds, tubers and fruits). This result is in line with the finding of Dagne(2016) that reported significance difference on thousands kernel weight of maize due to the effect of blended fertilizer.

Table 3: Main effect of varieties and fertilizer on yield component, yield and water productivity of sorghum

Varieties	PH (cm)	PL (cm)	LA (cm^2)	LAI	TKW (gram)	PW (gram $plant^{-1}$)	GY (Kg ha^{-1})	BY (Kg ha^{-1})	HI	WP (Kg m^{-3})
Kodom	281.3a	30.29a	7392a	4.93 a	46.28a	94.32ab	4650a	15984a	0.29c	0.96b
Meko	159.0b	24.52b	3895c	2.60c	30.83b	84.38b	4042b	9215b	0.44a	1.00b
Melkam	152.2b	30.98a	6353b	4.23b	32.17b	100.84a	4962a	10981b	0.46a	1.23
LSD	11.29	1.56	720.35	0.48	4.22	11.53	447.02	2600.78	0.11	0.24
CV	2.5	2.4	5.4	5.4	5.1	5.5	4.3	9.5	12.2	5.0
Fertilizers										
F1	192.6c	27.81	5510c	3.67c	34.44 c	83.44c	3931d	11289d	0.37c	-
F2	200.6a	28.64	5848ab	3.90ab	35.89b	91.49b	4597b	12074bc	0.41ab	-
F3	196.3b	28.40	5824b	3.88b	36.00b	90.33b	4342c	11761c	0.39b	-
F4	197.4b	28.42	5974ab	3.98ab	37.44a	99.02a	4715b	12300ab	0.40b	-
F5	201.7a	29.31	6103a	4.07a	37.89a	102.88a	5107a	12672a	0.42a	-
F6	196.6b	29.00	6021ab	4.01ab	36.89b	91.92b	4615b	12263ab	0.40b	-
LSD (p=0.05)	3.11	NS	260.86	0.17	1.26	5.92	201.99	468.91	0.02	-
CV	1.6	3.5	4.6	4.6	3.6	6.6	4.6	4.0	4.9	-

PH = plant height; PL = panicle length; LA = leaf Area; LAI = leaf area index; TKW = thousands kernel weight; HI = harvest index; WP = water productivity; Means followed by the same letter is not significance difference; PW = Panicle weight; GY = grain yield; BY = biomass yield.

Biomass yield is an important output as farmers are also interested in biomass yield for animal feed in addition to grain yield. As displayed in table 3 there was significance variation on the above ground dry biomass due to the effect of variety and fertilizers and no interaction effect on the variety and fertilizer. The highest above ground dry biomass yield (15984kg ha^{-1}) was obtained from the local variety Kodom and exceeds 45.56 % and 73.45% over the other varieties of Melkam and MekoI, respectively (Table 3).

In agreement with this result, Hussain *et al.* (2011) reported that varieties significantly affected the stalk yield of sorghum. Similarly, Wondoweson and Tekle (2014) and Mihret *et al.* (2015) reported that like grain yield significance difference among varieties of sorghum was found in above ground biomass yield.

The highest biomass yield of 12672 kg ha^{-1} is obtained from the application of blended fertilizer amended with N and P (F5) which was statistically at par with the application of blended fertilizer NPKSZn (F6). In contrary, the lowest dry above ground biomass of 11289 kg ha^{-1} was obtained from the nil fertilizer plots (Table 3). The strength of above ground part of sorghum plants due to high nutrients particularly N and P enables them to harvest ample solar radiation, which may result into the corresponding increment of photosynthetic rate. Related to this Finding, Piri (2012) found highest biological yield obtained from treatment of 200 kg ha^{-1} of P and the lowest belonged to 50 kg ha^{-1} of P that showed an increase by 77.16 percent in the biological yield of sorghum as compared with the 50 kg ha^{-1} P treatment. Similarly, Berhane *et al*. (2015) found that application of high N level results in high amount of biomass yield in sorghum. Likewise, Brhan (2012) found that high biomass yield is obtained from treatments that receive blended fertilizers compared with plots that receive DAP and urea and control plots in teff production.

The analysis of variance (Table 3) showed that the interaction effect of variety and fertilizer did not cause significance difference on the harvest index. On the other hand, significance difference ($P<0.05$) and highly significance difference ($P<0.01$) was observed due to the main effect of variety and fertilizers respectively. As presented in Table 3, the highest harvest index (0.46) was recorded in the improved variety of Melkam and statistically at par with Meko (0.44). The lowest harvest index (0.29) had been seen in the local variety Kodom (Table 3). Thus, as per the obtained results of high harvest index in the improved varieties, it can be implied that there is good partitioning of dry matter to grain yield in the improved varieties of sorghum than the local check variety. In contrast to this finding, Tekle and Zemach (2014) and Melesse (2016) found that there was no significance difference on the harvest index due to the main effects of sorghum varieties. The possible reason for this could be due to less partitioning of biological yield to economical yield of the long maturing and high plant height of the local variety and leads to high above ground dry biomass.

Table 3 also indicated that the highest (0.41) and lowest (0.37) harvest index had been due to the application of blended fertilizer amended with N and P (F5) and nil fertilizer, respectively. Likewise, there was no significance difference between harvest index obtained due to the application of blended fertilizer and recommended N and P alone. Thus, harvest index (HI) indicates the balance between the productive parts of the plant and the reserves, which form the economic yield. High harvest index indicated that the presence of good partitioning of biological yield to economical yield. Comparable reports by Brhan (2012) treatments received that blended fertilizers have high harvest index compared with the nil fertilizer treatments. In line with this Berhane *et al.* (2015) found that highest harvest index of 41kg N ha $^{-1}$ as compared with the nil fertilizer treatments.

The ultimate goal in crop production is maximum economic yield, which is a complex function of individual yield components in response to genetic potential of the cultivars and input used. Sorghum grain yield was significantly ($p<0.05$) affected by the main effect of varieties and fertilizers (Table 3). The interaction of variety and fertilizer did not show significance difference on the grain yield. As indicated in Table 3, the highest grain yield (4962kg ha^{-1}) was obtained from Melkam variety which was statistically at par with the local variety Kodom (4650kg ha^{-1}) while, the lowest grain yield (4042kg ha^{-1}) was obtained from the Meko I variety. Melkam gave 22.76% more grain yield than MekoI for which the lowest grain yield was obtained.

This result was in line with Mihret *et al.* (2015) reported that maximum grain yield of 5004Kg ha^{-1}, and 4562 Kg ha^{-1} were recorded for the sorghum varieties of Melkam and Meko I, respectively. This variation in yield might be due to the fact that crop yield is affected by the genetic make of the crop, climate, soil and management practice. Similar result was reported by Hussain *et al*. (2011) and Melese (2016) 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 thousands seeds weight, panicle length and panicle weight (Tekle and Zemach, 2014).

Application of blended fertilizer amended with N and P was significantly higher than other treatments. As displayed in table 3, the significantly highest grain yield (5107 kg ha^{-1}) was recorded from the blended fertilizer NPSZn amended with N and P, while the lowest grain yield of 3931 kg ha^{-1} was obtained from the unfertilized plots. Grain yield advantages of 29.92%, 17.62% and 11% were obtained from blended fertilizer amended with N and P over the unfertilized plot, plots received the blended fertilizer NPS and plots received DAP and Urea, respectively.

The maximum grain yield was obtained from the fertilizer types blended NPSZn as compared numerically with other blended fertilizers types. The lowest yield was obtained in unfertilized plots, which might be due to low fertility of the soil. This is in line with Dagne (2016) who reported that blended fertilizer and bended fertilizer with Cu + Zn have highly significance difference on the grain yield of maize. Similarly, Brhan (2012) reported that application of blended fertilizers under the planting method significantly affects grain yield of tef. Moreover, Sujathamma *et al*(2015) found that application of high amount of blended fertilizer result in maximum grain yield of sorghum as compared with the small amount of blended fertilizers.

Table 4: Main effects of varieties and fertilizer on protein content, iron, Zinc, moisture and Ash content

varieties	Protein (%)	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Ash (%)
Kodom	10.59b	47.35b	24.22	2.26
Meko	11.53ab	55.34a	24.68	2.19
Melkam	12.23a	57.88a	24.19	2.12
LSD(p=0.05)	0.43	3.93	Ns	Ns
CV	4.6	3.2	2.9	3.7
Fertilizers				
F1	10.86c	52.29	24.16	2.22
F2	11.52ab	53.43	24.49	2.21
F3	11.31bc	53.06	24.62	2.19
F4	11.23bc	53.48	24.18	2.18
F5	11.82a	54.24	24.35	2.21
F6	11.93a	54.63	24.37	2.15
LSD	0.22	NS	NS	NS
CV	4.1	6.1	3.2	3.3

Means with the same letter (s) are not significantly different at P< 0.05; LSD: least significance difference; CV = coefficient of variance; NS = non significance.

Table 5: Partial and dominance budget analysis of variety and fertilizers

Treatment combination	Total Cost (ETB ha^{-1})	Net benefit (ETB ha^{-1})	Domination rank
Kodom F1	80	37673.35	-
Meko F1	90	31072.27	D
Melkam F1	90	36447.77	D
Kodom F4	1728	41738.66	ND
Meko F4	1738	34849.92	D
Melkam F4	1738	43017.67	ND
Kodom F3	1970.24	38881.97	D
Meko F3	1980.24	31956.48	D
Melkam F3	1980.24	38768.60	D
Kodom F6	2200	42244.40	D
Meko F6	2210	31587.78	D
Melkam F6	2210	42022.75	D
Kodom F5	3010.57	43513.90	ND
Meko F5	3020.57	37142.71	D
Melkam F5	3020.57	44601.62	ND
Kodom F2	3050.56	40493.78	D
Meko F2	3060.56	31687.56	D
Melkam F2	3060.56	40443.84	D

Where; D = dominated treatment; ND = Non dominated treatment.

The analysis of variance showed that water productivity was highly significance ($P<0.01$) variation due to the main effect of varieties. Melkam variety recorded the highest value of water productivity (1.23 kg m^{-3}). The lowest water productivity (0.96 kg m^{-3}) was recorded at the long maturing local variety Kodem (Table 3). In line with this result; Abdel-Motagally (2010) found that water productivity was highly significant due to the varieties of sorghum and Shandweel-6 cultivar with highest value of water productivity of 1.54 kg m^{-3} as compared to other cultivars. Inclusion and promotion of drought–tolerant crops and varieties is required in arid and semi–arid agro–ecological zones of the world where water scarcity is a major limitation to cereal production.

Nutrition content

Four parameters of nutritional quality were considered in the present study (protein content, iron content, zinc content and ash content).

Sorghum varieties exhibited significant ($P<0.05$) variation on the protein content (Table 4). The protein content ranged from 10.59 up to 12.23 %. The maximum protein content was recorded in the improved variety of Melkam (12.23%) and statically similar with Meko variety (11.53%). The minimum protein content (10.59%) was observed in the local variety Kodom (Table 4). This variation is due the fact that protein content was affected by genetic make of the variety. In addition to grain yield, selection or improving of high nutritional value including protein content is important parameter in sorghum production. In agreement with the obtained result, Legodimo and Madibela (2013) reported that the protein level of grain was highly significant different among four cultivars of sorghum with the highest (13.8%) for Mahube variety and the lowest (10.1%) for Phofu variety. Similarly, Diallo (2012) reported that genotype of sorghum was highly significant different in the protein content that ranges from 8.58 up to 12.53%. Besides, Faisal *et al*. (2013) made a study on effect of maize varieties on protein content and found that significance variation in protein content due to the genetic difference.

The analysis of variance showed that there were highly significance variations among the main effect of fertilizers. The NPKSZn (F6) produced highest protein content (11.93%) which was statically at par with the blended fertilizer NPSZn amended with N and P F5 (11.82) and recommended Urea and DAP (11.52). The lowest protein content (10.86%) was produced in the unfertilized plots (Table 4). The increase in protein content is due to the fact that nitrogen is essential for synthesis of amino acids which builds the nitrogen content into high protein amount. The increase in crude protein content also might be due to the fact that P is an important structural component of DNA and RNA (Mengel and Kirkby, 2001). Suha *et al*. (2015) reported that the application of micronutrient enriched NPK fertilizer improves the nutritional quality by increasing the protein content and amino acid in the harvested grain.

Iron content was varied significantly due to the main effect of varieties; however, there was no significance variation on the zinc content due to the main effect of varieties and due to the fertilizers effects both in the iron and zinc content (Table 4). But the maximum zinc content was recorded at MekoI variety. In the case of the fertilizers high amount of iron was found at F6 and F5 fertilizers respectively and lowest one was at the unfertilized plot F1. In contrast, to this zinc content ranged between 24.18 and 24.62 with the maximum amount at fertilizer F3.

As displayed in table 4 the highest iron content (57.88 mg kg^{-1}) was recorded at improved Melkam variety and was statistically at par with MekoI variety. The lowest Iron content was gained from the local variety of Kodom. This is due to the fact that genetic difference has variations in the amount of micronutrient amounts in crop plants. In addition to the grain yield potential selection of high amount of Fe and Zn varieties is important to fighting the micronutrient starvation.

In agreement with this result, Ashok *et al*. (2010) found that the grain Fe content in sorghum was significantly different due to the effect of genotypes and varied from 29.8 to 44.2 mg kg^{-1}. Similarly, Ashok *et al.* (2013*)* reported that significant difference among varieties of sorghum in Fe content and ranged from 26 to 60 mg kg^{-1}.

Table 6: Marginal budget analysis of variety and fertilizer

Treatment combination	Total Cost (ETB ha^{-1})	Mariginal cost	Net benefit (ETB ha^{-1})	Marginal net benefit	MRR= MNB MC
Kodom F1	80	-	37673.35	-	
Kodom F4	1728	1648	41738.66	4065.31	246.68
Melkam F4	1738	10	43017.67	1279.01	12790.10
Kodom F5	3010.57	1272.57	43513.90	496.23	38.99
Melkam F5	3020.57	10	44601.62	1087.72	10877.20

Where; MRR= marginal rate of return; MNB = Marginal net benefit; MC= marginal cost.

Ng'uni *et al* (2011) found that Sorghum varieties exhibited significant variations in grain content of micro nutrients and Grain Fe content that ranged from 2.74 to 8.2 mg/100 g with a mean of 4.11 mg/100 g. A narrow range of 2.03 to 5.5 with the average of 2.79 mg/100 g was observed for grain Zn content. Pontieri *et al* (2014) found that there was high variation in Iron and Zinc due to the main effect of varieties. The two elements are essential micro elements in human nutrition and their deficiency are major public health threats worldwide (Ashok *et al*, .2010).

The ash content of the sorghum was not significantly ($p>0.05$) affected due to the main effect of variety, fertilizer and their interactions (Table 4). The ash content ranged from 2.12 % up to 2.16 % in the variety. The highest ash content was recorded from the local variety Kodom. The ash content in the fertilizer ranges from 2.15% up to 2.22%. This might be due to the effect of environment and genotype on the ash content of the crop. In line with this result, Pontieri *et al* (2014) found that there was no significance difference on the ash content of sorghum and ranged from 1.63% to 2.90%.

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, kinds and amount of fertilizer they apply as well as cost of fertilizer and price of yields are determining factors (Black, 1992). In the study area the demand and market price of sorghum grain and above ground dry yield is relatively important. Due to this fact increasing both grain and above ground yields can increase farmers' income.

The economic analysis of sorghum as affected by different varieties and fertilizers are presented in table 5. It is indicated that a maximum net benefit of (44601.62 ETB ha^{-1}) net benefit was obtained from the combination of Melkam variety with blended fertilizer amended with N and P (F5), while the minimum (31072.27ETB ha^{-1}) net benefit was noted from the Meko variety with the unfertilized treatment (Table 5).

The highest marginal rate of return (12790.10 %) was obtained from the combination treatment of melkam variety with NPSZn (F4) fertilizer followed by (10877.20%) NPSZn amended with enough N and P (F5) with Melkam variety (Table 6).

Generally, the analysis of marginal rate of return (MRR) indicated that the application of blended fertilizer and recommended fertilizers on productivity of sorghum had MRR of greater than 100. This indicates that sorghum production is profitable with these all alternatives. According to CIMMYT (1988), application of fertilizer with the marginal rate of return above the minimum level (100%) is economical. In agreement with this result Shah *et al. (*2011) reported that the maximum rate of return (446.21%) was recorded from the plots in which 120 kg Nha^{-1} was applied whereas the minimum rate of return (296.67%) was noted from the unfertilized plots.

Conclusion

This Experiment was conducted in Mehoni Agricultural Research center (MhARC) test station in 2016/2017 cropping season under irrigation to investigate the Effect of blended fertilizer on yield, nutritional content, and economic performance of sorghum varieties. The result obtained in this study showed that sorghum yield component, yield and nutritional content was significant affected by the main effect of variety and fertilizers.

The highest yield, nutritional content and high economic return were obtained from Melkam variety. Regarding to the fertilizer type, blended fertilizer amended with enough amount of Nitrogen and phosphorous gave the highest yield, nutrianal content and economic return. Based on the results of this study, it can be recommended that the Melkam variety and the blended fertilizer of NPSZn amended with enough amount of N and P fertilizer can be recommended for the study area.

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