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Agropastoralist Evaluations of Integrated Sorghum Crop Management Packages in Eastern Ethiopia

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Abstract

On farm participatory field experiment was conducted in 2013 cropping season in districts located in eastern Ethiopia to evaluate effect of different sorghum crop management packages on grain and fodder yield of improved variety *Teshale* and local check *Elmijam*. Six different sorghum management alternatives along with agro-pastoralist indigenous management practice were evaluated in six randomly selected agro-pastoralist fields in Ethiopian Somali province Fafen administrative Zone. The result reviled that compared to agro pastoralist indigenous practices on both varieties improved production practice had significantly increased fodder and grain yield of sorghum by 60-70%. The result also showed significant varietal differences between improved variety *Teshsale* and the local check *Elimjem*a in all aspects. Therefore based on agropastoralist interest and rating production packages composed of improved sorghum and local check variety, tide-ridge planting, fertilizer (urea and DAP application at 50 kg/ha and 100 kg/ha), hand weeding once at 45 days after emergence and with recommended seed rate 10 kg/ha were selected as best management package because it balanced both grain and fodder yield with the production costs.

Keywords: Participatory; Evaluations; Sorghum; Integrated; Management; Packages

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important cereal crops in the semi-arid tropics Catherine et al. [1]. It is the most widely grown cereal crops in Ethiopia 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 Asfaw [2]. Sorghum grows in a wide range of agro ecologies most importantly in the moisture stressed parts where other crops can least survive and food insecurity is rampant. Ethiopian national average yield is 1.302 ton/ha it far lower than other developing country and the world. The low productivity of sorghum in Ethiopia could be attributed to biotic and edaphic factors affecting directly and indirectly sorghum production and productivity Tekle and Zemach [3].

Sorghum is drought tolerant, widely produced and popular cereal crop in pastoralist and agro-pastoralist communities in eastern Ethiopia in Somali regional sate Mahdi et al. [4]. The target area is characterized by erratic rainfall and recurrent drought therefore the yield obtained is significantly lower than the other parts of the county. Mekbib F [5] reported that the low productivity of sorghum in this area could be due to the low level of sorghum research and low input production systems. Beside its popularity in Eastern part of the country its productivity is constrained by numerous factors. Among the factors including unspecified planting density, unfavorable rainfall patterns, soil infertility, and low yield potential of available varieties at farmers hand, poor crop management skills and low extensions systems contributed a lot in yield reduction and resulting food insecurity in the study area.

Traditional sorghum management practice in the study area involves seed broadcasting densely, no fertilizer application no weed management practices are employed moreover farmer don't use early maturing sorghum variety and don't know how to conserve soil moisture. This had resulted in reduced sorghum both grain and fodder yield. Currently no recommended integrated crop management practice for sorghum crop is available for the agro-pastoralist. Most research conducted in sorghum only focused on varietal improvement and agronomic practice limited only on fertility and planting density and the recommendations were also presented separately. Such kind of findings may not help the growers unless they integrated in suitable manner. Livelihood of current study area is characterized as pastoralism and agro-pastoralism this indicates that there is poor skill and knowledge of integrated crop management practices that led to the lower crop yield per unit of area there by resulting food insecurity Mahdi et al. [4].

According to Bellon [6] farmer participation in agricultural research is the most efficient way of technology transfer and adoption of new technology. Many innovations have spread from farmer to farmer without the intervention of any formal agricultural extension services Bellon, and Reeves [7]. It is crucial to involve agropastoralist or farmers in every step of technology development and transfer Obaa et al. Freeman [8,9]. Therefore current study was undertaken to evaluate effect of different sorghum crop management practices on grain and fodder yield of tow sorghum cultivars through participatory farmers' researchers' group approach in agro-pastoralist community in the eastern Ethiopia.

Description of study area

On-farm field experiment was conducted in Ethiopian Somali region Fafen zone Gursum district on randomly selected agropastoralist field. The area is located between 9º 15'N 43º00'E at an altitude of 1746 meter above sea respectively. It experiences a bimodal type of rainfall classified as a short from March to April rainy season and a main rainy season is from June to September with mean annual precipitation of

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890.55 mm. The mean annual temperature of the area is 28.21°C the soil of the area is characterized as light sandy to alluvial soil. (Figure 1) The farming system of area is mainly agro-pastoralism and they mostly produce sorghum, maize, wheat, and chat through traditional agronomic practices Mahdi et al. [4].

Establishing researchers and agropastoralist research group

A total of 56 participant farmers composed of female 16 and 30 male were selected from six villages in Gursum districts to form agropastoralist and researchers group. The researchers were composed of multi disciplinary and multi institutes including three local university researchers, invited two local research institute researchers and two district agriculture department experts with different fields of specializations.

Treatments and methods of evaluations

Six different sorghum management alternatives along with farmer's indigenous management practice were evaluated in six randomly selected agro pastoralist fields' in villages in Fafen administrative zone. Improved and local check sorghum verities namely *Teshale* and *Elimjema* respectively planted in experimental plot threatened with different production packages. The size of each plots were 7 m by 10 m each plots were separated by 2 m distance there were a total of 7 plots replicated in six different agropastoralist field. Participant agropastoralist evaluated production packages presented on trails on selected group of agropastoralist field. They evaluated sorghum management alternatives from different perspectives. They set their own six important treats including days to emergence, days to heading, and days to maturity, fodder and grain yield. .

Methods of data collections and analysis

Participant agro pastoralist evaluation data was collected using farmers ranking methods modified 1-4 scale was developed from Bellon MR [6] Bellon and Reeves [7], Obaa et al. [8] and Freeman HA [9]. Scale was developed after farmers picked five different types of livestock based on their importance to them (Table 1). Cards were prepared using livestock symbols selected by participant agro pastoralist. Then the cards with four types of live stock symbols were distributed among participant agro pastoralist finally they were allowed to cast the cards that contain livestock symbol in the basket prepared in front of the treatment plots for five types of quality parameters including days to emergence, heading, maturity, fodder and grain yield. After evaluations coded data was summarized ANOVA and descriptive statistics were performed using SPSS version 17 software (Table 2).

Results

Days to emergence, heading and maturity

Based on the agro-pastoralist perception the maximum (Good) rate was given to T6, T7 and T2 respectively for early emergence, they also rated T5 and T 4 as fair where T1 ranked as poor. Similarly participant agro-pastoralist evaluated days to heading and maturity of treatments

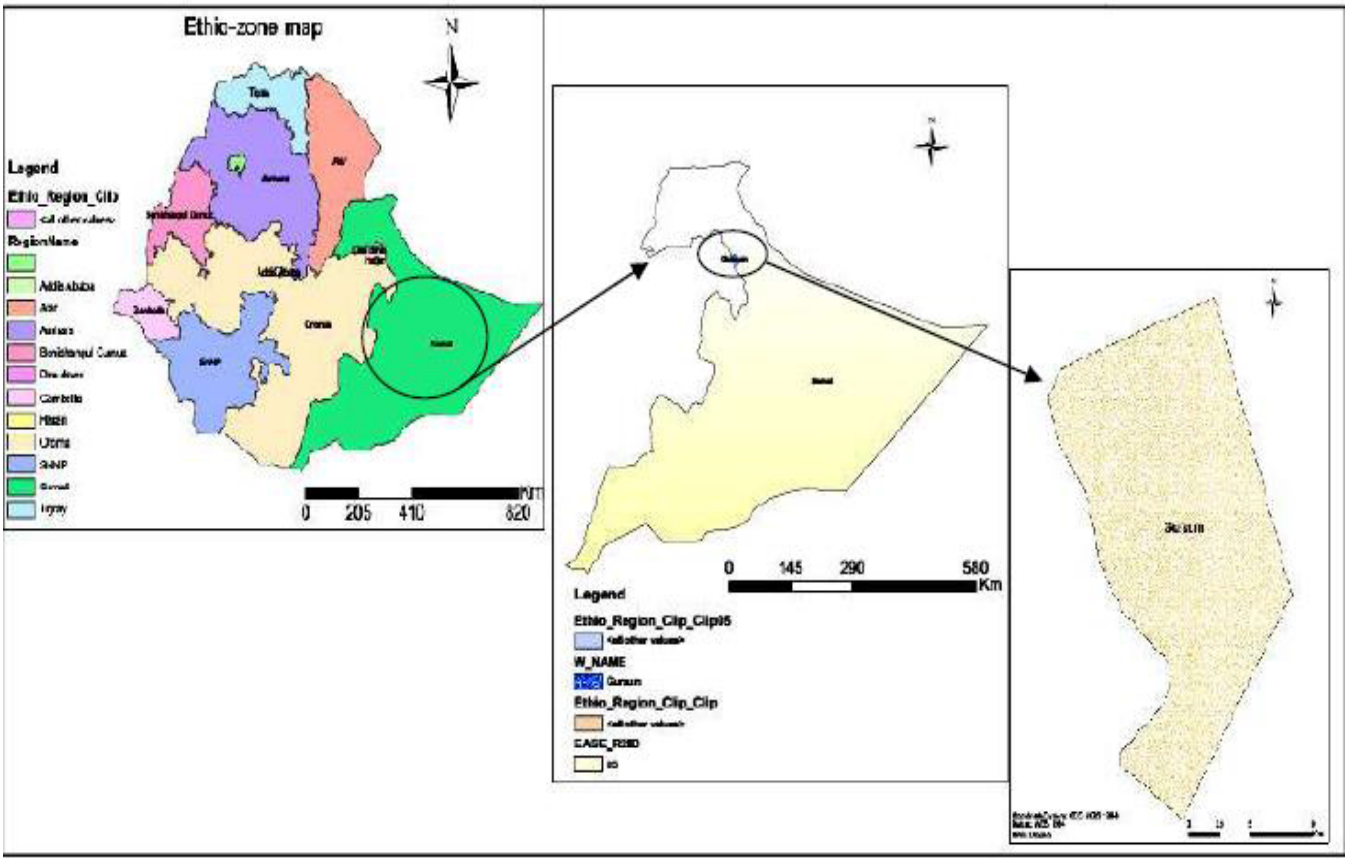

Figure 1: Shows map of Ethiopia, Ethiopian Somali province and Fafen administrative zone districts.

accordingly they gave maximum (Good) grade for T2, T4, T6 and T7 fair for T1 and poor for T5. In general participant agro pastoralist perceived that improved variety *Teshale* had advantage over their local one on days to emergence, heading and maturity. Agropastoralist observed that days to emergence of T1 and T3 was delayed compared to the other treatment this due that general crop management practices and seed quality in which participant agropastoralist used local seed and placed it deeper and coved it with traditional moldboard plough to the depth of at least 10 cm in average. The other treatments including T2, T4, T5, T6 and T7 showed early emergence.

They also differentiated effect of management practices on crop days to heading and maturity beside the varietal differences. Participant agropastoralist indicted that compared to their local management practices (T1) management practice involving tide-ridge planting, fertilizer (N at 50 kg/ha and P 100 kg/ha) and hand weeding once at (T6) resulted early heading and maturity. In this study variety *Tehsale* was significantly earlier than the local check both in days to heading and maturity regardless of management intensity. It was observed that compared to control treatment (T1 and T2 agro-pastoralist indigenous practice) application of fertilizes, weeding twice, straw mulch application at 2 ton/ha and tide-ridge planting for both varieties resulted in slight delay in heading and in maturity. Moreover when local agropastoralist variety was treated with in the same management at (T5) it became let for heading and maturity. Agropastoralist concluded that early matured improved sorghum variety *Teshale* was excellent type of variety when the rainfall condition is unreliable and short. They also indicated that it could be planted twice in a single season during long rainy season (from June to October) in the area (Table 3).

Fodder yield

The other participant agro-pastoralist criteria was fodder yield in this parameter the highest rank excellent(4) and good was give to treatment (T5) and followed by (T4) and where they categorizes T6 and T7 as fair and T2 as poor. According to their evaluations when local check sorghum variety was tasted in intense managements in T4 and T5 it produced maximum amount of fodder at this level improved variety (*Teshale*) showed low fodder yield under the same management it was categorized as poor to fair. Participant agro-pastoralist view of this parameter of the treatments revealed that better fodder yield could be obtained from the local variety through management intensification. They also compared fodder yield of both local check and improved variety under the same management they found that the local check was superior over the improved one. All treatments composed of *Teshale* showed reduced fodder yield (T2, T6 and T7) it was because *Teshale* was significantly shorter than that of local and it had also low number of leaf/plant and stem was also thin.

Livestock Symbol	Scale	Definitions
Camel	4	Excellent
Cow	3	Good
Goat	2	Fair
Chicken	1	Poor

Table 1: Modified agropastoralist treatment rating scale.

Grain yield and yield component

Finally participant agropastoralist compared and ranked total grain yield obtained from of each treatment. Based on their evaluations T6 and T7 ranked as good and the rest T5, T4, T3 and T2 evaluated as fair and T1 poor respectively. At this stage participant agropastoralist able to compare yield obtained from different treatments they also compared grain yield difference of both varieties at similar management. According to participant agropastoralist view grain yield obtained from improved variety *Teshale* was very high compared to their local check under similar management intensity. They indicted that grain yield obtained at T6 and T7 was far greater than other treatments. They perceived crop management options in T6 and in T7 had contributed in yield increment beside the nature of the variety.

Participant agropastoralist clearly demonstrated their understanding toward the use of early maturing variety and improved cultural practices. They explained early maturing sorghum variety not only excellent in crop yield but also it can be planted twice in one season as it matures early. During group discussion agropastoralist pointed out that tide-ridge planting and straw mulch application with fertilizer as most advantages compared with their tradition management practices (T1 using their own variety and T2 using improved variety respectively). They also noted that flat planting as not effective method for moisture conserving as tide-ridge they explained tide-ridge planting was an excellent way to conserve moisture and applied nutrient.

Discussion

Participant agro-pastoralist concluded that early days to emergence observed on both varieties were due to treatments especially on tide-

Code	Treatments detail
T1	Agropastoralist seed and indigenous management practice (local sorghum variety *Elmijama* was planted broadcasted planting pattern in flat bed densely and fertilizer was not applied. When the plant was 45 days old it was cultivated by locally produced animal drown cultivator.
T2	Improves variety *Teshale* with Agro-pastoralist practice. The seed was planted in broadcasted planting pattern in flat bed densely and fertilizer was not applied. When the plant was 45 days old it was cultivated by locally produced animal drown cultivator
T3	Agropastoralist variety *Elmijama* was planted in flat bed with row spacing (70 cm × 30 cm) with recommended seed rate at 8 kg/ha. N and P fertilizers were applied in the form of urea and DAP at 50 and 100 kg/ha respectively. When the plants were 45 days old it was hand weeding once.
T4	Agro-pastoralist variety *Elmijama* was planted in tied-ridge with row spacing (70 cm × 30 cm) with recommended seed rate at 8 kg/ha. N and P fertilizers were applied in the form of urea and DAP at 50 and 100 kg/ha respectively. When the plants were 45 days old it was hand weeding once
T5	Agro-pastoralist variety *Elmijama* was planted in tied-ridge with row spacing (70 cm × 30 cm) with recommended seed rate at 8 kg/ha. N and P fertilizers were applied in the form of urea and DAP at 50 and 100 kg/ha respectively. Dried straw mulch was applied at the rate of 2 ton/ha. The crops were weeded twice when the plants were 45 and 82 days old.
T6	Improved sorghum variety *Teshale* was planted in tied-ridge with row spacing (70 cm × 30 cm) with recommended seed rate at 8 kg/ha. N and P Fertilizers were applied in the form of urea and DAP at 50 and 100 kg/ha respectively. When the plants were 45 days old it was hand weeding once
T7	Improved sorghum variety *Teshale* was planted in tied-ridge with row spacing (70 cm × 30 cm) with recommended seed rate at 8 kg/ha. N and P Fertilizers were applied in the form of urea and DAP at 50 and 100 kg/ha respectively. Dried straw mulch was applied at the rate of 2 ton/ha. The crops were weeded twice when the plants were 45 and 82 days old.

Recommended rate of fertilizers application and seeding rate was used from the recommendations of Ethiopian Ministry of Agriculture (MoARAD, [10]

Table 2: Different sorghum management packages and agropastoralist indigenous production practices.

Treatment	Days to emergence	Days to heading	Maturity period	Fodder yield	Panicle size	Seed size	Grain yield
T1	1.40^{a}	2.40 ^{ab}	2.33^{a}	2.67^{a}	2.10^{a}	1.37a	1.00^{a}
T2	3.20^{b}	3.80^{b}	1.52^{b}	1.32^{b}	3.00^{b}	3.45^{b}	2.02^{a}
T3	2.40^{ab}	1.60^{a}	3.55^{ac}	3.90^{c}	2.47^{ab}	2.55^{bc}	2.75^{a}
T4	2.60 ^{ab}	3.40^{b}	3.90^{c}	4.75^{d}	2.22^{a}	2.50^{bc}	2.95^{ab}
T5	2.80^{ab}	1.60^{a}	3.00$_{ac}$	4.88^{d}	2.15^{b}	2.92 ^{bc}	3.55^{b}
T6	3.40^{b}	3.40^{b}	4.70^{d}	2.75^{ac}	4.10^{c}	4.35^{d}	4.40^{c}
T7	3.40^{b}	3.40^{b}	3.22^{ac}	2.35^{ac}	4.85^{c}	4.20^{d}	4.40^{b}
LSD $_{0.05}$	0.91	1.81	1.071	0.761	0.54	0.82	0.93
CV%	18.55	20.52	26.76	16.93	13.27	19.57	22.01

Rating scale 4=excellent; 3=Good; 2=Fair; 1=poor
Means followed by the letter are not statistically significant at p<0.05

Table 3: Agro-pastoralist evaluations of treatments for days to emergence maturity, heading and maturity.

ridge planting, straw mulch and fertilizes application promoted early emergence. Similar report was made by Ravender et al. [11] who reported that mulching is known to influence water use efficiency of crops by affecting the hydrothermal regime of soil, which may enhance root and shoot growth. Also Heluf [12] indicted that tide-ridge sorghum planting was advantageous over the flat for moisture conservation and applied nutrient management. Mulch application and tide-ridge planting resulted in better soil water condition and provided the plants with good moisture in stressed area positively affecting plant growth and yield Hari et al.[13], Sunday et al. [14]. In addition to the tide-ridge planting method straw mulch application and fertilize availability tends to affect days to emergence positively for both varieties. Despite management effect there was also varietal effect contributed for early emergence, heading and maturity. Similar result was reported by Tekle and Zemach, [3] who indicted that compared to local check improved variety *Tehsale* had germinated and matured earlier. It has been seen that when both verities were treated with (T5 and T7) with tide-ridge planting, fertilizer application (N and P), straw mulch application and hand weeding showed slight delay in both days to heading and maturity compared to the control. The delay to heading maturity in these treatments was due to management intensity in which resulted longer vegetative growth periods. Sorghum growth and yield could be affected by management practices like planting pattern, seed bed type, fertilizer application and weed removal [12,15-17].

Availability of fertilizer and weed removal along with tide-ridge planting method at (T4 and T5) resulted in higher fodder production compared to the control and other treatments (T1 andT3). It was due to treatment and varietal effect. Similar report Chiroma et al. [18] whom revealed that sorghum fodder yield was significantly influenced by straw mulch, land planting patterns and nutrient management and other essential cultural practices. In our study improving management practice in both local and improved variety showed increments in plant height, leaf number and stem thickness the result was in agreement with other previous findings who reported that sorghum fodder yield could be affected by management practices [15,16]. For both varieties fertilize application, weeding and tide-ridge planting gave better fodder yield. Similar findings of previous works indicated that fodder yields of *rabi* sorghum were significantly influenced by moisture conservation and fertilizer management practices Mudalagiriyappa et al. [19], Jehan et al. [20] also reported that tide-ridge sowing gave maximum stalk yield when compared with maize planted in other sowing methods. According to the result of this study and participant agro pastoralist discussions, fodder yield was significantly influenced by varietal and management differences. They noted that fodder yield of local variety was significantly greater than that of the improved *Teshale* regardless of treatment effect. However when management was intensified at (T6 andT7) the fodder yield tends to increase compared to untreated *Teshale* (T2). Current finding was in the contrary to that of Tekle and Zemach [3] who reported high biomass yield of improved variety *Teshale* compared to local check. In current study participant agro-pastoralist identified that when local variety planted in flat bed produced lower amount of fodder while those treatments treated with tide-ridge with straw mulch along with fertilizer produced maximum fodder yield.

Grain yield for both varieties were significantly affected by management practices (Table 4). Hence improved production packages regardless of varietal difference increased grain yield. Similar findings have also been reported that good production practices resulted in higher mean grain yield and net returns compared to farmers' practice Pandey et al. [21]. Tekle and Zemach [3] indicated that improved variety *Teshale* have grain yield superiority over the local check. Dinesh et al. [22] also reported that grain as well as straw yield of wheat increased significantly when the improved variety was sown in rows provided with balanced fertilizations. Moreover Heluf G [12] reported that tied ridge planting with appropriate fertilization gave the highest yield of sorghum in areas with low and erratic rainfall.

Conclusion

Improved variety showed best performance in yield and maturity duration in T6 and T7 local variety also produced significantly higher quantity of fodder and grain yield at T4 and T5. Participant agropastoralist understood that by practicing appropriate and recommended good cultural practice both grain and fodder yield can be increased to greatest extent. Finally both participant agropastoralist and the research team concluded that both grain and fodder yield of sorghum in current study area can be increased through the adoption of improved production packages. They also argued that improved sorghum variety *Teshale* can be used for grain production during uncertain and unreliable rainfall condition but also it coul be produced twice during longer rainy season in the area from June to October. Participant agropastoralist need their let maturing variety for its quality in fodder and stalk yield they decided to keep using it through adoption of improved cultural practice. Therefore based on agro-pastoralist interest and rating T6 and T4 were selected as best management practices because it balances the both grain and fodder yield with the production costs. Even though both grain and fodder yield was higher in T5 and T7 framers didn't interested to pick the as best management practices because of straw mulch application on T5 and 7. Therefore based on the interest of participant agropastoralist T6 and T4 were recommended for the current study areas and other similar places.

Treatments	Panicle length(cm)	100 seed weigh(gm)	Grain yield (ton/ha)	Biomass yield (ton/ha)
T1	21.80^{a}	1.22^{a}	0.72^{a}	20.00^{a}
T2	17.00^{b}	2.25^{b}	1.14^{ab}	14.33^{b}
T3	24.00^{c}	1.89^{a}	0.96^{a}	29.33^{c}
T4	26.66^{d}	1.99^{a}	1.48^{ab}	32.00^{d}
T5	27.00^{d}	2.24^{b}	1.91^{ab}	39.00^{e}
T6	21.00^{a}	3.55^{bc}	2.45^{c}	22.47^{af}
T7	20.67^{ab}	3.32^{bc}	2.39^{c}	21.12^{af}
$LSD_{0.05}$	1.67	0.59	0.85	1.60
CV%	13.59	20.61	6.94	20.03

Means followed by the same later are not statistical significant at P<0.05.

Table 4: Effect of different crop management practice on yield and yield components of sorghum.

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