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BASELINE SURVEY ON FACTORS AFFECTING SORGHUM PRODUCTION AND USE IN EASTERN KENYA

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ABSTRACT

Sorghum (*Sorghum bicolor* (L.) Moench) is an under-utilized crop and one of the most important cereal crops in semi-arid tropics. In Kenya, sorghum is grown in the often drought-prone marginal agricultural areas of Eastern, Nyanza and Coast Provinces. Due to its C_4 photosynthetic nature, extensive root system, waxy leaves and ability to stop growth in periods of drought the crop is well adapted to low lands that have higher temperatures, prone to drought and flooding. Sorghum, which is closely related to maize in utilization, therefore, could be an alternative staple food crop in arid areas prone to drought. As an indigenous Kenyan crop, sorghum could provide food security and become a suitable alternative in eastern Kenya. Despite its suitability in the semi-arid areas, the area under sorghum production is still low and farmers attain low yields in eastern Kenya. Most farmers still opt to grow maize which is frequented by crop failures. The purpose of this study was to gather information on socio-economic factors affecting sorghum production and the sorghum farming system used by the farmers in the region, landraces grown by farmers, source of seed, traits preference, maturity period, cultural practices, pre and post harvest handling, utilization and constraints in sorghum production in lower eastern Kenya region. The study was conducted in Mbeere, Kitui, Makueni and Mutomo districts of eastern Kenya. Parameters studied were expressed as percentages and bar graphs constructed. Analysis of Variance was performed, and Least Significant Differences were used for separation of means at 0.05 level of confidence. Sorghum is grown widely as source of food and seed for planting is obtained from informal systems. Farmers hardly use inputs due to low income. Eastern region is a high agricultural area and productivity could be improved by use of locally available germplasm. The study found out that farmers in eastern Kenya maintain a diversity of sorghum landraces unique in their adaptation, food quality, grain yield, quality of harvested products and biotic stress resistance. Sorghum grain has high levels of iron and zinc, hence may be used to reduce micronutrient malnutrition. However, the production is low due to constraints such as lack of income to purchase fertilizer and chemicals, inadequate quality seed, susceptibility to pests and diseases resulting to low yields.

Key words: food security, seed quality, sorghum

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INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is an under-utilized crop and one of the most important cereal crops in Arid and Semi-Arid Tropics (ASAT). Sorghum is highly tolerant to drought and able to withstand periods of water-logging [1, 2]. The crop is characterized by an extensive root system, waxy bloom on leaves that reduces water loss, ability to stop growth in periods of drought and resume it when the stress is relieved, and C_4 photosynthesis [3, 4]. As a result, sorghum crop can survive the harsh climatic conditions of the arid environments [5]. The crop performs well in areas between 500 metres and 1700 metres above sea level, with seasonal rainfall of 300mm and above. In Kenya, it is grown in the often drought-prone marginal agricultural areas of Eastern (1385m ASL, 76mm month^{-1}), Nyanza (1190m ASL, 130mm month^{-1}) and Coast Provinces (185m ASL, 87mm month^{-1}) [6]. As an indigenous Kenyan crop, sorghum could provide food security and become a suitable alternative in eastern Kenya where maize crop failure is common [7, 8]. Sorghum is closely related to maize in utilization therefore it is an alternative crop in arid areas prone to drought [9, 10].

Sorghum is used as human food, where it is a staple food for millions of people; as animal feed and industrial raw material [11, 12]. Industrially, the grain is used to manufacture wax, starch, syrup, alcohol, dextrose agar, edible oils and gluten feed [12, 13]. As food, the grain is used in making fermented and non fermented porridge, ugali, pilau, traditional dishes where it is mixed with legumes [14]. The grain has high levels of iron (>70 ppm) and zinc (> 50 ppm), hence may be used to reduce micronutrient malnutrition. There is high demand for sorghum mainly in brewing industry to replace barley, yet the amount produced by farmers is too low to satisfy the market demand. Sorghum yields in Africa are low with an average of 0.85 t ha^{-1} [15].

Sorghum has been neglected and regarded to be of low potential yet untapped natural resource. It has one of the largest crop germplasm collections, comprising more than 42,000 accessions [16, 17]. The large diverse germplasm provides great opportunities for sustainable crop production, provide diversity in diet and supply deficient micronutrients, provide extra income for farmers, and prevent the loss of genetic diversity [18, 16]. However, in many sorghum growing areas of Africa, many sorghum accessions have been lost or are under serious risk of genetic erosion, and hence, genetic diversity within primary gene pools has been decreasing [19]. Sorghum production by small scale farmers in arid areas is constrained by lack of inputs, seeds, susceptibility to pests and diseases, and low yields attained.

Most small scale farmers who plant landraces crop varieties in sub-Saharan Africa use on-farm produced and saved seed whose quality is usually poor [20, 21, 22, 23]. The informal seed system includes methods such as retaining seed on-farm from previous harvests to plant the following season and farmer-to-farmer seed exchange net works [24, 20, 25]. Seed quality is of basic importance for a good seedling establishment and crop development. Maintaining crop production in terms of yield and product quality which give the farmer maximum return requires good seed which

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carries the genetic, physiological, and physical quality aspects [26]. Good seed requires constant care to prevent loss of quality and to ensure high yield for farmers. The study aimed at gathering information on factors that affect sorghum production and use in lower eastern Kenya.

Understanding socio-economics, farming and/or cropping systems, cultural practices, pre and post harvest handling, constraints, landraces grown, traits preferred, source of seed and utilization could be of importance in improving sorghum production in this region.

METHOD

A survey was conducted in four regions of eastern Kenya varying in agro climatology namely: Mbeere, Makueni, Kitui and Mutomo which are major sorghum growing areas in Kenya. The regions range from Zone IV (Semi Humid to Semi Arid) to Zone V (Semi Arid) [27]. The Mbeere and Kitui sites are classified as Lower Midland (LM) with some regions in transitional zone towards Upper Midland (UM). Makueni and Mutomo sites are classified as Lower Midland (LM) [7]. The zones are temperature belts distinctly classified according to the maximum temperature limits within which the main crops in Kenya can flourish [7]. The tropics land slant is classified as tropical alpine, highlands, midland, lowland and coastal zones whereby annual mean temperature increases with the decrease in altitude above the sea level. Similarly, the aridity within each major zone increases as one move from zone 1 to 7. Midland zone lies between the highland and the lowland. The zone is further classified into upper midland and lower midland as sub zones. The annual mean temperature in upper midland is lower than in lower midland. Depending on increase in level of aridity, each subzone ranges from 1 to 5 where; 1 is humid and 5 is semi arid [7]. The survey covered the following regions; Mbeere in LM_3, LM_4; Makueni in LM_5, LM_6; Kitui in LM_3, LM_4, LM_5; and Mutomo in LM_4, LM_5.

Structured questionnaires were used to collect information on socio-economic factors, farming systems, landraces grown, source of seed, traits preference, cultural practices, pre and post harvest handling, utilization and constraints in sorghum production in lower eastern Kenya region. Information obtained from Agricultural office indicated that about 150 farmers were purely sorghum farmers in this region. A sample size of 120 farmers was arrived at using the table on sample size selection and standardization equation,

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

where; N is the known population; n is sample size; and n_o is the unknown population [28, 29]. The required sample size for each agro ecological zone was calculated using the formula according to Cochran (29). Farmers to be interviewed were picked

randomly ensuring the whole coverage of the area with the assistance of Agricultural extension officers.

Random sampling of farmers in different agro ecological zones per district was done to cover 120 farmers in the whole region. In Kibwezi (LM_5) and Mutomo zone 1 LM_4, 17 farmers were interviewed from each agro-zone. Sixteen farmers were interviewed in Kitui central (LM_3); 15 in Siakago (LM_3); 14 in Kitui west ((LM_3); 13 in Kiritiri (LM_4) and Mutomo zone 2 (LM_5). In Ishiara (LM_4), 12 farmers were interviewed while five and eight farmers were interviewed in Makindu ((LM_5) and Kiboko (LM_5; LM_6), respectively.

Parameters were expressed as percentages, Analysis of Variance was performed, and Least Significant Differences were used for separation of means at 0.05 level of confidence.

RESULTS

Gender, occupation and education level of farmers interviewed at Kitui, Mbeere, Makueni and Mutomo districts of Eastern Kenya

The number of female farmers was more than that of men in each district surveyed. Mutomo had the highest percentage (67%) of female farmers compared to Makueni and Kitui while Mbeere had the lowest percentage of female farmers but there was no significant difference ($P \leq 0.05$) between the four regions (Table 1). Makueni had the highest percentage of farmers (40%) interviewed who were males while Mutomo had the lowest percentage (33%). There was no significant difference ($P \leq 0.05$) between the four regions in percentages of male farmers interviewed (Table 1).

Kitui and Mutomo had the highest percentage (100%) of interviewees who were farmers while Mbeere had the highest percentage (10%) of interviewees who were employed and did farming as a secondary occupation. Makueni had the highest percentage (20%) of farmers who were also involved in business. There was no significant difference ($P \leq 0.05$) in percentage of farmers relying on farming alone between Kitui, Mbeere, Makueni and Mutomo (Table 1). The percentage of farmers involved in business as a secondary source of income differed significantly ($P \leq 0.05$) between Makueni and Kitui, Mbeere, Mutomo; while there was no significant difference between Kitui and Mbeere; Kitui and Mutomo; Mbeere and Mutomo (Table 1).

Kitui had the highest percentage (43%) of farmers who had never gone to school and also a higher percentage of farmers with secondary (27%) and tertiary education compared to all the other districts. Makueni had the highest percentage of farmers with primary education while Kitui had the lowest percentage (20%) (Table 1). The percentage of farmers with primary education in Kitui differed significantly ($P \leq 0.05$) with Mbeeere, Makueni and Mutomo. There was no significant difference in percentage of farmers with secondary and tertiary education between the four regions. There were no farmers interviewed with no education in Mbeere and Makueni but there was no significant difference ($P \leq 0.05$) between the two districts (Table 1).

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Sorghum varieties grown

Sorghum is grown by majority of the farmers in the region. Of all the farmers interviewed, 96% grow sorghum while only 4% from Makueni did not grow sorghum. The percentage of farmers growing sorghum in Makueni (82%) was low compared to the other three regions which had 100% of farmers growing sorghum (Table 2).

The number of farmers growing sorghum landraces was higher in Mbeere, Kitui and Mutomo than in Makueni. In Makueni, the percentage of farmers growing sorghum hybrids was higher than in all the other districts and significantly differed ($P \leq 0.05$) with the other three regions where there were no farmers growing hybrids (Table 2). The percentage of farmers growing local varieties of sorghum in Makueni (84%) was low and differed significantly ($P \leq 0.05$) with Kitui, Mbeere and Mutomo, which had 100% farmers growing landraces (Table 2).

The percentage of farmers growing sorghum for food was highest in Makueni (100%) and lowest in Kitui (50%). Kitui had the highest percentage (17%) of farmers who sell the harvest while Mbeere had the highest percentage (37%) of farmers growing sorghum for both food and for sale (Table 2). There was no significant difference ($P \leq 0.05$) between Kitui and Mbeere; Makueni and Mutomo in percentage of farmers using sorghum as food, and both (food and sale) (Table 2). There was significant difference in percentage of farmers who sell sorghum grain between the four regions with highest percentage in Kitui (17%) and none in Makueni.

Farming systems practiced by farmers

Mbeere had the highest number of farmers practicing mixed farming system intercropping sorghum with cowpeas, maize, green grams and pigeon peas compared to Makueni, Mutomo and Kitui. The percentage of farmers practicing mixed crop farming in Kitui (50%) and Mutomo (60%) was low and differed significantly ($P \leq 0.05$) with Mbeere (87%) and Makueni (84%) with highest percentage of farmers practicing mixed farming (Table 2). The number of farmers practicing mono cropping system, that is, grow either sorghum, pigeon pea, maize, cowpea, green grams alone per season was highest in Mutomo while more farmers in Kitui practiced strip farming than in all the other districts. The percentage of farmers practicing this farming system in Mbeere (13%) and Makueni (13%) was low and significantly differed ($P \leq 0.05$) with Kitui and Mutomo which had 33% and 40% of farmers respectively (Table 2). There was a significant difference ($P \leq 0.05$) in percentage of farmers practicing strip farming between Kitui (17%), which was highest and the other three regions where none of the interviewees practiced the system (Table 2). Farmers interviewed that use mixed and strip farming system intercrop sorghum with other crops such as maize, green grams, cowpea, pigeon pea, finger and pearl millet, beans, and dolichos.

Use of farm inputs by farmers while growing sorghum in the region

The percentage of farmers using organic fertilizer was highest at Mbeere while Makueni had the highest percentage (13%) of farmers using both inorganic and

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organic fertilizers. Mutomo district had the highest percentage of farmers planting sorghum without any type of fertilizers (Table 2). Mbeere had the highest percentage (77%) of farmers using organic fertilizer which significantly differed ($P \leq 0.05$) with Makueni (7%), Mutomo (12%) and Kitui (27%) but there was no difference between Makueni (7%) and Mutomo (12%) (Table 2). The percentage of farmers that use inorganic fertilizer was significantly different ($P \leq 0.05$) between the four regions. Percentage of farmers that use both organic and inorganic fertilizer was significantly different ($P \leq 0.05$) in Makueni compared to Mbeere with highest percentage of farmers in Makueni (13%) and none in Mbeere. Mutomo had the highest percentage (67%) of farmers who do not use any fertilizer and was significantly different ($P \leq 0.05$) in percentages of farmers in Kitui (23%), Mbeere (6%) and Makueni (3%). There was no significant difference in percentage of farmers that do not use any fertilizer between Kitui and Mbeere; Kitui and Makueni; Mbeere and Makueni (Table 2).

The percentage of farmers using chemicals to control pest and diseases was highest (77%) in Makueni (Table 2). Mutomo region had the highest percentage (80%) of farmers that do not use any chemicals to control pests and diseases on sorghum crop (Table 2). The percentage of farmers using chemicals was lowest in Mutomo (20%) and was significantly different ($P \leq 0.05$) compared to Kitui (67%), Mbeere (63%) and Makueni (77%) while there was no significant difference between Kitui (67%), Mbeere (63%) and Makueni (77%) (Table 2). There was a significant difference in percentage of farmers who do not use chemicals between Mutomo, which had the highest (80%) and the other three regions.

Source of sorghum seed used for planting

Kitui had the highest percentage (70%) of farmers who save own seed for planting next season while Mbeere had the highest percentage of farmers buying their seed from the market. Makueni and Kitui had the highest percentage of farmers borrowing seed from neighbours (Table 2). The percentage of farmers that save seed for planting next season differed significantly ($P \leq 0.05$) between Makueni (13%), which had the lowest and Kitui (70%), Mbeere (60%) and Mutomo (47%) (Table 2). There was no significant difference ($P \leq 0.05$) in the percentage of farmers who bought seed from the market between the four regions. The percentage of farmers who borrowed seed for planting was highest in Makueni (37%) and lowest in Kitui (20%) and Mutomo (20%).

All the farmers that save own seed in Kitui, Makueni, Mbeere and Mutomo do not separate seed crop from grain crop. The farmers also harvest the crop together then set aside some amount of grain to be used as seed in next planting season in the four regions.

Traits preferred and constraints in production in the region

Traits preferred by the farmers in the landraces grown were high yields, high vigor, good taste, ease in cleaning, resistance to drought, early maturing, resistance to birds and other pests. Percentage of farmers preferring drought resistance in sorghum planted was only reported in Mbeere with 30% (Table 3). Farmers preferring

resistance to other pests were only in Mbeere with 30% while none were reported in the other three regions. Kitui had the highest percentage of farmers preferring resistance to birds with 27% followed by Mbeere with 3%. Percentage of farmers preferring early maturing sorghum varieties was highest in Kitui (33%). Most varieties take two to four months to maturity with only a few taking six to twelve months. Landraces with good taste were more preferred in Mbeere with 40%. High yielding varieties were preferred in the four regions with Mutomo having the highest percentage (73%). Varieties high in vigour were only preferred in Makueni with 20% while those known to be easy in cleaning were preferred only in Kitui with 7% (Table 3).

The major constraints cited by interviewed farmers in sorghum production were susceptibility to pests such as shoot fly, birds, ants, aphids and borers. Diseases reported included smut and honey dew. After harvesting, most farmers store the grain at the fire place and in granaries where weevil infestation was reported as a major drawback in sorghum storability. Majority of the farmers were small scale self employed in agricultural production which portrayed the probability of low income status of the farmers. As a result farmers are not able to purchase fertilizers and necessary chemicals to control pests and diseases in their farms. Low prices are offered to farmers by individuals who consolidate surplus harvests from different farmers. Lack of seed was reported as a major constraint where farmers consume all the harvest. As a result, the farmers rely on neighbors, buying from the market due to low prices and availability in small quantities, and supplies from the ministry of agriculture.

Farm sizes and grain yield attained by farmers

Farm sizes were quite variable ranging from 0.4-6 ha across the region. Majority of farmers interviewed had farms ranging up to 2ha with 88% of farmers in Makueni, 78% in Mbeere, 53% in Mutomo and 52% in Kitui. The average sorghum farm size was 0.1ha in the region. Of the farmers interviewed, only 5% allocated more than 0.1 ha for sorghum production while 30% allocated ≤0.05 ha of land to sorghum. Most farmers had sorghum grain yield ranging from 1.0 to 3.5 t ha^{-1} which is low compared to the research potential yield of more than 4.0 t ha^{-1}.

DISCUSSION

Eastern Kenya ranges from Semi Humid to Semi Arid zones [7, 27]. Sorghum is crucial in the driest environments, where rural farm households have the poorest resources and the lowest incomes. Sorghum being tolerant to drought, water logging, saline - alkaline, infertile soil and high temperatures, has a strong adaptive advantage and lower risk of failure than other cereals in such environments [30].

The study showed that literacy level is still low in the region with majority of the farmers having reached primary school meaning that their knowledge on sorghum production was probably through hands-on experience. This would be a possible reason for the numerous poor crop agronomic practices reported in this region. Of the number of farmers interviewed, females were more than males. This could be

attributed to the assumption that farm activities are a woman's job as men search for income elsewhere. Earlier study in the region indicated that women are fully involved in planting, bird scaring, harvesting and post harvest processing of most crops including sorghum possibly due to the difficulty in post harvest processing [31].

Majority of people are farmers by occupation and only a few are employed or do business as livelihood. Unemployment has been cited as a major cause of poverty in this region resulting to lack of income necessary for meeting basic needs [7]. The results showed that most farmers do not use fertilizers while planting and do not control pests and diseases. This agrees with other findings whereby it was reported that many small scale farmers in Sub-Saharan Africa do not apply fertilizers to their farms [32]. This is attributed to the fact that sorghum is often grown under marginal rainfall conditions and fertilizer prices are unfavorably high in relation to sorghum grain price. The fact that majority of the interviewed farmers could not afford farm inputs may lead to the production of poor seed quality and yield of the crop because many soil nutrients have become depleted. Seeds produced under conditions of low soil fertility usually express poor germination and vigour [33]. Failure to control pests and diseases could also have serious implications on the quality of farm saved seeds. Earlier studies indicated that, the use of inputs by the farmers in the farms is limited [34, 35]. This could be attributed to lack of money in most households cited as one of the constraints in sorghum production by the farmers interviewed.

The study showed that sorghum is grown by majority of farmers in eastern region with only 5% of the farmers who do not plant the crop at Makueni. Though the crop appears to be grown by majority of the farmers, it's grown on very small portions occupying ≤0.05 ha either as few stands within another crop or strips along the farm edge. Farmers mix sorghum crop with other crops such as maize, cowpea, pigeon pea, green grams in the field. This is in line with earlier studies that majority of farmers practice mixed farming in eastern Kenya region [35]. Earlier studies showed that sorghum crop is mainly used as human food, where it is a staple for millions of people in Africa and India [11]. Farmers in eastern Kenya plant sorghum as a source of food in the household alongside maize, cowpea, green grams, finger millet and pearl millet and only a few sell to supplement their income.

Majority of farmers use farm saved seeds to plant the following season while those who cannot save enough seed borrow from neighbors, relatives or buy from the market. The role of neighbors and relatives in traditional seed systems is not new; and involves farmer-to-farmer seed exchange, seed donations and other transfer methods to meet social obligations [36]. In Malawi, up to two-thirds of farmers' obtain bean seed from neighbors, relatives and other local sources [37]. Sources of seed for planting most indigenous crops include farm saved, local markets, borrowed from neighbors and relatives [38, 39, 40]. A study in Ethiopia indicated that, most seed transactions take place between neighbors and relatives because farmers prefer to see the crop stand in a neighbors' farm before deciding on obtaining the variety [41]. An earlier study conducted in Mbeere showed that, only 10% of farmers use certified seed for other crops while 90% relied on locally selected seeds [31].

Landraces are mainly grown due to the variable traits preferred by farmers compared to hybrids which occurred only in Makueni. Earlier studies showed that, most families in eastern part of Kenya grow sorghum landraces which are used for making fermented and un-fermented porridge. The grains are also used for making ugali and other traditional dishes [14]. Traits preferred by farmers in landraces grown were high yields, high vigor, good taste, ease in cleaning, resistance to drought, early maturing, resistance to pests and diseases. A study conducted in India showed that, farmers planted sorghum varieties that were high yielding, good in quality of both grain and fodder, resistance to biotic and abiotic stresses [42]. Another study conducted in Mali showed the general interest of farmers was in variety adaptation to general environmental conditions, eating quality, yield and resistance to different biotic stresses [43, 44]. The quality of a variety to be used as food largely determines its acceptability by the farmers while adaptation to biotic stresses determines the survival in the field and in storage. Sorghum landraces are well adapted to the various eastern Kenya environments [43].

From the information gathered during the survey, major constraints sited in sorghum production were lack of money to buy farm inputs to boost the yields, lack of seeds, and susceptibility to pests such as shoot fly, birds, ants and borers. Weevil infestation in storage was also reported as a major drawback in sorghum storability. The disease that affects sorghum mostly is the sorghum midge, which is one of the most damaging and widely distributed in all sorghum growing regions of Africa [35]. Diseases reported included smut and downy mildew. Losses occurring as a result of pests range between 10% and 25%, mainly due to weevils, larger grain borer and rodents.

Sorghum grain yields attained by farmers are quite low compared to research yield potential of more than 4 t ha^{-1} (45, 46). This low sorghum grain yield could be attributed to some constraints to production identified in this study such as lack of market incentives, low income to buy inputs, use of low quality seed, poor agronomic practices and crop infestation by pests and diseases.

CONCLUSION

Farmers maintain a diversity of sorghum landraces unique in their adaptation, food quality, grain yield, quality of harvested products, biotic stress resistance and in post-harvest processing. Since the region has a high agricultural potential, productivity could be improved by use of locally available germplasm. Sorghum has a potential of high yields more than 4 t ha^{-1} and its known to have high levels of iron and zinc, therefore may be used to reduce micronutrient malnutrition and for food security. The production may be effectively increased by use of improved production technologies and creating awareness to farmers on importance of the crop to increase the production area. For framers to realize logical returns from the crop, economists should analyze the profitability of purchasing farm inputs (fertilizers, pesticides and certified seed) in sorghum.

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The low education level and lack of exposure could have contributed to high levels of unemployment, poor crop management practices resulting to poverty and recurrent food shortages. Also, low farm returns could be as a result of inadequate fertilizer use, and lack of pest and disease control measures. A study to identify sorghum landraces in eastern Kenya and establish quality levels for seed used by farmers could help promote sorghum as an industrial and food crop, and also improve quality of seeds produced by farmers.

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Table 1: Gender, occupation and education level percentage means of farmers interviewed at Kitui, Mbeere, Makueni and Mutomo districts of eastern Kenya

	Percentage of farmers								
	Gender		Occupation			Education			
	Females	Males	Farmer	Business	Employed	Primary	Secondary	Tertiary	None
Site									
1	63a	37a	100a	0a	0a	20a	27a	10a	43a
2	63a	37a	83a	7a	10b	63b	20a	0a	0b
3	60a	40a	73a	20b	7ab	77b	17a	6a	0b
4	67a	33a	100a	0a	0a	67b	20a	0a	13c
LSD	**37**	**18**	**57**	**10**	**7**	**24**	**12**	**15**	**2**

(*P*=0.05)

*Any two means having a common letter within a column are not significantly different at 5% level of significance according to the LSD test

Where: - 1 Kitui site; 2 Mbeere site; 3 Makueni site; 4 Mutomo site

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Table 2: Percentage means of farmers growing sorghum under different agronomic practices and use in Kitui, Mbeere, Makueni and Mutomo districts of eastern Kenya

Percentage of farmers

		Varieties		Farming System			Fertilizer Use				Other Inputs		Seed Source			Purpose		
Growing Sorghum		Local	Hybrid	Mixed	Mono	Strip	Organic	Inorganic	Both	None	Use	None	Saved	Market	Borrow	Food	Sell	Both
Site																		
1	100a	100a	0a	50a	33a	17a	27a	3a	47a	23a	67a	33a	70a	10a	20a	50a	17a	33a
2	100a	100a	0a	87b	13b	0b	77b	0b	17a	6a	63a	37a	60a	10a	30b	60a	3b	37a
3	82b	84b	16b	84b	13b	0b	7c	13c	60ab	3a	77a	7b	13b	33a	37c	100b	0c	0b
4	100a	100a	0a	60a	40c	0b	12c	7d	13ac	67b	20b	80c	47a	33a	20a	87b	6d	7b
LSD	**17**	**15**	**11**	**14**	**2**	**1**	**14**	**2**	**39**	**20**	**39**	**31**	**28**	**28**	**5**	**19**	**1**	**18**

(*P*=0.05)

*Any two means having a common letter within a column are not significantly different at 5% level of significance according to the LSD test

Where: - 1 Kitui site; 2 Mbeere site; 3 Makueni site; 4 Mutomo site

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Table 3: Percentage of farmers preferring different traits in sorghum varieties grown at Kitui, Mbeere, Makueni and Mutomo districts of eastern Kenya

	Percentage of farmers								
	Drought resistance	Resistant to pests	Resistant to birds	Early maturing	Good taste	High yield	Vigor	Ease of cleaning	All traits
Site									
1	0	0	27	33	10	20	0	7	20
2	30	3	3	30	40	20	0	0	7
3	0	0	0	0	0	63	20	0	0
4	0	0	0	0	7	73	0	0	20

Where: - 1 Kitui site; 2 Mbeere site; 3 Makueni site; 4 Mutomo site

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