SORGHUM PRODUCTION CHALLENGES IN DROUGHT AREAS OF SIAYA AND BARINGO COUNTIES, KENYA

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ABSTRACT

Sorghum bicolor (L.) is an important food in Sub-Saharan Africa where drought is one of the major abiotic stresses that limit its productivity. In Kenya production is low despite having a rich diversity in Arid and Semi-Arid Lands (ASALs). A cross section survey was conducted between 12th and 21st January, 2021 with the objectives of collecting different sorghum accessions, identifying preferred traits, identifying production constraints and finding out challenges faced by farmers in sorghum production in Siaya and Baringo counties. The respondents interviewed from the two counties included 43 sorghum farmers who provided 48 sorghum accession. Results from this study indicated that majority (80%) of farmers acquired primary education, while 79% of farmers listed sorghum as their first priority crop among maize, beans, green grams, groundnuts, cassava and bananas due to its drought tolerance, resistance to pests, less labour and fertilizer requirements and its ability to ratoon. Most respondents grew sorghum landraces from their own saved seeds (46%), local market (21%) while less than 20% planted certified seeds. In addition, 90% of the farmers in the two counties grew sorghum for food, sale (72%) and fodder (23%). Consumers in these counties preferred taste, good germination, early maturity, bird resistance, colour (non-red) and drought tolerance while farmers identified drought, pests (birds), diseases, striga weed, marketing and low yields as the key constraints in sorghum production. Evaluation of the collected sorghum accession would help to identify suitable ones for increased yields.

Key words: Accessions, Drought, Sorghum traits, Production constraints

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INTRODUCTION

Sorghum bicolor (L) is quantitatively ranked as the world's fifth most important cereal grain after wheat, maize, rice and barley (Batista *et al.*, 2019). Its cultivation is mainly practiced in developing countries with 90 percent of the cultivated area found in African and Asian countries. Africa is the largest producer of sorghum accounting for one-third of the global production (Munda *et al*., 2019). The suitability and adaptability to tropical conditions prevalent in Africa explain the crop's dominance (Munda *et al*., 2019). It is able to perform relatively well under unfavourable, harsh and unpredictable weather conditions which are predominant in Sub Saharan Africa (SSA). In SSA, the crop prominently serves as a viable cereal crop in the water scarce regions with the most food insecure households (Power *et al*., 2019). Sorghum is an essential food security crop in semi-arid areas of Africa (Munda *et al*., 2019). It is an integral ingredient in the production of sorghum beer as malt. Alternative uses of sorghum encompass the utilization of grain and sweet stalk in food and non-food sectors for the production of commercially valued products, such as alcohol, syrups, glucose, modified starches, maltodextrins, jaggery, sorbitol, and citric acid (Ratnavathi *et al*., 2016).

Statistics by the Ministry of Agriculture, Livestock and Fisheries (MOALF), 2014 showed that sorghum provided livelihoods to more than three million people in Kenya. Its demand is increasing at 275,000 T per year against production of 150,000 T (FAO, 2019). Sorghum has high production potential in the marginal areas of Kenya where it encounters myriad of challenges that translates to low yields of poor quality (Ochieng *et al*., 2011; Muui *et al*., 2013; Mueti *et al.,* 2019). Subsistence farmers in these regions use local varieties, informal seed supply system mostly recycled from local seed accessions retained on-farm from previous harvests to plant the following

season and farmer-to-farmer seed exchange networks that compromise yields and quality (Ahmed *et al*., 2009; Ochieng *et al*., 2011; Muui *et al*., 2013; Mueti *et al.,* 2019).

Due to the rising food shortage and use in the brewing industry, sorghum has been identified as one of their priority value chains for upgrading by eight Kenya Climate Smart Agriculture Project (KCSAP) counties among them Baringo and Siaya. The effects of climate change that leads to erratic rainfall, drought and salinity stress in arid and semi-arid regions (ASALs) have resulted to low yields of sorghum making it difficult to meet the rising demand. Hence the need to exploit drought tolerant crops such as sorghum would reduce the impact of these associated climate change challenges. Production of sorghum has also stagnated due to lack of suitable drought tolerant varieties adaptable to the changing climate (FAO, 2019). Sorghum can withstand high temperatures, is drought resistant and can endure periods of exposure to waterlogging hence under rising trends in global warming and climate change, it is a promising alternative.

In ASAL environments there is a tendency of intermittent rainfall that interferes with the plant biophysical processes resulting to stress. Since drought in plants is usually transient, the capacity of the crop to recover from stress following rains is also very important.

MATERIALS AND METHODS

Cross section survey of sorghum production status in Siaya and Baringo Counties

A survey was conducted between 12th and 21st January, 2021 to establish the sorghum production status and collect sorghum accessions in Siaya (0.0626° N, 34.2878° E) and Baringo (0.8555° N, 36.0893° E) Counties of Kenya (Figure 1). The climate for these sites is semi - arid typical for drought tolerant varieties in agro-ecological zone (AEZ) UM_5 (Jaetzold *et al*., 2006). The region experiences long rains from March to May and short rains from October to December with a well-defined dry season between May and July (Jaetzold *et al*., 2006). The sampling sites covered the sorghum growing areas of Siaya and Baringo counties. Two survey activities were carried out in each sampling site including interview and collection of sorghum accessions.

Interviews

Farmers were interviewed using a semi - structured questionnaire to determine the sorghum production status in the regions. The sample was drawn from the sorghum farmers in each county with the assistance from respective County agricultural officers. The sample size for the households to be interviewed was determined using the formula: Nassiuma (2000):

$$n = \frac{NC^2}{C^2 + N - 1)e^2}$$

Where n= sample size, N= population size, C=coefficient of variation (0.5), and e = error margin (0.05).

A total of 43 sorghum farmers were interviewed from both counties of Siaya (23) and Baringo (20). The questionnaires were administered with the help of the local agricultural staff for ease of communication. Information gathered in the questionnaire included: GPS location, crops grown, sorghum varieties grown, area under sorghum, purpose of growing, customer preferred traits within varieties, yields per unit area and constraints encountered during production.

Collection of local sorghum germplasm

From the interview sites, sample of sorghum varieties grown by the farmers were obtained. They comprised of varieties grown in the previous. The GPS coordinates for the sites visited were recorded. The samples were preserved for evaluation for drought tolerance.

Data analysis

Survey data on socio economic characteristics, source of seeds, land races grown, traits preferred and production challenges were collected. Data were analysed using descriptive statistics using Statistical Programme for Social Sciences (SPSS) (IBM SPSS Statistics 20). The main descriptive indicators employed were frequencies and mean values.

RESULTS

Gender, education level and purpose for production

The overall sample consisted of 63.6% males and 36.4% females (Table I). Regarding educational level,

Figure. 1 Map of Kenya showing the Baringo and Siaya survey sites

majority of the respondents from Siaya (82%) and Baringo (75%) had attained both primary and secondary education, respectively. Only a small proportion (4.7%) had not attended school from both counties (Table I). The respondents were asked to indicate the purpose for sorghum production. Results show that the main purposes of sorghum production were for food provision (91.3 %), sale (72.3%), and fodder (25.0%). Similar trends on purpose of sorghum production were also observed in Siaya (Food = 83%, Sale = 70%, and fodder = 0%) and Baringo (Food = 100%, Sale = 72%, and fodder = 23%) counties.

Sorghum Production

Majority of farmers in the two counties grew local accessions. A total of 48 accessions were collected during the survey, 45 from farmers and three from seed merchants (Table II). The results show that some of the respondents grew more than one accession on the same piece of land.

TABLE I - GENDER PARTICIPATION, EDUCATION LEVEL AND REASON FOR SORGHUM PRODUCTION (%)

Gender	Siaya	Baringo	Overall
Male	52.2	75.0	63.6
Female	47.8	25.0	36.4
Education			
Secondary	43.5	35.0	39.25
Primary	39.1	40.0	39.55
Above	8.7	25.0	16.85
None	8.7	0.0	4.35
Purpose for production			
Food	82.6	100	91.3
Sale	69.6	75.0	72.3
Fodder	0	50.0	25.0

TABLE II - ACCESSIONS COLLECTED FROM THE FARMERS IN BARINGO AND SIAYA

Accession name	No of entries	Accession name	No of entries
Adventor	1	local red	8
Ex KALRO	1	local white	1
Ex Kitui	2	Nyagemu	1
Ex Ugunja	1	Nyakabala	1
Hela	2	Nyakitosi	1
Gadam	5	Nyaurang'	1
H293	1	Ochuti	3
IESV-24029-54	3	Ochuti_Nyakabala mix	1
IS 9183	1	Ofunji	1
IS 9184	1	Orimba joleje	1
KARI mtama	1	Saitoti	1
local gus nook	2	Seredo	2
local mix	1	Serena	1
IS 9184	1	Sila	1
IS 9183	1	Total	48

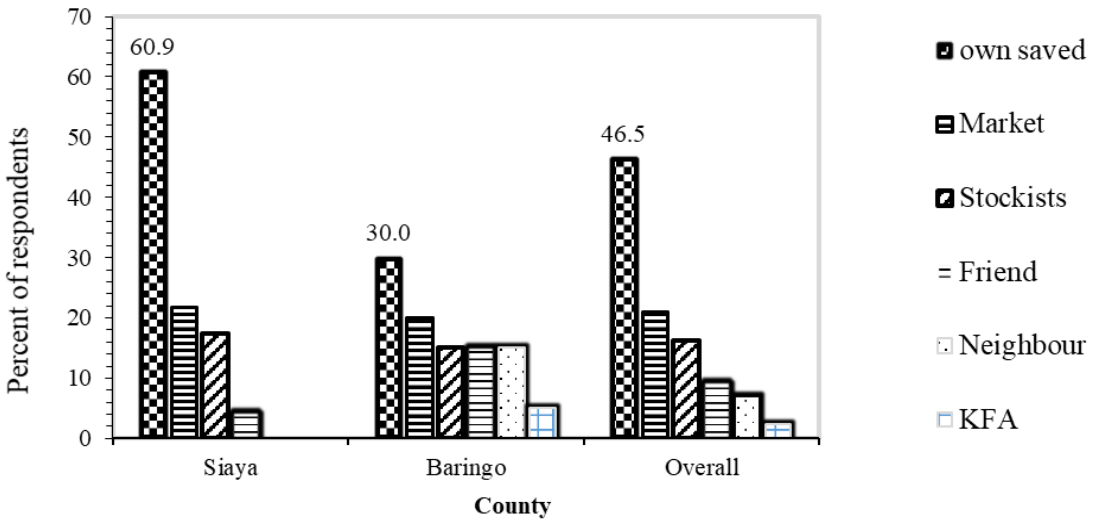

Figure 2. Source of planting seeds

Source of planting seeds

Majority of the farmers planted own saved seeds comprising (47%) (Figure 2). Siaya had higher proportion (60.9%) compared to Baringo (30%). From the two counties it was observed that some of the farmers obtained seeds from the local market (21%) while a smaller fraction bought from the stockists (16%). The rest of the farmers acquired seeds from friends (9%), neighbours (7.3%), while a few farmers obtained seeds from the Kenya Farmers Association (KFA) (2.3%).

Sorghum as a priority crop

Apart from sorghum farmers grew other food crops including maize, beans, millet, cassava, bananas and cash crops. Farmers chose sorghum as a first priority due to several attributes (Table III). A larger percentage was due to drought tolerance as observed in Baringo (100%) as compared to Siaya County (61%). Another reason for prioritizing sorghum among other crops was due to resistance of insect and bird attack (39.5%), less labour requirement (32.6%), never required hybrid seeds since sorghum seeds can be recycled (32.6%), ability to perform well with less fertilizers (26%) , and good ratoon ability (16%).

Consumer preferred traits

The preferred traits by the sorghum consumers included good taste (47%), good germination rate (30%), early maturity (20%), non-red colour (13%), resistance to bird damage (10%), storability (7%) and low production cost (3%) (Table V).

Challenges facing sorghum farmers

All the farmers interviewed grew sorghum under rainfed. Their biggest challenge was drought since the counties lie within the marginal areas that experience low erratic rainfall. The main production challenges on overall (Table VI) were pest and diseases (93%), weeds (striga) (88.4%), drought (86%), market (81.4%) and low yields (72.1%). In Siaya County drought alone accounted for 100% while in Baringo County it contributed to 70% (Table VI)

TABLE III - REASONS FOR CHOOSING SORGHUM AS A FIRST PRIORITY CROP (%)

	County		
Attribute	Siaya	Baringo	Overall sample
Drought tolerance	60.9	100.0	79.1
Resistance to insects and birds attack	30.4	50.0	39.5
Require less labour	13.0	55.0	32.6
No need of hybrid seeds	17.4	50.0	32.6
Require less fertilizers	8.7	55.0	30.2
Ratooning	0.0	55.0	25.6
Other reasons	30.4	0.0	16.3
Total	100	100	100

Use of manure and fertilizers

During planting, majority of the farmers from the two counties used organic manure (49%) while some used inorganic fertilizers, either DAP or NPK (34%). The results in Table IV also indicate that quite considerable proportion of farmers did not plant with either fertilizers or manure (23%). In Baringo 50% of the respondents used manure as compared to 48% in Siaya (Table IV).

TABLE IV - FARMER USE OF FERTILIZERS (%)

Type of fertilizer	Siaya	Baringo	Overall
Organic manure	47.8	50.0	48.8
Inorganic fertilizer	34.8	50.0	41.5
Planting fertilizer.- DAP	30.4	38.9	34.1
Top dressing. fertilizer - CAN	26.1	38.9	31.7
None	30.4	16.7	24.4
Planting. fertilizer – NPK	0.0	11.1	4.9
Planting. fertilizer - YALA.MILA	4.3	0.0	2.4
Planting. fertilizer -.SSP	4.3	0.0	2.4
Topdressing-fertilizer-YALA.MILA	4.3	0.0	2.4

TABLE V -TRAITS PREFERRED BY CONSUMERS (%)

Trait	Siaya	Baringo	Overall
Taste	62.5	28.6	46.7
Germination rate	6.3	57.1	30.0
Early maturity	37.5	0.0	20.0
Colour non red	25.0	0.0	13.3
Bird tolerance	18.8	0.0	10.0
Storability	6.3	7.1	6.7
Low cost	0.0	7.1	3.3
Good colour	6.3	0.0	3.3
Drought tolerance	6.3	0.0	3.3
High yields	6.3	0.0	3.3

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TABLE VI - PRODUCTION CONSTRAINTS FACING SORGHUM FARMERS (%)

Constraints	Siaya	Baringo	Overall
Disease and pests	91.3	95.0	93.0
Weeds	95.7	80.0	88.4
Drought	100.0	70.0	86.0
Marketing	100.0	60.0	81.4
Low yields	87.0	55.0	72.1

DISCUSSIONS

This study revealed that sorghum production was dominated by males in both counties. Being the heads of the households in most families, men were readily available for interview. Meanwhile, women were involved in most farming activities, but when it came to decision making men played the key role. This is in agreement with the results by Muui. (2019) who identified women as key players in sorghum production in Coast and Nyanza regions. Robert *et al*. (2013) and Partrick. (2013) identified females as key in providing labour in sorghum production activities. Majority of the respondents had acquired primary education and above. With such literacy level the farmers in these regions can understand and apply good agricultural practices in their farming activities. Literacy helps one to understand how skills involved in farming such as quality seeds and good agronomic practices among others that are necessary for realization of high quality yields.

Farmers from the two counties planted landraces from own saved seeds or local market and this was due to the high cost of certified seeds. There was also a possibility of lack of technical knowledge from agricultural extension staff to promote the use of certified seeds. In these regions, lack of finances to buy quality seeds largely contributed to the practice. Previous studies show that farmers used own saved seeds that translated to low yields (Muui *et al*, 2020). For better yields, use of certified seeds is of paramount importance since it translates to vigorous crop capable of utilizing available resources for conversion to yields.

The consumers in the study region preferred traits with good taste, high germination rate, early maturity, bird resistance, colour (non-red) and drought tolerance (Table IV). In their study, Muui *et al.* (2011); Muui *et al*. (2020) and Timu *et al*.(2014) established the same. Most farmers in the study region grew sorghum for food hence taste was essential in choosing the variety to grow. Leder. (2004); Ministry of Agriculture. (2010), Munda *et al*., 2019) and Muui *et al*. (2013) also reported that farmers cultivated sorghum for preparing foods including ugali, porridge and other traditional dishes.

Similar to studies by Shashidar, *et al*. (2000), varieties that matured early were mostly preferred due to drought escape mechanism since the region experienced unpredictable. Drought tolerance was also prioritized while selecting

varieties in the region. Bird damage was a great menace as most labour was spent on bird scaring. In this respect varieties resistant to birds gained much popularity. In the study areas, sorghum farmers had a number of constraints experienced in the cause of production. They identified drought, pests (birds), diseases, striga weeds, marketing and low yields as the key constraints in sorghum production. Similar findings were observed by Muui *et al*., (2019) in their studies on sorghum, land races production practices in Nyanza, Coast and Eastern Regions of Kenya.

CONCLUSIONS

Drought, pests, diseases and marketing, have been identified as major constraints in sorghum production from the study regions. Farmers from the marginal areas lack resources to address the constraints hence realize low yields and poor grain quality. Sorghum is an important crop in ASALs due to its ability to tolerate drought, resistance to pests, require less labour and fertilizer and its ability to ratoon. Accessions with these attributes are adapted in those areas which could be exploited and recommended for production. The local germplasm collected from the survey will be used to evaluate drought resilient candidates desired by farmers for increased production and food security.

ACKNOWLEDGEMENTS

The work was supported by the Kenya Agricultural & Livestock Research Organization, Department of Agricultural Science and Technology of Kenyatta University and the Government of Kenya with funding from the Kenya Climate Smart Agricultural Project.

REFERENCES

Ahmed, H. M. I., Gregg, B. R. and Louwaars, N. P. (2009). Seed Systems for Underutilized crops. Acta Horticulture (ISHS), 806, 459-464. https://doi.org/10.17660/ActaHortic.2009.806.57

Batista, P.S.C., Carvalho, A.J., Portugal, A.F., E.A. Bastos, E.A., Cardoso, M.J., Torres, L.G., Mingote, Júlio M.P. and de Menezes, C.B. (2019). Selection of sorghum for drought tolerance in a semiarid environment *Genetics and molecular research*: 18(1), doi: http://dx.doi.org/10.4238/gmr18194

Food and Agriculture Organization (FAO). (2019). Index Mundi Statistics. USDA sorghum statistics.

Jaetzold, R., Schmidt, H., Hornetz, B. and Shisanya, C. (2006). Farm Management Handbook of Kenya, Vol. II/C1. Ministry of Agriculture, Kenya and German Agency Technical Cooperation team (CTZ)

Leder, I. (2004). Sorghum and millets. Cultivated Plants, Primarily as Food Sources, 66-84.

Ministry of Agriculture Livestock and Fisheries. (2010). Annual Report.

Munda C. W., Secchi S Akamani K and Wang G (2019). A Regional Comparison of Factors Affecting Global Sorghum Production: The Case of North America, Asia and Africa's Sahel. *Sustainability* 11, 2135; doi:10.3390/su11072135

Muui, C.W., Muasya, R. M. and Kirubi, D. T. (2011). Baseline survey on factors affecting sorghum production and use in eastern Kenya. A paper submitted to *African Journal of Food, Agriculture Nutrition and Development* in July, 2011.

Muui, C. W., Muasya, R. M. and Kirubi, D. T. (2013). Baseline survey on factors affecting sorghum production and use in eastern Kenya. African Journal of Food, Agriculture Nutrition and Development, 13, 7339-7342. https://doi.org/10.18697/ajfand.56.11545

Muui, C. W., Muasya, R. M. Ngululu, S.,Kambura, A., Kathuli, P. Mweu, B. and Odhiambo. D.O (2019). Sorghum Landraces Production in Nyanza, Coast and Eastern Regions, Kenya. J*ournal of Economics and Sustainable Development::ISSN 2222-2855(online) doi: 10.7176/JESD Vol 10, No.10, 2019*

Muui C. W., R. M. Muasya, S. Nguluu and A. Kambura. (2020). Evaluation of Seed Quality Attributes of Sorghum Germplasm Accessions from Eastern, Coastal and Nyanza Regions, Kenya. *Journal of Sustainable Agriculture Research*; Vol. 9, No. 3; 2020 ISSN 1927-050X E-ISSN 1927-0518

Nassiuma, D.K. (2000) Survey Sampling: Theory and Methods. University Press, Nairobi.

Ochieng, L. A., Mathenge, P. W. and Muasya, R. M. (2011). A survey of on-farm seed production practices of sorghum (*Bicolor L. Moench*) in Bomet district of Kenya, African Journal of Food, Agriculture, Nutrition and Development, 11(5), 5232-5253.

Power, R., Güldemann,C., Crowther, A. and Boivin

N. (2019). Asian Crop Dispersal in Africa and Late Holocene Human Adaptation to Tropical Environments. *Journal of World Prehistory* 32:353–392.

Ratnavathi, C.V., Patil, J.V. and Chavan U.D. (2016). Sorghum Biochemistry an Industrial Perspective. *Science Direct*: Sorghum Biochemistry: pp 63:105

Robert, M. O., Erick, C., Patience, M. and Charles, N. O. (2013). Sorghum production for ood security: A socioeconomic analysis of sorghum production in Nakuru County, Kenya. African Journal of Agricultural Research, 8(47), 6055-6067

Shashidar, R., Saroj, S. D., Harjare, S., Dhokane, V., Sharma, A. and Bandekar, J. R. 2000. Tropics. Inheritance of flower colour in chickpea. *J. Hered*., 91: 5.