Farm Production Factors Affecting Malt Sorghum Production among Contracted Sorghum Farmers in Homa Bay County, Kenya

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Abstract

Sorghum is a globally important food security crop with high commercial importance, particularly in arid and semiarid regions. Though its production in Kenya is crucial in ensuring increased agricultural productivity and income, sorghum farmers in Homa Bay County still record low yield. This research was intended to determine the factors affecting production of malt sorghum among contracted sorghum farmers in Homa Bay County, Kenya and a total of 217 East Africa Breweries Limited (EABL) contracted farmers participated. Survey information were analyzed using descriptive statistics and double log Cobb-Douglas production function. Results revealed that the mean age of the contracted malt sorghum farmers was 45 years with 1.5 years of experience and produce on average 2,203kg of malt sorghum per acre per cropping season. On average, 20% of the farmers planted Sila while 49.2% planted Gadam varieties of malt sorghum. Analyzed results revealed a one percent increase in land size would increase malt sorghum yield by 155.4%, while a one percent increase in quantity of seed, pests and disease attack, labor would lead to a decline in malt sorghum yield by 57.2%, 26.8% and 11.4% respectively. To improve malt sorghum productivity, recommendation to the county and the national governments of Kenya is made come up with strategies to address the challenges of seed quantity, pests and diseases and labor. Such strategies may involve the introduction of drones and chemical perch repellants that are neither harmful to sorghum grain nor human beings and farmers should be encouraged to plant simultaneously.

Keywords: Production factors, Sorghum farmers, Malt sorghum, Double log Cobb-Douglas function

INTRODUCTION

Sorghum (*Sorghum bicolor L.*) is a universal important source of food, especially in areas with inadequate rainfall. It is indigenous to Africa having originated from Northern Africa. It is among the important and widely grown crop after maize (*Zea mays*), wheat (*Triticum spp*.), rice (Oryza sativa) and barley (*Hordeum vulgare*) (Orr *et al*.,2016). Domestically and industrially its used to make porridge, bread, lactic, alcoholic beverages and for manufacture of biofuels, wax, starch, syrup, alcohol, dextrose agar, edible oils and gluten feed (Mundia *et al.*, 2019). Sorghum is also a high-input commercial crop and is fast emerging as a biofuel crop (Hariprasanna and Rakshit, 2016).

In Kenya sorghum has been traditionally grown in many parts with majority of sorghum farming being registered in areas with unreliable rainfall. It is grown for subsistence use. However, its cultivation has dwindled over time as more people prefer maize as their staple cereal. Nevertheless, revamped research in drought resistant cereals to address food insecurity in the country, has brought back its cultivation in the limelight (GOK, 2009). It is cultivated in western and eastern Kenya. However, its production has dropped from 164,066 metric tons in 2010 to 117,000 metric tons in 2017 (FAOSTAT, 2017).

In the Nyanza region of Kenya, small- scale production of sorghum is concentrated mainly in Kisumu, Homa Bay, Siaya and Migori Counties. According to Orr *et al*., (2016), it is a multipurpose crop and an essential crop in the Lake Basin area and is used as a supplementary starchy staple that is also drought resistant. According to (HBCIDP) 2018-2022, (2018), maize farmers in Nyanza are shifting to sorghum production because of a ready market that is provided by the brewers. However, even though sorghum farming is more lucrative and fetch more income that support various families in the county, its yield is still insufficient. This is attributed to lower-than-average rainfall, which has been experienced successively especially during the growing seasons. Other constraints include overreliance on traditional methods of production, technology adoption constraints, and environmental setbacks (Oyier *et al*., (2016). Unexpectedly, the low production of sorghum has also been witnessed among contracted sorghum farmers where the production over the years has been decreasing (Muui *et al*., 2019). This not only threatens the sustainability of the contracting firm, but also leads to poor socio-economic wellbeing of the farmers and their households. Therefore, this study was carried out to analyze the farm production factors affecting malt sorghum production among contracted sorghum farmers in Homa Bay County, Kenya.

METHODOLOGY

Study Area

This study was conducted in Homa Bay County, Kenya. The county lies between latitude 0^o15’South and 0^o52’South, and between longitudes 34^oEast and 35^oEast (HBCIDP 2018- 2022, 2018). The County receives an annual rainfall ranging from700 to 800mm.Temperatures in the county range from 17.1°C to 18.6°C, with hot months being between December and March. This temperature favors sorghum production. The County is divided into seven agro-ecological zones which support the growing of maize, millet, pineapples, sorghum, sunflower, and tomatoes. The dominant soil types in the county for agricultural production are Sandy loam soil, black cotton soil, and volcanic soils. These types of soils especially black cotton soil are suitable for sorghum production

Research Design

A cross-sectional research design was used. The primary unit of analysis was all the 2030 contracted malt sorghum farmer households in Homa Bay County.

Sample Size Determination

The required sample size for the malt sorghum farmer households was determined by the use of Cochran‘s sampling technique as shown in equation 1 below (Cochran 1977).

$$n = \frac{Z^2 pq}{e^2} \text{........} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where n is the desired sample size, Z is the standard deviation at the desired confidence level, at 95%, Z is 1.96, Z^2 is 3.8416, e is the desired level of precision equivalent to 0.029270, and p is the estimated proportion of the population which has the attribute in question, q = (1-p). To find the sample size, the variable values were then fitting into equation 2. as shown below.

$$n = \frac{1.96^2 (\frac{2030}{39899})(1-0.0509)}{0.029270^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

n = 217

Therefore, based on the sample size calculation, a total of 217 contracted malt sorghum farmers were sampled.

Sampling Procedure

The study area has seven sub-counties and the contracted malt sorghum farmer's households in each of the Sub-County were purposively sampled. Thereafter, a proportionate sampling procedure was used to pick the 18 farmers from Ndhiwa, 31 from Rangwe, 17 from Kasipul Kabondo, 17 from Karachuonyo,13 from Homa Bay Town, 14 from Mbita, 13 from Kabondo Kasipul, and 91 from Suba. A list of all the contracted sorghum farmers in each of the 7 sub counties was obtained from the EABL office and the Ministry of Agriculture, Livestock, Fisheries and Food Security. Farmers names in the lists were serially numbered and randomly arranged and then picked using a simple random sampling technique. This technique gave each farmer an equal opportunity of being selected and increased the chances of obtaining an appropriate and representative sample size.

Data Types and Sources

Primary and secondary data sources were used to collect information used in the study. Primary data was collected from contracted malt sorghum farmers and EABL officers and the aggregators through personal interviews using structured questionnaires.While secondary data was collected through a literature review of reports from EABL, published theses and economic journals, Economic journals and surveys, abstracts, reviews from conferences, magazines, books, County and National development and strategic work plans, the Kenya National Bureau of Statistics(KNBS) publications, desktop reviews, and internet sources.

Analytical Frameworks

Descriptive statistics and econometric models were used to analyze information from the respondents (households with malt sorghum farmers). Percentages, means, and standard deviations were generated from descriptive statics analysis in the process of comparing the socio-econmic profile of malt sorghum farmer households. To estimate the effects of farm factors on malt sorghum production among contracted sorghum farmers in the study area, the Cobb-Douglas production function-double log was used in a way consistent with the production theory. Cobb-Douglas is a functional form of the production function.

Econometric Analysis

Outcome equation was, used to represent the technological relationship between the amounts of two or more inputs (particularly physical capital and labor) and the amount of output that can be produced by those inputs. The specification of the model is as indicated in equation (3) and as adopted from Meeusen *et al*., (1977).

$$Y = AL^{\beta} K^{\alpha} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (3)$$

Where Y =Total Production (in terms of Kilograms), α and β are the output elasticities of labor and capital, respectively that were estimated. These values are constants and determined by the available technology.

Model Estimation

Taking on the logarithm on both sides of equation (3), the function transforms to a double log -Linear form as shown in equation 3.

$$LogY=log\alpha+\beta_1 logX_1+\beta_2 logX_2+\beta_3 logX_3+\beta_4 logX_4+\beta_5 logX_5+\beta_6 log+\beta_7 logX_7+\beta_8 logX_8+\beta_9 logX_9 + \mu \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where Y = Output of Malt sorghum in Kgs, X_1 is the Farm size (Acres), X_2 is labor (Man hour/day), X_3 is capital (Ksh), X_4 is seeds (Kgs), X_5 is fertilizer (Kgs), X_6 is management, X_7 is Pest and diseases, X_8 is household Assets (Ksh), X_9 is land tenure, B_0 is a constant or intercept and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7\ \beta_8, \beta_9$are the coefficients to be *estimated*.

$\mu$is the error term that is independently and normally distributed with mean zero and constant variance of $\varepsilon_i \sim N(0, \zeta^2)$.

Definition, Measurement of Variables and Expected Signs

Table 1 shows the variables that were used and their measurements. The positive sign (+) means an increase in the variable causes an increase in the yield of malt sorghum, while the negative sign (-) means an increase in the variable causes a decrease in the yield of malt sorghum.

Table 1: Descriptions and Measurement of Variables

Variables	Description	Units	Expected sign
Dependent variable			
Yield	Continuous	Kilograms (kgs)	+/-
Independent variables			
Socio-Demographic Factors			
Age	Continuous	Years	+/-
Gender	Categorical	1 = male, 0 = female	+/-
Family size	Continuous	Continuous	+
Farming experience	Continuous	Years	+
Education level	Ordinal	1=None, 2=Primary 3=Secondary,4=College, 5=University	+
Farm Production Factors			
Land Tenure	Ordinal	1=Registered,2=Leasehold, 3=Ownership without title, 4=Communal, 5=Next of kin	+
Land/farm size	Continuous	Acres	+
Land preparation	Ordinal	1=hand digging, 2=ox plough, 3=Tractor, 4=Not ploughed	+
Seed quantity	Continuous	Kilograms	-
Fertilizer use	Dummy	1 = Yes, 0 = No	+
Sorghum variety	Ordinal	1=Gadam, 2 = Sila, 3 = both	+
Labor Use	Continuous	Man hour per day	-
Pest and diseases	Dummy	1=Yes, 2=No	-

Source: Author 2020

Diagnostic Tests

Analytic examinations were also carried out from the regression results of STATA output. STATA has some routines for detecting multicollinearity which allowed correction before the analysis was done. Diagnostic test results provide information on how these raw data may be modelled. When a model is estimated, diagnostic tests on model residuals yield information about model adequacy (Mahmood, 2018). In this study, a heteroscedasticity test was performed to check for the correctness of the estimates. A test on heteroscedasticity was done based on ordinary least square residuals. Therefore, for this study, a heteroscedasticity test was performed to test whether the variance of the errors from the regression is dependent on the values of the independent variables. Godfrey, (1978) and Breusch and Pagan, (1979) independently proposed testing for heteroscedasticity based on squared least squares residuals. Empirical expression of heteroscedasticity test model, the OLS assumption that error terms in the regression should all have the same variance holds as shown

$$Var(\varepsilon_j \mid X \mid) = \sigma^2 \qquad (5)$$

If this variance is not constant (i.e. dependent on X's), then the linear regression model has heteroscedastic errors and likely to give incorrect estimates. According to Halbert (1985), this OLS regression assumption allows the use of white test formulae in testing for heteroscedasticity. The usual calculation of the White test is expressed by letting ε be uncorrelated with the independent variables, x_j, the squares of the independent variables X_j^2 and the cross products of the independent variables $x_h x_j$, where j=h, and j, $h = h = (1, 2, \ldots\ldots, k)$. This led to the White test which suggests the inclusion of all the above as covariates in the second step regression. To perform the white test auxiliary regression is performed i.e ε^2 is regressed on all the explanatory variables (Xj), their squares (X_j^2) and all their cross products. The white test was a special case of the Breusch–Pagen.

RESULTS AND DISCUSSION

This section of the article presents the analysed result of the study.

Socio-economic Profile of Malt Sorghum Farmer Households

Out of the 217 sampled malt sorghum farmer households, 49.2 % grow Sila sorghum, 30% grow Gadam sorghum while 30.8% grow both Gadam and Sila sorghum. From the results, the mean age of a contracted malt sorghum farmer in the study area was 45 years. Farmers within this age bracket are said to be very energetic and productive therefore, most of their efforts will be directed to farm activities that range from land preparation to post-harvest practices thus boosting production (Omondi, 2019). This finding is in convergence with that of Kanana *et al.*, (2019) in Imenti North, Meru County who reported that the majority of sorghum farmers had between 40-50 years. However, the current study findings are contrary to the findings by Muui *et al.*, (2013) in Mbeere, Kitui, Makueni, and Mutomo districts of Eastern Kenya where he found out that the most farmers were between 30-40 years of age.

The average land size under sorghum of the malt sorghum farmer household was 2.6 ha with a minimum size of land being 0.4 ha and a maximum land size of 12 ha under sorghum. The recent finding is near similar to the findings by Muui *et al*., (2019) who carried out a study in western Kenya and found out that most of the farmers had farm sizes ranging between 0.5-5acres. This is also supported by Odhiambo (2019), who found out that the farmers in Nyanza, Coast, and Eastern regions of Kenya cultivated their sorghum plots ranging from 0.5-4 ha for farming. Studies by Kenya Food Security Steering Group, (KFSSG) (2008); Muui *et al.*, (2013); Odhiambo (2019) have found the reason behind these small sizes of farms for sorghum. The reason they identified was that farmers also plant other crops such as maize, beans, and cassava on the same farm thus decreasing the land sizes under sorghum and this may lead to further food insecurity. These findings are in line with the findings of Lacy and Cleveland (2006) who observed relatively bigger land sizes of between 2-3 ha under sorghum in Southern Mali.

On average, each household in the county had approximately 7 members with the highest household size having 24 members while the smallest having only one member. As the household size increases in the study area, the household labor provision also increases thus a malt sorghum farmer will hire limited laborers to work in his or her sorghum farm. These findings are comparable to those of Chepng'etich *et al.*, (2013) in Machakos and Makindu districts of Kenya and found out that on average, households had 6 persons. Further, Jongwe (2014) in Zimbabwe reported almost a similar result that on average, each household had 8 members. Jatoe *et al.*, (2005) in a study in Ghana reported a contrary result that on average each household had 4 members.

The average years of experience of contracted malt sorghum farmer in the study area is 1.5 years, with a minimum of one and a maximum of 3 years of experience respectively. Farmers having lots of experience in a particular field/area can apply such skills for effective production and sustainability. Years of experience can also bring about increase in income; more years in cultivation of sorghum which is also associated with improved yields (Omoro, *et al*., 2013). Contrary findings were reported by Oboko *et al.*, (2016) in a study in Tharaka South in Kenya where they found out that 67% of the respondents had been engaging in sorghum farming for 10-19 years.

Majority of the contracted sorghum farmers suggested a mean price increment of up to Ksh 51.1 per kilogram of sorghum grain from Ksh 32 that they do receive for their sorghum grain. If a market offers fair prices, farmers will be propelled to produce more of that commodity/item. Chepngetich *et al.*, (2013) in her study in Makindu and Machakos Districts of Kenya found that majority of the sampled farmers suggested a competitive price ranging from Kshs 41-60/kg for sorghum grain.

Table 2: Socio-Economic Profile of Malt Sorghum Production

Variable	Observation	Mean	Std. Dev.	Min	Max
Age	130	45.2	11.3	20	76
Household size	130	6.5	3.1	1	24
Dependants	130	4.6	2.6	1	12
Land size	130	2.6	1.6	0.4	12
Experience	130	1.5	2.82	1	3
Yield	130	2203.2	2238.1	58	18000
Price suggestion	130	51.1	12.8	32	100

Source: Author's Computation from Survey Data 2020

The average yield per cropping season was 2,203 Kgs/ha with a minimum of 58 and a maximum yield of 18,000 Kgs/ha realized by the farmers. These results are higher than the average yield realized in western Kenya of less than 1,000 kg per ha as reported by Muui *et al.*, (2013). In a study by Kebeney *et al*., (2015), for the years 1990 to 2011, found that the mean yield of sorghum in western Kenya was as low at 0.8 tons per hectare.This was attributed to the fact that smallholder farmers in Western and Nyanza regions in Kenya use low input levels and have inadequate access to modern technologies (Omondi, 2019).However, with the advent of new seed varieties, there is the potential to increase the yield by 2 to 5 tons per hectare (Kilambya & Witwer, 2019).This could explain the findings in the current study.

Econometric Analysis

Effects of Farm Production Factors on Malt Sorghum Production

Results from Table 3 presents estimates of farm production factors influencing malt sorghum production, the double log Cobb-Douglas production function was employed. Results show that the coefficient of determination (R^2) and adjusted R^2 were 0.829 and 0.795 respectively. This implies that 79.5 percent of the variability in the output of malt sorghum in the study area is accounted for by the specified independent variables. The remaining 20.5% is due to other factors beyond the scope of this study. From the results, the output shows that the independent variables statistically significantly predict the dependent variable, F (9,120) =14.54, $p < 0.000$. From the results $p<0.000$ which is less than 0.05 indicates that the overall regression model is statistically significant and predicts the outcome variable, that is, it is a good fit for the data.

Table 3: Empirical Results of the Cobb Douglas Double Log Model

Source	**SS**	**Df**	**MS**	**Number of observations**	**=130**
				F(9, 120)	=14.54
Model	177143.083	9	7380.877	Prob > F	=0.000
Residual	24075.077	120	210.810	R-squared	=0.829
				Adj R-squared	=0.795
Total	2012118.16	129	7591.687	Root MSE	=4.761

Natural log yield	Coefficient	Standard Error	T	P>|t|
Natural Log Land size	1.554392	0 .0141173	110.11	0.006*
Natural Log Seed Quantity	-0.57211	0.0242137	-23.63	0.027**
Natural Log Fertilizer	0.381015	0 .0418597	9.10	0.070
Natural Log Capital	0.050157	0 .0209616	2.39	0.605
Natural Log Labor	-0.1140	0 .0131753	-53.66	0.012**
Pest and Diseases	-0.26751	0 .0145972	-18.33	0.035**
Land Tenure	0.252232	0.019302	13.07	0.069
Land Preparation	-0.50932	0.0107533	-47.36	0.503
_Cons	6.777966	0.1865401	36.34	0.018**

Legend

Number of observations =130 Log likelihood = -35.78

LR $chi^2(9)$ = 224.292 Pro chi^2 = 0.000

Pseudo R^2 = 0.822

**=significant at 1% level, **=significance at 5% level*

***Source**: Researcher's Calculations from the Survey Data, 2020*

The result on the quantity of seed planted has a negative coefficient of -0.572 though statistically significant at the 5% level. The result implies that a one-kilogram increase in the amount of seeds planted results in a 57.2% decrease in the yield of malt sorghum produced by the contracted sorghum farmers. Malt sorghum farmers in the study area should therefore use the correct seed rate if they want to maximize production from their farms. They should not overcrowd their sorghum plants as planting too many seeds in an area will lead to plants competing for nutrients and essential conditions required for them to germinate. A study on rice in Ethiopia found seeds to be statistically significant in the stochastic frontier production function of irrigation agriculture but the effect of seed on the stochastic frontier production function of rain-fed agriculture was found to be negative though statistically significant (Gebregziabher, *et al.*, 2012). A contrary finding was reported by Shehu *et al*., (2007) in a study in Nigeria where the quantity of seeds had a positive sign and statistically significant ($P < 0.05$). Gooding *et al.*, (2002) reported a contrary finding where seed rate had a positive sign and significant to wheat grain yield in the United Kingdom.

The result on pests and diseases is statistically significant at a 5% level with a negative coefficient of -0.268. This implies that as the number of pests and diseases keep increasing and attacking malt sorghum, the yield declines by 26.8 percent. Pests and diseases will lower the quality and quantity of malt sorghum in the study area thereby resulting in underproduction of malt sorghum. Similar results were reported by Muui *et al*., (2013) who reported that sorghum in Eastern Kenya was affected by pests and diseases that led to a decline in yield by up to 70%. According to the study findings by Kibet *et al*., (2011), diseases such as leaf rust and sorghum blight reduce yield by over 60% thus affecting the productivity of smallholder farmers. Omoare *et al*., (2020) in a study in Nigeria reported similar negative and significant results and that a 1% increase in pests and diseases and Kibet *et al.,* (2011).

Results further indicate that labor used in malt sorghum production is statistically significant at a 5% level with a negative coefficient of -0.1140. This implies that if a farmer hires an additional unit of labor per day (man-hour per day) on his or her sorghum farm, then the yield of malt sorghum will reduce by 11.4%. However, this result does not conform to the expected sign. This finding means that a contracted malt sorghum farmer in the study area should not hire additional laborers since the hiring of extra laborers per day will have a negative impact on malt sorghum yield. There is continuous knowledge build-up and attachment to the farm when family labor is involved in the production as opposed to hired labor. A similar finding was put forward by Ogundele and Okoruwa (2006) who found a negative relationship between labor and rice production using traditional technologies in Nigeria. On the contrary, they found a positive correlation between labor and rice production under improved technologies in Nigeria. Contrary results were also put forward by Luzinda *et al*., (2019) in a study in Uganda where he reported that availability of labor had a positive and significant effect on the adoption of improved coffee technologies. The analysis shows that a 3% increase in labor would increase adoption by 1%. Factors such as fertilizer, capital, land tenure, land preparation might be vital in any production though they were not signifant in this study.

CONCLUSION

In conclusion, the descriptive results of this study revealed the mean age of a contracted malt sorghum farmer was 45 years. The average yield of malt sorghum produced per farmer in the study area was 2,203 kilograms per cropping season while the lowest and highest yield being 58 and 18000 kilograms respectively. The average land size of the malt sorghum farmer household was 2.6 acres with a minimum size of land being 0.4 acres and a maximum land size of 12 acres under sorghum. Average years of experience of contracted malt sorghum farmers in the study area is 1.5 years, with a minimum of one and a maximum of 3 years of experience respectively.

Variables such as land size were statistically significant with a positive coefficient of 1.55, quantity of seed planted has a negative coefficient of -0.572 though statistically significant at the 5% level, pests and diseases is statistically significant at a 5% level with a negative coefficient of -0.268. Therefore, the estimated results of this study rejected the null hypothesis that farm production factors do not significantly affect malt sorghum production among contracted malt sorghum farmers in Homa Bay County, Kenya.

RECOMMENDATIONS

From the results of this study, pests and diseases were a major constraint to malt sorghum production. Therefore, both the national and county governments, through the Ministry of Agriculture, Livestock Development and Fisheries should come up with strategies that will help in managing birds which are the major pests that attack/eat sorghum grain. Such measures could include the use of drones and chemical repellants that are neither harmful to sorghum grain nor human beings and farmers should be encouraged to plant simultaneously. Extension officers/agents should educate contracted sorghum farmers on the correct seed rate to be used so as to get maximum yield from their parcels of land.

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