Factors Influencing Pearl Millet Production among Smallholder Farmers in Bahi District, Tanzania

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Ikisiri

Utafiti huu ulifanywa ili kupima vipengele vya kushawishi uzalishaji wa uwele katika wilaya ya Bahi iliyopo eneo la nusu ukame katikati ya Tanzania. Muundo wa utafiti wa sehemu mtambuko ulitumika. Jumla ya wahojiwa 96 walihusika katika utafiti huu. Mbinu mbalimbali zilitumika wakati wa uchambuzi wa data. Matokeo ya utafiti yanaonesha kuwa umri wa mkulima mdogo mdogo ni miaka 48.4 na 55.2% ya waliohojiwa walikuwa wa kiume. Pia, matokeo yalibaini kuwa asilimia 92.7 ya waliohojiwa wameolewa na ukubwa wa kaya ni watu 5.3. Zaidi ya hayo, matokeo ya utafiti yalionesha kuwa wastani wa ukubwa wa shamba la uwele ni ekari 2.7 na mavuno ya wastani ya uwele yalikuwa kilo 405.2 kwa ekari. Zaidi ya hayo, matokeo yalibainisha kuwa asilimia 80.2 ya wakulima walitumia nguvu kazi ya familia kwa kutumia jembe la mkono; ikifuatiwa na 18.8% ambao walitumia plau na asilimia 1.0 tu walitumia vibarua kwa kutumia jembe la mkono. Aidha, umri wa mkulima, ukubwa wa kaya, elimu ya mkulima, shughuli zisizohusiana na kilimo na eneo lililolimwa kwa kiasi kikubwa ($p < 0.05$) uliathiri uzalishaji wa uwele. Mikakati ya kuongeza viwango vya uzalishaji wa uwele zinaweza kuweka msisitizo zaidi katika kuwahamasisha wakulima kutumia mbinu za kisasa za kilimo ili kuongeza mavuno.

Abstract

A current study was carried out to assess factors influencing pearl millet production in Bahi district located in semi-arid central Tanzania. Cross-sectional research design was adopted. A total of 96 respondents were involved in this study. Both descriptive and inferential statistics were employed during data analysis. The study findings indicate that the mean age of smallholder farmers was 48.4 years and 55.2 % of respondents were males. Also, findings revealed that 92.7% of the respondents were married and the size of the household was 5.3 persons. Furthermore, the study findings showed that the mean farm size under pearl millet is 2.7 acres and the average pearl millet yield was 405.2 kg/acre. Additionally, results disclosed that 80.2% of the farmers used family labour using hand hoes; followed by 18.8% who used draught power and only 1.0% used hired labour with hand hoes. Moreover, age of farmer, size of farming household, education of the famers, off-farm activities, and cultivated area significantly ($p < 0.05$) influenced pearl millet production. The strategies to increase levels of pearl millet production could place more emphasis on encouraging farmers to utilize modern farming practices to increase yields.

Keywords: ***Determinants, Pearl Millet, Semi-arid, Smallholder farmers***

1. INTRODUCTION

Pearl millet (*Pennisetum glaucum*) is an important staple crop in the semi-arid regions of Asia and Africa due to its high nutritive value and adaptation to varying stress conditions (Pattanashett *et al.,* 2016). Pearl millet is among the cereals belonging to the grass family Graminae grown globally with differential importance across continents and within regions of the world. They form a diverse group of small grains generally called millets cultivated in diverse and adverse environments, mostly in the dry, semi-arid to sub-humid drought-prone agroecosystems. Millets were among the first plants that were domesticated and have served as a traditional staple crop for `millions of farmers in Sub-Saharan Africa and Asia (FAO, 2018). Millets can grow on poor soils with little or no inputs, are resistant or tolerant to many crop diseases and pests, and can survive adverse climatic conditions.

The global millet production was 32 million tonnes in 2016 and has been declining since the sharp increases seen in the early 2000s. Millet production is shared between Africa and Asia. Africa accounts for more than 55 percent of global production, followed by Asia with 41percent Europe represents 3 percent of the world market while the Americas accounts for only 1 percent (FAOSTAT, 2017).

Pearl millet accounts for more than half of the total worldwide production of all millets. It is the sixth most important cereal crop in the world, next to maize, rice, wheat, barley, and sorghum (FAOSTAT, 2014). It is the most droughts tolerant of all domesticated cereals (Govindaraj *et al.,* 2010). It is commonly grown in the hottest and driest regions where other cereals are likely to fail because of drought, high-temperature stress, and poor soil conditions. Thus, it is a critical staple crop for more than 90 million people across the Sahel of Africa and the fringes of the Thar Desert in India (Gulia *et al.,* 2007; USAID, 2014). Pearl millet is more nutritious than wheat, rice, maize, and sorghum (Muthamilarasan *et al.,* 2016). Its nutritional superiority comes from high levels of protein, vitamins, essential amino acids, antioxidants, and essential micronutrients, such as iron and zinc (Agte *et al.,* 1999). Many traditional foods and beverages are made from pearl millet, including couscous, flatbreads, doughs, porridges, gruels, nonalcoholic beverages, and beer. Pearl millet is also a suitable feed ingredient in poultry diets (Davis *et al.,* 2003).

However, in some countries in Africa or India, millet production has declined for economic reasons in some cases, but also because dietary habits have changed, the authorities /food sector has not stimulated an appreciation of the benefit of millets. Consequently, the nutritional content of the food basket is decreasing and the risk of nutrient deficiencies may be severe among children and women (FAO, 2018). Nevertheless, sorghum and millets are major food crops in sub-Saharan Africa. The two grains account for 56% of the area planted to cereals in this region, and 41% of the region's cereal grain production (Mitaru *et al*., 2012).

It is estimated that in developing countries, pearl millets account for 8% of the cultivable land area which supports about 9% of the population mainly in the agro-pastoral pearl millet farming system (Dixon *et al.,* 2001). There is perpetual food insecurity among the people living in developing countries due to the existence of unfavorable agricultural conditions.

Under these considerations promotion of adoption of drought tolerant crops like pearl millet have taken place despite their low market value, increase the potential to ensure households food sufficiency especially when crops like maize fail (Monyo *et al.,* 2004).

Tanzania produced about 243,729 tons of pearl millet in the year 2011/2012 (URT, 2012). Regions that mostly produce pearl millet in Tanzania include Dodoma, Singida, Shinyanga and Lindi. Tanzania particularly in areas where rainfall is scarce, smallholder farmers engaged in pearl millet production. On the other hand, pearl millet is important for food security in the central high plateau comprising the Dodoma and Singida regions of Tanzania (Monyo *et al.,* 2004). Conversely, pearl millet to large extent is cultivated by the majority of farmers in the Bahi district in the Dodoma region which is raised to an altitude ranging between 560 -1200m above sea level and located in semi-arid areas of Tanzania. For many years pearl millet in the district was adopted as the staple food crop and as an important source of farm income for smallholders. Despite the efforts by the government in supporting pearl millet production in Bahi district, still the production is low. The pearl millet yield of 294.1 kg per acre (Charles, 2013) is significantly lower than the African average of 1,850 kg per acre (Mitaru *et al.,* 2012). Various studies have been conducted on pearl millet such as increasing utilization of sorghum and millet-based food in Tanzania (DFID, 2010), adoption of improved technologies for sorghum and pearl millet production in the central part of Tanzania (Mwanga, 2002) and commercialization prospects for sorghum and pearl millet in Tanzania (Rohrbach and Kiriwaggulu, 2007) and pearl millet value chain approach (Charles, 2013). However, there is a dearth of information about factors leading to low levels of production in the study area. Therefore, the current study aimed at assessing factors influencing pearl millet production in the Bahi district.

2. RESEARCH METHODOLOGY

2.1 The Study Area

The study was conducted at Bahi district located in Dodoma region, which lies between latitude 4°7" and 7°21" South of the equator and also between longitudes 36°43" and 35°5" East of Greenwich. Dodoma region has a dry savanna type of climate, which is characterized

by a long dry season lasting between late April to early December and a short single wet season during the remaining months. The temperature in the region varies according to altitude but generally the average maximum and minimum for October to December are 31^0C and 18^0C, respectively. The corresponding figures for the cool dry season of June – August is 10^0 to 11^0C. The average rainfall for Dodoma is 600 mm, and about 85% of this falls in four months between December and March. Rainfall is somewhat higher in the more agriculturally productive parts of the Mpwapwa and Kondoa districts. Rainfall in the Dodoma region is not only low but is rather unpredictable in frequency and amount, particularly in January in which most crops are generally sown (URT, 2003).

2.2 Research Design, Sampling and Data Collection

The cross-sectional research design was used since it allows the collection of data at a single point at a time. Also, the sampling frame was all pearl millets farmers and a sampling unit was a pearl millet farmer in the study area. Consequently, simple random sampling was used to select 96 farming households for interview. In addition, the purposive sampling technique also was used to obtain the key informants such as district agriculture extension officer and ward agricultural extension officers.

For data collection purposes the interview method was used, whereby well-structured questionnaire utilized as a data collection tool. In addition, documentary review used to collect secondary data and fine-tuning literature especially empirical findings related to the study topic and checklist used as a tool.

2.3 Data Analysis

Descriptive statistical analysis employed to analyze percentage, frequency, and mean. Also, a multiple linear regression was employed in analyzing factors influencing pearl millet production in the study area. The dependent variable pearl millet quantity produced measured in kg/acre regressed on the independent variables described in Table 1. The following model was adopted:

$$Y_i=\beta o+\beta_1\chi_1+\beta_2\chi_2+\beta_3\chi_3\ldots\ldots\beta_8\chi_8+\mu_i \quad (1)$$

Where: Yi = dependent variable, βo = intercept term, βi = parameters to be estimated, χ_i= vector of independent variables assumed to influence household pearl millets production and μi = error term which is independently and normally distributed with a mean of zero and a constant variance.

The final model was as follows:

$$Y_i=\beta o+\beta_1 EDUC+\beta_2 AGE+\beta_3 GF+\beta_4 HHS+\beta_5 OFACT+\beta_6 INC+\beta_7 FSIZE+\beta_8 LOWN+\mu i \quad (2)$$

Table 1 portrays the measurements of variables used in the model and their expected signs.

Table 1: Measurements of Variables used in model and Expected signs

Variable	Description	Units of measure	Expected sign
Y	Pearl millets quantity produced	Kg/acre	
EDUC	Education of the farmer	Number of years of schooling	+
AGE	Age of the farmer	Years	+/-
GF	Gender of the farmer	1=Male, 0=Female	+/-
HHS	Size of the farming Household	Number of people(Aged from 15 years up to 64 years)	+
OFACT	Engagement in off-farm activities	1=Engaged, 0=Otherwise	+/-
INC	Household income	Tanzania shillings	+
FSIZE	Farm area under pearl millet	Acres	+
LOWN	Land ownership	1=Own , 2=leased	+/-

3. RESULTS AND DISCUSSION

3.1 Characteristics of Respondents

The study findings in Table 2 indicate the age of the farmers ranged from 26 to 75 years with a mean age of 48.4 years. The results further showed that the majority (43.8%) of farmers aged between 46 to 64 years, followed by those aged above 64 years (34.4 %) while 16.7% of them aged between 36 and 45 years. The last group was farmers aged between 18 to 35 years (5.2 %). This indicates that pearl millet production in the study area is dominated by farmers aged 46 to 64 years. This denotes that there is a high proportion of adults in the community who mostly make up the community labour force. This age group is an important

variable in agricultural production because production activities require experience and maturity in negotiation and decision making especially in the use of farm inputs. However, Ghimire and Kefle (2014) observed that when it comes to the question of adopting new crop husbandry technologies there is a negative relationship between age and innovativeness.

Also, the results in Table 2 show that 55.2 % of respondents were males and 44.8% were females. However, it can be noted that according to FAO (2000), in most developing countries like Tanzania, women contribute about 75% of the total labour force in agricultural activities. Furthermore, findings revealed that 92.7% of the respondents were married followed by the widow (6.3 %,) and single (1%). This implies that the majority of farmers have a fairly good amount of labour for farming activities in the study area.In addition, findings revealed that the mean size of household was 5.3, which approximately concurs with the national average size of 5.4 persons per household in rural areas of Tanzania (URT, 2016.), which implying that they have satisfactory labour for farm activities. Additionally, findings in Table 2 indicate that 62.1 % of households had more than 5 members, 29.6 % of households had 3 to 5 members and 8.4 % had less than 3 members. This suggests that the study area is dominated by reasonably large family sizes which can be deployed for various farm activities especially those aged 10 years and above.

Furthermore, findings in Table 2 showed that 62.5% of farmers attained primary education and 37.5% had no formal education. The result implies that the level of basic education in the study area is relatively high; which can be advantageous in embracing knowledge on better farming practices. This is consistent with the work of Bruce (2015) on innovation adoption, where the education of the household head was found to have a positive and significant impact on the adoption of various better farming practices.

Table 2: Characteristics of Respondents

Variable	Category of respondents	Frequency (n =96)	Percentage
Age	18-35	5	5.2
	36-45	16	16.7
	46-64	42	43.8
	> 64	33	34.4
Sex	Male	53	55.2
	Female	43	44.8
Marital status	Single	1	1.0
	Married	89	92.7
	Widow	6	6.3
Household size	Less than 3 members	8	8.4
	3 to 5 members	28	29.6
	More than 5 members	60	62.1
Education level	Primary education	60	62.5
	No formal education	36	37.5

3.2 Pearl Millet Production in Bahi District

To determine the status of pearl millet production in the study area, various aspects were considered which included total farm size, the total area under pearl millet, total yield, sources of labour and costs in pearl millet production.

3.2.1 Total farm size and farm under pearl millet production

Agricultural activities depend largely on the availability of land either owned or rented from others to engage in farm activities. Also, it is important to examine how resources are managed, and their effects on productivity. The empirical literature indicated that small farmers have restricted access to modern input, and this can hold back their productivity, at the same time, small and large farmers may differ in their attitude to risk and uncertainty. The large farmers may be more willing and able to carry greater risks. The total area cultivates by farmers in the study area ranged from 5 to 24 acres per year making an average of 7.8 acres per year. The findings further showed that 67.7% of farmers owned land between 1-5 acres, 26.1% of farmers had 5.1 -10 acres, 3.1% of farmers possess between 10.1 to 15 acres and 3.1% of them have above 15 acres.

Also, the study revealed that farm size under pearl millet cultivation ranged from 1 to 8 acres with a mean of 2.7 acres. Additionally, the results in Table 3 showed that 41.7 % of farmers cultivated pearl millet in 1-2 acres, 52.1 % (2.1-4 acres), 3.1% (4.1 - 6 acres) and 3.1% cultivated in above 6 acres.

Table 3: Distribution of farm size by respondents

Total farm size (Acre)	**Frequency (N=96)**	**Percentage**
1 – 5	65	67.7
5.1 -10	25	26.0
10.1 -15	3	3.1
Above 15	3	3.1
Area under pearl millet production (Acre)		
1-2	40	41.7
2.1 -4	50	52.1
4.1 -6	3	3.1
Above 6	3	3.1

3.2.2 Pearl Millet Yield

Findings revealed the mean yield was 1094.9 kg from an average farm size of 2.7 acres, which translates to the productivity of 405.2 kg/acre in the study area. These findings differ with Lameck, (2012) who reported that due to interventions by INADES the farmers have increased the yield of pearl millet from 120kg/acre to 800 kg/acre in semi-arid areas of Tanzania included Bahi district. Furthermore, the results in Table 4 show that 24.0 % of farmers produced between 102 to 300 kg per acre, 51.0% (301-500 kg per acre) and 25.0 % produced 501-760 kg per acre. According to agricultural extension officers from wards and district levels, most farmers are reluctant to adopt improved varieties that lead to higher yields.

Table 4: Distribution of pearl millet yield

Yield (kg)	**Frequency (N=96)**	**Percentage (%)**
120 – 300	23	24.0
301 – 500	49	51.0
501–760	24	25.0
Total	**96**	**100.0**

3.2.3 Sources of Labour and Costs in Pearl Millet Production

This section looked on sources of labour and costs of pearl millet production among smallholder farmers in the study area. The findings are presented in Table 5 and 6.

3.2.3.1 Sources of labour

The findings in Table 5 revealed that 80.2% of the farmers used family labour using hand hoes; followed by 18.8% who used draught power and only 1.0% used hired labour with hand hoes in pearl millet production. This shows that the majority of farmers embraced traditional farming practices by using hand hoe which is not labour and time-saving. According to Ozowa (1995), the agricultural technologies for the small-scale farmer help to minimize the drudgery or irksomeness of farm chores. The technologies should be labour-saving, labour-enhancing, and labour-enlarging. Also, Nyoro (2000) narrated that high costs of farm machinery affected the quality and timeliness of farm operations such as the land preparation in the key maize production zones in Kenya. The high costs of farm operation have forced farmers to reduce the quality of seedbed preparation (Nyoro,2000). As a result, most farmers had reduced the number of times they ploughed and harrowed thereby reducing the quality of the seedbed.

Table 5: Sources of labour

Labor	Frequency (N=96)	Percentage
Draught power	18	18.8
Hired labor (Hand hoe)	1	1.0
Family labor (Hand hoe)	77	80.2
Total	**96**	**100.0**

3.2.3.2 Sources of costs

The findings in Table 6 revealed that 87.5 % of the pearl millets farmers indicated that land preparation is the costliest in pearl millet production followed by seed acquisition (28.1 %), weeding (27.1 %), and fertilizer acquisition (26.0 %) and lastly was the cost of planting (20.8 %). These findings agree with Wanyama *et al.* (2010), who reported that preparation of land

can influence negatively or positively pearl millet yields; if the cost decreases farmers cultivate larger area, meaning they will apply more fertilizers leading to higher yields and if it increases farmers cultivate less land and purchase fewer fertilizers, therefore apply less that will lead lower yields.

According to Nyoro (2000), thorough land preparation normally involves deep ploughing and thorough incorporation of weeds and crop residues, row planting, correct placement of fertilizers through use of machinery; superior and thorough crop protection against weeds, and better harvesting operations due to the use of machinery. Thus reduction in the quality of land preparation due to high cost as mentioned by the majority of smallholder farmers could have adversely affected pearl millet yield in the current study. Furthermore, Wekesa *et al.* (2003) reported that hiring labour for land preparation might not directly influence the adoption of improved varieties, but it was a proxy for available cash to invest in agricultural production.

Table 6: Sources of cost in pearl millet production

Activities Done	Responses	Percent
Land Preparation	84	87.5
Planting	19	20.8
Fertilizer acquisition	25	26.0
Seed acquisition	27	28.1
Weeding	26	27.1

3.3 Factors Influencing Pearl Millet Production in the Study Area

A multiple linear regression was used to examine factors influencing pearl millet production among smallholder farmers in the study area. The result in Table 7 indicates independent variables included in the model were good determinants of pearl millet production. About 91.6 % of the variation was explained by explanatory variables included in the model. The result further indicates that explanatory variables included in the model collectively had a significant influence on the pearl millets production ($F = 103.541$, $p<0.001$). Variables such as the age of the farmer, size of farming household, education of the farmer, off-farm

activities, and cultivated area significantly ($p < 0.05$) influenced pearl millet production while nature of land ownership, gender of the farmer, household income, and inadequate extension services had insignificant ($p > 0.05$) effects on pearl millet production.

3.3.1 Age of farmer

The result revealed that the age of the farmer statistically significantly ($p < 0.05$) influenced pearl millet production and had a positive coefficient. This means to increase the age of farmers by one year while holding other factors constant will increase production by 6.8 kg per acre. This result concurred with the results from Wiredu *et al.* (2010)who assert that the age of a farmer can be used as a proxy for the farmer's experience. It is generally expected that experienced farmers would most likely have high crop productivity than their counterparts.

3.3.2 Size of the farming household

Also, findings disclosed that household size significantly ($p < 0.05$) influenced pearl millets production with a positive coefficient. This implies that an increase in the size of the household by one unit will lead to an increase in the level of pearl millet yield by 152.0 kg per acre when other factors are held constant. This could be explained by the fact that an increase in the size of the household implies an increased demand for food. To meet the demand, the household seeks better pearl millet production practices to boost levels of production. Also by having a large household size may lead to having more labour that can be utilized in farming activities. This result concurred with Libois and Somville (2017) and Jerome and Perreault (1991) who observed that household size has relevant implications for household engagement in production activities. Also, Cage (1989) and Kalwij *et al.* (1998) concluded that household size was a positive and significant factor in determining levels of engagements in agricultural activities. Additionally, Sdrali (2006) noted that households with large family sizes engage more in pearl millets production than households with small family sizes, *ceteris paribus*.

3.3.3 Education of the farmer

In addition, findings revealed that the education of the household head had a positive and significant ($p < 0.05$) influence on pearl millet production. Thus, the yearly increase in the education level will lead to the production of an extra 168.9 kg per acre while keeping other variables in the model constant. The positive effect implied that educated farmers were more likely to apply better farming practices and set aside more time to engage in pearl millet production compared to their counterparts. These findings concur with Bruce (2015), who reported that the education of the household head had a positive and significant impact on the adoption of conservation tillage and integrated pest and weed management at a 10 and 5% level of significance, respectively among rice farmers in Ghana. According to Namara *et al.* (2014) educated farmers are believed to have a higher ability to obtain, interpret, and respond to new information about technologies than their peers with little or no education. Additionally, more educated farmers are more likely to access information and advice from extension workers which inspire them to adopt and use newly introduced innovations.

3.3.4 Off-farm Activities

Moreover, the finding showed that off-farm activities influence positively and significantly ($P<0.05$) pearl millets production in the study area. Thus, holding other factors constants, engaging more with off-farm activities will lead those farming households to harvest an extra 203.1 kg of millet per acre. This result corresponds with the result from Djauhari *et al.* (1987) who observed with relatively small landholdings and limited income from their farms, the existence of alternative sources of income provides farmers with the means and flexibility to meet the expenses of farm operations which might lead to higher production.

3.3.5 Area cultivated

Finally, results revealed that the area under pearl millet cultivation positively and significantly ($p < 0.001$) influenced yield in the study area. A unit increase in farm size associated with an increase of 126.3 kg per acre, holding other factors constant. This can be explained by the fact that a large area of agricultural land provides an opportunity for additional production. These findings concur with Urassa (2015) who conducted his study on factors affecting maize production at the household level in the Rukwa region, Tanzania.

Table 7: Regression outputs on factors influencing pearl millets production

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-493.186	255.109		1.933	.056		
Age of the farmer	6.801	3.383	.110	2.010	.048	.329	3.038
Size of the Farming Household	151.597	21.710	.446	6.983	.000	.241	4.156
Gender of the farmer	28.833	52.205	.020	.552	.582	.756	1.323
Off farm activities	203.083	80.581	.126	2.520	.014	.393	2.546
Area cultivated	126.300	25.327	.290	4.987	.000	.290	3.448
Education level of the farmers	168.934	68.160	.119	2.479	.015	.424	2.359
Household Income	28.128	57.888	.022	.486	.628	.466	2.147
Inadequate Extension Services	-15.549	48.972	-.011	-.318	.752	.801	1.248
Land ownership	69.209	71.214	.034	.972	.334	.812	1.231

F = 103.541, p-value = 0.0000, R^2 = 91.6%, Adj. R^2 = 90.7%

4. CONCLUSION AND RECOMMENDATIONS

From the findings, the study concluded that pearl millet production is predominantly done by middle-aged and advanced aged farmers and mostly have attended primary education only. The household size is higher than the national average. Pearl millet productivity is lower than the national average and most farmers are using hand hoe and family labour in undertaking agricultural activities. The land preparation was the costliest activity in the study area. Additionally, regression analysis substantiated that age of the farmer, size of the farming household, level of education of the farmer, area under cultivation and off-farm activities significantly influenced pearl millet production.

Based on the findings, the strategies to increase levels of pearl millet production could place more emphasis on encouraging farmers to utilize modern farming practices like utilizing tractors and ploughs during cultivation which might lead to an increase in area under cultivation and consequently higher yields. In addition, improved seeds, and fertilizers should be affordable to smallholder farmers to boost productivity. Similarly, relevant stakeholders should encourage and assisted farmers to engage in off-farm activities, since this has been revealed to have a positive and significant influence on yield.

REFERENCES

Agte, V.V., S. Khot, S.T. Girigosavi, K.M. Paknikar, and S.A. Chiplonkar. (1999). Comparative performance of pearl mil-let- and sorghum-based diets vs. wheat- and rice-based diets for trace metal bioavailability. J. Trace Elem. Med. Biol. 13(4):215 –219. doi:10.1016/S0946 - 672X (99)80038 -8

Bruce, A. K. K. (2015). Improved Rice Variety Adoption and Its Effects on Farmers' output in Ghana. (Doctoral dissertation)

Bruce A. K. K. (2015). Improved Rice Variety Adoption and Its Effects on Farmers' output in Ghana. (Doctoral dissertation)

Cage, R. (1989). Spending differences across occupational fields. *Monthly Labor Review Journal* 112(12): 33-43.

Charles. G. (2013). Constraints in Pearl Millet Marketing in Tanzania: The Value Chain Approach**.** Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 132pp.

Davis, A.J., N. Dale, and F.J. Ferreira. (2003). Pearl millet as an alternative feed ingredient in broiler diets. J. Appl. Poult. Res. 12:137–144. doi:10.1093/japr/12.2.137

DFID. (2010). Department for International development: Increasing utilization of sorghum and millet based food in Tanzania. [http://www.research4developm ent. info/] site visited on 4/05/2019.

Dixon J., Gulliver A, Gibbon, D. (2001). Farming systems and poverty: Improving farmers' livelihoods in a changing world. FAO and World Bank, Rome and Washington, D

Djauhari, A., Djulin, A. and Soejono, I. (1987). Maize production in Java: Prospects for farm level production technology. CGPRT Centre.

FAO. (2000). Gender and food security, Women and population division.

FAO. (2018). Food and Agricultural Organization of the United Nations. Proposal for an International Year of Millets.

FAOSTAT. (2014). FAO statistical yearbook. FAO, Rome.

FAOSTAT. (2017). Global Millets Production.

Ghimire B and Kefle, N. (2014). Integrated pest management practice and its adoption determinants among apple farmers in Mustang district of Nepal. *Scholars Journal of Agriculture and Veterinary Sciences; 1(2):83-89*

Govindaraj, M., P. Shanmugasundaram, P. Sumathi, and A.R. Muthiah. (2010). Simple, rapid and cost effective screening method for drought resistant breeding in pearl millet. Elec-tron. J. Plant Breed. 1:590–599.

Gulia, S.k., J. Wilson, J. Carter, and B.P. Singh. (2007). Progress in grain pearl millet research and market development. In: J. Janick and A. Whipkey, editors, Issues in new crops and new uses. ASHS Press, Alexandria, VA. p. 196–203.

Jerome, M. E. and Perreault, D. W. (1991). Essentials of marketing. *Agricultural Economics Journal 49:* 128-144.

Kalwij, A., Alessie, R. and Fontein, P. (1998). Household commodity demand and demographics in the Netherlands: Micro econometric analysis. *Journal of Population Economics*, 11(1): 551-577.

Lameck, P. G. M. (2012). Sorghum and millet production in the Tanzanian lowlands: Experience of Institut Africain pour le Development Economique et Social (INADES). In: Proceedings of the ECARSAM Stakeholders Conference, 20–22 November 2006, Dar es Salaam, Tanzania. ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa), Entebbe.

Libois, F and Somville, V. (2017). Fertility, Household Size and Poverty in Nepal. 2017. halshs-01662761

Mitaru BN, Mgonja MA, Rwomushana I, Opio F, eds. (2012). *Integrated sorghum and millet sector for increased economic growth and improved livelihoods in Eastern and Central Africa.* Proceedings of the ECARSAM Stakeholders Conference, 20–22 November 2006, Dar es Salaam, Tanzania. ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa), Entebbe.

Monyo, E. S., Ngereza, J., Mgonja, M. A., Rohrbach, D. D., Saadan, H. M. and Ngowi, P. (2004). *Adoption of Improved Sorghum and Pearl Millet Technologies in Tanzania.* International Crops Research Institute for the Semi-Arid Tropics Workshop, Bulawayo, Zimbabwe. 28pp.

Muthamilarasan, M., A. Dhaka, R. Yadav, and M. Prasad. (2016). Exploration of millet models for developing nutrient rich graminaceous crops. Plant Sci. 242:89–97. doi: 10.1016/j.plantsci.2015.08.023

Mwanga, J. N. W. (2002). Adoption of improved technologies for sorghum and pearl millet in Dodoma Region in Central Tanzania. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 172pp.

Namara RE, Hope L, Sarpong EO, De Fraiture C, Owusu D (2014). Adoption patterns and constraints pertaining to small-scale water lifting technologies in Ghana. Agricultural Water Management 131:194-203.

Nyoro J. K (2000) Kenya's Competitiveness in Domestic Maize Production: Implications for Food Security. Tegemeo Institute, Egerton University, Kenya.Working Paper 24. Tegemeo Institute. Nairobi, Kenya: Egerton University.

Ozowa, V. N. (1995). Information Needs of Small Scale Farmers in Africa. The Nigerian Example. Quarterly Bulletin of International Association of Agricultural Information Specialists, IAAID/CABI. Vol. 40, No. 1. 1995.

Pattanashetti, S. K., Upadhyaya, H. D., Dwivedi, S. L., Vetriventhan, M and Reddy, K. N. (2016). Pearl Millet: In Genetic and Genomic Resources for Grain Cereals Improvement. 2016, Pages 253-289.

Rohrbach, D. D. and Kiriwaggulu, J. A. B. (2007). Commercilization prospects for Sorghum and Pearl millet in Tanzania. SAT eJournal Vol. 3(1): 1 – 25. An Open Access Journal published by ICRISAT.

Sdrali, D. (2006). Effects of socio-demographic and economic factors on food expenditure in a prefecture of Greece. Dissertation for the Award of PhD at Harokopio University of Athens, Greece. 187pp.

Urassa, J. (2014). Factors influencing maize production at household levels: A case of Rukwa region in Southern Highlands of Tanzania. African Journal of Agricultural Research, 10(10):1097-1106.

USAID. (2014). Agricultural adaptation to climate change in the Sahel: A review of fifteen crops cultivated in the Sahel. African and Latin Am. Resilience to Climate Change Project Rep. U.S. Agency Int. Dev., Washington, DC

URT. (2012). United Republic of Tanzania. Ministry of Agriculture, Food Security and Cooperatives.

URT. (2016). Tanzania Mainland - Basic Demographic and Socio-Economic Profile, 2012 Population andHousing Census, URT, 2016

URT. (2003). *Dodoma Region Agriculture Socio-Economic Profile*. National Bureau of Statistics, Tanzania. 339pp.

Wanyama, J., Mutoko, M.C., Mose, L. O., Nyambati, E. M., Wanyonyi, W. M., Rono, S. C and Wanjekeche, E. (2010). Assessing impact of soil management technologies on smallholder farmers' livelihoods in North Western Kenya. *African journal of agricultural research* 5(21):2899-2908.

Wekesa, E., W. Mwangi, H. Verkuijl, K. Danda, and H. De Groote. 2003. Adoption of maize production technologies in the coastal lowlands of Kenya. Mexico, D.F.: CIMMYT.

Wiredu, A.N., Gyasi, K. O., Marfo, K.A., Asuming-Brempong, S., Haleegoah, J., Asuming-Boakye, A and Nsiah, B. F. (2010). Impact of improved varieties on the yield of rice producing households in Ghana. *Second Africa Rice Congress, Bamako, Mali, 22–26 March 2010: Innovation and Partnerships to Realize Africa's Rice Potential.*