INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 12, No. 2, p. 68-77, 2018

RESEARCH PAPER OPEN ACCESS

Assessing factors influencing adoption of drought tolerant common bean varieties: a case study of Machakos County, Kenya

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Article published on February 28, 2018

Key words: *Phaseolus vulgaris*, Water use efficiency (WUE), Drought tolerant, Climatic conditions, Adoption

Abstract

In Kenya, one of the major and cheap source of protein is bean (*Phaseolus vulgaris* L.). The crop is consumed in almost every household on a daily basis due to its cheapest nutritional source. Machakos County, where the survey was carried out during 2016 / 2017 cropping season, experienced crop failures and low bean production due to annual occurrence of drought, sparse rainfalls and soil fertility issues. This study seeks to determine the socio-demographics of the household, crops being domesticated and production constraints, cropping systems, challenges facing production of common bean in the region, information on the availability of drought tolerant bean varieties and factors influencing the adoption of these bean varieties. Data was collected using a focus group approach where open ended questionnaires were distributed to each farmer and was filled in, photos for each group was taken during each session. Results obtained showed that 55% of the farmers obtained clean seeds for production while 44% are still using uncertified seeds for production. A regression and correlation analysis showed that preference of KATX56, KAT/B1, GLPX92 and KATRAM bean varieties led to an increased adoption by most farmers due to seeds availability by Government, the Dryland Seed Company (DLSC), Agro-dealers and Research Institutions. Most importantly, the farmers attributed their adoption to KATX56, GLPX92, KAT/B1 and KATRAM based on yields, market demand and WUE. However, research is required in documenting the WUE of the various drought bean varieties to increased farmers decision making process during drought.

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Introduction

Common bean (*Phaseolus vulgaris* L.) is an important legume for human consumption and is second to maize as a food crop in Sub-Sahara Africa (Beebe, 2012; Broughton *et al.,* 2003; Mwang'ombe *et al.*, 2008). Despite the importance of the crop, the productivity of common bean has been decreasing. According to Mwang'ombe *et al.* (2008), biotic and abiotic constrains as well as low external inputs like fertilizers are believed to have reduced the yield of common bean by up to 25% of the potential yield. In addition, erratic and poorly distributed rainfall, use of poor genetic materials, pests and poor soil fertility contribute to the low yield (Kavoi *et al.*, 2016). However, among the efforts to increase bean production in semi-arid areas, the adoption of improved early maturing and drought resistant genotypes is a viable option (Katungi *et al.*, 2009).

In Kenya, several research centers including Centro International de Agricultura Tropical (CIAT) and the National Drylands Research Centre in eastern part of Kenya have been producing improved bean varieties and sensitize farmers on innovative production methods in the arid and semi-arid areas. As a result, drought tolerant bean varieties like the Katumani Bean series were developed (Kitonyo *et al.*, 2013), but the supply has not reached outside semi-arid localities as seed demand remain unmet (Buruchara *et al.*, 2011 and Rubyogo *et al.*, 2010). This has led to approximately 63% of farmers in eastern Kenya adopting the improved bean varieties with majority of them growing more than one variety on the farm while the rest of the farmers grow only one type of improved bean for domestic and commercial purposes (Value and Analysis, 2013). Because of the high demand and market value of beans, farmers have abandoned growing other unprofitable crops for bean and are keen to adopt the improved varieties (Value and Analysis, 2013). Despite the adoption of new varieties by farmers, common bean productivity in Kenya remains one of the lowest in the region (FAO, 2013 and Enid *et al.*, 2015).

Production of beans can easily be adopted by small-scale farmers in semi-arid areas due to preference, economic potential as well as its short maturation period which permits production when rainfall is erratic (Katungi *et al.*, 2010; and Gichangi *et al.*, 2012). This study seeks to document information on the adoption of drought tolerant common bean varieties in Machakos County in Kenya and the factors underlining their adoption or lack of adoption by the small-scale farmers, the variety adopted and reasons for selecting those varieties. Information on the availability of drought tolerant bean varieties and the challenges facing bean production. Understanding of these issues, by breeders and stakeholders, as well as the involvement of smallholder farmers in the selection of varieties based on their preference attributes, will increase production of beans.

Materials and methods

Study Area

Katumani dryland Research Centre is located in Machakos County at latitude 01º 34' S, longitude 37º14' E, and an altitude 1600m above sea level and 80km southeast of Nairobi. Rainfall is bimodal with annual mean rainfall as 711mm whilst the average seasonal rainfall is 301mm for the long rains (March-May) and 283mm for the short rains (October-December). The short rains tend to be more reliable for crop production than the long rains (Kwena *et al.*, 2017). Temperature range between 17 and 24ºC (Jaetzold *et al.*, 2006). The mean potential evaporation is in the range of 1820mm to 1840mm per year (Gicheru and Ita, 2000). However, the semi-arid eastern Kenya, rainfalls are unpredictable with coefficients of variation in seasonal rainfall often exceeding 50% (Kwena *et al.*, 2017).

Katumani is covered by Lixisols soils derived from granitoid gneiss of the Basement System Complex. They are deep to very deep, well drained, dark red to reddish brown, weakly structured and friable, with sandy and sandy loam near the surface (Gicheru and Ita, 2000). In semi-arid Eastern Kenya, soils are faced with fertility and slightly acidic in reaction. The cation exchange capacity (CEC) of these soils is generally low to very low (e.g. 7.8cmol kg^{-1}), (Composition *et al.*, 2016 and Itabari *et al.*, 2013).

The soil also exhibits high erodibility, surface capping under raindrop impact resulting in poor infiltration of rain water hence high runoff, serious erosion, and lose of nutrients on many of the steeper cropland sites (Simpjol& Luhllfwa, 1996). The landscape of Katumani consists of flat to hilly elevations with a relief variation of 10 - 20m. The slopes are straight to gradient range between 2% and 20% (Kutu, 2012). Fig. 1.0: shows map of the study site.

Sampling method and data collection

Sampling method

Purposeful sampling method was carried out. Three locations were sampled based on the regions where common beans are mostly grown and these locations included: Mwania village, Kaathi village and Kyamuluu village where the Mbilini self-help group, Green shade self-help group and the Kyamuluu Tree Nursery group were interviewed, respectively. From each location, a focus group approach was carried out such that each farmer was presented a questionnaire and the questions were discussed and then later answered by each of the farmer. This process was carried out on separate days as per the meeting time of each group and location. This approach was used as a means to easily access these farmers outside of the planting season when they are engaged with tree nursery activities to up keep their families until the next planting season begins. The area chiefs together with the extension staffs helped in mobilizing the community and partially in data collection. Due to language barriers, the local leaders were used in the translation.

Data Collection

Information on the socio-demographics, Bio-data: farmers' details such as education level, sex, marital status and farm size in acres were from the farmers through the open and close ended questionnaire, crops being domesticated and production constraints, cropping systems in Machakos County, challenges facing production of common bean in the region, information on the availability of drought tolerant common bean varieties and factors underlying adoption of drought tolerant varieties was obtained through focus group's approach. The data described above were collected using photos snapping of farmers photos and combined open ended questionnaire; targeting at least thirty respondents per location but due to personal engagements of respondents outside of the farming season, a total of thirty eight farmers were accessed from the three locations to partake in the focus group discussion.

Data Analysis

Descriptive statistics like frequency distributions of farmers in the focus group discussion, drought tolerant common bean varieties; Information on the domesticated common bean variety, Reasons for their preference, information on their availability, Challenges facing their production and farmers' Bio-data was sorted, coded and analysed using the Statistical Package for the Social Sciences (SPSS 21.0.0.0.) version (Learning,). P values ≤ 0.05 and 0.01 were considered as statistically significant. Bivariate analysis was carried out with the same SPSS 21.0.0.0. (Learning,). Pearson Correlation Coefficients was used to investigate the correlative relationships of socio-economic variables: gender, education, farmers' awareness of drought tolerant common bean varieties, yield per acre, production constraints and sources of information on growing DTCBV (Table 6). Only variables that were linked to this study form the focus group discussion were used in the analysis. A logistic regression analysis was also carried out using the Statistical Package for the Social Sciences (SPSS 21.0.0.0.) version to determine which variable among the independent variables were closely related to the dependent variable: type of drought tolerant bean varieties, yield per acre, Varieties types aware of, sources of information and seeds sources are related to the dependent variable: preference to determine the strength of the relationship that increased the adoption of farmers to the these drought tolerant varieties.

Results and discussions

Socio-Demographics Characteristics of Farmers

Most of the farm household dwellers in Machakos County were headed by males (90%), most of whom (40%) had an average age of between 20-50 years (Table 1.0), which implies that age of the households' heads described the sample size of the population (Kecskemeti, 1996).

Age shows the position of individuals in tradition societies. Majority of the farmers above 20 years were married (82%) and had more children than their younger counterparts as indicated by the positive correlation between number of children and age of the household heads (Table 5).

In the study area, the rest from 20 years (5.3%) were not married but own homes and farm lands inherited from their parents or grandparents. The proportion (47.4%) of farmers who have attained secondary level education, indicate that the majority of the farmers had prior knowledge and have adapted to planting these drought tolerant varieties.

The significant relationship found between education level of the household heads and awareness of drought tolerant bean varieties (Table 5), implies that probability of increased adoption depends on the level of education. This is in agreement with Amaza *et al.* (2017) reported direct relationship between improve maize varieties (IMV) adoption and educational status.

However, Gichangi *et al.* (2012) confirmed that the ability of farmers to obtained, process and use information relevant to production is increased by education. Conversely, the proportion of household heads (23.7%) who have not accessed or at least had informal education account for farmers who still subscribed to their traditional technology and are using recycled seeds from the previous seasons of which the viability chances are not known and are still having challenges adopting to modern technologies which shows a non-adoption factor and reduction in production.

The negative but significant relationship between education level and gender of the household heads indicate that adoption to these new varieties by farmers who have not attained any form of education is still a problem and a factor to food insecurity in many rural household. Table 1.0 show the social demography of farmers in the study area.

Crops Being Domesticated and Production Constraints

Generally pulses in Eastern province serve as a means of income and food security for rural household as shown in (Table 2).

Due to the semi-arid nature of Machakos County Eastern Kenya, production of the crop is faced by several constraints such as biotic and abiotic factors, whereas drought (34%) (Table 2) was considered major abiotic factor, with fertility biotic factor exacerbating problems (Ngugi *et al.,* 2011).

Farmers are forced to engage in mixed cropping systems to get food on the table for the household and maximized the resources that are in sight hence avoiding total production failures. This according to FOOD SECURITY BRIEF, (2013) implies the structure production deficit of several staples in Kenya. Farmers in the study area produce several crops as coping mechanism to drought.

As a result of this, researchers have worked over time to generate improved drought tolerant bean varieties for improvement in production. However, many varieties have been disseminated by KALRO, the Ministry of Agriculture, and Dryland Seeds Company amongst other organizations in the study area.

However, despite the production constraints faced by farmers, majority of them are still involve in the mass production of this crop due to its important role in household up keep and income based as shown by the 53% increase of bean above other crops (Table 2).

Value and Analysis, (2013) reported 58% increase in male involvement in pulse production in Machakos County as being associated with the continuous increased, improved prices leading to higher income as evident by the 53% bean (Table 2).

Despite, the tremendous production of various crops by household, there is still some production constraints like disease and pests, competition for fodders between both wild and domesticated animal like cattle competing for crops they have access to under such semi-arid condition. Inputs and drought (34%) exacerbating the problem as being the major contributor to crop failures in eastern Kenya food Security Brief, (2013), and this is being experienced almost on an annual basis.

Table 1. Demographic characteristic of respondents.

		%	Mean (SD)
Household head	Male	89.5	
	Female	10.5	
Gender	Male	57.9	
	Female	42.1	
Age (years)	20-40	39.5	
	40-50	39.5	
	50-70	10.5	
	70-90	10.5	
Marital status	Married	81.6	
	Divorced	2.6	
	Separate	2.6	
	Single	5.3	
	Widow/widower	7.9	
Education level	Primary	26.3	
	Secondary	47.4	
	Tertiary	2.6	
	Informal	23.7	
Number of children	2-3	15.8	
	3-4	52.6	
	>4	31.6	
Occupation	Civil job	10.5	
	Farming	81.6	
	Casual	7.9	
Average family size			6.4 (1.15)
Average land size			1.42 (0.50)
Land tenure	Communal	100	

Numbers in the brackets represent the standard deviation of the means of the average family size and the average land size used under cultivation by farmers.

Table 2. Crops being domesticated and production constraints.

	Crops	%
Crop grown	Green gram	2.6
	Cowpea	5.3
	Dolicos	5.3
	Pigeon pea	7.9
	Maize	26.3
	Bean	52.6
Production constraints	Inputs (Seeds &fertilizers)	13.2
	Blight (fungal)	15.8
	Pests	15.8
	Wild and domestic animals	21.1
	Drought	34.2

Challenges Facing Production of Common Bean in the Region

Most of the respondents interviewed (71%) were members of some financial institutions and had savings with commercial banks while others (29%) were not members of any financial institution and had no savings at all (Fig. 1).

Although members of these financial institutions could access credits, majority of them (82%) complained of high interest rate; while 3% of them did not need loans. Whereas, others (11%) feared taking loans and the rest (5%) lacked security accessing loan (Fig. 2). These challenges could probably be the reason for which most of the farmers fear to take loan. In sub-Saharan Africa, Kavoi *et al.*, (2016) reported challenges of common bean production create relatively slow expansion in cultivated area due to scarcity of arable land and aggravated by rapid population growth (not included on table).

Older farming folks and their younger counterparts have difficulties accessing loan from financial institutions due to high interest rate and fear of forfeiting their properties to these financial institutions.

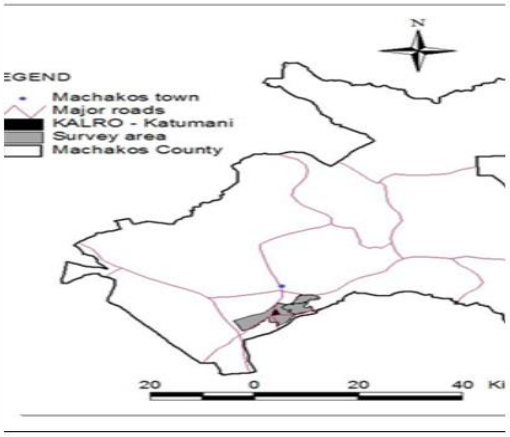

Fig. 1. Showed map of the study area.

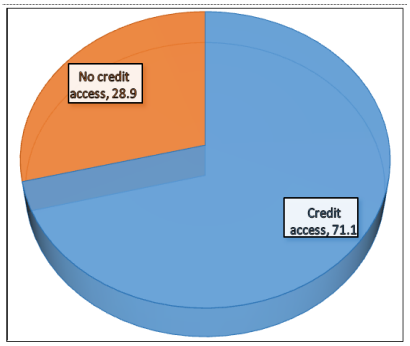

Fig. 2. Farmers with credit access and those without credit access.

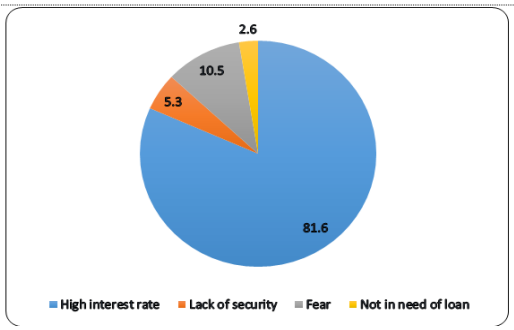

Fig. 3. Proportion of farmers with credit access constraints.

Information on the availability of drought tolerant common bean

From the interviewed of thirty eight respondents, 28.9% obtained information from Ministry of Agriculture/KALRO, and another 28.9% relied on farmers' experience by recycling seed from the previous harvest. While 26.3% of farmers got information from Research Organization, the rest (15.8%) got information from the non-governmental organizations (NGOs) (Table 4).

The common bean choice varies among farmers within a given locality and the integration of these varieties is based on production attributes which influence the choice of these varieties as indicated in (Table 4). Of the respondents interviewed, majority (31.6%) preferred KAT X56 and (26.3%) GLPX92, (23.7%) KAT/B1 and (18.4%) preferred KATRAM due to their drought tolerant attributes.

However, these results shows that farmers in the study area were knowledgeable about these drought tolerant bean varieties as indicated in (Table 4) by the various entities responsible to addressing the farmer's needs. From the negative correlation of gender and sources of information, implies that older farmers where more likely to stick to the use of traditional farming methods as compared to their younger counterparts who preferred modern methods of farming.

Table 3. Sources of information on the availability, preferred varieties and reasons for the preference of these drought tolerant bean varieties.

	Responses	Percentages
Sources of information on the availability of DTCBV	Farmers experience	28.9
	Research Organization	26.3
	NGOs	15.8
	Ministry of agriculture/KALRO	28.9
Preferred varieties	KATRAM	18.4
	KAT/B-1	23.7
	GLPX92	26.3
	KAT X56	31.6
Reasons for preference	High grain yielding & highly selling	50
	WUE and high grain yielding	50

Table 4. Correlation among socioeconomic characteristics, farmers awareness, source of information, yields and production constraints of drought tolerant bean varieties.

	Gender	Education level	Aware of DTBV	Yields per acre	Production constraints	Sources of information	Information on growing DTBV
Gender	-						
Education level	-.382**	-					
Aware of DTBV	-0.179	.719**	-				
Yields per acre	0.146	-0.154	-0.151	-			
Production constraints	-0.171	0.085	0.028	-0.083	-		
Sources of information	-.322*	0.163	-0.086	-0.193	.448**		
Information on growing DTBV	-.278*	-0.128	-0.24	-.459**	0.064	.290*	-

** Correlation is significant at the 0.01 level and *. Correlation is significant at the 0.05 level. DTBV=drought tolerant bean varieties, KALRO = Kenya Agriculture and Livestock Research Organization, DTCBV= drought tolerant common bean varieties, NGOs= non-governmental organization.

However, sources of information on the availability of common bean among farmers, influences the choices of varieties within a given locality and the integration of these varieties is based on production attributes as shown by the positive relationship between education level and awareness of drought tolerant common bean varieties implies that awareness creation and the application of the knowledge acquired is more likely to increase adoption among farmers. Elsewhere in Uganda, Nankya *et al.* (2017) in a study "Yield Perceptions, Determinants and Adoption Impact of on Farm Varietal Mixtures for Common Bean and Banana in Uganda" agrees with results of the study that awareness creation increase adoption among farmers. Work done by other researchers and results from this study indicates that farmers in Machakos had adequate information on the availability of drought tolerant common bean varieties which is likely to increase adoption.

Preference and factors underlining adoption among respondents

Most of the respondents during the focus group discussion preferred KATX56 followed by GLPX92, KAT/B1 and KATRAM. Equal proportion of respondents said their preference is based on high grain yielding and high selling and WUE these varieties. But preference of the farmers were confined in the order of importance to this study. Moreover, the significant but weak relationship at 10% between gender and education level of the household implies that there is still a problem of education among the gender of the household especially with the proportion of respondents that have not received any form of education and are comfortable with their traditional technology. According to Indimuli, (2013) lack of education hinders the ability of farmers to perceived, interpret, and make use of modern technology. Additionally, sourcing and understanding information on growing of these drought tolerant bean varieties was a problem for some of the farmers probably due the lack of education hence yield per acre was affected due to the lack of technical knowhow base on their refusal to incorporate new knowledge on the production of these varieties with drought and fertility exacerbating issue.

However, there correlation between level of education and awareness of drought tolerant common bean varieties (DTCBV) at 10% level implies that the greater proportion of respondents with formal or informal education, were aware of the existence of these drought tolerant bean varieties and were knowledgeable and could interpret their usage than their other counterparts who were not educated. Moreover, based on the information received from

the relevant authorities or research institution, respondents in this category were able to adapt and mitigate the production constraints they were faced with in making use of the information they had on growing these drought tolerant common bean varieties. However, if farmers are aware of the drought tolerant common bean varieties and the various types as well as their production constraints under extreme circumstances, the preference and adoption of these varieties will be increased among the farmers. Elsewhere in Southern Ethiopia, Sheikh *et al.*, (2017) reported that farmers preference was based on yield and yield attributing trait with earlier maturity which agrees with result from this study. In other research, farmer's preference was attributed to cooking time, colors, size of grains, number of grains, early maturity and rate of selling. A regression analysis was conducted to determine the factors influencing adoption of drought tolerant bean varieties by respondents of the household in the study area (Table 5). There was a perfect relationship observed between the preference and type of drought tolerant bean varieties grown at P = 0.000 with a positive coefficient and significant level at 5%, which implies that preference of these improved varieties by farmers will increase adoption as long as drought and other production constraints continue to be prevalence. Similar trend was also observed between preference and varieties types aware of at P = *0.000* though, significantly correlated, it had a negative coefficient which implies that in the study area, the more awareness is increased among farmers, the greater the rate of adoption to these drought tolerant varieties this is in line with priori expectation (Amaza *et al.* 2007) which suggest that the more experienced the farmer, the higher the rate of improved varieties adoption. It also indicate that the level of education and sensitization of farmers on these new varieties will increased the adoption of farmers to these varieties. However, Elias *et al.*, (2017) reported that there is a need to give emphasis to participatory research, which is farmers' inclusive, technology preference criteria and priorities seriously. Goa and Kambata, (2017) stated that farmers have their own preference criteria. However, when these preference criteria are disregarded by policy makers and breeders, it creates a propensity for farmers lacking confidence in such varieties because, being front liner in the production chain, they wouldn't want to risk their capital and labor in something they do not trust. In such medium to marginal area like Machakos County that is so hilly with erratic rainfall and annual drought occurrence, the involvement of all actors using this approach will make adoption beneficial and successful. Gichangi *et al.* (2012) reported the lack of trust in the improved varieties as a result of mismatch in preference criteria of farmers could be the reason for the usage of recycled seeds from the previous season.

Table 5. Regression among type of drought tolerant bean varieties grown, yield per acre, varieties types aware of, sources of information and sources of seeds.

	Unstandardized coefficients	Std. Erro	Standardized coefficients		
	B	r	Beta	t	Sig
(Constant)	1.714	0.322		5.326	0.000
Type of DTBV grown	0.425	0.082	0.647	5.215	0.000
Yield per acre	0.002	0.183	0.001	0.013	0.99
Varieties types aware of	-0.579	0.065	-0.964	-8.905	0.000
Sources of information	-0.006	0.167	-0.004	-0.073	0.971
Sources of seeds	0.007	0.035	0.017	0.187	0.853

a. Dependent Variable: Preference.

Conclusions

There exist drought tolerant varieties that farmers are currently growing in Machakos County Because of production constraints, farmers preferred mixed cropping drought tolerant bean with other crops and animals on a minimum land size of 1-2 acres to avoid total failure of crops and food insecurity. Farmers acquired varieties seeds from relatives, other farmers, and research organization or from the local markets. Farmers are highly devastated by the occurrence of drought during the planting season, hence leading to farms abandonment.

Recommendations

There is a need for Government and research organizations to see farmers as stakeholders in the front line of the production chain by including their preference technology to improved bean varieties. Government should rejuvenate the extension services to work in line with the research organizations in getting quality and affordable seeds to farmers on time to enhance production of common bean. Extension agents, should work closely with meteorological stations in disseminating weather forecast information to farmers in preparing them for harsh climatic conditions. They should also be able to provide mitigation strategies to avoid food insecurity within the household in rural areas of semi-arid regions.

Acknowledgements

I want to thank the Government of the Republic of Liberia, through the Ministry of Agriculture (MOA), through the Smallholder Agriculture Productivity Enhancement and Commercialization Project (SAPEC) for the financial support in conducting this research. My special thanks goes to Mr. Kizito Kwena of KALRO/Katumani who made available vehicle to take me to the various communities to conduct this survey. I am more gracious to the Extension officer, driver and the interpreter who help to facilitate my movement in the various communities. Most importantly, I want to appreciate and thank the farmers for giving me their time and cooperation in conducting interviews in their communities as pertaining the cord of this study.

Appendix

Plate 1. Shows focus group discussion in Kaathi village, Machakos County, Kenya.

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