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Socioeconomic and demographic predictors for adoption of new sugarcane varieties in Nandi County, Kenya

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Despite there being high demand for sugarcane products globally, low yielding varieties in Kenya persist. A study was conducted in Nandi, Kenya to assess age, level of education, gender, level of awareness, price of produce and cost of changing to new varieties, perception of risks, planting materials and scale of farm operations as predictors of adoption for new sugarcane varieties. Purposive and multistage sampling techniques were used to select participants in the study. A sample of 198 farmers participated in the ex-post-facto survey study. Data was collected using questionnaires and analyzed using cross tabulations and logistic regression. All the variables except gender, price and costs showed significant ($p < 0.05$) relationship with adoption. A prediction model with the six explanatory variables was a well-fitting model, could correctly classify 87.4% of the outcome and explains 60.4% of the variation in adoption. It is concluded that farmers' age, education, awareness, perception of risks and uncertainties about new varieties, availability of planting materials and scale of operation have significant association with and are significant predictors of adoption. It is recommended that for improved adoption, stakeholders consider the factors in their intervention plans. Further research on their effect on sugarcane productivity is recommended.

Key words: Socio-economic, demographic, predictors, adoption, new sugarcane varieties, Nandi, Kenya.

INTRODUCTION

Sugarcane is the fourth largest crop enterprise that supplies sugar to millions of beverage takers and industrial sugar for confectionaries, as well as providing molasses; by-products for livestock feed supplementation. It is a major cash crop grown in the western parts of Kenya. In the year 2015 Kenya produced an estimated 450,000 metric tons of sugarcane against a domestic

consumption of 700,000 tons according to Ministry of Agriculture (MOA, 2015), resulting in a net deficit of 250,000 metric tons which had to be imported to meet the local consumption demands. The inability of Kenya's production to meet local consumption requirements has persisted for quite a while (Ibid).

The deficit on sugar production in Kenya has been

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blamed on a number of factors among them being low farm yields, poor processing technologies and poor agronomic practices by the producers. The low yields have often been attributed to low yielding varieties. The traditional varieties in production in the Western Kenya sugar belt include CO945, CO421 and CO617 which is thought to account for over 80% of the area occupied by sugarcane as reported by Rono et al. (2007). In the recent years, however, there are varieties that have been introduced ostensibly for their better adaptation to agro ecological zones and for their higher yields compared to the traditional varieties (Jamoza, 2005). The adoption of these new varieties, however, remains relatively low. Some of the reasons that have been advanced to explain this status of low adoption include poor payments received by the farmers from the processors of the sugarcane, high investment costs associated with changing over from the traditional varieties to the new ones, lack of knowledge among the farmers and other reasons. Although these various factors have been blamed for low adoption, detailed literature on the influence of these factors on adoption of KEN-82 and KEN-83 varieties that were developed by the Kenya Sugar Research Foundation for faster maturity, disease/pest resistance and higher yields (KESREF, 2013) are currently scanty.

Technology adoption in agriculture has been extensively studied, particularly in relation to awareness; a variable that can be attributed to many factors. The diffusion of innovation theory widely used in agricultural extension holds the view that knowledge is first accessed by a few farmers, a fraction of which decides to adopt while a majority do not, but over time the technology diffuses to the non-adopters. The diffusion of innovation model recognizes the central role played by information channels (Sahin, 2006) in relaying information over time from an original source through a social structure to individuals in a society. The communication channels are made up of interacting individuals who are either of similar characteristics such as sharing of socio economic characteristics, beliefs and education or dissimilar in certain attributes. Sahin (2006) has argued that some degree of dissimilarity among interacting individuals may be necessary for diffusion of innovation to occur although some similarities in terms of values and beliefs are also necessary ingredients for mutual understanding to take place and facilitate the process of adoption. The Kenya Sugar Research Foundation (KESREF), now Sugar Research Institute (SRI), has the mandate of developing and disseminating sugarcane production technologies to sugarcane producers and processors in Kenya. In the year 2003 new sugarcane varieties were released by KESREF. There are many sugarcane varieties grown in Kenya, but the old varieties grown from the 1960s to the 1980s such as CO421, CO945, CO617 and N14 continue to dominate the sugarcane farming systems, occupying about 89% of the total sugarcane area and was grown by

about 78% of the sugarcane farmers in the country as in 2011 (KESREF, 2013). There has been concern that the trend continues despite there being many improved varieties available to the sugarcane producers at the sugarcane processing facilities and at the local research station. According to KESREF (2013) report, early maturity has been a major advantage highlighted by the government of Kenya in a bid to encourage the adoption of the newly released varieties which also have the advantage of high sucrose content, high cane yields and resistance to diseases such as smuts.

Objectives

The objectives of the current study were:

- (1) to determine the rate of adoption of improved sugarcane varieties
- (2) determine the relationship between selected socio economic and demographic factors with the adoption of new sugarcane varieties.

Research questions

The study set out to answer the research questions:

- (1) What is the rate of adoption of improved sugarcane varieties in Nandi County?
- (2) Can the selected farmers' socio economic and demographic factors be used to predict adoption of new sugarcane varieties?

Conceptual framework

Adoption refers to the decision by the farmer to establish new varieties instead of the traditional varieties. This is a nominal dichotomous variable where the farmer has either adopted or not adopted. A farmer is said to have adopted if part or the entire farm is occupied by the new variety and not adopted if the farmer has not grown any of the new varieties at all. The explanatory variables in the current study are: age (AG), education levels (ED), level of awareness (LOA), scale of operation (SCA), availability of planting materials (APM), market price of sugarcane (MP), cost of changing to new technology (COC) and fear of risks and uncertainties due to change (ROC) are classificatory variables. Age refers to age in terms of years completed and the farmers are categorized into young (below 35), middle aged (36-45), old (46-55) and elderly (over 55). Education levels refer to any of three categories: one is no formal education or primary, the second is secondary and the third is tertiary, where tertiary refers to post-secondary training. The price of sugarcane and cost of establishing new varieties refers

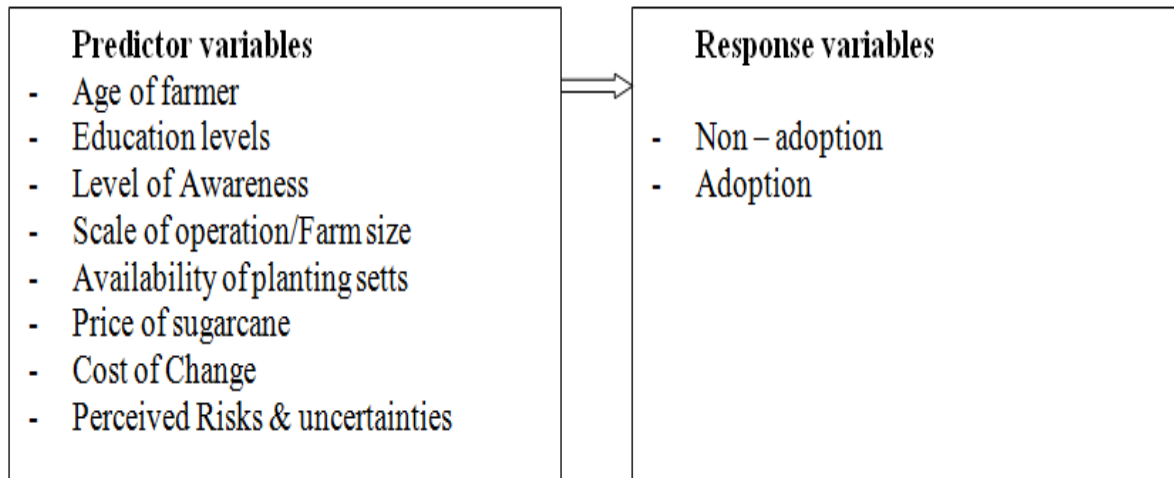


Figure 1. Conceptual framework on potential predictor variables for adoption.

to the perception of the farmers and is categorized as low, medium or high as rated by the farmers. Awareness levels are grouped into two categories (Low and High) based on farmers perception of their knowledge on the new varieties, while the scale of operation is small, medium or large scale as determined by the hectares cultivated for sugarcane production.

The fear of risks and uncertainties was thought to influence the decision of farmers in the adoption of new sugarcane varieties; this variable was measured based on the farmers' perception of whether the new varieties pose low, average or high risk to their sugarcane productivity (Figure 1).

Site location

The study was carried out in Nandi County, in the Rift Valley region of Kenya and the lowland areas where sugarcane is grown was purposely targeted. The site is characterized by medium and low altitude areas towards the Lake Victoria Basin and receives high rainfall, well distributed. The County was deliberately selected because of its high sugarcane production potential attributed to fertile soils and well distributed annual rainfall for the rain-fed agriculture.

MATERIALS AND METHODS

Research design

The study adopted an ex-post-facto survey design to carry out the study which describes the relationship between independent variables that had occurred and the dependent variable of variety adoption as at the time of primary data collection in September, 2018. The survey method was employed to collect primary data from the target population; the sugarcane farmers of Nandi County

in the Western parts of Kenya.

Sampling procedures

A deliberate sampling was used to select Nandi County which has both low and medium altitudes and high rainfall, fairly well distributed throughout the year where only rain-fed sugarcane farming is practiced in the sugarcane growing zones in Kenya. In the county, as in other sugarcane growing counties, sugarcane produce is marketed through farmers' cooperatives with varying membership ranging from as low as 20 farmers to as high as 250 farmers depending on the locality. The farmers' cooperatives are distributed across all the sugarcane growing locations and there are 9 Administrative Locations where sugarcane is grown in the sub county. The 9 locations in the sub county constituted a primary sampling unit for the purpose of the study. Further sub sampling units were created on the basis of the cooperative societies serving the farmers and one cooperative society in each location was randomly selected to participate in the study; this representing about 30% of the number of cooperatives in the location. Consequently, 9 cooperative societies participated in the study. From the selected cooperative societies, one third of their members were randomly selected to participate in the study as suggested by Mugenda and Mugenda (2003) through simple random sampling techniques.

Sample size

A simple random sample of 30% of the farmers from 9 cooperative societies whose membership ranged from 20 to 183 yielded a population of about 198 farmers to participate in the study.

Research instruments

From the sampled 198 farmers, a questionnaire was administered to collect information regarding age, education levels, scale of operation and sugarcane varieties grown. Those who had adopted new varieties were asked questions on their reasons for adoption and captured accordingly. Those who had not adopted were asked

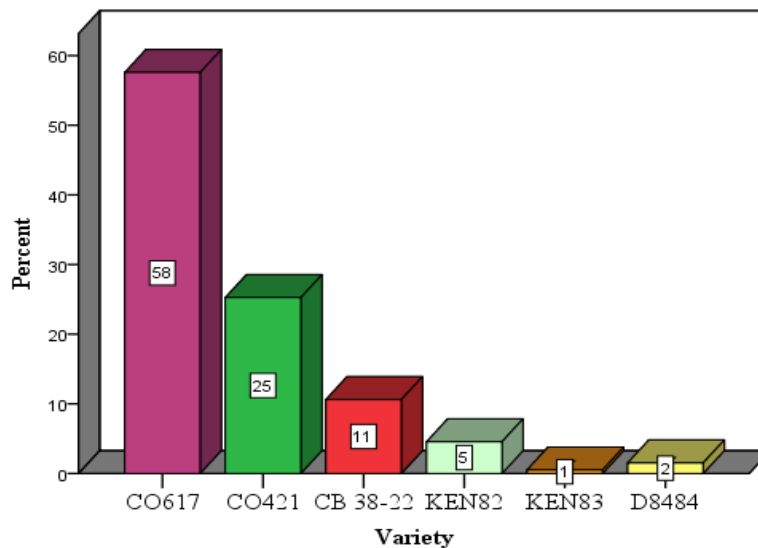


Figure 2. Frequency of sugarcane varieties grown.

a set of questions to establish their reasons for non-adoption, care being taken not to influence their choice in the set of questions. The care in particular is in light of the 'pygmalion' effect in which the expectations of the farmers' response by the questioner may influence the response as argued by Mugenda and Mugenda (2003). In the 'pygmalion' effects people internalize their labels and act accordingly, a kind of self-fulfilling prophecy. This observer-expectancy effect sometimes referred to as the rosenthal-effect may subconsciously influence the participants' responses and compromise internal validity. Both structured and unstructured questions were utilized to elicit responses from the farmer respondents in order to get a complete picture of the farmers' feelings as argued by Kothari (2010) regarding use of both structured and unstructured questions in questionnaires. In order to standardize the data collection process the questionnaires were administered by trained enumerators. This approach was deemed appropriate in light of the fact that the farmers had diverse backgrounds, varying literacy levels and varied understanding levels so that the administration of the questionnaire by a trained enumerator would ensure that questions are understood the same way by all the respondents.

The farmers selected were requested for their honest responses and assured of confidentiality in the handling of their individual responses. All the farmers selected for the study were willing to participate in the study and their responses were recorded accordingly.

Data analysis

The data collected was subjected to analysis to generate descriptive statistics on means and frequencies. Cross tabulations were carried out using Statistical Package for Social Sciences (SPSS) to test for associations between variables using Chi square method. The explanatory variables that showed significant relationship with adoption, at 5% level of significance, were used as predictor variables in regression analysis. Logistic regression was used to estimate the potential of the independent inputs to predict the process of adoption. The variables were tested for their effect on adoption rate and the significant ones isolated at 5% significance level.

RESULTS AND DISCUSSION

Socio economic characteristics of the respondents

There were a total of 198 respondents included in the study; drawn from 9 sugarcane marketing locations in 9 administrative locations in Nandi County, Kenya. Among the respondents (n=198), 31% were females, while 69% were male and 18% were youth aged 35 years and below, while majority were aged between 36 and 55 years; 36% (aged 36-45), 21% (46-55 years) and 25% were aged over 55 years. Majority of the respondents had primary level education (60%), while 20% had secondary level education.

A few of the respondents did not have any formal education (7%) while 14% had post-secondary school education. Education has implications on receptiveness to new agricultural technologies. On average, the sugarcane enterprise occupied 1.6 ha per farmer with a mean yield of 110 tons per ha.

Adoption of new varieties

Majority of the farmers grew sugarcane varieties that were released for commercial production in the 1960s; mainly CO617 and CO421. A large proportion of the farmers; 58% were growing CO617, a variety which according to the respondents required little management inputs.

Another 25% grew another old variety CO421, indicating that 83% of the respondents grew traditional varieties, while only 17% had adopted the improved varieties (Figure 2). Given that the first batch of improved sugarcane varieties were released for commercial

Table 1. Relationship between explanatory variables and adoption.

Variable	Cramer's V coefficient	Chi square p value	Strength of association
Gender (GE)	0.067	0.349 ^{NS}	Negligible
Age (AG)	0.252	0.006*	Moderate
Level of education (ED)	0.231	0.005*	Moderate
Scale of operation (SCA)	0.508	0.000**	Relatively strong
Sugarcane price (MP)	0.166	0.065 ^{NS}	Weak association
Cost of change (COC)	0.124	0.064 ^{NS}	Weak association
Risk of change (ROC)	0.194	0.025*	Weak association
Planting materials (PM)	0.181	0.039*	Weak association
Level of Awareness (LOA)	0.322	0.000**	Moderate association

**Highly Significant ($p < 0.001$), *Significant ($p < 0.05$), NS: Not Significant ($p > 0.05$).

Source: Field Data (2018).

production in 1998, the 17% adoption rate over the last 19 years may be regarded as quite low. As in 2011, KESREF (2013) reported that old varieties were grown by about 78% of the farmers in the country. Jamoza et al. (2013) reported that only 6% of the sugarcane area in Western Kenya was devoted to improved varieties; the old varieties were thus dominating at 94%. The authors then underscored the need for sensitization and training of farmers on new sugarcane varieties.

The current finding of 83% thus appears to be consistent with the KESREF (2013) report, given that there may be minor variations within the sugarcane growing zones.

Variables dropped from prediction model

Gender showed a negligible association with adoption of new sugarcane varieties, consequently the variable was dropped from further analysis using the regression model; its association with adoption was not significant ($p > 0.05$). The market price of sugarcane and the cost of changing over to new varieties did not appear to be associated with adoption of new sugarcane varieties charging from their Pearson Chi Square correlation coefficients (Table 1); consequently the two variables were also dropped from the regression model.

Variables captured in the prediction model

Gender, market price and cost of changing over to the new varieties did not have a significant relationship with adoption and was dropped from further analysis using regression; only those variables that showed significant association with adoption were included in regression analysis.

The significant variables which were finally included in the prediction equation were: age, level of education, scale of operation, risk of change, availability of planting materials and awareness of the farmer. These variables

could explain between 40% and 60.4% of the variation in adoption (Cox and Snell R^2 of 40.9% and Nagelkerke R^2 of 60.4%). This observation suggests that about half of the variation in adoption of new sugarcane varieties could be attributed to these explanatory variables. The model from these six variables correctly classified 87.4% of the outcome, a major improvement from 74.7% correct classification from the baseline model where only a constant is included; an improvement of 12.7% points. There was no significant difference between the predicted frequencies and the observed (Hosmer – Lemeshow, $p > 0.05$) indicating that the model was a good fit.

Age category

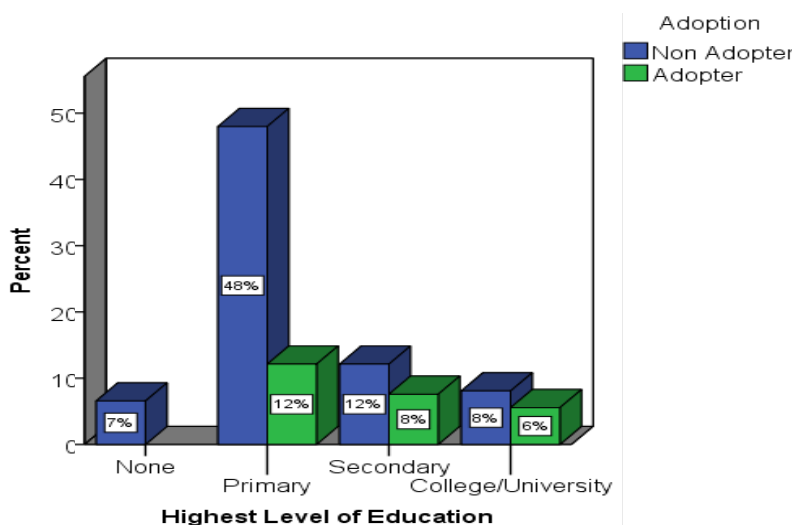
The age of the participating farmers significantly contributed to the adoption regression model ($P < 0.05$) with the middle age category of the respondents showing a higher likelihood to adopt new sugarcane varieties compared to the youths. The middle age group (45 - 55 years old) were 11 times more likely to adopt compared to the youth, while the elderly (over 55 years of age) were 1.84 times more likely to adopt new sugarcane varieties compared to the youth (35 years and below) an indication that increasing age may be associated with a higher willingness to change to the new sugarcane varieties. This finding disagrees with the results of the study by Tadesse (2008) who found a negative effect of age on access and adoption of new information. Kodiwo et al. (2015) also reported a negative association between age and adoption of soil conservation technologies.

In the current study, the increased adoption with age probably may be attributed to higher experiences that the elderly have on sugarcane farming. Elderly farmers probably also have accumulated more capital over the years and the availability of the necessary resources required to change the technology may have aided the adoption process by the aged. More categories of farmers' age groups may be necessary in future in an

Table 2. Qualitative interpretation of Cramers' V and phi coefficients.

Value	Effect size
0.0 to under 0.1	Negligible association
0.10 to under 0.20	Weak association
0.20 to under 0.40	Moderate association
0.40 to under 0.60	Relatively strong association
0.60 to under 0.80	Strong association
0.80 to under 1.00	Very strong association

Source: Kotrlik et al. (2011).

**Figure 3.** Education levels and adoption of new sugarcane varieties.

effort to exactly determine the age category that may be more receptive to new technologies. It would probably be expected that youthful farmers may not have adequate resources to enable them adopt new technologies, while the elderly may not be too keen to invest in new technologies, the exact age brackets of innovators cannot be clearly established with the current age categories.

Education levels

Did levels of education have a significant influence on the outcome? Farmers had been asked to rate their levels of education in terms of the highest level of education completed. These were categorized into three, namely: none and primary level, secondary, and tertiary education. An analysis to test for association between the levels of education attained with adoption of new sugarcane varieties using Pearson Chi Square returned a significant relationship ($P < 0.05$) between education and adoption of new sugarcane varieties with a Cramer's V Coefficient of 0.257 (23.1%). A Cramer's V Coefficient of 23.1% can

be classified as a moderate strength association (Table 2) according to Kotrlik et al. (2011).

Education, as a predictor variable contributed significantly to the regression model as indicated by Wald statistic ($p < 0.05$). Those who attained secondary level education were 2.8 times more likely to adopt the new sugarcane varieties compared to those who had no formal education or left from primary level category, while the odds for adoption was 6.9 times higher for those who joined colleges and university compared to those with no formal education/primary level leavers, suggesting that the influence of education levels on adoption was progressive (Figure 3). This appears to indicate that farmers' level of education is a good predictor of adoption. In the absence of formal education among many farmers in the area of study, there might be a need for adult literacy programs in order to bridge the gap associated with lack of formal education. Lack of formal education has been found to be a factor for non-adoption of technology elsewhere (Nsabimana and Masabo, 2005), an indication that it may be playing a major role in non-adoption of a variety of new agricultural technologies.

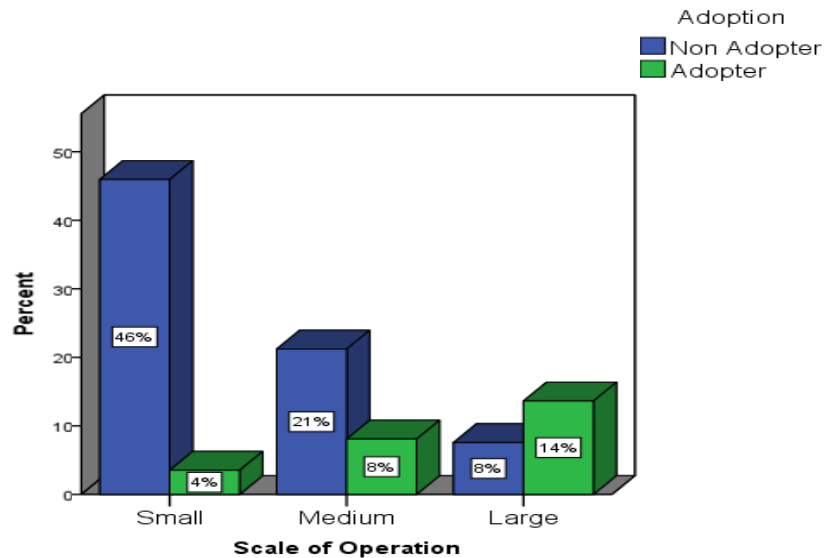


Figure 4. Scale of operation and adoption of new sugarcane varieties.

Kodiwo et al. (2015) reported a positive relationship between adoption of soil conservation technologies and education. However, in the sugarcane subsector, Owino et al. (2018) reported that farmers' education levels did not affect sugarcane production technology since farmers learn production by doing and thus did not necessarily depend on the level of formal education. The finding by Owino et al. (2018) is inconsistent with the current findings. However, the current finding is in agreement with the observations made by Nsabimana and Masabo (2005) and the one made by Kodiwo et al. (2015). These varied observations may suggest that the influence of education levels on adoption of agricultural technologies may be technology-specific.

Scale of farm operations

The respondents were classified according to the size of sugarcane farms they owned at the time of the survey into: Small, Medium and Large representing 1 ha and below, over 1 to 3 ha and over 3 ha, respectively. Cross tabulations between the scale of operations and adoption (non-adopter, adopter) showed evidence of a strong relationship between the two variables with a Cramer's V coefficient of 0.508 (50.8%), a significant relatively strong association by convention according to Kotrlik et al. (2011). Consequently the scale of operation was included in the adoption prediction model. The scale of operation variable contributed significantly as estimated by Wald statistic ($p < 0.05$). The odds for adoption by medium scale farmers were 5 times greater than that for small scale producers, while the odds for large scale category were 53 times more than that for small scale, suggesting

that the large scale farmers were several times more likely to adopt compared to the small scale farmers (Figure 4). Previous studies elsewhere have indicated a higher tendency for farmers to adopt technologies such as fertilizer application when they have allocated a large area of their farm to sugarcane growing compared to smaller units as reported by Wawire et al. (2006) in a study on technology adoption in the Kenya sugar industry. Ashiagbor et al. (2018) reported similar findings where adoption of agro-forestry technology was associated with size of farm land. The study finding suggests that a small scale farmer may be a poor adopter of new agricultural technologies probably due to low income status that tends to characterize them and yet new technologies require additional expenses. Wawire et al. (2007) reported low yields from small scale producers compared to large scale, suggesting small scale farmers tend to earn less per unit of investment from the sugarcane enterprise compared to their large scale counterparts.

Perception of risks and uncertainties

The respondents were asked to state whether risks and uncertainties influenced their decision on the sugarcane variety to grow and if so to rate the risks associated with new varieties if at all there were any. The ratings with respect to the new varieties were categorized into none at all, slight or high. The reference point for purposes of analysis was the 'High' category as it was expected to correspond more to non-adoption, while 'None at all' was expected to correspond more to adoption.

A test for relationship between the level of perception of

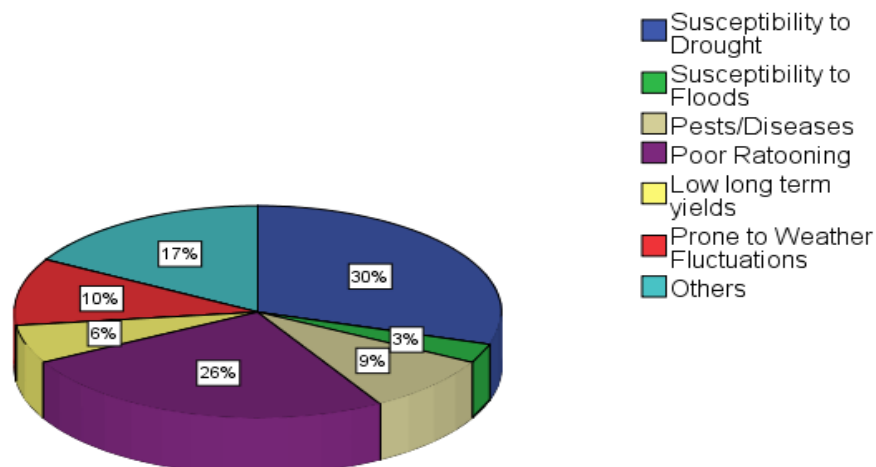


Figure 5. Risks of adopting new varieties as cited by the respondents.

risks and adoption showed there was some association ($r = 0.19$). The variable contributed significantly to the prediction model ($p < 0.05$) based on Wald statistic. The category that perceived the new varieties as being associated with 'No risk at all' were 66 times more likely to adopt than those who perceived the new varieties to be associated with 'High' risks.

Some of the risks cited by the respondents included such factors as possibility of the new varieties not being able to withstand fluctuations in weather conditions and their probable failure to yield ratoons over many seasons.

The respondents had been asked to give comments on risks about the new varieties if there were any. A number of responses received centered on perceived risks related to climatic factors. Some respondents argued that the new varieties appeared to be susceptible to drought; others cited susceptibility to floods, pests and diseases. The other perceived risk was that the new varieties may not produce many productive ratoons similar to the traditional varieties; suggesting that the new varieties may yield low overall yields in the long run. There were also other comments suggesting that they may be more prone to weather fluctuations thus adversely affecting productivity of the varieties (Figure 5). Since the perceived risks were cited mostly by farmers who have not established the new varieties, these comments were treated as perceived risks rather than potential risks. However, in view of the high frequency with which these perceptions were cited, they may be important factors in non-adoption of the new sugarcane varieties.

Level of awareness

The respondents were asked to rate their knowledge about improved sugarcane varieties and the response choices were on a 3-point scale; low, fair and good. The

two low categories were treated as being generally low for purposes of analysis, while those who believed they had good knowledge were placed in the high category. Pearson chi square test showed a significantly high relationship between level of awareness and adoption of the new varieties with a phi coefficient of 0.322 (32.2%), indicating a moderate strength association (Table 2). The variable contributed significantly to the prediction model ($p < 0.001$). Those who perceived their knowledge on the new sugarcane varieties as being high were 13.6 times more likely to adopt than those who perceived it as being low. Thus the odds of adoption increased by 13.6 times when the respondent level of awareness changed from low to high. This result has implications for extension agents as it calls for more capacity building of the farmers on new sugarcane varieties. Confidence on the level of knowledge or awareness about the new varieties appears to be associated with high adoption rates (Figure 6). Similar findings were reported by Ashiagbor et al. (2018) regarding the adoption of agroforestry technology where the authors argued that membership to a livelihood group which was regarded as a source of information was strongly associated with adoption of sustainable land resource management technologies.

The diffusion of innovation model in extension holds the view that technologies are first adopted by individuals who become aware of the technology then they seek further information about it, evaluate it, and eventually adopt (Rogers, 2003). The initial stage of awareness is therefore critical before any adoption can take place. Some farmers have cited a lack of awareness as the reason for non-adoption of new sugarcane varieties in Western Kenya as reported by Wawire et al. (2006) in a study on technology adoption on sugarcane in Kenya. In view of the current findings, it is apparent that low levels of awareness are still a contributory factor to non-adoption of new sugarcane varieties.

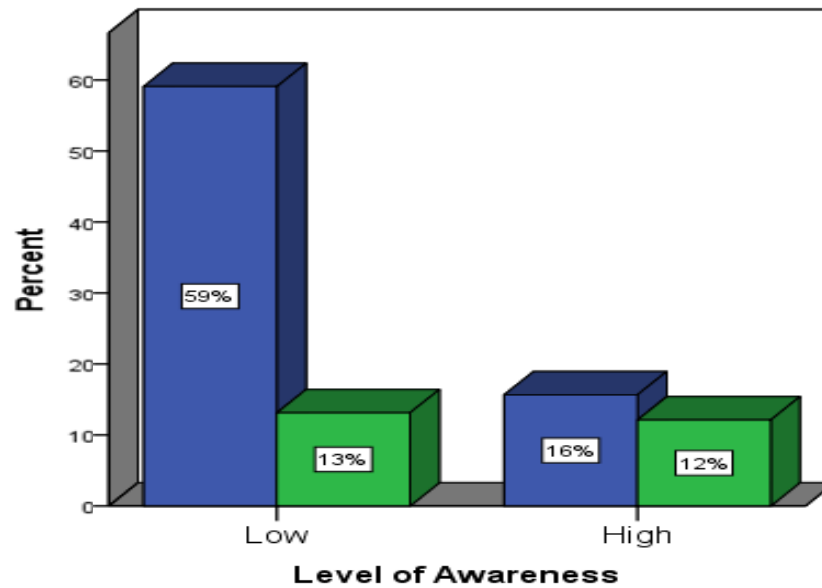


Figure 6. Participants perception of level of awareness and adoption.

Availability of planting materials

The study sought to establish whether the availability of planting materials in anyway influenced the decision of the farmers on the varieties to grow. The response categories were: 'not at all', 'slightly' and 'strongly'. Those who indicated availability of planting materials as 'strongly' influencing their decision on what variety to grow were 6.2 times more unlikely to adopt compared to those who indicated availability did not influence their decisions at all. This suggests that availability of new sugarcane varieties may be a factor in the decision by farmers to adopt or not. There was an association between availability of planting materials and adoption as measured by Cramers' V ($r = 0.18$), though a weak one in accordance with Kotrlík et al. (2011) classification, but it was not an association that can be ignored. The factor contributed significantly to the prediction model based on Wald statistic ($p < 0.05$). In the year 2006, poor availability of planting materials for new sugarcane varieties was cited as hampering adoption, with about 45% of the farmers according to Wawire et al. (2006) indicating that they had not adopted ostensibly due to lack of seed cane. Ashiagbor et al. (2018) in a study conducted in Ghana similarly reported that access to materials and inputs had a significant relationship with adoption of agro-forestry technology. In Kenya, Jamoza et al. (2013) reported that lack of seed cane was a major limitation to adoption of new varieties. The authors then recommended a seed multiplication policy framework to address the constraints. The current findings suggest that adoption is still adversely affected by the availability of setts for new sugarcane varieties.

Conclusion

The predictor model with farmers' age category, level of education, scale of farm operations, perception of risks associated with new varieties, level of awareness on the new varieties and availability of planting materials as explanatory variables was a well-fitting model for the prediction of adoption of new sugarcane varieties in the Western Kenya region. The explanatory variables could explain a significant proportion of variation in adoption.

Recommendation

There was evidence of non-adoption attributed to low levels of awareness, it is recommended that relevant stakeholders address this with a view of attaining universal awareness on the superior, high sucrose content varieties of sugarcane that have been developed through investments in breeding research. Interventions by stakeholders to improve on adoption of new sugarcane varieties should take into consideration the influence of farmers' age, level of education, scale of farm operations, perception of risks associated with new varieties, levels of awareness on the new varieties and availability of the planting materials.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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