
Factors Influencing Adoption of Improved Cultivars of Macadamia (*Macadamia* spp.) among Small-Scale Farmers in Embu County, Kenya

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Abstract

*The study investigated the factors influencing adoption of improved cultivars of macadamia (*Macadamia* spp.) among small-scale farmers in Embu County, Kenya. Data was collected from a sample of 384 small-scale farmers obtained through multistage sampling procedure in ten sub-locations. Binary Logit model was used to determine the effect of selected institutional and socio-economic factors on adoption of improved cultivars of macadamia. The results revealed that education level (wald=26.160), access to extension services (wald=6.246) and farm size (wald=4.271) had significant positive influence on adoption of improved cultivars of macadamia while age of the farmer (wald=5.235) and market distance (wald=5.519) had a negative influence on the same. There is need to encourage the youth to embrace macadamia farming and to develop smart marketing strategies to promote adoption of improved cultivars.*

Keywords: Adoption, macadamia, small scale farmers.

Introduction

Macadamia (*Macadamia* spp.) are edible tree nuts that belong to the Protaceae family. They are grown in the tropical countries with altitude levels ranging from 1500 to 1850 meters above sea level (Murioga, 2018). There are two main species of macadamia grown for production of edible nuts: *Macadamia integrifolia* (smooth shelled) and *Macadamia tetraphylla* (rough shelled) (Nortje, 2017). The two species originated from Australia and spread to other parts of the world where they are commercially grown together with their hybrids (O'Connor, Hayes, Hardner, Alam, Henry, and Topp, 2019). The nut consists of the hard dry inner shell which is usually protected by a green fibrous husk that splits open when the nut matures. The hard shell is normally removed using a cracking machine fitted with steel rollers or rotating

knives to get the high value edible kernels (Quiroz, Kuepper, Wachira and Emmott, 2019).

The edible macadamia kernels are a good source of oil and can also be consumed as a snack, or used as an ingredient in bakery products and ice creams (Hardner, 2019). This makes macadamia a popular high value industrial crop. South Africa is the leading macadamia producer in the world followed by Australia, while Kenya and China are emerging competitors in the export market due to their expansion in production (Takadi, 2018). In Kenya, commercial production of macadamia began in 1970 following the crisis in the coffee sector and after realization that the crop had great export potential (Murioga, 2018). In recent years, farm gate prices of macadamia have been ranging between KES 200 and 250 (≈US \$ 1.9 and 2.4) per kilogram making it one of the most lucrative cash crops in Kenya (Quiroz *et al.*, 2019).

High nut yield, nut stability (consistency yields in consecutive years) and faster growth are the main traits of focus when selecting macadamia varieties (O'Connor *et al.*; 2021). At first, propagation of macadamia trees was through seed which took long time to mature. Thereafter grafting was used which increased the yields, maintained the cultivar characteristics and improved homogeneity of nut quality (da Silva, de Melo, Blain, Perdoná and Sobierajski, 2021).

All varieties grown in Kenya belong to either *M. tetraphylla* or *M. integrifolia* or their hybrids. Seeds of *M. tetraphylla* germinate uniformly and produce vigorous seedlings with some resistance to anthracnose, thus preferred as rootstocks during propagation. The varieties grown in Kenya include Murang'a 20 (MRG-20), Kirinyaga 15 (KRG-15), Kiambu 3 (KMB-3) and Embu 1 (EMB-1) (Maina, 2020). Adoption of improved varieties is key in enhancing agricultural productivity among the rural farm households (Okeyo, Ndirangu, Isaboke and Njeru, 2020).

Despite the high potential of macadamia nuts in poverty reduction and improvement of food and nutritional security, there has been low production and low quality of nuts among small-scale farmers in Kenya. This is attributed to among other factors, low adoption of improved varieties and low macadamia productivity. Some socio-economic and institutional factors have been shown to influence adoption of improved varieties of some crops such as cashew nuts (Nhantumbo, Takeshita, Uaciquete and Miura, 2017; Takyi, 2020). However, there is no sufficient data to show the impact of socio-economic and institutional factors on adoption of improved macadamia cultivars in Kenya. This study sought to evaluate the socio-economic and institutional factors affecting adoption of improved varieties of macadamia among small-scale farmers in Embu County, Kenya.

Methodology

The study was carried out in Embu North Sub-County in Embu County, Kenya. Embu North Sub-County lies between latitudes of 0° 8' and 0° 35' South and longitudes 37° 19' and 37° 42' East, with an elevation ranging from 1500 m to 1800

m above sea level. The annual mean temperature ranges from 12°C to 30°C with the coldest month being July and the hottest being September (Wambua, Gichimu and Ndirangu, 2021). The area receives an annual rainfall of between 1120 and 1495 mm per annum which falls in a bimodal pattern (Wambua *et al.*, 2021). The soils are humid andosols which are well drained, deep dark brown in colour, clay loam to clay with acid humic top soils. The study area has a population of 79,556 (KNBS, 2019). In selecting respondents, multi-stage sampling procedure was employed. In the first stage, five out of the seven locations in Embu North Sub-County were purposively selected on the basis of their high macadamia production. Secondly, two sub-locations from each of the five selected locations were randomly selected to make 10 sub-locations. In the third stage, probability proportionate to size was used to determine the macadamia households to be sampled from each sub-location.

Table 1 shows a summary of the sampled locations and sub-locations, the total number of small-scale macadamia farmers in each sub-location and the selected sample size in each sub-location.

Table 1: Sampled farmers in selected sub-locations

Location	Sub-location	Total number of farmers	Sample Size
Ngandori East	1. Rianjagi	1117	40
	2. Kirigi	1005	36
Ngandori West	3. Kithungururu	1229	44
	4. Kairuri	1033	37
Ruguru	5. Mukuria	1033	37
	6. Kithangariri	1117	40
Kibugu	7. Gicherori	1061	38
	8. Ngerwe	950	34
Gaturi North	9. Kianjuki	1117	40
	10. Kavutiri	1061	38
Total		10,724	384

Data were collected on socioeconomic factors of the respondents including sex, age, family (household) size, farming experience, education level and occupation. Data were also collected on institutional factors including access to extension services, availability of credit, access to market information and distance to the market distance. Additional data were collected on the level of adoption of improved macadamia varieties among the small-scale farmers. The data were collected using a semi-structured questionnaire which was first pretested to ascertain it was valid and the scales were reliable. The correlation coefficient was 0.83.

Data were analysed using IBM-SPSS statistical software version 24. The binary Logit model was applied to analyse the selected institutional and socio-economic factors on adoption of improved varieties of macadamia. Adoption was measured as a binary variable which takes the values 1 for adopter of improved varieties and 0 for

non-adopters of improved varieties. The binary Logit model was empirically specified as follows;

$$Z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + U_i \dots\dots\dots$$

Where: Z_i is the probability of farmer adopting improved varieties of macadamia,
 α is the constant in the model
 $\beta_1 \dots \beta_n$ are the coefficients of the regressors,
 $X_1 \dots X_n$ represent the i^{th} explanatory variables,
 U_i is the error term.

Results and Discussion

Institutional Factors Associated with Farmers

Table 3 shows that the majority (76.3%) of the respondents in the study area had no access to extension services on production of macadamia. The most shocking observation was that 93.2% of the farmers had no access to credit, while 78.9% had no linkage to market information. This was a big departure from the findings of Wambua *et al.* (2021) that 70.5% of coffee farmers in the same area were accessing credit facilities. The low credit access reported by the macadamia farmers may be attributed to lack of organized groups among the farmers. On proximity to market, the respondents were located on an average of 1.35 km to the nearest market. This was attributed to the fact that macadamia is a non-perishable product whose market is mainly driven by demand and supply and mainly coordinated by middlemen.

Table 2: Institutional factors of respondents

Variables	Categories	Percentage
Extension services	Available	23.7
Access to credit	Available	6.8
Market information	Available	21.1
Proximity to market (Km)	0 to 5	64.1
	6 to 10	35.9

Adoption of Improved Varieties among Small-scale Macadamia Farmers

The improved macadamia varieties grown by farmers in the study area are EMB-1, KRG-15, MRG-20 and KMB-3 with percentage adoption of 22.4%, 8.9%, 7.8% and 3.6% respectively (Table 4). Therefore, the majority (57.3%) of the farmers were growing the traditional varieties while 42.7% had adopted the improved varieties. In a similar study conducted in the same area by Wambua *et al.* (2021), the majority (62.7%) of the farmers were still growing traditional coffee varieties. The low adoption of the improved varieties was mainly attributed to small land sizes and lack of adequate extension services. Bigger land size enables the farmer to test new technologies without affecting the scale of the main crop, hence promoting adoption. Muriithi, Onyari, Mogaka, Gichimu, Gatumo and Kwena (2021) reported that

availability of agricultural extension agents in a given area plays a major role in influencing adoption of improved technologies such as climate change adaptation strategies.

Table 3: Adoption of improved varieties

Adoption	Percentage
Non adopters	57.3
Adopters	42.7
EMB-1	22.4
KRG-15	8.9
MRG-20	7.8
KMB-3	3.6

Factors Influencing Adoption of Improved Macadamia Varieties

The age of the household head (wald = 5.235)) portrayed a negative influence on adoption of improved macadamia varieties (Table 4). This implies that the rate of adoption decreased as smallholder farmers advanced in age, thus young farmers are more likely to embrace improved macadamia varieties as compared to older farmers. According to Salau, Yusuf, Apata and Adesina (2017), youths are usually more willing to try modern practices than the older farmers who have a tendency of being conservative. Consequently, the aged farmers rely on traditional production methods which have no significant effect on productivity (Ingabire, Yonggong, Pasha and Hardi, 2018).

Table 4: Factors affecting adoption of improved macadamia varieties

Variable	B	S. E	Wald	EXP. (B)	VIF
Constant	0.392	0.981	0.160	0.676	
Age	0.045	0.020	5.235*	0.956	1.077
Sex	0.208	0.353	0.347	1.231	3.832
Household size	0.204	0.119	2.935	1.226	2.584
Education level	0.962	0.188	26.16	2.617	1.829
Experience	0.020	0.020	1.002	1.020	3.213
Extension access	1.471	0.589	6.246	4.355	1.518
Market distance	0.167	0.071	5.519	0.846	1.113
Credit access	0.627	1.175	0.285	1.872	1.374
Occupation	0.189	0.211	0.802	1.208	1.652
Farm size	0.490	0.237	4.271	1.633	2.628
Land size	0.056	0.308	0.033	0.945	2.261

The level of education among household heads (wald= 26.160) was also found to significantly influence adoption of improved macadamia varieties (Table 4). This infers that there is a higher likelihood for an educated farmer to adopt improved macadamia varieties than a non-educated counterpart. Higher education creates awareness which enhances the adoption of technologies. These results were consistent with those of Hagos, Ndemo and Yosuf (2018), who found that more

educated farmers were more likely to adopt upland rice in the Northern region of Ethiopia than the uneducated ones.

Availability of extension services (wald=6.246) in the study area was another factor that influenced adoption of improved macadamia varieties (Table 4). This implies that respondents who accessed technical advice were more likely to adopt improved macadamia varieties. Yitayew, Abdulai, Yigezu, Deneke and Kassie (2021) also reported that access to extension services positively impacted on the farmers' decision to adopt new wheat variety in Ethiopia. Extension services would include training programs on improved varieties to increase productivity, and consequently enhance adoption (Okeyo *et al.*, 2020b). The results were also in line with Folefack, Tsafack and Kamajou (2018), that extension agents played a positive role in promoting adoption of goat keeping among non-pastoral farmers in Cameroon.

Market proximity (wald=5.519) and adoption of improved macadamia varieties had an inverse relationship (Table 4). This infers that the longer the distance to the market, the lesser the probability of respondents embracing improved varieties of macadamia. This was attributed to the fact that markets provide some key benefits such as information on the current trends. Hagos *et al.* (2018) noted that farmers who were distant from the input and output market were less likely to adopt improved rice varieties.

The farm size (wald=4.271) also recorded a positive relationship with adoption of improved macadamia varieties among smallholder farmers (Table 4). The result revealed that farmers with large farm sizes were more likely to adopt improved macadamia varieties than their counterparts who had small farm sizes. Farm size is an important resource that largely dictates the decision to adopt new technologies since there is more room for experimentation with minimal food security risk (Mwangi, Ndirangu and Isaboke, 2020; Okeyo *et al.*, 2020b). Wambua *et al.* (2021) reported that coffee farmers in the same area with bigger land sizes were more motivated to adopt new farming technologies. Similarly, it was observed that farmers with relatively bigger land sizes were more willing to adopt eucalyptus woodlots (Derbe & Agitew, 2018).

Conclusion and Recommendations

Adoption of improved macadamia varieties among small-scale farmers in Embu North sub-county is significantly influenced by age and level of education of the household head, farm size, access to extension services, and market proximity. Enhanced adoption can therefore be achieved by ensuring youth engagement in macadamia farming as well as improving farmer extension services and market accessibility. In addition, there is need for policy makers to review land use policies and land tenure systems in order to avail adequate agricultural land for long-term investments.

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