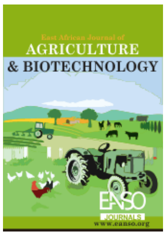

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Original Article

Socio-Economic and Technological Factors Affecting Macadamia Farming Among Small-Scale Farmers in Meru County, Kenya

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ABSTRACT

The global market demand for macadamia has surged significantly over the past two decades, driven by its exceptional nutritional value. This surge has led many farmers to diversify into macadamia farming. However, a considerable number of small-scale farmers in Africa are yet to realize optimal returns. This study examined the socio-economic and technological factors affecting macadamia farming among small-scale farmers in Meru County, Kenya. The research utilized a descriptive survey research design, employing the stratified sampling technique to select respondents, with the four wards of Central Imenti sub-county serving as the strata. The sample size of 98 respondents was proportionally distributed across the four wards, and a simple random sampling technique was employed for their selection. The data instruments included observation schedule, interview schedule and questionnaires. The analysis of quantitative data employed descriptive statistics, while thematic analysis was used for qualitative data. Cobb-Douglas production function was used to test the relationship between the independent and dependent variables. The findings indicated that social, economic and technological factors affect macadamia farming. Significant social factors include household size, education level, marital status and gender. Significant economic factors encompass household income, farm size, number of macadamia trees, access to credit, labour and market type. Significant technological factors include cultivation of improved varieties, pesticides usage, application of inorganic and organic fertilizers, irrigation practices and access to agricultural technology extension. The study recommends that macadamia farmers in the study area should form a cooperative society which can assist in offering credit to farmers. Additionally, the study recommends that the county Government of Meru should avail adequate access to certified seedlings. Further, the study recommends that extension officers should work collaboratively with macadamia farmers to boost the adoption of technology, ultimately leading to increased yields.

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INTRODUCTION

Globally, macadamia yields have risen from 28,000mt in 2007 to 59,300mt in 2018 on a kernel basis. The leading countries in macadamia production include South Africa, Australia, Kenya, the U.S., and China, with 29%, 25%, 13%, 9%, and 8%, respectively (Quiroz *et al*., 2019). Half of the global macadamia produce is from South Africa and Australia, which is attributed to an increase in investment in the macadamia industry, increase in land under macadamia farming, and the use of improved varieties (Sibulali, 2021).

In Kenya, macadamia nut yields have risen over the last decade, from approximately 2,000 mt on a kernel basis in 2009 to 7,750 mt in 2018 (Quiroz *et al*., 2019). The cultivation of the crop commenced in 1946, and plantings began as a complimentary cash crop to coffee in 1967 and were mainly grown in the central and eastern regions (Gitonga *et al*., 2008). Small-scale farmers dominate the sector; currently, they are 200,000 in number (Quiroz *et al*., 2019). The top five leading counties in macadamia production include Embu (36.5%), Muranga (17.2%), Meru (11.8%), Machakos (7.8%), and Kiambu (7%) (Kenya Agricultural and Livestock Research Organization [KALRO], 2019).

Macadamia nuts hold a vital position in shaping Kenya's economic landscape. According to Quiroz *et al.* (2019), macadamia nuts exported in 2018 were 6,400 mt on kernel basis worth Ksh 8.8 billion. Rockle *et al*. (2019) found macadamia farming to be profitable and a means of livelihood for numerous households in Kibungu, Embu County, Kenya

Despite the rise in the popularity of macadamia farming in Kenya, the yield per tree is low. A macadamia tree has the potential to produce 70-100kg. However, in 2021, the average yield was approximately 39kg and 17kg per tree per year for mature and young trees, respectively (Agriculture and Food Authority [AFA], 2022). This challenge has existed since the early 2000s. Muthoka (2008) found out that small-scale macadamia farmers were faced with the obstacle of low macadamia yields. Further, the study observed that the macadamia cultivation sector of Kenya was unexploited despite its potential for development.

In Meru County, farmers are diversifying in macadamia farming as an alternative income source to coffee. The land under macadamia farming is 1,146 ha, and the total annual macadamia nuts production is approximately 6,992 mt; the average macadamia yield per tree per annum is half the potential output (AFA, 2022). Thus, this study was conducted to examine the socio-economic and technological factors affecting small-scale macadamia farmers, with the anticipation of providing guidance in the formulation of policies aimed at unlocking the full potential of the macadamia sector in Meru County.

METHODOLOGY

The study was guided by a descriptive survey design. A descriptive study collects data by describing the attributes of a population in a natural setting (Kothari, 2004). It was the most suitable design for this study as it helped in an in-depth understanding of the small-scale macadamia farmers' social and economic factors.

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The study targeted small-scale macadamia farmers in Central-Imenti sub-county. According to the Central-Imenti agricultural officer there are 6,100 small-scale farmers in the sub-county. The sample size for the study was determined using the Yamane (1967) formula, at a confidence level of 90% and a precision of 10%.

Yamane's formula is: $n = \frac{N}{1+N(e)^2}$

Calculation: $n = \frac{6,100}{1+6100(0.1)^2}$n = 98.38 (98 respondents).

The respondents were proportionally distributed in the four strata (Abothuguchi Central, Abothoguchi West, Mwangathia, and Kiagu). This helped to ensure unprejudiced representation of every ward because the number of small-scale macadamia farmers, varied from one ward to another. Simple random sampling technique was used to choose respondents from each stratum. The technique was deemed suitable for this study as it gave every respondent in the strata an equal opportunity to be selected (Alvi, 2016). Purposive sampling was employed in the selection of two key informants: the Central Imenti agriculture officer and an agricultural extension officer from the macadamia agribusiness.

The study employed three research instruments: questionnaires, an interview guide, and an observation schedule. Questionnaires were administered to small-scale macadamia farmers. The interview guide was utilized in collecting data from two key informants that are the Central Imenti agriculture officer and an agricultural extension officer from the macadamia agribusiness.

Observation checklist guided on field observations on significant aspects of macadamia farming, such as the planted varieties, farming practices like irrigation and availability of the macadamia nut market.

The collected data was coded and then entered into SPSS v28. Quantitative data was analyzed using descriptive statistics. For Qualitative data, thematic analysis was employed, encompassing the generation and review of themes to derive meaningful conclusions. Cobb-Douglas production function model was used for inferential statistics.

The model specification employed for this study is outlined as follows:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots \; \beta_3 D_3 + \beta_4 D_4 \ldots + \varepsilon$ ………………………………… (1)

The natural logarithm of model (1) is as follows:

$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 \ldots + \beta_3 D_3 + \beta_4 D_4 \ldots + \varepsilon$……………………………(2)

Where (lnY) is the natural logarithm of the dependent variable, (β_0) is the constant term, (X1X2) are the continuous independent variables, (D3, D4) are the dummy variables, (β_0 β_1 β_2 β_3 β_4) are the regression coefficients, and (ε) is the error term.

RESULTS AND DISCUSSION

Demographic Characteristics of the Respondents

The study aimed to describe the demographic features of small-scale macadamia farmers, categorized as social factors, in order to comprehend how they affect macadamia farming. The social factors examined include household size, age, marital status, gender, education level, and farming experience. The results are outlined as follows:

Gender

Based on the findings, out of 98 respondents, 54.17% were male while 45.83% were females.

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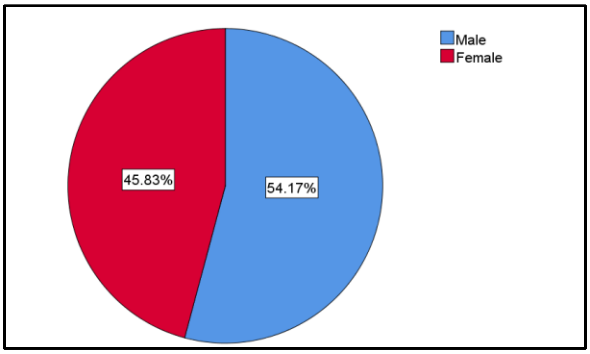
Figure 1: Gender

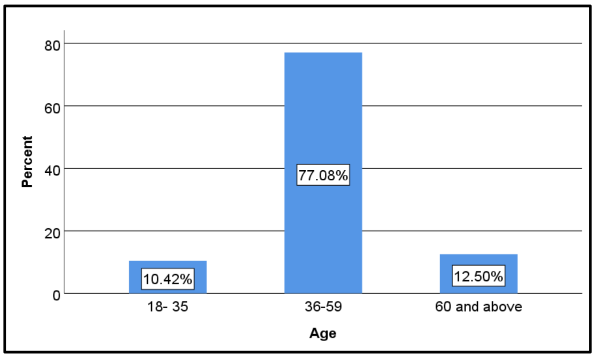


The findings are consistent with Murioga (2018) who observed that there were more men (56%) than women (44%) involved in macadamia farming in Kenya. This can be attributed to the fact that macadamia falls under the category of cash crop sector which is dominated by men. Peterman *et al.* (2014) revealed that the production of food crops is linked to women while men engage themselves in cash crops.

Age Distribution

The study revealed that that most of the farmers (77.08%) were in the age range of 36 to 59 years, with the next highest percentage (12.50%) belonging to the category of 60 and above years, and the least (10.42%) were in the category of 18-35 years.

Figure 2: Age Distribution

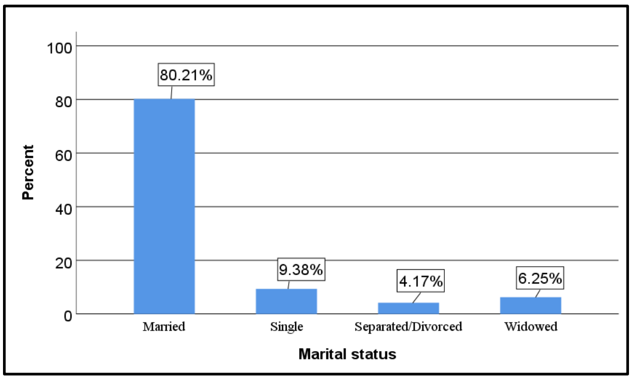


The results imply that the majority of the macadamia farmers are middle-aged, an age bracket that is regarded to be productive. The study also indicates there is low (10.42%) youth participation in macadamia farming. This can be attributed to the challenge of land ownership among youths.

Marital Status

The findings revealed that 80.21% of the respondents were married, 9.38% were single, 4.17% were separated/divorced, and 6.25% were widowed.

Figure 3: Marital Status



The study findings imply there is high involvement of married individuals in macadamia farming which may be attributed to obligations that arise from having a family such as feeding and educating the children. The findings are similar to Ngeywo *et al*. (2015) who observed that married people were more likely to be involved in farming, unlike individuals without spouses.

Education Level

The mean number of years of formal education for respondents was 11, ranging from 0 to 18 years.

Table 1: Years of Formal Education

	N	Min	Max	Mean	Std. Dev
Education	98	0	18	11.04	4.086
Valid N (listwise)	98				

The findings infer that most of the respondents had attained basic education. The findings are consistent with a report by the World Bank (2021) which revealed that the literacy rate of Kenyans above 15 years was 83%. The mean of 11 years is also an indication that people with higher levels of education are less inclined to participate in farming activities.

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Farming Experience

The respondents' mean years of farming experience was 17.91, ranging between 9 to 38 years.

Table 2: Farming Experience

	N	Min	Max	Mean	Std. Dev
Experience	98	9	38	17.91	6.463
Valid N (listwise)	98				

The findings suggest that farmers possess extensive experience in macadamia farming. Experienced farmers are likely to have high yields as they have agricultural knowledge. However, the macadamia farmers in the study area have low yields despite being rich in experience. An indication that there are other factors that affect macadamia farming.

Household Size

The findings disclosed that the mean number of persons per household was 6.47. The smallest household had 3 members while the largest had 10 members. The mean of adults and children per household was 3.35 and 3.14, respectively.

Table 3: Household Size

	Min	Max	Mean	Std. Dev
Household size	3	10	6.47	1.812
No. Adults	1	8	3.35	2.583
No. Children	0	7	3.14	1.890

Relationship Between Social Factors and Macadamia Farming

Cobb-Douglas production function was used to analyze how social factors affect macadamia farming. The findings are as follows:

Table 4 Regression Coefficients of Cobb-Douglas Production Function on Social Factors Affecting Macadamia Farming

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	2.127	.535		3.973	.000
Gender	.412	.123	.312	3.340	.001
Age	-.052	.095	-.021	-.551	.583
Marital status	.423	.123	.320	3.446	.001
Education	.271	.110	.154	2.455	.016
Experience	.142	.113	.070	1.260	.211
Household size	.123	.058	.158	2.129	.036

a. Dependent Variable: Macadamia yield

The gender of the farmer positively affected macadamia farming (β=0.412, P=0.001). This implies that being a male farmer is likely to increase macadamia yield by 41. 2%. The plausible explanation for these findings is that male farmers have higher chances of accessing knowledge and resources that help in improving their crop yields. The findings are consistent with Gebre *et al*. (2021) who found that male farmers had more agricultural productivity compared to female farmers in Ethiopia.

Age of the farmer had a negative insignificant relationship with macadamia yield (β=-0.52, p=0.583). The results imply that age of the macadamia farmer does not affect the yield. The findings are consistent with Ateka *et al*. (2018) who found that the age of the farmer had no significant relationship with yield among tea

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farmers in Kenya. Conversely, Deng *et al*. (2020) found that agricultural productivity among farmers in China decreased as the age increased.

The marital status of the farmer demonstrated a positive significant relationship with macadamia yield (β=0.423, p= 0.001). The results imply that being a married macadamia farmer is likely to increase yield by 42.3%. A plausible explanation for these findings is that farmers with spouses are more likely to collaborate on-farm activities, thereby reducing the need for hired labour and, consequently, lowering expenditures. The findings are similar to Kolapo *et al*. (2022) who observed that married farmers in Nigeria were more likely to use agronomic practices and thus, improve crop yields. Conversely, Ngeywo *et al*. (2015) reported that marital status had no significant relationship with crop yields.

Education level of the farmer positively affected macadamia yield (β=0.271, p=0.016). The findings imply that increase in farmer's level of formal education by one year is likely to increase macadamia yield by 27.1%. This may be because farmers who have gone through formal education and have acquired knowledge and skills on resource management and the importance of using technologies hence, they are likely to adopt new farm technologies like the use of improved varieties, thus improving their yields. The findings agree with Stimpson *et al*. (2019) who observed that increase in education level increased macadamia yield in Australia. Contrarily, Elahi *et al*. (2020) found that education unrelated to agriculture did not exert any significant effect on crop productivity in Pakistan.

The experience of the farmer had a positive insignificant ((β = 0.142, p=0.070) relationship with macadamia yield. The plausible explanation for these findings is that while farmers may have accumulated experience in terms of the time they have been involved in macadamia farming, they might still lack the essential knowledge and skills needed to fully maximize their potential. The findings agree with Kamau (2019) who found farming experience to have no significant relationship with potato production in Kenya. Incongruently, Stimpson *et al*. (2019) discovered that increase in macadamia farming experience increased yields in Australia.

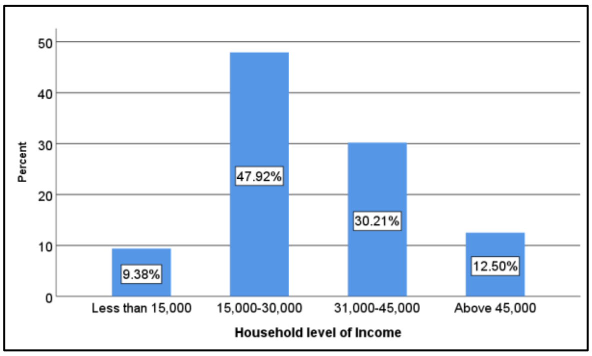
Household size had a positive significant relationship with macadamia yield (β=0.123, p=0.036). The results indicate that an increase in household size by one adult is likely to result in a 12.3% increase in the yield of macadamia. A plausible explanation for this is that an increase in household size is likely to result in greater availability of labour for macadamia farming. This, in turn, is more cost-effective compared to hiring external labour, ultimately reducing the overall production costs. The findings align with Abubakar and Sule (2019), who discovered that an augmentation in household size was associated with a rise in agricultural output in Nigeria. Contrary, Obasi *et al*. (2013) discovered an insignificant relationship between household size and crop yields in Nigeria.

ECONOMIC FACTORS

The study aimed to determine the economic factors affecting macadamia farming. The economic factors examined were: household level of income, farm size, number of macadamia trees, source of labour, credit access, and market type. The description of the hypothesized economic factors is as follows:

Household Level of Income

Figure 4: Household Level of Income



The findings revealed that out of 98 respondents, 47.92% had a monthly income of 15,000-30,000, (30.21%) had 31,000-45,000, (12.50%) had income above 45,000, and (9.38%) had less than 15,000. This, therefore, implies that the

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household income of the macadamia farmers is higher because only a few (9.38%) had a household income of less than 15,000. This may be attributed to high returns gained from macadamia farming.

Farm Size

The findings revealed that the mean area of farm size under macadamia farming was 1.6 acres. The farm sizes ranged from 0.25 to 5 acres (Table 5).

Table 5: Farm size

	N	Min	Max	Mean	Std. Dev
Farm size	98	.25	5.00	1.6328	1.29521
Valid N (listwise)	98				

The mean of 1.6 acres indicates that the farmers were practicing macadamia farming in relatively small pieces of land. The findings are similar to Rockle *et al*. (2019) who noted most (57.1%) of farmers in Embu County owned macadamia farms that were less than one acre. This can be ascribed to the existing challenge of land fragmentation.

Number of Macadamia Trees

Table 6: Number of Macadamia Trees

	N	Min	Max	Mean	Std. Dev
No. of Macadamia trees	98	17	345	128.61	91.771
Valid N (listwise)	98				

The study revealed that the mean number of macadamia trees per farmer was 128, with the highest at 345 trees and the lowest at 17 trees. The difference indicates that there has been diversification in macadamia farming in the last 15 years. The finding was also confirmed by the sub-county agriculture officer who noted that most of the coffee farmers in the region had diversified to macadamia farming.

Source of Labour

Table 7: Source of Labour

Source of Labour	Frequency	Percent
Family labour	46	46.94
Hired labour	52	53.06
Total	98	100.00

The study revealed that 46.94% of the respondents relied on family labour while 53.06% relied on hired labour.

The study revealed that 74.49% of the participants lacked access to credit, whereas 25.51% had credit access.

Credit Access

Table 8: Credit Access

Credit Access	Frequency	Percent
Do not have access	73	74.49
Have access	25	25.51
Total	98	100.00

The results imply that there is low access to credit among macadamia farmers, which can be attributed to lack of macadamia cooperative or society in the region. The results align with Njiru *et al.* (2021) findings, indicating that the majority

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(93.2%) of macadamia farmers in Embu County, Kenya, had no credit access.

Market Type

The study disclosed that most (46.94%) of the respondents sold their nuts to buyers in the market, (30.61%) sold them at farm gate, and (22.45%) sold them to macadamia companies.

Table 9: Market Type

Market Type	Frequency	Percent
Farm gate	30	30.61
Companies	22	22.45
Market center	46	46.94
Total	98	100.00

Further, the findings imply that majority (77.55%) sold their macadamia through middlemen that is by selling at farm gate or in the market center while only (22.45%) sold directly to companies. The findings agree with Rockle *et al*. (2019) who disclosed that most (80.6%) of macadamia farmers in Embu County sold their nuts to brokers either at the market or at the farm gate.

Relationship Between Economic Factors and Macadamia Farming

Cobb-Douglas production function was used to analyze how economic factors affect macadamia farming. All economic variables were significant (P=<0.05).

Table 10: Regression Coefficients of Cobb-Douglas Production Function on Economic Factors Affecting Macadamia Farming

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	T	Sig.
(Constant)	2.327	.098		23.647	.000
Household level of income	.142	.040	.080	3.549	.001
Farm size	.181	.036	.156	4.980	.000
No. Macadamia trees	.109	.029	.134	3.734	.000
Credit access	.174	.033	.120	5.328	.000
Labour	.131	.026	.101	5.084	.000
Market type	.666	.034	.488	19.780	.000

a. Dependent Variable: Macadamia yield

The results indicate that household level of income had positive significant relationship with macadamia yield (β=0.142, P=0.001), implying that increase in household level of income is likely to increase macadamia yield by 14.2%. The credible explanation for these findings is that increase in household income means an increase in finances that are likely to be used in purchasing farm inputs which helps in improving the yields. The results are similar to Emran *et al*. (2021), who noted that an increase in the household level of income was linked to an increase in crops' productivity in Bangladesh.

The size of the farm had a positive and significant relationship with macadamia yield (β=0.181, p=0.000). The results suggest that an increase in farm size by 1 acre is likely to lead to a corresponding 18.1% increase in macadamia yield. These results are consistent with Amaefula (2021) who discovered that increase in farm size led to higher yields among yam farmers in Nigeria. Conversely, Wu *et al*. (2018) observed that farm size had a negative and insignificant correlation with crop yields in China.

The number of macadamia trees had a positive and significant relationship with macadamia yield (β=0.109, p=0.000). The results indicate that increasing macadamia trees by one is likely to increase the yield by 10.9%. The plausible rationale for these observations is that farmers with high number of macadamia trees are likely to invest more in taking care of their trees as they

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view them as a major source of income, unlike farmers who have few numbers of trees.

Credit access had a positive and significant relationship with macadamia yield (β=0.174, p=0.000). The findings imply that having access to credit is likely to increase macadamia yield by 10.9%. The findings can be ascribed to the fact that credit acts as a source of finance for farmers, which they can utilize in purchasing farm inputs. These finding agree with Sabasi *et al*. (2021) who noted that credit access promoted agricultural productivity in the United States of America. Conversely, Fowowe (2022) found out that credit that was received in the form of cash had a negative significant relationship with agriculture productivity.

There was a positive and significant relationship between labour and macadamia yield (β=0.131, p=0.000). This implies that utilizing family labour is likely to increase macadamia yield by 17.4%. The plausible explanation is that having access to family labour lowers the amount of money that would otherwise be utilized in hiring labourers, thus lowering the production cost. The results are similar to Gebeyehu (2016) who observed that the utilization of family labour contributed to increase in crops' yield in Ethiopia. However, in the case of large farm sizes, Taylor and Charlton (2018) noted that family labour was highly irrelevant because a large number of farm workers are required.

Market type had a positive and significant relationship with macadamia yield (β=0.666, p=0.000). The results imply that having access to direct market is likely to increase macadamia yield by 66.6%. The plausible explanation for these findings is that farmers who have the opportunity to directly sell their nuts have the advantage of making more returns as they avoid being exploited by middlemen, thus they are in a position to generate more income that can be used in purchasing farm technologies. The findings agree with Keru (2021) who noted that coffee farmers with a direct sale of their yields in Kenya made higher profits compared to other farmers.

TECHNOLOGICAL FACTORS

The technological factors examined were: improved varieties, dehusker machine, inorganic fertilizer, organic fertilizer, pesticides, pruning, irrigation, and access to agricultural technology extension. The description of these factors is as follows:

Type of Variety

Table 11: Type of Variety Cultivated

Variety type	Frequency	Percent
Improved variety	35	35.71
Traditional variety	63	64.29
Total	98	100.00

The results imply that most (64.29%) had planted traditional varieties while 35.71% had planted improved varieties. These findings align with Njiru *et al*. (2021) who observed that in Embu County, only 42.7% of the macadamia farmers who had embraced the improved varieties while majority (57.3%) had planted the traditional variety.

Dehusking Method Used in Macadamia Farming

Table 12: Dehusking Method Used in Macadamia Farming

Dehusking Method	Frequency	Percent
Mechanical method	38	38.78
Manual method	60	61.22
Total	98	100.00

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The study revealed that only 38.78% of the farmers used dehusker machines while 61.22% used the traditional method.

Application of Pesticides in Macadamia Farming

Table 13: Application of Pesticides in Macadamia Farming

Application of Pesticides	Frequency	Percent
Do not apply	67	68.37
Apply	31	31.63
Total	98	100.0

The findings imply that most of the respondents (68.37%) did not apply pesticides to their macadamia trees, only 31.63% reported applying pesticides. The key informant noted that the low usage of pesticides in macadamia farming can be attributed to the high costs associated with purchasing pesticides (R. Mutuma, Personal communication, May 2023).

Application of Inorganic Fertilizer in Macadamia Farming

The study revealed that only 11.22% of the respondents who applied inorganic fertilizer in macadamia farming while majority (88.78%) did not apply.

Table 14: Application of Inorganic Fertilizer in Macadamia Farming

Application of Inorganic Fertilizer	Frequency	Percent
Do not apply	87	88.78
Apply	11	11.22
Total	98	100.00

These findings may be attributed to high prices involved in purchase of macadamia fertilizer and lack of subsidy for fertilizer used in macadamia farming. The limited application of inorganic fertilizer in macadamia farming may be one of the factors resulting to decrease in yield as Zuza *et al.* (2021) noted that fertility of the soil plays a crucial role in macadamia farming as it affects the quantity and quality of nuts yield.

Application of Organic Fertilizer in Macadamia Farming

The study findings disclosed that the majority (73.47%) of the farmers applied organic manure on their macadamia trees, while 26.53% did not apply.

Table 15: Application of Organic Fertilizer in Macadamia Farming

Application of organic fertilizer	Frequency	Percent
Do not apply	26	26.53
Apply	72	73.47
Total	98	100.00

The findings are similar to Mwaura *et al.* (2021), who noted that 97% of the study's respondents in central highlands Kenya had adopted the usage of organic manure in crop farming. This can be attributed to easy access of inorganic fertilizer and its affordability.

Pruning Practices in Macadamia Farming

Table 16: Pruning Practices in Macadamia Farming

Pruning Practice	Frequency	Percent
Do not practice	33	33.67
Practice	65	66.33
Total	98	100.00

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Pruning macadamia trees is important as it helps in increasing light penetration and removal of the branches that have been attacked by pests and diseases (KALRO, 2019). The study disclosed that most (66.33%) of the respondents pruned their macadamia trees, while 33.67% did not prune. The key informant confirmed that pruning was a common practice among macadamia farmers in the region and should be done after the harvesting period. However, a few were resistant to practicing it as they did not believe in the benefits of pruning trees (R. Mutuma, personal communication, May 2023).

Irrigation Practices in Macadamia Farming

This study revealed that 37.76% of the respondents practiced irrigation while 62.24% did not practice.

Table 17: Irrigation Practices in Macadamia Farming

Irrigation practice	Frequency	Percent
Do not practice	61	62.24
Practice	37	37.76
Total	98	100.00

The findings are in line with Hornum and Bolwig (2020) who found that there was low uptake of irrigation technologies among farmers in Kenya. This can be attributed to the challenge of inadequate water. Similarly, Mbuthia (2018) revealed that banana farmers in the study region were also faced with the challenge of inadequate water for irrigation.

Access to Agricultural Technology Extension

The study disclosed that most (57.14%) of the respondents had access to agricultural technology extension while 42.86% did not have.

Table 18: Access to Agricultural Technology Extension

Access to Agricultural technology extension	Frequency	Percent
Have access	56	57.14
No access	42	42.86
Total	98	100.0

The findings can be attributed to the active involvement of private macadamia companies in offering agricultural technology extension services to farmers.

Relationship between Technological Factors and Macadamia Farming

Cobb-Douglas production function was used to analyze how technological factors affect macadamia farming. The findings are as follows:

Table 19: Regression Coefficients of Cobb-Douglas Production Function on Technological Factors Affecting Macadamia Farming

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	2.737	.023		119.488	.000
	Improved variety	.308	.061	.229	5.039	.000
	Dehusker machine	.107	.076	.077	1.409	.162
	Pesticides	.114	.056	.080	2.029	.046
	Inorganic fertilizer	.134	.029	.066	4.616	.000
	Organic fertilizer	.252	.021	.168	12.022	.000
	Pruning	.047	.026	.024	1.851	.068
	Irrigation	.460	.070	.334	6.609	.000
	Agricultural technology extension	.240	.045	.181	5.316	.000

a. Dependent Variable: Macadamia Yield

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Improved variety had a positive and statistically significant relationship with macadamia yield (β=0.308, p=0.000). This implies that cultivation of improved variety was likely to increase macadamia yield by 30.8%. The plausible explanation for these findings is that improved macadamia varieties have been genetically modified to produce higher yields. The findings are similar to Takahashi *et al*. (2020) who observed that adoption of enhanced varieties increased crop yields in third world countries. Similarly, Ojo *et al*. (2019) noted that the use of improved varieties among sorghum farmers in Nigeria increased the yields.

Dehusker machine had a positive insignificant relationship with macadamia yield (β=0.107, p=0.162). The results imply that use of dehusker machine does not affect the macadamia yield. This may be attributed to high cost associated with acquiring dehusker machines which is comparable to that of hiring labourers who use the traditional method. The findings contradict Qing *et al*. (2019) who observed that mechanization services helped in the improvement of farm productivity in China.

The relationship between pesticides and macadamia yield is positive and significant (β=0.114, p=0.046). This implies that application of pesticides on macadamia tree is likely to increase the yield by 11.4%. The plausible explanation is that utilization of pesticides to control pests and insects which destroy the nuts, result to decrease in yield loss. The findings are similar to Tudi *et al*. (2021) who observed pesticides to be indispensable in crop production as they help in reducing diseases and thus improving yields. Similarly, Dwivedi *et al*. (2022) noted that pesticides help in enhancing crop production.

There was a statistically significant positive relationship between the use of inorganic fertilizer and macadamia yield (β = 0.134, p = 0.000). This imply that application of inorganic fertilizer on macadamia tree was likely to increase the yield by 13.4%. The findings agree with Lin *et al*. (2022) who noted that inorganic fertilizer application increased crop yields. Similarly, Purba and Supriana (2019) found that inorganic fertilizer application in farming of Arabica coffee contributed to increase of crop yields in Indonesia

Organic manure had positive and significant relationship with macadamia yield (β=0.252, p=0.000). This implies that application of organic manure on macadamia trees is likely to increase macadamia yield by 25.2%. The credible explanation for these findings is that organic manure does supply nutrients that are needed by macadamia trees and thus improvement of yields. The findings are similar to Du *et al*. (2020) who found manure to positively affect crop yields in China. Similarly, Bidzakin *et al*. (2023) observed a strong relationship between organic fertilizer application and increased crop yields in Ghana.

Pruning had a positive insignificant relationship with macadamia yield (β=0.047, p=0.068). The findings may be because the farmers were not pruning their trees in the right way and required intervals. The findings are inconsistent with Christie and Schoeman (2022) who found out that one of the factors that have caused South Africa's macadamia sector to fail short of their expected production is insufficient pruning.

Irrigation and macadamia yield had a positive and significant relationship (β=0.460, p=0.000). This indicates that irrigating the macadamia trees is likely to increase the yield by 46%. This can be explained by the fact that when macadamia trees are irrigated, they yield throughout the year. The results are similar to Dunusinghe (2019) who found that irrigation of crops in Sri Lanka contributed to improved productivity. Similarly, Kathuri *et al*. (2021) observed that the practice of irrigation among banana farmers in Kenya contributed to an increase in yields.

Agricultural technology extension had a positive significant relationship with macadamia yield (β=0.240, P=0.000). This imply that having access to agricultural technology extension is likely to increase macadamia yield by 24%. The plausible explanation for these findings is that having access to extension education allows the farmers to learn about technological knowledge and practices such as how to control pests and diseases, recommended types of fertilizers, existing varieties and how to irrigate the crops, and thus improvement of yields. The findings agree with Danso-Abbeam *et al*. (2018) who observed that the extension program helped improve farm productivity in Ghana. Conversely, Sebaggala and Matovu (2020) found extension education and farm productivity to have positive insignificant relationship in Uganda. This was attributed to existence of weaknesses in the country's extension services which was not in a position for it to translate to a positive significant impact on farm output.

CONCLUSION

The study concludes that the average macadamia yield of the farmers was below the potential yield. Social, economic, and technological factors were significant in understanding the variance of macadamia yield. Irrigation practices, pesticide application, market type, and use of improved varieties are the major factors affecting macadamia farming. Three of these variables (irrigation, pesticide, and improved variety) fall under the category of technological factors an indication that agricultural technology plays a vital role in macadamia farming.

RECOMMENDATIONS

The study recommends that:

- The macadamia farmers in the study area should form a cooperative society which will help solve the challenge of inadequate access to credit.
- The County Government of Meru should avail adequate access to certified seedlings to solve the problem of farmers purchasing uncertified seedlings.
- Extension officers should collaborate with farmers to enhance the adoption of technology, thereby contributing to an increase in macadamia yields.

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