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Effect of Product Strategy on Production of Macadamia Nuts by Small-Scale Farmers in Kirinyaga County, Kenya.

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ABSTRACT

Macadamia farming offers an important source of income for producers worldwide and especially for small-scale-farmers in Kenya. Kirinyaga County is one of the major macadamia producers within the central and eastern highland of Kenya, however, the county is experiencing low average yields with trees producing only 50% of the crop potential. The objective of the study was to analyze the effect of product strategy on production of macadamia nuts by small-scale-farmers in Kirinyaga County. The study is anchored on the classical theory of production. The Target population was 8,004 small-scale macadamia farmers in Kirinyaga County. The study used descriptive survey design and the multistage random sampling technique. A structured questionnaire was adopted and data was analyzed with the aid of SPSS version 26. Simple linear regression model was used in data analysis. The OLS assumptions were tested before conducting regression analysis. The results are presented in tables and figures. The results revealed a positive and significant association between product strategy and production of macadamia nuts (r = 0.365, p =0.000) and R = .133 meaning that 13.3% of the variance in production of macadamia nuts is explained by product strategy. ANOVA analysis reported an F- statistic (49.032) with a p= .000. The null hypotheses that "There is no significant effect of product strategy on production of macadamia nuts by small-scale-farmers in Kirinyaga County" was rejected by a t value of 7.002 that was higher than the critical t statistic (1.96). The study concluded that product strategy (factor inputs) had a significant effect on production of macadamia nuts by small-scale farmers in Kirinyaga County. The study recommended that farmers should be motivated to increase the use of factor inputs in order to improve on yields per tree/acre. The government should support farmers by providing them with affordable factor inputs necessary in macadamia farming.

Keywords: *Small-scale-farmers, product strategy, production and of macadamia nuts and production theory and*

1. Introduction

1.1 Background of the Study

Macadamia farming is a significant agricultural enterprise in Kenya, contributing to household incomes, rural employment, and national revenue. In 2023, Kenya exported approximately 99% of its macadamia produce, valued at KSh 7.1 billion, reinforcing the crop's role in foreign exchange earnings and overall agricultural GDP (AFA, 2024). However, the sustained growth of the sector depends not only on sound production practices but also on strategic marketing mix decisions, particularly the product strategy, which determines the quality of inputs, seed varieties, and agronomic practices made available to farmers.

Globally, countries have adopted marketing mix strategies, with particular emphasis on the product strategy, to support macadamia production. In Australia, high-performing varieties developed through national breeding programs have improved yields and pest resistance, though farmers continue to face high input costs and limited bargaining power (Australia Macadamia, 2020; AMC, 2022). In China, government initiatives and private investments have promoted high-yielding, locally adapted varieties and subsidized inputs, encouraging greater farmer participation. However, inconsistent seedling quality remains a persistent challenge (Li, Zhang & Huang, 2021; Zhang & Liu, 2022). In the United States, Hawaii remains the leading production region, where improved seedlings and pest-resistant varieties have enhanced productivity. Yet, rising labor and land costs, along with aging orchards, present ongoing challenges for small-scale producers (United States Department of Agriculture [USDA], 2021; Hawaii Macadamia Nut Association, 2020).

Across Africa, the product strategy, one of the four key marketing mix elements (product, price, place, and promotion), has become central to enhancing small-scale agricultural production. Countries such as Malawi and Mozambique have made efforts to integrate farmers into the macadamia value chain, but access to quality inputs and price instability continue to limit performance. South Africa, despite holding 29% of the global market share in 2019 (International Nut and Dried Fruits Council (INC), 2020), faces fluctuating production levels due to limited farm sizes and inadequate access to improved planting materials (Sibulali, 2018). In Ghana, Agyemang, Retinger, and Bavorove (2021) found that increased use of farm inputs does not always lead to higher productivity due to limitations in household land sizes.

Uganda has recently identified macadamia as a priority export crop, recognizing its ecological suitability and the benefits of intercropping with other crops. Government policies, along with support from NGOs and private investors, have helped promote macadamia farming through the distribution of improved seedlings and subsidized inputs. However, despite these efforts, the country continues to face challenges related to access to high-quality seedlings, inadequate agronomic training for farmers, and limited infrastructure for processing and marketing, which hinder the sector's growth potential (Afrinspire, 2019; Senyonyi, 2020).

In Kenya, macadamia is grown both as a cash crop and a vital foreign exchange earner (Gitonga, Muigai, Kahangi, Ngamau & Gichuki, 2017), contributing approximately 13% of global production (Quiroz, 2019). Although national production has shown an upward trend overall, it remains highly volatile, with significant year-to-year fluctuations in yields (Wasilwa, 2019). The highland regions surrounding Mount Kenya, particularly the counties of Kiambu, Kirinyaga, Meru, Murang'a, and Nyeri, are the leading production zones (Quiroz et al., 2019). Despite the expansion of the sector, the average yields remain low, with macadamia trees producing only about 50% of their potential, and most farmers harvesting less than 100 kg annually.

Kirinyaga County is among the key macadamia-producing regions in Kenya's central and eastern highlands (Quiroz et al., 2019; Velden & Paniagua, 2019). However, production in the county has remained relatively low, despite the crop's high returns and strong demand in both local and international markets (Quiroz et al., 2019). The county experienced a consistent decline in production over three consecutive years, with annual production estimated at 4,484.7 MT in 2018, 3,959.6 MT in 2019, and 3,912 MT in 2020, even as the area under macadamia increased slightly from 1,722 hectares in 2018 to 1,734 hectares in 2020 (AFA, 2019). In 2017, Kirinyaga contributed only 4.4% to national macadamia output, ranking lower than other major producing counties such as Kiambu, Meru, Murang'a, and Nyeri. According to Quiroz (2019), the county's low average yields—estimated at just 50% of potential output—indicate significant underutilized production capacity. This underperformance is likely influenced by gaps in farmers' adoption of product-related decisions, such as the selection of seed varieties, soil fertility management, pest and disease control, and orchard management practices.

This study therefore focuses on the product strategy of the marketing mix as the independent variable, aiming to understand how product-related decisions influence macadamia nut production among small-scale farmers in Kirinyaga County. By examining the effect of product-related decisions—such as seed selection, soil fertility management, pest and disease control, and fertilizer use—this research seeks to identify practical strategies for improving yields and optimizing the county's contribution to national macadamia production. The focus of this study is on understanding the effect of product strategy on the production of macadamia nuts.

1.2 Statement of the Problem

Macadamia farming provides an important source of income for producers worldwide, particularly for small-scale farmers in Kenya. Studies by Murioga (2017) and Gitonga et al. (2017) confirm that while the macadamia industry in Kenya has considerable growth potential, the sector's growth has not kept pace with demand or the crop's full potential. Despite the high poverty reduction potential of the crop, macadamia production in some of Kenya's major growing areas has been declining (Maina, 2020; Murioga, 2017). Kirinyaga County, a key macadamia producer in Kenya's central and eastern highlands, has seen low production levels over the years, despite strong local and international demand and high returns (Quiroz et al., 2019; Murioga, 2017).

The county has experienced a downward trend in macadamia output over three consecutive years, with annual production estimates at 4,484.7 MT in 2018, 3,959.6 MT in 2019, and 3,912 MT in 2020. In contrast, the area under macadamia farming slightly increased from 1,722 hectares in 2018 to 1,734 hectares in 2020 (Agriculture and Food Authority [AFA], 2019). While the number of hectares under macadamia cultivation has been growing, total output has been declining. According to Quiroz (2019), Kirinyaga's low average yields—estimated at just 50% of the potential output—point to significant underutilization of the county's production capacity. This productivity gap is likely influenced by gaps in farmers' adoption of key product-related decisions, such as seed variety selection, fertilizer use, pest and disease management, and orchard management practices.

This low productivity poses a risk to Kenya's global market share, which currently stands at approximately 13% of global macadamia production (Quiroz, 2019). Small-scale farmers in Kirinyaga are experiencing declining incomes, increased economic vulnerability, and diminished rural economic growth, while household livelihoods are weakening. These challenges underscore the need to investigate the impact of product strategy, including decisions on seed varieties, soil fertility, pest control, and other agronomic practices on macadamia production in the region. The goal of this study is to identify ways to enhance farmer decision-making, optimize yields, and improve Kirinyaga's contribution to Kenya's macadamia production and global supply.

1.3 Objectives of the Study

The objective of the study was to analyze the effect of product strategy on production of macadamia nuts by small-scale farmers in Kirinyaga County.

1.4 Research Hypothesis

H_{O1}: There is no significant effect of Product strategy on production of macadamia nuts by small-scale farmers in Kirinyaga County.

2.0 Theoretical Framework

This study is guided by the Classical Theory of Production, originating from Adam Smith's 1776 work. The theory posits that production outcomes depend on the optimal combination of physical inputs, expressed through the production function $Y = f(X_1, X_2, \ldots, X_n)$, where Y is output and X_1 *to* X_n represent factor inputs (Marilis & Tsoilfidis, 2016). It assumes that increases in input use lead to higher output and that producers allocate inputs based on their perceived contribution to production efficiency.In macadamia farming, the product strategy encompasses farmers' decisions on seedling varieties, pest and disease control, fertilizer use, and quality management. These inputs directly influence macadamia yields among small-scale farmers, aligning with the theory's assertion that higher investment in production inputs results in higher output. However, the Classical Theory of Production does not account for wider economic conditions—such as input prices, output prices, and market incentives—which also shape farmers' production decisions (Mendelsohn & Wang, 2017).

2.1 Conceptual Framework

The conceptual framework in Figure 2.1 presents the relationship between the independent variable (product) and the dependent variable (production of macadamia)

Independent Variable **Dependent Variable**

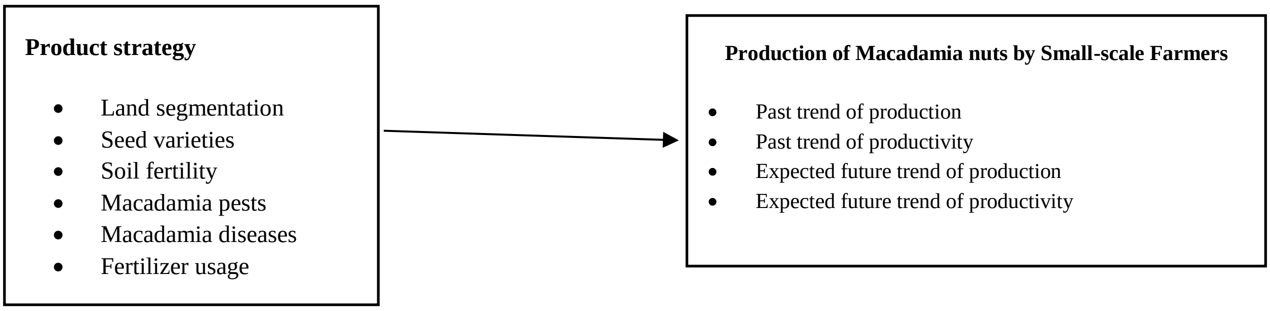

Figure 1: The Conceptual Framework

Production of macadamia nuts is defined as the total quantity harvested by small-scale farmers per year, while yield refers to the average output per tree (AFA, 2022). In this study, production is the dependent variable influenced by product-element decisions such as seed variety, soil fertility management, pest and disease control, and fertilizer use. Its indicators include past trends of production, reflecting historical fluctuations in output based on farmers' recall of estimated annual harvests (Food Agriculture and Organization (FAO), 2017; AFA, 2022), and projected future trends of production, capturing anticipated changes in upcoming seasons based on farmers' predictions of whether output is likely to increase, remain constant, or decrease (Central Bank of Kenya, 2023; (Food Agriculture and Organization (FAO), 2017).

2.2.1 Production of Macadamia Nuts

Production of macadamia nuts is defined as the total quantity harvested by small-scale farmers, measured in kilograms per year (Agriculture and Food Authority (AFA), 2022). In contrast, yield refers to the average quantity of nuts produced per tree per year, measured in kg (AFA, 2022).

In this study, the indicators are categorized into past trends and projected future trends for both production and productivity. This temporal division reflects a growing understanding that agricultural dynamics requires both retrospective analysis and prospective anticipation. Past trends of production and productivity offer empirical evidence of how farming systems have evolved over time, influenced by technological adaptation, market conditions, and environmental factors (Gitonga et al., 2017; Wasilwa, Karuri, Muthoni & Wanyoike, 2019). These historical patterns enable the identification of bottlenecks such as, poor marketing infrastructure or low quality planting materials, which have constrained growth (Masira, 2017). On the other hand, projected trends based on farmer expectations, reflect perceptions of future production. Although inherently subjective, such projections offer valuable insights into farmers' confidence, anticipated challenges, and planned investments (Central Bank of Kenta, 2023). Integrating both past and projected trends provides a more comprehensive picture of the sectors performance and future trajectory informing evidence-based policy and intervention strategies.

2.2.2 Product Strategy

The product strategy is one of the broader marketing mix framework including product, price, place, and promotion. Kotler and Keller (2016) describe the product as the core offering designed to meet customer needs and generate the desired response in the target market. In agriculture, the product strategy involves decisions that address challenges such as seasonality, perishability, and limited rural infrastructure while aligning farm production with market expectations to enhance farmer participation and profitability.

In this study, the product strategy is conceptualized as a set of flexible, farmer-driven decisions shaped by local agro-ecological conditions, resource limitations, and production objectives. Among small-scale macadamia farmers in Kenya, the product strategy manifests through decisions such as selecting high-yielding, drought-tolerant, or early-maturing macadamia varieties to improve productivity and meet market preferences. These product-related choices directly influence seed variety, agronomic performance, and the quality of nuts supplied to processors and exporters**.** For example, the adoption of improved grafted macadamia seedlings has significantly enhanced yields and nut quality due to their superior disease resistance and adaptability to local conditions (Muchangi, Okello & Wambugu, 2021). Intercropping macadamia with food crops such as bananas and maize is also common, allowing farmers to maximize land productivity and strengthen household food security.

However, in Kirinyaga County, several product-element constraints limit the realization of the crop's full production potential. A key barrier is the limited access to certified, high-quality grafted seedlings, forcing many farmers to rely on uncertified or recycled planting materials that lead to poor yields and inconsistent nut quality (Masira, 2017). Small average farm sizes, often below two acres further restrict the number of macadamia trees that can be planted, limiting farmers' ability to optimize orchard design or benefit from economies of scale.

Low fertilizer use is another major constraint many farmers apply minimal or no fertilizers due to financial limitations or inadequate knowledge of soil fertility management, resulting in nutrient-deficient soils that hinder tree vigor and yields. Pest and disease pressures including macadamia stink bugs, borers, and fungal infections also negatively affect nut quantity and quality. These challenges are compounded by limited farmer training on orchard establishment, integrated pest management, and soil fertility improvement.

Although local cooperatives, private nurseries, and extension programs have initiated efforts to distribute improved seedlings and provide agronomic support, these initiatives remain limited in scale and inadequate to address the widespread gaps in product-element decisions. Consequently, significant potential remains underutilized among small-scale macadamia farmers in Kirinyaga County.

2.3 Empirical Review

In South Africa, Bringhenti, Joubert, Abdulai, Hoffmann and Morindo (2023) examined how orchard management and input selection influence macadamia yields along an altitudinal gradient. Using mixed-effects models, the study found that cultivar choice, irrigation, tree age, and planting density significantly affected yields, with orchards using irrigated micro-sprinklers, suitable cultivars, and optimal planting density achieving higher production. The study also highlighted challenges such as aging orchards, limited access to high-quality seedlings, and resource constraints, which can limit productivity.

In Kenya, Mwendwa, Muiruri, and Mbuthia (2024) analyzed socio-economic and technological determinants of macadamia production in Meru County using a Cobb-Douglas production function. Improved varieties, fertilizer use, pesticides, irrigation, and extension access significantly enhanced yields. However, many farmers lacked access to certified seedlings and sufficient extension support, which limited the consistent application of best practices.

Gichangi et al. (2019) examined factors influencing smallholder farmers' use of agricultural inputs in Kenya's bean production corridors. Using a Probit model on data from 417 respondents, the study found that income from crop sales was a key driver of input use, while improved seeds and fertilizers significantly enhanced yields. Despite this, input utilization remained low among smallholder food crop producers, reflecting constraints in access to inputs and financial resources.

Kathula (2023) investigated factors affecting agricultural production and the role of extension services in Kenya. Using a cross-sectional survey and purposive sampling, the study found that pests and diseases, soil fertility decline, land subdivision, population pressure, over-cultivation, limited extension services, and poor infrastructure were key constraints to agricultural production. The study identified these factors but did not quantify their specific impact on yields.

3.0 Research Methodology

This study adopted a descriptive survey design, which is effective for systematically collecting data from a broad spectrum of participants. The target population comprised 8,004 small-scale macadamia farmers across Kirinyaga Central, Mwea, Gichugu, and Ndia Constituencies in Kirinyaga County. A sample of 382 respondents was determined using Yamane's (1967) simplified formula, ensuring proportional representation across constituencies and assembly wards (Oribhabor & Anyanwu, 2019).

Primary data were collected through a self-administered, unstructured questionnaire. A pilot test was conducted with 38 respondents, representing 10% of the sample, in line with Mugenda's (2012) recommendation. Content validity was established through expert consultation, while reliability was confirmed using Cronbach's alpha, a widely accepted measure of internal consistency.

4.0 Data Analysis, Results and Discussion

4.1 The study analyzed the effect of product strategy on production of macadamia nuts by small-scale farmers in Kirinyaga County. The product strategy was measured using six items. These items are land subdivision, seed variety, soil fertility, macadamia pests, macadamia diseases and fertilizer usage. Using a Likert scale of 1 – 4, where 1= strongly disagree (SD), 2= disagree (D), 3= agree (A) and 4= strongly agree (SA), the study sought to find out respondents extent of agreement or disagreement with six statements relating to product strategy of macadamia marketing. This information was expected to unveil the factors which influence production of macadamia nuts.

Table 1: Descriptive Statistics for Product strategy

Statements	SD	D	A	SA	Mean	Std Dev
There has been a lot of sub-division of my household land	23.1%	24.7%	22.2%	30.0%	2.59	1.142
I have adopted high-yield macadamia seed varieties in my farm.	15.9%	26.9%	33.8%	23.4%	2.64	1.009
Fertility of the soil in my macadamia farm has been improving due to fertilization.	12.8%	31.6%	37.8%	17.8%	2.61	.923
I have been facing the problem of pests every year	20.6%	38.4%	25.9%	15.0%	2.36	.974
Macadamia diseases have been a major problem in my farm	20.6%	38.4%	25.9%	15.0%	2.38	.984
I have been using fertilizer every year	37.2%	19.7%	28.1%	15.0%	2.21	1.101
average					**2.465**	**1.022**

KEY

Mean	**Decision Criteria**	**Standard Deviation**	**Decision Criteria**
1–2.50	Low level of agreement	Less than 2	Responses are valid
2.51- 4	High level of agreement	More than 2	Responses not valid

According to 4.3 above, the mean values range between 2.2.1 and 2.64, while all standard deviations are below two, indicating that the responses were generally consistent and valid. The results show that small-scale macadamia farmers in Kirinyaga County had a moderate level of agreement with statements related to product strategy affecting macadamia nut production. Among the six items, the highest mean score was for the adoption of high-yield macadamia seed varieties (Mean = 2.64), followed by soil fertility improvement (Mean = 2.61), and land subdivision (Mean = 2.59). All three are slightly above the 2.51 threshold, indicating a moderately high level of agreement that these factors influence production. These results suggest that farmers are increasingly recognizing the importance of adopting improved seed varieties, maintaining soil health, and managing land resources effectively.

On the other hand, relatively lower mean scores were recorded for pest problems (2.36), disease challenges (2.38), and fertilizer use (2.21). These findings imply that pests and diseases are not perceived as major issues by most farmers, or that they may not be well-monitored or understood. The low mean for fertilizer usage suggests that many farmers do not consistently apply fertilizer, which could be due to high costs, lack of access, or limited awareness of its benefits. The overall average mean of 2.465 reflects a moderate perception of the influence of product-related factors on the production of macadamia nuts. Since all standard deviations were below 2, the data is considered reliable and not highly dispersed.

These results align with findings by Mwangi (2018**)**, who noted that land subdivision and the adoption of high-yield macadamia seed varieties significantly influenced macadamia productivity in Central Kenya. The moderate concern about soil fertility is also consistent with Karanja and Maina (2020), who found that most smallholders rarely test or amend soil. However, the low concern for pests and diseases differs from Kamau (2019), who reported pest infestations as a key constraint in macadamia farming in Embu and Meru counties. Similarly, the low fertilizer usage in this study contrasts with Wekesa (2021), who observed that fertilizer application was common in more productive farms. These discrepancies may be due to differences in location, awareness, or access to agricultural inputs and extension services.

These findings are also supported by the classical theory of production, which emphasizes that output is a function of input utilization. According to this theory, factors such as land (land subdivision), labor, capital (e.g., fertilizer and improved seeds), and entrepreneurship must be effectively combined for optimal productivity. Therefore, the limited use of key inputs like fertilizer, despite its recognized role in enhancing soil fertility and crop yields, could be limiting overall production among small-scale macadamia farmers.

4.2 Inferential Analysis

4.2.1 Correlation Analysis

The findings were further subjected to correlation analysis to examine the relationship between product strategy and production of macadamia nuts. A Pearson correlation test was performed to measure the strength and direction of the relationship between the two variables. The correlation coefficient (r) ranges from -1 to +1, with values closer to +1 or -1 indicating stronger relationships. The results are presented in Table 4.4.

Table 2: Pearson Correlation Matrix for Product Strategy and Production of Macadamia Nuts

Correlations			
		Production	**Product**
Production of Macadamia Nuts	Pearson Correlation	1	.365**
	Sig. (2-tailed)		.000
	N	321	321
Product strategy	Pearson Correlation	.365**	1
	Sig. (2-tailed)	.000	
	N	321	321

****. Correlation is significant at the 0.01 level (2-tailed).**

The results indicate a positive and significant relationship between product strategy and production of macadamia nuts ($r = 0.365$, $p < 0.01$). This means that improvements in product-related factors—such as seed variety selection, soil fertility management, fertilizer application, and pest and disease control—are associated with increased production of macadamia nuts among small-scale farmers in Kirinyaga County.

The correlation coefficient of 0.365 indicates a moderate association between product strategy and production of macadamia nuts. To understand the proportion of variance explained, the correlation was squared ($r^2 = 0.365^2 = 0.133$), indicating that approximately 13.3% of the variability in the production of macadamia nuts is explained by product strategy. The remaining 86.7% is influenced by other factors not captured in this analysis.

These findings suggest that while product strategy is a significant factor in macadamia nut production, other variables such as market access, labor, extension services, and climatic conditions also play substantial roles in determining overall productivity.

4.2.2 Regression Analysis

The data were further subjected to regression analysis to investigate the relationship between product strategy and the production of macadamia nuts. The ordinary least square model was used to analyze the strength of the effect and the results are presented in Tables 4.5, 4.6 and 4.7 respectively.

Table 4.3: Model Fitness

Model Summary					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
1	.365	.133	.131	.88081	1.838

a. Predictors: (Constant), Product

b. Dependent Variable: Production

To determine how well the model fits the data, the goodness of fit statistics in Table 4.5 were examined. R is the strength of the correlation between product strategy and production of macadamia nuts in kirinyaga County. The finding shows a moderate correlation of 0.365 between the two variables.

R square tells how much of the variance in the dependent variable is explained by the independent variable. R square values range from 0 – 1 and are commonly stated in percentages from 0% to 100%. The higher the R^2 value, the better the model fits the data. The finding show R square value of .133. The R square value of .133 shows that 13.3% of the variance in production of macadamia nuts is explained by product strategy. Hence the model was found fit for further analysis.

The Dab-Watson statistic ($d = 1.838$), which is between the two critical values of $1.5 \leq d \geq 2.5$ and therefore the study concluded that there was no autocorrelation in the data.

Table 4.4: Analysis of Variance

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	38.040	1	38.040	49.032	.000[b]
	Residual	247.487	319	.776		
	Total	285.527	320			

a. Dependent Variable: Production

b. Predictors: (Constant), Product

Analysis of variance consists of calculations that provide information about levels of variability within a regression model and form the basis for tests of significance. F is a test for statistical significance of the regression equation. It tests how good the regression equation is in predicting values of Y, for given values of X. If F is significant, then the regression equation will help to understand the relationship between the predictor and the response variables. F- Value and the associated p-value tells whether the model is statistically significant.

The results in Table 4.7 show an F- statistic (49.032) with a p-value of .000 which is less than the conventional 0.05. The results indicate that product strategy had a significant effect on the production of macadamia nuts. Since the F statistic (49.032) is greater than the F- critical (7.88), the study concluded that the regression model linking product strategy and production of macadamia nuts is statistically significant.

Table 4.5: Regression Coefficients and Hypothesis Test

Coefficients						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		β	**Std. Error**	**Beta**		
1	(Constant)	2.153	.192		11.241	.000
	Product	.514	.073	.365	7.002	.000
a. Dependent Variable: Production						

The study used regression coefficients to test the effect of product strategy on production of macadamia nuts and for hypothesis test. The beta coefficients can be positive or negative, and have a t-value and a significance of a t-value. The beta coefficient is the degree of change in the outcome variable for every 1-unit of change in the predictor variable. The findings indicate a beta coefficient value of .514, which is significant at p = .000, which is less than alpha 0.05, see Table 4.13. Therefore, the results imply that for every 1 – unit improvement of the product strategy, production of macadamia nuts will improve by .514 units.

After evaluating the beta value, the regression model was written as follows; Y= a + bx

Production of macadamia nuts y = 2.153 constant + 0.514 product strategy

The study also tested the first null hypothesis to find out whether it can be accepted or rejected. The tested hypothesis was;

H_{01}: ***There is no significant effect of Product strategy on production of macadamia nuts by small-scale farmers in Kirinyaga County***.

The hypothesis was tested using a t-test statistic at a significance level of 0.05. The decision rule was to reject the null hypotheses if the value of t-test statistic was greater than 0.05 (t > 0.05) and fail to reject the null hypotheses if the value of t-test statistic was less than 0.05 (t < 0.05). The null hypotheses that "***There is no significant effect of Product strategy on production of macadamia nuts by small-scale farmers in Kirinyaga County***" was rejected by a t value of 7.002 that was higher than the critical t statistic (1.96). The study concluded that product strategy had a significant effect on production of macadamia nuts by small-scale farmers. The study findings agree with the proponents of the classical theory of production which focuses on the physical resources that are directly involved in production and on which value and cost can then be accounted for.

The classical theory of production denotes that high or low levels of output have a linear relationship with the level of investment in factor inputs. Meyo (2020) argued that when farmers increase their investment in factor inputs, output increases while low investment in factor inputs translates to low crop output. However, high cost of factor input reduces the quantity of inputs used in production which ultimately results to low agricultural production. The study further conform to Chakraborty & Mistri (2015) who concluded that declining soil fertility is a major constraint in improving the yields of annual crops resulting into dwindling production, however, by increasing spending on fertilizer usage, macadamia farmers are able to grow their yields. However, the findings contradict with those of Agyemang, Retinger & Bavorove(2021) that increased use of farm inputs does not always lead to increased productivity due to limitations by the household's size of land.

4.3 Conclusion

This study examined the effect of product-related factors on the production of macadamia nuts among small-scale farmers in Kirinyaga County. The descriptive findings revealed moderate levels of agreement regarding the influence of land subdivision, adoption of improved seed varieties, soil fertility, pests, diseases, and fertilizer usage on production. Farmers showed relatively higher agreement on the importance of improved seed varieties, soil fertility improvement, and land resource management, indicating growing recognition of these factors as essential for enhancing productivity. Conversely, lower levels of agreement on pest and disease challenges and fertilizer use suggested limited awareness, resource constraints, or inconsistent monitoring of these aspects.

Inferential analysis further demonstrated that product strategy had a statistically significant and positive effect on the production of macadamia nuts. The correlation results indicated a moderate relationship ($r = 0.365$), while regression analysis showed that product strategy explained 13.3% of the variance in production. The regression coefficient ($\beta = 0.514$, $p < 0.05$) confirmed that improvements in product-related factors lead to meaningful increases in macadamia output. Consequently, the null hypothesis stating that product strategy have no significant effect on the production of macadamia nuts was rejected.

Overall, the findings align with the classical theory of production, which emphasizes that efficient utilization of factor inputs—including land, improved seed varieties, fertilizers, and pest management—enhances agricultural output. The study demonstrates that while farmers recognize the importance of some inputs, limited adoption of key practices such as fertilizer application and effective pest and disease control may be constraining productivity. Strengthening farmers' access to quality inputs, promoting soil fertility management, and improving extension service delivery are therefore essential for sustained growth in macadamia nut production among small-scale farmers.

4.4 Recommendations

Based on the study findings, several practical and policy-oriented recommendations are proposed to enhance macadamia production through improved product-element strategies among small-scale farmers in Kirinyaga County.

4.5.1 Farmer-Level Recommendations

- **Adopt Certified, High-Yield Macadamia Varieties**

  Since improved seed varieties significantly influence production, farmers should prioritize planting certified, high-yielding, and disease-resistant macadamia cultivars sourced from registered nurseries.

- **Strengthen Soil Fertility Management**

  Farmers should adopt regular soil testing, integrate organic manure, and apply recommended fertilizers to address declining soil fertility and improve productivity.

- **Improve Pest and Disease monitoring**

  although farmers reported low concern for pests and diseases, regular monitoring and early detection are essential. Adoption of integrated pest management (IPM) is recommended to minimize losses.

- **Optimize Land Use Amid Subdivision**

  Farmers facing land subdivision should consider high-density planting, grafting, and intercropping to maximize production on smaller plots.

4.5.2 Extension and Training Recommendations

- **Expand Macadamia-Specific Extension Services**

  The county government should deploy more extension officers trained in macadamia agronomy, marketing, and pest management to improve farmer knowledge and adoption of best practices.

- **Enhance Farmer Capacity Building Programs**

  Continuous training on input utilization, fertilizer application, disease identification, and orchard management should be offered through farmer field days, demonstrations, and digital advisory platforms.

- **Promote Awareness of Improved Inputs**

Extension officers should educate farmers on the benefits of improved varieties, fertilizer use, and pest control technologies to increase input adoption.

4.5 Policy and Institutional Recommendations

- **Improve Access to Quality Agricultural Inputs**

  County and national governments, in partnership with private nurseries, should strengthen the distribution of certified seedlings, appropriate fertilizers, and pest management products to ensure availability and affordability.

- **Introduce Input Subsidy or Credit Schemes**

  to address low fertilizer usage and limited input adoption, policymakers should develop input financing mechanisms such as subsidies, low-interest credit, and farmer cooperatives to reduce cost barriers.

- **Strengthen Soil Health and Land Management Policies**

  Policies promoting soil testing services, soil conservation, and land-use planning should be enforced to mitigate the impacts of land subdivision and soil degradation on macadamia productivity.

- **Support Market-Linkage and Agribusiness Programs**

  since the 4Ps influence production levels, government and development agencies should facilitate stronger linkages between farmers, processors, and exporters to enhance market incentives for increased production.

4.6 Industry-Level Recommendations

- **Encourage Partnerships with Macadamia Processors and Buyers**

  Processors should collaborate with farmers through contract farming, input support programs, and capacity-building initiatives to ensure consistent supply and improved production quality.

- **Promote Value Chain Integration**

  Strengthened coordination among actors in the macadamia value chain can enhance information flow, stabilize input supply, and support adoption of improved production technologies.

- Australia Macadamia Society

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