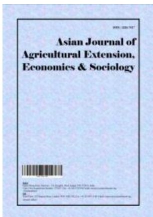

Asian Journal of Agricultural Extension, Economics & Sociology

39(7): 122-129, 2021; Article no.AJAEES.69214
ISSN: 2320-7027

Analysis of Socioeconomic Factors Influencing Adoption of Integrated Pest Management (IPM) among Smallholder Tomato Farmers in Buuri Sub-County, Meru County, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2021/v39i730616
Editor(s):
(1) Dr. Philippos I. Karipidis, International Hellenic University, Greece.
Reviewers:
(1) Zahra Khoshnood, Islamic Azad University, Iran.
(2) Jayesh Sudhakar Sarode, DBATU University Faizpur, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/69214

Original Research Article

Received 02 April 2021
Accepted 08 June 2021
Published 24 July 2021

ABSTRACT

The study examines the socioeconomic factors that influence the adoption of Integrated Pest Management in 152 smallholder tomato farmers in Buuri Sub-County, in Meru County Kenya. A random stratification sampling procedure was used to obtain smallholder tomato farmers and a semi-structured questionnaire was used to collect primary data which was analyzed using a binary logistic regression model. The results showed that the average land size for tomato production in the area was 1 acre, with average yields of 35 tonnes per acre, Kshs 592,000 net returns/ acre for IPM adopters. The study established that gender type (5%), farm size (5%), labor (5%), and access to information (5%), and age of the farmers (5%) were statistically significant. Additionally, gender type resulted in an increase of adoption of IPM by 43%, farm size by 8%, labor by 11%, while access to information by 40%. The study concluded that different stakeholders should ensure a support system to various IPM practices to lower production costs and encourage adopting the techniques.

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Keywords: Adoption; integrated pest management; production; smallholder farmer; tomato.

1. INTRODUCTION

Agriculture is the main sector of Kenya's economy. About 80% of population living in rural areas are engaged in agricultural activities. In 2017, it contributed an average of about 26% of gross domestic product (GDP) and at least 60% of the total labor force employed [1]. Agriculture is also responsible for most of the county's export, accounting for up to 65% of merchandise exports in 2019 [2]. Horticulture provides women with economic opportunities in rural economies, employment enables access to education and health care, and it's where the production of fruits and vegetables takes place.

Kihoro & Gathungu, 2020 reported that the productivity of the horticultural sector in Kenya is below the optimal potential. The sector's volume was recently recorded as 310.74 million tonnes, which were higher than the previous year. Efforts to improve horticultural production have been focused on adopting improved technologies, which has led to increased allocation of resources to horticultural research. This has stimulated increased technology adoption.

According to Dhakal & Poudel [3], crop pests have been found to cause substantial losses, and to reduce these losses, small-scale and large-scale producers use chemicals. Abid et al. [4] argued that integrated pest Management (IPM) is an ecosystem-based strategy that focuses on the long-term prevention of damage of crops by pests through a combination of cultural, chemical, biological, and mechanical controls to suppress pest population levels below those causing economic injury.

Tomatoes are an edible, often red berry of the plant *Solanum Lycopersicum* which belongs in the same family as potatoes, capsicum, brinjals, and black nightshade [5]. Some of the leading countries in production include China, India, Egypt, Brazil, Iran, Spain, Mexico, and the USA. The estimated total world production for tomatoes in 2017 was 182,301,395 metric tons, where China contributed to about 33% of the global output [6].

Kenya is ranked 6th among Africa's leading tomato producers with a total production of 400,204 metric tons. valued at KES11.8 million [7]. Tomato is mainly produced in Bungoma, Kirinyaga, and Kajiado, which accounted for 37% [8]. Tomato is grown either in open fields or under greenhouse technology. Tomato production and productivity are faced with a number of challenges. As a horticultural crop, tomato is faced by biotic factors such as lack of improved seeds, pests and diseases and abiotic factors such as droughts, markets, input supply and soil nutrients [9].

In 2012, the HCDA horticulture performance report showed that Meru County is the leading in horticultural production with small-scale farmers venturing into the sector [10]. Most horticultural smallholder farmers in Meru County have formed groups to enjoy economies of scale.

In Meru, small-scale tomato production has numerous challenges associated with the poor pest and disease management, affecting the general cost of production, effects of pesticides on population, and low farmers' income. According to Kariathi et al. [11], most of the tomatoes produced in Meru have high pesticide residues affecting their marketability in international, national, and local markets. Ombaso & Luketero [12] argued that out of the 9200 tonnes of tomatoes produced in 2017, only 400 tonnes had below the maximum residue limit (MRL). Poor application of IPM program in Meru has negatively affected the tomato farmers' incomes and livelihoods. Nevertheless, tomato production remains one of the significant agricultural activities in the county in the provision of livelihoods for small-scale farmers. Despite having efforts by different key players in the county to influence the adoption of IPM as tomato pests and diseases control methods, there is low adoption of the practice. Different scholars have researched on institutional factors influencing the adoption of IPM programs in the production of tomatoes in Meru County. However, limited studies have focused on the socioeconomic factors influencing the adoption of the program. Therefore, this study was done to fill the research gap.

2. METHODOLOGY

2.1 Study Area

The study was carried out in Buuri Sub-County, Meru County. The neighbouring Counties are Tharaka Nithi to the South, Isiolo to the North and East, Laikipia and Nyeri counties to the west. Buuri Constituency lies on the leeward side

Mt. Kenya, and altitudes ranging from 600m-2145m above sea level. The Sub-County lies within latitudes $0^0 6'$ and $0^0 40'$ North and longitude $37^0 50'$ and $38^0 25'$ East (MCIDP, 2013). The area experiences low to high rainfall ranging from 300mm to 2500mm per year with temperatures of 8^0C to 32^0C [13].

2.2 Research Design

In the study, descriptive design was employed in the description of the status of the study's variable. The descriptive design was also effective in describing the traits of the tomato farmers in the entire Buuri Sub-County. Data collection was done through use of semi-structured questionnaires to tomato farmers with help of research enumerators.

2.3 Sample Size and Sampling

The target population for the study was the 2450 small-scale farmers producing tomatoes who work with the help of field extension officers from Real IPM LTD. A multi-stage sampling technique was adopted for the selection of smallholder pr smallholder tomato farmers in the study area. The first stage involved purpose selection of Buuri Sub County because of good agro-ecological zone suitable for tomato farming. The second stage involved stratified random sampling of research respondents from five wards in the study area and lastly snowballing method was used to trace the smallholder tomato farmers.

The sample size was obtained using Yamane (1967) formula:

$$n = \frac{N}{1+N(\mathrm{e})^2} . \qquad 1$$

Whereby:

n=size of sample required, N=size of the total population as 2450, e=Acceptable error given as 0.05 and the target population was 152 and was calculated as follows:

$$n = \frac{2450}{1+245(0.05)^2} = 152.$$

The data was collected from 152 smallholder tomato farmers from five wards in Buuri Sub-County.

The 152 respondents were selected proportionately to the population size as shown in Table 1.

2.4 Data Collection

The questionnaires captured different data about factors influencing the adoption of the IPM program in Buuri Sub-County. The study ensured face, content and construct validity was examined with the help of experts in Agricultural Extension prior to data collection. Additionally, Cronbach Alpha was calculated, and a value of 0.80 was obtained, thereby noting that the items used in the questionnaire were worthy of investigation.

The three ethical principles of the fundamental assumption that include consent, fidelity, and confidentiality, were applied in the study. Therefore, all data collected from the respondents was used only for the purpose of the proposed study with no reference to particular respondents. Finally, all secondary data used in the research was acknowledged and cited in the reference section of the study.

2.5 Data Analysis

Statistical Package for Social Science (SPSS) version 25 was used to analyze the data collected from the tomato farmers in Buuri Sub-County. Descriptive statistics was used to provide interpretation for analyzed data. This study estimated farmer's adoption decision of IPM practices by using a logistic model.

$$\mathrm{n}\Omega_{y\leq m}(x) = \tau_m - x\beta$$

where,

$$\Omega_{y\leq m}(x) = \frac{pr[y\leq m\mathrm{Ix}]}{pr[y>m\mathrm{Ix}]}. \qquad 2$$

The logit model can take the following form:

$$p(y = 1\mathrm{Ix}) = \mathrm{p}(\mathrm{y} = 1\mathrm{I}X_1, X_2 \ldots \ldots X_4) \qquad 3$$

Where x denotes a full set of the explanatory variable X_1, Gender, X_2, Farm Size, X_3, Labour, and X_4, Access to Information.

$$y = \begin{cases} 1, & \text{Adopters of IPM} \\ 0, & \text{Non} - \text{adopters of IPM} \end{cases}$$

Table 1. Sample size distribution as per the smallholder tomato farmers

Ward	Population for each stratum	Population constant	Sample proportion
Timau	441	0.062	27
Kisima	503	0.062	31
Naari	529	0.062	33
Rwarera	539	0.062	34
Kibirichia	438	0.062	27
Totals	2450		152

Source: Author, 2021

3. RESULTS AND DISCUSSIONS

The descriptive results show that most of the sampled farmers were males, who consisted of 64%, while only 36% were female (Table 2). The findings of the study reflect the results of Dhakal & Poudel [3] and Dara [14] but contradicts the findings of Ghosh et al. [15]. According to Egwuonwu & Iwunwanne [16], females are involved in land preparation, planting, weeding spraying, and harvesting. The land allocated for tomato farming was less than 5 acres, with the majority having 1 acre represented by 24%. The result of the study concurred with the findings of Dara [14], who reported that most of the small-scale farmers allocated less land to different horticultural crops in their farms. On the other hand, the study's findings were against the results of Cushman [17], who reported that most small-scale farmers allocated more land to horticultural production. This study noted that most of the farmers in the area practice crop diversification. Similarly, the study also established that most small-scale farmers have small farms associated with subdivision of land due to inheritance. The study found out that smallholder tomato farmers utilized both hired and casual labor (45%) as shown in table 2. The findings are not consistent with the work Dhakal & Poudel [3], who reported that most of the farm activities for small-scale farmers are assigned to casual family members. According to Kihoro & Gathungu [2]; Holland et al. [18], family labor is affordable and accessible to different farming activities. Therefore, using both family and casual labor proved very affordable by reducing the number of paid casual workers, contributing to reduced production costs.

3.1 Effects of IPM on Smallholder Tomato Farmers

The effect of IPM was accessed in terms of yield, cost of production, and net returns in Table 3. A comparison of IPM adopters and non-adopters was done. This study revealed that IPM adopters had average yields of 35 as compared to 25 tonnes per acre for non-adopters. The findings of this study were in consonance with the results of [19], who noted that the application of IPM increased returns at the farm level in the long run as most of the soil micro-organisms are not destroyed by excessive application of chemicals. However, the study results were against the findings of Holland et al. [18], who found that the application of IPM does not have an effect on production.

The findings of this study also showed that those who were practicing IPM had average net returns Kshs 592,000 as compared to the non-adopters who had Kshs 422,500 per acre. The findings of this study concurred with Dhakal & Poudel [3], who noted that there are high returns associated with IPM since the farmers can use alternative means to control pests and diseases. The findings of this study did not concur with the work of Saeidi [20], who reported that the IPM does not increase returns unless other production factors support it.

This study indicated that the average cost of production for adopters was Kshs 250,000 compare to Kshs 300,000 for non-adopters which was associated by increased spending on pests and diseases control measures. The findings of this study concurred with results of Rahman [21], who concluded that tomato farmers who had not adopted IPM had high production costs due to higher spending on pesticides to control pests and diseases. The research found that farmers use large portions of their capital to purchase pesticides and control diseases. Moreover, the research established that adoption of IPM results in a gradual reduction in pests and diseases hence saving resources.

Table 2. Characteristic of Smallholder tomato farmers

Variable		Frequency	Percent	Mean	Standard deviation
Gender	Male	97	64	1	0.482
	Female	55	36		
Age	20-30 years	27	17		
	30-40 years	36	24		
	40-50 years	45	30	3	1.287
	50-60 years	22	14		
	60-70 years	22	15		
Access to Information	Yes	10	7		
	No	52	34	3	0.817
Labour	Family labor	29	19		
	Casual labor	54	36	2	0.761
	Both	69	45		
Land size	1/4 acre	25	16		
	1/2 acre	32	21		
	1 acre	36	24		
	2 acres	24	16	3	1.645
	3acres	18	12		
	4acres	12	8		
	5acres	5	3		

Table 3. Comparison of yields, net returns, and cost of production between an IPM Adopter and a Non-IPM Adopter

Variables	Adopters	Non adopters
Average yields per acre (tonnes)	35	25
Average Net returns per acre (Kshs)	592,000	422,500
Average cost of production per acre (Kshs)	250,000	300,000

3.2 Estimation of IPM Technology Adoption

Logit model was used to estimate IPM technology adoption by analyzing socioeconomic factors which included gender, access to information, labor and land size.

The value of the new model indicates a decrease in the -2LL of the obtained model (with explanatory variables); therefore, the new model is a better fit and significant than the baseline model. The new model also indicated that the pseudo-R^2 values were adequate. The R^2 values indicate the variation in the outcome that the model can explain. The model explained roughly that 34% of the variation in the results was due to explanatory variables, which was a reasonable threshold since it was above 20% (Table 4). Hence, the values indicated no need to make any omission of the variables used in the logistic model during analysis.

The model indicates that gender (5%), farm size (5%), access to hired labor (5%), access to information (5%), and age of the farmer were statistically significant (Table 4). The finding of this study was consistent with Saeidi [20]; Gott & Coyle [22] noted that gender, farm size, access to hired labor, access to information, and age of the farmer affected the adoption of IPM. Similarly, the study's findings established that gender had a negative and significant (p=0.000) effect on the adoption of IPM technology. The study established that males were in apposition to adopt IPM more than females by 43% (Table 5). Kihoro & Gathungu [2] reported consistent findings with the study where they stated that males are likely to adopt different agricultural technologies. However, the study's findings were contrasting with Dhakal & Poudel [3]; Dara [14] noted that females are the people who adopt technologies such as IPM more than males due to lack of credit availability.

Similarly, the study sought to establish the effect of farm size on the adoption of IPM technology. The study indicated that farm size had a negative and significant (p=0.03) effect on the adoption of IPM technology (Table 5). Moreover, the study

Table 4. Model Summary

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
153.201[a]	0.21	0.34

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001

Table 5. logit estimation for the adopter of IPM technology (dependent variable: adoption of IPM (1= adopter,0= non adopter)

Parameter	B	Std. Error	95% Confidence Interval		Sig.	Exp(B)
			Lower	Upper		
Gender	2.2913	54.5957	-16	66	.000	0.43
Farm size	0.00381	19.6823	-11.364	2.364	0.03	0.08
Labour	-0.00316	75.4037	-16.821	48.821	.000	0.11
Access to information	-0.00451	63.4686	-74.167	65.903	.011	0.4
Intercept	22.566	35.9742	-18.47	33.602	.021	0.33

Source: Field Survey, 2020 Number of obs=152, Log pseudo likelihood=-153.201, and Pseudo R^2 =0.34. Significant, at 5%

indicated that a decrease in land size results in an increase in IPM technology adoption by 8% (Table 5). The findings of this study were consistent with Gott & Coyle [22], who noted that farmers with small sizes of land were able to adopt the IPM technology since their land was manageable but contradicts the findings of Dara [14], who found a positive significant influence of large land size and adoption of IPM practices in efforts to ensure sustainable agriculture.

The findings also indicated that hiring of labor (p=0.00) negatively impacted the adoption of IPM technology among tomato farmers. The reduction in the labor cost by one unit resulted in an increase in the IPM technology of tomato by 11% (Table 5). This corroborates the results of Saeidi [20] Who found out that access to labor is essential in the practice of IPM since it assisted in different tomato pest and disease management.

Access to information had a negative and significant effect (p=0.011) on the adoption of IPM technology of tomato production. This study indicated that access to information increases the adoption of IPM technology on tomato production by 40% (Table 5). The study also noted that access to information, knowledge, and skills assists tomato farmers in understanding different IPM technologies applicable in tomato production. Thomas et al. [23] advanced the similar argument that access to information is crucial in giving institutional mechanisms aimed at disseminating knowledge among farmers to facilitate the adoption of new production technologies.

4. CONCLUSION

The was a decline in the cost of production of tomato for the farmers who adopted IPM technology. Therefore, it was evident that having access to information on IPM technologies and their benefits in tomato production facilitates adoption since farmers will know the profitability and sustainability of the techniques in the long run. Hence, understanding factors that affect the adoption of IPM practices capable of improving production will help design successful policies and programs to improve tomato production. The use of IPM practices focuses on the farmers' economic or social goals to get the production process.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/69214