Farmers' Perceptions of Maize Stem Borer and Adoption of Integrated Pest Management Practices in Nakuru and Bomet Counties, Kenya

By

Josphat Korir, Geoffrey Muricho and Menale Kassie, icipe

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This IPM series record assesses farmer's knowledge, attitudes and current pest management practices in Nakuru and Bomet counties in Kenya. The intent is to identify major pests and diseases affecting Maize production, to test and promote the appropriate technology that combat challenges in maize production and productivity in the areas. The series also ensures that recorded data and other information gathered, generated and analyzed are part of the research work of International Centre of Insect Physiology and Ecology (http://www.icipe.org). The series is reviewed internally by icipe staff. It can be freely accessible both in hard copy and electronically and cited due acknowledgement.

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The authors:

Josphat Korir is a PhD student in the project studying the Economics of Grain IPM in East Africa. He is based at ICIPE, Nairobi-Kenya and registered at the University of Nairobi.

Menale Kassie (PhD) is a senior researcher and head of the Social Science and Assessment unit at icipe, Nairobi-Kenya.

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Summary

Sustainable maize production in Kenya is threatened by pest and diseases infestations. The Integrated Pest Management (IPM) grain project in Kenya was implemented to identify major maize pests and test and promote technologies that can combat these challenges. This baseline survey sought to fill the knowledge gap on awareness, attitude towards grain IPM as well as assess the pest management practices currently being used by farmers in Bomet and Nakuru counties. The baseline survey will be used as a bench mark to monitor the implementation status of the project and the findings are important to organize research agenda, education and training around farmers' problems. The survey was conducted using literatures reviews, key informants interviews and household survey to obtain statistical information. The results of the study show that Stem borer affected 81% of maize farmers, followed by Cutworm with 39%, Aphids 39% and Termites about 27% in the two counties. Furthermore, maize lethal necrosis, maize streak virus and maize ear rot diseases respectively cause about 50%, 47%, and 49% of the maize damages in both counties. The most commonly used pest control practices strategies in both counties included; removal of infected crops, crop rotation, intercropping and bio-pesticides. The push-pull technology which has been touted as an effective and safe (for human health and environment) pest management practice, particularly the maize stem borer and *striga* weed was adopted by 3% of sampled farmers. The factors influencing adoption of the push-pull technology were; gender, experience, group membership and tropical livestock unit. Farmers who adopted bio-pesticides were more educated, realized higher maize yields, had received IPM training but kept fewer livestock.

1. Introduction

Maize is a major staple and cash crop for majority of the inhabitants of sub-Saharan Africa (SSA). It is by far the most important crop grown in Kenya, both in terms of its contribution to total value added in agriculture and its position as the dominant staple food consumed by the majority of Kenyans (Karanja et al, 2003). Its importance not-withstanding, maize production is curtailed by numerous challenges chief among them being pest and disease infestation. The stem-borer particularly poses serious challenge to maize production in East Africa since it causes losses ranging between 30%-40% but can be as high as 80% depending on the plant cultivar, stage of the growth and the environmental conditions (Kfir, et al, 2002). In Kenya, it is estimated that stem borer causes maize yield loss of about 12.9% of total output, amounting to 0.39 million tonnes of grain, with an estimated value of US$ 76 million annually (De Groote, 2002). Pesticide application has over time been the most preferred pest control strategy employed by Kenyan farmers to control a wide range of crop pests including the stem-borer. However, it has been established that intensive and widespread use of pesticides can worsen pest problems due to pesticide resistance by targeted pests (Hristovska 2009; Debass 2000). Furthermore, overuse of pesticides leads to environmental and health hazards which can be detected in natural water, on produce, in wildlife and human tissues (Pimentel 1997).

It is against this background that agricultural stakeholders and policy makers are considering alternative pest management practices, such as IPM, which involve minimal use of pesticides. One such IPM technologies applicable to control of the stem-borer is the push-pull technology

(PPT) which has been widely promoted and adopted in western Kenya. The PPT has been shown to be a viable option for enhancing productivity and diversification for small holder farmers who largely depend on limited land resources in western Kenya (Khan et al,. 2008). Despite the success of the PPT there is little penetration in the rift valley region, a high potential maize region but equally prone to stem-borer infestation. This study therefore sought to assess the farmers' knowledge, attitudes and current pest management practices in Nakuru and Bomet Counties before the introduction of the technology in the areas. Assessment of current stock of knowledge, attitudes and practices used by farmers is essential since farmers and researchers may attach different level of importance to a particular pest (Tadele, 2004). Findings from this study will not only provide insights into current pest management technologies but also the most effective method of disseminating the PPT based on farmers' preferences for existing methods.

2. Materials and Methods

2.1 Description of the study areas

Two counties Bomet and Nakuru, mainly producing maize in the rift valley region were selected for this study. The study was conducted in Bomet East and Bomet Central Sub-counties, which are the most arable and major maize producing areas in the county relative to the other sub-Counties. Three wards namely; Longisa and Chemanrer wards in Bomet East and Silibwet Township in Bomet Central were randomly sampled to be surveyed from a list of wards in the two sub-counties. In Nakuru, two sub-counties namely; Nakuru town East and Naivasha Sub-Counties were randomly selected from a list of eleven sub-counties. From these sub-counties Menangai was sampled in Nakuru town while Biashara, Maela and Naivasha East were randomly sampled for survey in Naivasha sub-county.

2.2 Survey

The data were collected through face to face interview using pretested semi-strucutred questionnaire coded into CSPro program between June and July, 2016. A total of 206 respondents leading farm responsibilities, 105 from Bomet and 101 from Nakuru, participated in this study. The interview was conducted in local languages understood by the respondents. The questionnaire was designed to capture primary data on the demographic characteristics, maize production, constraints to maize production, pest management strategies used, perception towards IPM and gender roles with regards to maize production among others.

3. Results

3.1 Socio-economic and demographic characteristics of sampled farmers

Descriptive statistics of household demographic characteristics showed that majority of the households were male headed (Table 1). Over 89% of sampled households in the two counties were headed by men. Nakuru County had the highest female headed households (11%) compared to their counterparts in Bomet County (4%). Overall, the average age of the household head in the two Counties was about 46 years. At county level, an average farmer in

Nakuru was slightly older (about 49 years) compared to their Bomet counterparts who were about 43 years old. This difference in age structure should be considered while developing and disseminating new IPM technologies. The mean number of years of formal education completed by the household head was 9 years and was slightly higher in Nakuru (9.6 years) compared to Bomet (8.1 years). Although lower, this pattern of result was replicated among the spouses of the household heads (Table 1). Further analysis revealed that more than three-quarters (about 76%) of the surveyed households depended mainly on agriculture for their livelihoods and this phenomenon was comparable across the two counties (Table 1). Overall, less than 10% of the respondents were mainly business operators while slightly more than 10% mainly depended on salaried employment as their main occupation. An average household in the two counties had 5 members with Nakuru and Bomet having comparable household sizes of about 6 persons.

Table1: Socio-economic and demographic characteristics of sampled households

Variable	Bomet (n=105)	Nakuru (n=101)	Pooled (N=206)
Household size (Number of members)	6.57	6.12	6.35
Dependency ratio	0.62	0.63	0.62
Distance to market	2.73	5.42	4.05
Distance to agricultural extension service office	5.1	13.67	9.30
Years of farming experience	13.36	15.74	14.52
Required loan to finance crop production	14.29	25.56	21.84
Acquired the amount of loan required	6.67	18.81	12.62
Male	96.19	89.11	92.72
Female	3.81	10.89	7.28
Age of the household head	43.35	49.85	46.53
Years of formal education of head	9.64	8.09	8.91
Mobile phone ownership	98.10	97.03	97.57
Primary occupation of household head			
Agriculture	76.19	77.23	76.70
Business	9.52	9.9	9.71
Wage jobs	12.38	11.88	12.14
Other	1.9	0.99	1.46

Source: Survey data; 2016

The mean dependency ratio in Nakuru was 65%, slightly higher than Bomet whose dependency ratio stood at 63%. The mean number of years practicing farming among the sampled households was about 15 years with Bomet and Nakuru counties having 13 and 16 years respectively (Table 1). This disparity in years of farming experience should be factored in the IPM dissemination campaigns in the two counties.

3.2 Maize production and contribution to household income

Table 3 below presents descriptive statistics for economic status of the households and contribution of maize to household incomes. Results revealed that maize contributed about 30% of the total household income and was comparable in both counties (Table 2). The result indicates that maize is not only a food crop but also an important source of income in Bomet and Nakuru Counties. The mean maize production per acre was higher in Nakuru at 14.24 bags while Bomet recorded 9.21 bags. However, maize yield per acre was slightly higher in Bomet (891 Kgs) compared to Nakuru (847 kilograms). However this falls below the national average yield of about 1656 Kgs per acre (GoK, Economic review of Agriculture, 2015).

Table 2: Household income, maize production and contribution of maize to household income

	Bomet (n=105)	Nakuru (n=101)	Pooled (n=206)	Difference
Contribution of maize to household income (percent)	30.57	29.35	29.97	1.22
Number of 90kgs bags of maize produced per acre	9.21	14.24	11.68	5.03*
Maize yield (kgs per acre)	891.31	847.33	870.10	43.97
Total value of maize produced (Ksh.)	15,244.83	25,295.61	20,172.64	10,050
Proportion of maize consumed	66.22	64.52	65.38	1.69

Source; Survey data 2016. Level of significance, ***1%, **5%, *10%

Notably, an average farmer in Nakuru earned annual income of Ksh. 25,293, slightly higher than that of his counterpart in Bomet who earned Ksh. 15,244 from sale of maize. This indicates that maize farming remains an important economic activity. In addition to income, farmers consumed about 65% of total harvested maize in the study sites. This result emphasizes the centrality of maize as a food security crop in the area and therefore damage abatement technologies, such as IPM should be promoted.

3.3 Gender disaggregated assessment of social network

This refers to the networks of relationships among people who live and work in a society, enabling that society to function effectively. Table 3 below presents the type of groups farmers belonged to in the two counties. Overall, more farmers of both gender were members of merry go rounds than any other type of groups. At county level, significantly more women in Bomet subscribed to merry-go-round groups than their counterparts in Nakuru. However, almost equal proportion (about 52%) of men subscribed to merry go rounds in both counties. Surprisingly, savings groups had equal membership at 28% among men in both counties while there was a significant difference in women membership in the same groups with greater membership being recorded in Bomet (20%) compared to Nakuru (9%). Male membership in community organization was comparable at about 45% in both counties. However, slight difference was noted with female membership in community organizations with Nakuru trailing Bomet by about 7%. Notably, marketing groups recorded the least membership of less than 10% in both counties and in both genders.

Table 3: Social Capital among farmwes in Nakuru and Bomet Counties (% response)

	Bomet(n=105)		Nakuru (n=101)		Pooled (n=206)		Difference	
Group type	Women	Men	Women	Men	Women	Men	Women	Men
Community organization	19.05	44.8	11.9	44.6	15.5	44.5	7.2	0.2
Savings group	20	27.6	9	27.6	14.6	27.6	11**	0
Marketing group	7	8.57	4	5.94	5	7.3	3	2.6
Merry go round	36.19	52.4	20.79	50.5	28.64	51.5	15.4**	1.9

Source; Survey data, 2016. Level of significance: ***1%, **5%, *10%

3.4 Source of agricultural information or advice

Majority of the sampled farmers had received agricultural information from a myriad of sources (Table 4). Notably, uptake of agricultural extension services was above average at 63% in both sites but was higher in Bomet at 67% compared to Nakuru at 51%. A closer examination of the results reveals that neighbours and friends were important source of agricultural information in the two counties, though slightly higher in Bomet compared to Nakuru.

Table 4: Sources of agricultural information or advice

	Bomet (n=105)	Nakuru (n=101)	Pooled (n=206)
Agricultural extension officer	67.33	51.49	63.28
Relatives	66.67	47.52	49.38
Neighbours and friends	82.86	65.35	74.03
Field days	48.5	22.77	34
Agricultural input distributor	52.38	46.53	40.94
Radio	92.38	73.27	82.38
Television	32.38	51.49	52.36
Mobile phones	15.24	13.86	19.35
Newspaper	40.95	31.68	39.21
Other farmers	39.05	41.58	50.12

Source; Survey data, 2016

About half of all sampled farmers in both counties relied on fellow farmers for agricultural information while slightly more than 80% relied on radio for agricultural advice, although its usage was slightly higher in Bomet relative to Nakuru. Although ownership of mobile phones was wide spread in the two counties, averaging about 97%, uptake of mobile phone technology as source of agricultural information remains low at 15% and 13% of farmers in Bomet and Nakuru counties respectively. About half (about 49%) farmers in Bomet obtained agricultural information from field days compared to their Nakuru counterparts (23%). Agricultural input distributors and sellers such as *agrovets* were important source of agricultural information for about 41% of the farmers in both counties.

3.5 Labour utilization in maize production

Farmers in Nakuru County spent more person days weeding maize comparing to farmers in Bomet. This was expected due to the varying scales of farm operations in the two counties where farmers in Nakuru operated larger maize fields than farmers in Bomet. Although with less than one person day, farmers in Nakuru spent more time spraying their maize comparing to their Bomet counterparts.

Table 5: Labour utilization in maize production in 2015 season (mean person days)

Variable	Bomet (105)	Nakuru (101)
Person days used to weed maize	14.25	29.53
Person days used in pesticide application on maize	0.031	0.435

Source; Survey data

4. Maize pests and diseases and Management practices

4.1 Maize pests

Descriptive results for the major maize pests in Bomet and Nakuru Counties are presented in Table 6 below. Stem borer was the most prevalent pest in the two counties as reported by a high and comparable proportion (about 80%) of households in the two counties. Similarly, a comparable proportion of farmers in both counties mentioned cutworm as a major problem with about 38% and 40% reporting the pest in Bomet and Nakuru Counties respectively. However, a significant difference was noted with respect to termite infestation in the two counties with about 37% and 19% of farmers in Nakuru and Bomet Counties, respectively, mentioning termites as a major maize pest. Aphid infestation was comparable in both counties as reported by 39% in Bomet and 38% in Nakuru.

Table 6: Major Maize infesting pests

Pest and Diseases	Bomet(n=105)	Nakuru (n=101)	Pooled (n=206)	Difference
maize stem borer	80	82.17	81.06	2.17
Striga weed	3.81	1.98	2.91	1.83
Cutworm	39.05	37.62	38.83	1.42
Aphids	38.1	39.6	38.9	1.5
Thrips	10.47	1.98	6.31	8.49**
Termites	19.04	36.63	26.67	17.58***

Source; Survey data, 2016. Level of significance: ***1%, **5%, *10%

When asked to mention the worst maize pest, majority of respondents (40% and 45% in Bomet and Nakuru respectively) mentioned stem borer. This was followed by cutworm and aphids. This result indicates that the stem borer poses a serious challenge to maize farming in the two counties.

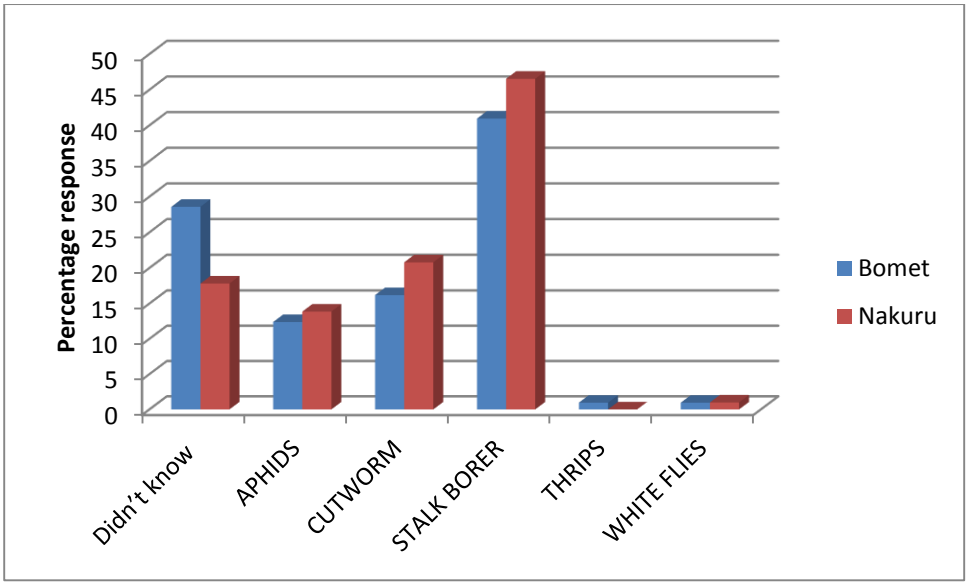

Figure 1: graph showing the worst maize pest in Nakuru and Bomet Counties

4.2 Major diseases infesting Maize in Bomet and Nakuru Counties

Descriptive results of the major diseases in the two counties are presented in table 7 below. Generally, maize diseases infestation was higher in Bomet County compared to Nakuru County. About 66% and 33% of respondents in Bomet and Nakuru counties respectively indicate that maize lethal necrosis (MNL) was a major problem. This result was expected since the MNL disease originated from Bomet County and little success has been forthcoming with the control strategies that have been employed in the past. However, the disease has spread to other regions including Nakuru. About 56% and 38% of farmers in Bomet and Nakuru respectively reported maize streak infestation in their farms.

Table 7: Major diseases infesting maize in Bomet and Nakuru Counties in 2015 (% response)

	Bomet	Nakuru	Pooled	Difference
Maize lethal necrosis (MNL)	65.71	32.67	49.51	33.04***
Grey leaf spot	8.57	2.97	5.82	5.60
Rust	23.81	22.77	23.3	1.04
Maize streak virus	56.19	37.62	47.09	18.56***
Maize ear rot	62.86	33.66	49.03	28.20***
Stem and root rot	2.86	6.93	4.85	4.07
Head smut	0.95	2.97	1.94	2.01
Leaf blight	17.14	20.79	18.93	3.64

Source; Survey data, 2016

Maize ear rot disease was common in the study sites with 63% and 34% of respondents from Bomet and Nakuru respectively recording cases of the disease in their farms. Rust and leaf blight infestation level was comparable on the two counties.

4.3 Control of maize pest and diseases

4.3.1 Pest management practices

Descriptive statistics on the maize pest and disease control strategies are presented in Table 8 below. Majority of the respondents used easy to implement novel pest management strategies such as practicing crop rotation and removal and burying of infected crops (roguing). A significantly greater proportion of farmers in Bomet county practised crop rotation compared to their Nakuru counterparts. Similarly, more than half of the farmers in both counties practised maize legume intercrop not only as a means of controlling pest and diseases but also as a way of maximizing on the productivity of the dwindling land sizes. About 3% of the farmers in both counties are using push-pull technology even though it has not been formally promoted in the two counties. This is an indication that there is a high likelihood of uptake of the technology once trials are conducted and promoted in the two counties. Use of bio-pesticides such as, *neem* extracts, Mexican marigold, tobacco and ashes was relatively low with only 7% and 4% of the farmers using it in Bomet and Nakuru counties respectively. Use of resistant varieties stood at about 25% in both counties.

Table 8: Maize pests and diseases management practices

	Bomet (105)	Nakuru (101)	Pooled (n=206)	Difference
Use pest resistant varieties	30.48	21.78	26.21	8.69
Push-pull technology	2.91	3.06	2.98	0.1
Apply bio-pesticides	6.67	3.96	5.33	2.7
Remove and burry infected crops	66.67	76.24	71.36	9.57
Practice crop rotation	80.95	49.5	65.53	31.44***
Use of maize legume intercrop	54.28	63.37	58.73	9.08

Source; Survey data, 2016

4.3.2 Perceptions about maize IPM practices among sampled farmers in Bomet and Nakuru Counties

When asked about their perceptions toward maize IPM practices about 62% of the farmers thought that IPM was affordable compared to the conventional pesticides application (Table 9). Notably, about 45% and 48% of farmers in both counties perceived maize IPM to be safer to human health and the environment respectively. These results indicate that farmers already

have a positive attitude towards IPM and more sensitization programs should be rolled out to educate more farmers on the importance of IPM practices. Interestingly, about 21% of the farmers were already aware that IPM is good for beneficial insects which check the population of the pests in the farm. Majority of the farmers mentioned the lady bird and the earth worm responsible for preying on insect pests and soil aeration respectively as important beneficial insects. These results are a precursor to the positive reception that the grain IPM will be accorded once it is promoted in the study sites.

Table 9: Perceptions about IPM in Nakuru and Bomet Counties

	Bomet (105)	Nakuru (101)	Pooled (206)	Difference
IPM is affordable	63.8	59.41	61.65	4.4
IPM is effective	35.23	26.73	31.1	8.5
IPM is safer for human health	46.67	41.58	44.17	5.08
Environmentally friendly	54.28	40.6	47.57	13.69**
Good for beneficial insects	18.1	23.76	20.87	5.67

Source; Survey data, 2016

4.4 Sources of Maize Integrated pest management information

Only 14% the farmers in both Counties had received training and were aware about IPM and this was comparable in both counties. The frequency of access to IPM training was equally low with a mean of 0.12 times. At county level Nakuru farmers in Nakuru had slightly higher frequency of accessing IPM training compared to their Bomet counterparts (Table 10).

Table 10: Access to IPM information and frequency of access

	Bomet	Nakuru	Pooled	Difference
Ever received training on IPM (%)	13.33	14.85	14.08	0.15
Frequency of access to IPM information (mean)	0.2	0.32	0.26	0.12

Source; Survey data, 2016

Results indicate that about 5% of the sampled farmers had received training on IPM from extension service providers (Table 11). Similarly, farmer groups were important source of IPM information to about 5% of farmers in both counties. Only 2% learnt about IPM from non-governmental organizations while about 6% had been trained by research organizations on IPM. Only 1 farmer in Nakuru County had been trained on IPM by a private company known as real IPM.

Table 11: Sources of IPM training

Source	percentage response			
	Bomet	Nakuru	Pooled	Difference
Extension service providers	4.67	4.95	4.85	0.19
Non-governmental organization	1.9	1.98	1.94	0.08
Farmer group	4.67	4.95	4.85	0.19
Research organizations	5.71	5.94	5.83	0.02
Real IPM (private company)	0	0.99	0.99	0.99

Source; survey data, 2016

4.5 Gender roles in management of maize pests and disease

Table 12 below shows the gender roles with respect to decision making in pest management and pesticide use. More men than women made decisions on purchasing and the amount of money to be spent on purchasing pesticides in both counties. Similarly, more men than women apply pest management once the decision on the practices to be used have been reached. Interestingly, about 55% of the households in Bomet County made joint decisions (man and woman) on the use of proceeds from sale of maize, slightly higher than that of Nakuru County (46%). This implies that women are being empowered to participate on decision making with respect to spending of maize proceeds even though they have little influence on pest management practices. The community should be sensitized on the need to incorporate women in all stages of crop production particularly on pest management.

Table 12: Gender roles in pest management

	Bomet			Nakuru		
	Man	Woman	Jointly	Man	Woman	Jointly
Buys pesticides	68.57	18.1	10.48	61.39	16.83	7.92
Decides on pesticide expenditure	68.57	15.24	14.29	15.84	12.87	15.84
Applies pest management practices	15.84	8.57	11.43	52.48	14.85	3.96
Make decisions during pest outbreak	58.1	14.29	24.76	56.44	6.93	27.72
Decides on proceeds from sale of maize	22.86	2.86	55.24	41.58	1.98	45.54

Source; Survey data, 2016

5. Determinants of adoption of IPM strategies in Bomet and Nakuru County

Table 13 below presents the estimation results for the factors influencing maize farmers' adoption of integrated pest management strategies. The likelihood ratio test for *rho* was positive thus the null hypothesis of error correlation was rejected and multivariate probit was appropriate for this data. The significant (P=0000) of the chi-square wald test indicates that the independent variables taken jointly have an influence on the dependent variable. Results further revealed that experience in maize farming; group membership and tropical livestock unit had a positive influence on adoption of push-pull technology. With exception of push-pull technology we found no gender difference in the other four technologies. The tropical livestock unit had a negative influence while education, maize yield per acre, IPM training and group membership had a positive influence on adoption of bio-pesticides. Tropical livestock unit and access to IPM training negatively influenced adoption of crop rotation and removal of pest infested plants respectively.

Table 13: Multivariate Probit Model results for determinants of adoption of different IPM technologies in Nakuru and Bomet Counties

	Push-Pull technology	Bio-pesticides	Maize-legume intercropping	Crop rotation	Removal of infected plants
	4.348***	-0.3763	-0.112	0.142	0.400
Gender	(1.349)	(0.441)	(0.351)	(0.354)	(0.504)
	-0.00796	.01705	-0.0125	-0.020**	-0.007
Age	(0.027)	(0.011)	(0.008)	(0.009)	(0.010)
years of formal	0.093	0.149***	-0.013	0.060**	0.024
education	(0.066)	(0.046)	(0.030)	(0.033)	(0.029)
Experience in	0.040**	-0.017	0.010	0.008	0.019
maize farming	(0.020)	(0.013)	(0.007)	(0.008)	(0.010)
	-0.845	0.035	-0.092	0.693	-0.625
Dependency ratio	(1.217)	(0.497)	(0.4292)	(0.491)	(0.439)
Distance to nearest	0.025	-0.007	-0.003	-0.010	-0.021
market	(0.024)	(0.020)	(0.014)	(0.015)	(0.020)
	0.017	0.210	0.242	-0.137	0.351
Access to credit	(0.540)	(0.326)	(0.234)	(0.259)	(0.237)
	1.407***	0.360	-0.109	-0.306	0.207
Group membership	(0.520)	(0.307)	(0.212)	(0.226)	(0.221)
	-0.012	0.442***	-0.077	0.137	-0.185
maize yield (Kgs)	(0.206)	(0.167)	(0.097)	(0.101)	(0.119)
Tropical livestock	0.160***	-0.154**	-0.054	-0.086*	-0.010
unit	(0.057)	(0.067)	(0.053)	(0.048)	(0.036)
Access to IPM	0.184	0.634*	-0.591**	-0.276	-0.476*
training	(0.601)	(0.326)	(0.274)	(0.292)	(0.272)
	-8.667****	-6.271***	1.697	-0.185	1.793*
Constant	(2.492)	(1.373)	(0.836)	(.892)	(.921)

Log pseudo likelihood = -330.79492, Wald chi2 (55) = 554.51, Number of observations=186, Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 65.3258 Prob > chi2 = 0.0000, figures in parenthesis are robust standard errors.

Source; Survey data, 2016

6. Discussion

The results of the study reveal that farmers in both counties were fairly agile with an average of 46 years and are therefore amenable to adopting labour intensive technologies. Furthermore, farmers in both counties were fairly educated thus they are more likely to appreciate the benefits accruing from productivity enhancing technologies such as the PPT. Education enhances an individual's ability to decipher productivity enhancing technologies and thus are more likely to adopt them (Abdullahi and Hauffman, 2005). With a mean farming experience of 15 years, farmers in the two counties are more likely to understand the pest and diseases challenges facing their enterprises and thus are more likely to try out innovative technologies such as IPM.

Bomet County recorded slightly higher maize yield per acre than Nakuru. However, yields in both Counties were lower than the national average and this can be attributed to pest and disease infestation chief among them being stem borer and maize lethal necrosis. Farmers perceived stem borer as a major maize pest, followed by cutworm and termites in that order. Infestation of termites and cutworms was comparable in the two counties but termite infestation was significantly higher in Nakuru County. Half of the farmers reported maize lethal necrosis and maize ear rot infestation in their farms. Infestation of maize lethal necrosis (MLN) was however significantly higher in Bomet than in Nakuru. This was expected since Bomet was the original hotspot of the disease from where it spread to other areas.

Majority of the respondents used easy to implement novel pest management strategies such as practicing crop rotation and removal and burying of infected crops (roguing). A significantly greater proportion of farmers in Bomet county practised crop rotation compared to their Nakuru counterparts. This could be attributed to the smaller farm sizes in Bomet county thereby necessitating intensive production by rotating long season crops such as maize with short season crops such as potatoes and beans.

Adoption of the push-pull technology was positively influenced by education implying that more educated farmers were more likely to adopt knowledge intensive technology. The positive influence of tropical livestock unit on adoption of push-pull technology highlights the benefits accruing to livestock farmers in terms of fodder availability as a result of desmodium component of the technology. Group membership had a positive influence on adoption of PPT, policy implication being that farmers in groups were more likely to receive information about new technologies due to knowledge sharing during group interactions. We therefore recommend that policy makers should encourage farmers to form or join existing groups through which information on push-pull technology can be channelled. The positive sign of

experience on adoption of push-pull suggests that older farmers have over time appreciated ineffectiveness of traditional technologies, such as pesticide against the stem borer, and are therefore more likely to try new strategies in a bid to improve effectiveness.

More educated farmers adopted bio-pesticides technologies such as use of ashes and concoctions containing pepper, Mexican marigold and tobacco. The likely interpretation of this result is that more educated farmers are more aware of the health hazards of pesticides and thus resort to alternative methods however mundane they may be. Similar result was observed with access to IPM training suggesting that training of farmers on bio-pesticide use increase chances of adoption. Maize yield influence on use of bio-pesticide points to a possibility of productivity improving capabilities of this technology and we therefore recommend that further research should be conducted with regard to this aspect.

Access to IPM training negatively influenced adoption of both maize-grain legume intercrop and removal of damage crops. This could be so since these are less knowledge intensive technologies which have been practiced by farmers not only for pest control but also to intensify their farm operations. As expected, tropical livestock unit had significant negative influence on adoption of crop rotation. This is could be due to the fact that majority of farmers in both counties graze their livestock thus crop rotation leaves little space for grazing.

7. References

Abdulai, A., & Huffman, W. E. (2005). The diffusion of new agricultural technologies: The case of crossbred-cow technology in Tanzania. *American Journal of Agricultural Economics*, *87*(3), 645-659.

Cook, S. M., Khan, Z. R., & Pickett, J. A. (2006). The use of push-pull strategies in integrated pest management. *Annual review of entomology*, *52*(1), 375.

De Groote, H. (2002). Maize yield losses from stemborers in Kenya.

Debass, T. (2000). Economic Impact Assessment of IPM CRSP Activities in Bangladesh and Uganda: A GIS Application.

Government of Kenya (2015). Economic review of Agriculture, 2015

Hristovska, T. (2009). Economic Impacts of Integrated Pest Management in Developing Countries: Evidence from the IPM CRSP *(Doctoral dissertation, Virginia Polytechnic Institute and State University).*

Karanja, D. D., Renkow, M., & Crawford, E. W. (2003). Welfare effects of maize technologies in marginal and high potential regions of Kenya. *Agricultural Economics*, *29*(3), 331-341.

Kfir, R., Overholt, W. A., Khan, Z. R., & Polaszek, A. (2002). Biology and management of economically important lepidopteran cereal stem borers in Africa. *Annual review of entomology*, *47*(1), 701-731.

Khan, Z. R., Midega, C. A., Njuguna, E. M., Amudavi, D. M., Wanyama, J. M., & Pickett, J. A. (2008). Economic performance of the 'push–pull'technology for stemborer and Striga control in smallholder farming systems in western Kenya. *Crop protection*, *27*(7), 1084-1097.

Khan, Z. R., Midega, C. A., Pittchar, J. O., Murage, A. W., Birkett, M. A., Bruce, T. J., & Pickett, J. A. (2014). Achieving food security for one million sub-Saharan African poor through push–pull innovation by 2020. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *369*(1639), 20120284.