

Research Application Summary

Knowledge management structure and effectiveness of interventions on fall army worm (FAW) management among smallholder maize farmers in Kilungu, Makueni County, Kenya

Aoko, P.,¹ Chimoita, E.L.,² Nzuve, M.F.,³ Maina, D.,⁴ Jadesola, E.⁵ & Syanda, J.⁶

¹University of Nairobi, Department of Agricultural Economics, P. O. Box 29053, – 00625, Kangemi, Nairobi, Kenya

²University of Nairobi, Department of Agricultural Economics, P. O. Box 29053, – 00625, Kangemi, Nairobi, Kenya

³University of Nairobi, Department of Plant Science and Crop Protection, P. O. Box 29053, – 00625. Kangemi, Nairobi, Kenya

⁴Karatina University, Department of Agricultural Sciences, Karatina, Kenya

⁵University of Cincinnati, Department of Electrical Engineering and Computer science, Cincinnati, USA

⁶Kenya Agricultural and Livestock Research Organization, Katumani, Kenya

Corresponding Author: aokopauline@gmail.com

Abstract

Maize productivity in Kenya has reduced by 4.3 per cent, partly attributed to Fall Army Worm (FAW) infestation with yield losses of up to 37 % of the annual maize production over three years. Innovators have developed practices that manage FAW infestation and increase maize yield. Knowledge of these interventions is not available to all farmers and thus not applied. This occasioned for an investigation into the knowledge management and effectiveness of FAW control practices in maize producing regions of Kenya. This study conducted structured interviews with key informants and households in Kilungu, Makueni County. It sampled 387 respondents with a 95% confidence level and applied multi stage sampling. Statistical analysis using STATA found a significant influence of education and total income on the selection and adoption of FAW management practice. Handpicking recorded p values of 0.033 and 0.013 respectively. Analysis of adopted FAW management practices against maize output showed a significant effect from handpicking, use of pesticides, detergents and/or soil with p values of 0.099, 0.049, 0.025 and 0.075 respectively. Fellow farmers and workshops as sources showed a significant influence on maize output with p values of 0.012 and 0 respectively.

Keywords: Fall Army Worm management practices, fellow farmers, workshops

Resume

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practices in maize producing regions of Kenya. This study conducted structured interviews with key informants and households in Kilungu, Makueni County. It sampled 387 respondents with a 95% confidence level and applied multi stage sampling. Statistical analysis using STATA found a significant influence of education and total income on the selection and adoption of Fall Army Worm management practice. Handpicking recorded p values of 0.033 and 0.013 respectively. Analysis of adopted Fall Army Worm management practices against maize output showed a significant effect from handpicking, use of pesticides, detergents and/or soil with p values of 0.099, 0.049, 0.025 and 0.075 respectively. Fellow farmers and workshops as sources showed a significant influence on maize output with p values of 0.012 and 0 respectively.

Keywords: FAW management practices, fellow farmers, workshops

Introduction

Kenya's population growth rate of 2.2 percent per annum (KNBS, 2019) is leading to an increased demand for food. Maize is the staple food in Kenya and accounts for 40 % of total area of crop production (Abate *et al.*, 2015). Despite the recent increase in agricultural growth rate (80%) between 2019 and 2020, maize production has reduced by 4.3 % (KNBS, 2019). This reduction in maize production is mainly attributed to Fall Army Worm (FAW) infestation. In Africa, this pest has caused significant damage to agricultural production, with maize yield losses of up to 37 % of the annual average production over three years (Abrahams *et al.*, 2017). A study by De Groote *et al.* (2019) found that by 2017, Kenya's maize farmers had a 30 % yield loss with the small and medium potential agro ecological zones (AEZs) recording more than 50 % losses. Following the adverse effects of FAW infestation, recent studies by Ansah *et al.* (2021); Fitri *et al.* (2021); Harrison *et al.* (2019); Kumela *et al.* (2021); Niassy *et al.* (2021) describe practices that are commonly applied to manage the pest. Previous studies on the application of FAW control practices in Ghana and Zambia by Abrahams *et al.* (2017) found that farmers rarely apply these methods with regard to the perceived effectiveness of the practice. Consequently, this leads to the evidenced reduced agricultural productivity particularly in terms of maize production.

Therefore, this study sought to assess the knowledge management structure and effectiveness of interventions on FAW management among smallholder maize farmers in Kilungu, Makueni County in Kenya. The study anchors on the notion that FAW control practices have been disseminated to a significant proportion of maize farmers through various platforms, channels and methods. The uptake, application and exchange of knowledge is based on both socio-economic factors and knowledge management factors such as the structure, organisation and exchange.

Materials and Methods

The study adopted a descriptive research design methodology and conducted a field study through five key informant interviews, one focus group discussion and a household survey in Kilungu, Makueni County. The study used multistage sampling method to identify respondents, Kilungu sub-county was purposively selected in the first stage, for the second stage, two sub-wards were selected using purposive random sampling and subsequently five development clusters from each

sub ward were selected. The study sampled 387 respondents using Yamane's Formula with a confidence level of 95%. The respondents were identified using line transect random sampling method by interviewing the third household across the identified transect. A transect in this case was a river (geographical feature) or a minor road/path within a village. Data from the research findings were analyzed using STATA statistical package through cross tabulations, frequencies and regression analysis of selected variables.

Results and Discussion

Descriptive analysis showed a 52 % male representation against the females 48 % from 301 respondents. Disaggregated data by age, household size and schooling years reveals that on average, males have one more year of schooling compared to females. These findings are consistent with studies carried out in Siaya, Kericho and West Pokot, which found that girls/females have a higher dropout and class repetition rates compared to boy/males (Koech *et al.*, 2017; Luganza *et al.* (2017; Andiemma and Manasi, 2022). Linear regression analysis found a statistically significant influence of number of years in school on the adopted and applied FAW control practice.

Table 1. Linear regression analysis of number of years in school versus applied Fall Army Worm control practice

Number of years in school	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig	
Hand picking	-1.391	.649	-2.14	.033	-2.669	-.112	**
Plant rogueing	-.575	.967	-0.59	.553	-2.48	1.33	
Use of pesticides	.894	.756	1.18	.238	-.596	2.383	
Use of resistant varieties	1.584	3.014	0.53	.6	-4.355	7.522	
Use of botanical plants	5.335	4.246	1.26	.21	-3.034	13.703	
Sand or soil	.332	.723	0.46	.646	-1.093	1.757	
Use of detergents	-.679	.927	-0.73	.465	-2.506	1.149	
Push pull	1.014	2.992	0.34	.735	-4.883	6.912	
Crop rotation	.33	1.049	0.31	.753	-1.737	2.398	
Intercropping	-.135	1.205	-0.11	.911	-2.511	2.24	
IPM	3.258	2.44	1.34	.183	-1.55	8.066	
Use of pheromones	1.738	4.167	0.42	.677	-6.475	9.951	
Other	-1.158	.967	-1.20	.232	-3.063	.747	
Constant	9.93	.761	13.04	0	8.43	11.43	***
Mean dependent var	10.102	SD dependent var	4.169				
R-squared	0.076	Number of obs	235				
F-test	1.407	Prob > F	0.157				

*** p<.01, ** p<.05, * p<.1

The results show that respondents that selected handpicking as the Fall Army Worm control practice spent an average of 8 years in school which is an equivalent of primary school education. Given that handpicking requires little to no technical expertise, it is easier to implement and thus the go to practice for such farmers.

The study found that the highest total income earner receives KES 320,000 from selling of green grams (KES 270,000) and the least earner being at KES 800 from maize production. Averagely, the total income is at KES 24,882.

Further analysis of the effect of total income on Fall Army Worm control practice selection revealed a significant influence on handpicking and use of sand and/or soil. This information may be attributed to the little to no cost incurred by the farmer to implement these practices and as such, low-income earners prefer it.

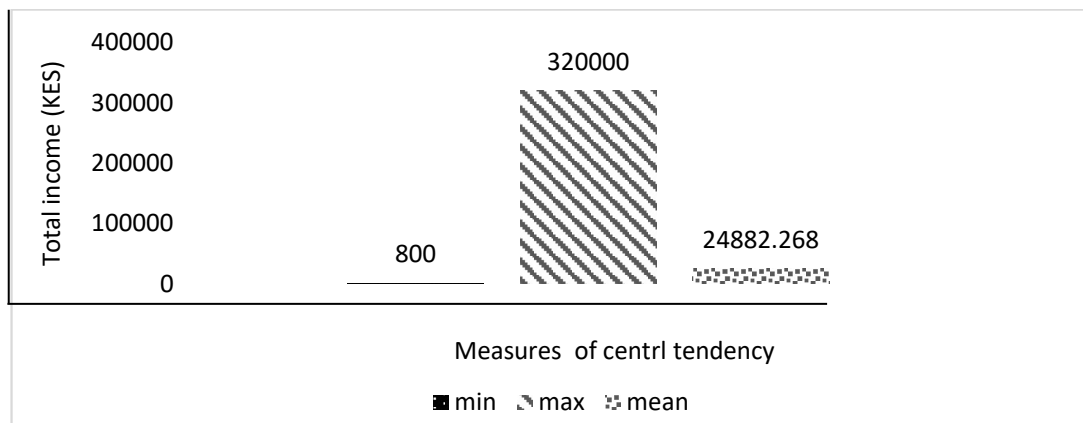


Figure 1. Distribution of total income in KES

Table 2. Regression analysis of total income versus Fall Army Worm practices

Total income	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Hand picking	-14760.43	5891.027	-2.51	.013	-26371.993	-3148.866	**
Plant rogueing	4998.207	8676.488	0.58	.565	-12103.664	22100.077	
Use of pesticides	5754.788	6869.763	0.84	.403	-7785.921	19295.497	
Use of resistant varieties	-10695.764	27102.723	-0.39	.694	-64116.833	42725.305	
Use of botanical plants	-14531.827	38044.222	-0.38	.703	-89519.238	60455.584	
Sand or soil	-11726.877	6613.473	-1.77	.078	-24762.423	1308.669	*
Use of detergents	-2219.644	8324.834	-0.27	.79	-18628.384	14189.096	
Push pull	13717.26	26810.453	0.51	.609	-39127.728	66562.248	
Crop rotation	-856.598	9664.949	-0.09	.929	-19906.784	18193.588	
Intercropping	-1829.954	11721.639	-0.16	.876	-24933.997	21274.089	
IPM	14328.901	21872.905	0.66	.513	-28783.888	57441.689	

Use of pheromones	15836.102	37333.224	0.42	.672	-57749.89	89422.094	
Other	-4388.736	8680.276	-0.51	.614	-21498.073	12720.6	
Constant	32665.775	6926.193	4.72	0	19013.839	46317.712	***
Mean dependent var	27876.769	SD dependent var	37618.308				
R-squared	0.091	Number of obs	229				
F-test	1.657	Prob > F	0.072				
Akaike crit. (AIC)	5480.153	Bayesian crit. (BIC)	5528.225				

*** p<.01, ** p<.05, * p<.1

Regression analysis of the quantity of maize harvested against applied Fall Army Worm practices showed a statistically significant influence for handpicking, use of pesticides, sand/soil and detergents. Farmers that applied these practices recorded an average output of 210 kg, 348 kg, 117 kg and 343 kg, respectively. Remarkably, farmers that applied pesticides and detergents to control Fall Army Worm harvested maize quantities above the average of the sampled respondents. This result is corroborated by studies that found use of pesticides effective against Fall Army Worm (Abrahams *et al.*, 2017) and thus enhanced maize productivity per farm/ household. On the contrary, handpicking and use of sand/soil indicate outputs less than the sampled average of 277kg per household.

Table 3. Regression analysis of quantity of maize harvested against Fall Army Worm control practices applied

Quantity of maize harvested	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig
Hand picking	-72.488	43.807	-1.65	.099	-158.843 13.867	*
Plant rogueing	-38.721	67.141	-0.58	.565	-171.075 93.633	
Use of pesticides	101.952	51.543	1.98	.049	.346 203.558	**
Use of resistant varieties	-125.837	199.772	-0.63	.529	-519.641 267.967	
Use of botanical plants	64.876	281.68	0.23	.818	-490.391 620.143	
Sand or soil	-109.5	48.519	-2.26	.025	-205.144 -13.855	**
Use of detergents	113.144	63.245	1.79	.075	-11.53 237.817	*
Push pull	138.225	198.185	0.70	.486	-252.452 528.902	
Crop rotation	-105.464	70.371	-1.50	.135	-244.184 33.256	

Intercropping	38.052	81.199	0.47	.64	-122.014	198.118	
IPM	7.923	161.72	0.05	.961	-310.872	326.717	
Use of pheromones	-78.788	276.064	-0.29	.776	-622.985	465.41	
Other	-5.115	66.598	-0.08	.939	-136.398	126.168	
Constant	288.287	52.137	5.53	0	185.511	391.063	***
Mean dependent var	291.817	SD dependent var	287.413				
R-squared	0.151	Number of obs	225				
F-test	2.883	Prob > F	0.001				
Akaike crit. (AIC)	3176.148	Bayesian crit. (BIC)	3223.973				

*** p<.01, ** p<.05, * p<.1

The most purchased and applied pesticides used to control Fall Army Worm attack in Kilungu, Makueni County included: Match, Escort, Belt and duduthrin as reported by the key informant interviews, particularly the agro dealers. Studies by Abrahams *et al.* (2017) evaluated effectiveness of active ingredients against FAW in Africa (Ghana and Zambia) and found that cypermethrin and lambda cyhalothrin as the most effective. On the contrary, the pesticides perceived as effective by the sampled population contain lufenuron, metsulfuron methyl and flubendiamide as active ingredients. This statistic confirms the knowledge and perception established in Kumela *et al.* (2019) study which reported use of pesticides against Fall Army Worm as ineffective in Kenya in comparison to Ethiopia.

The least applied control practices include use of pheromones, resistant varieties; push pull technology and use of botanical plants such as *Mexican marigold*, *Tithonia diversifolia*, etc. Conversely, studies by Midega *et al.* (2018) reported push-pull as an effective FAW control practice recording reductions of 82.7 % and 86.7 % larvae per plant and plant damage per plot, respectively. Similarly, Abraham *et al.* (2017) reported biological control with regard to use of pheromones and resistant varieties against FAW in Africa as not available in Africa and recommended use of neem products recommended by the government as an alternative to industrial pesticides.

The results indicate that the most preferred sources of information are fellow farmers, radio and extension officers respectively. Similarly, studies by Wanyama *et al.* (2015) found that public and private not for profit organizations as key sources of agricultural information in Kenya. The study categorized extension officers and research scientists as public organizations and fellow farmers, farmer groups, NGOs, CBOs, FBOs as private nonprofit organisations. Of the two categories, public organizations represented 59.2 % of the 6152 sampled respondents across 38 counties in Kenya.

Regression analysis of the selected sources of FAW control information found a statistically significant influence on the quantity of maize harvested by farmers, particularly for respondents

with workshops and fellow farmers as key sources of FAW control methods. These respondents had an average output of 724 kg and 268 kg of maize with a p value of 0 and 0.012, respectively against the study's confidential interval of 0.05%.

Table 4. Regression analysis of sourcing channels versus quantity of maize harvested

Quantity of harvested maize	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Fellow farmers	-146.836	57.635	-2.55	.012	-260.441	-33.232	**
Extension officers	20.578	46.22	0.45	.657	-70.527	111.684	
Mass communication	7.529	277.843	0.03	.978	-540.131	555.188	
Workshops	422.852	107.472	3.93	0	211.014	634.691	***
Farmer associations	18.785	126.985	0.15	.883	-231.516	269.087	
Traditional healers	-52.53	70.384	-0.75	.456	-191.264	86.205	
Radio	-21.537	42.665	-0.50	.614	-105.634	62.561	
TVs	4.838	105.56	0.05	.963	-203.232	212.909	
Internet	-78.41	116.648	-0.67	.502	-308.336	151.515	
Other	28.965	81.481	0.36	.723	-131.643	189.574	
Constant	409.308	59.866	6.84	0	291.304	527.311	***
Mean dependent var	291.817	SD dependent var	287.413				
R-squared	0.116	Number of obs	225				
F-test	2.799	Prob > F	0.003				
Akaike crit. (AIC)	3179.281	Bayesian crit. (BIC)	3216.858				

*** p<.01, ** p<.05, * p<.1

Generally fellow farmers and extension officers are key sources of agricultural information due to perceived credibility and ease of access of the information sought. A study (Tambo *et al.*, 2020) analysed communication strategies, methods and effects on FAW management in Uganda and found fellow farmers, extension workers and radio as key information channels used to disseminate FAW management information. Additionally, Hudson *et al.* (2017) evaluated the impact of radio, as a communication channel, on food security in sub-Saharan Africa and reported that ICT-enhanced radio campaign approach significantly increases the rate of adoption of agricultural technologies and thus enhances agricultural productivity.

Notably, the farmers disseminate amongst each other through church meetings, farmer groups, farmer field schools and community based organisations (CBOs). The delivery is majorly through word of mouth and mental memory preferred as the common retention method. Extension officers also use word of mouth through workshops, seminars and trainings of CBOs, farmer groups, farmer field schools and communities of practice to disseminate FAW control practices in Kilungu,

as reported by the extension officers during the key informant interviews.

Likewise, FAO (2018) report on integrated management of FAW on maize emphasized on the use of farmer field schools to disseminate FAW management technologies. It provides a guide on FFS implementation through a FAW management curriculum based on demonstration as the training methodology through use of word of mouth and observation. Furthermore, Fabregas *et al.* (2017) evaluated dissemination of agricultural information in Western Kenya and found that farmer field day (s) had a statistically insignificant influence on the adoption of agricultural technology. However, the approach had an impact on the awareness or farmer knowledge and perceptions on the technology.

Further analysis of the delivery channels found a statistically significant effect on quantity of maize harvested versus internet as a channel with a p value of 0.064. Only five respondents selected internet as the preferred delivery channel/platform and had an average output of 190 kg of maize. This output is slightly below the average output (277kg) for the sampled population but higher than the minimum (0 kg) of the sampled population.

Table 5. Regression analysis of delivery platforms versus quantity of maize harvested

Quantity of harvested maize	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Word of mouth	73.81	115.725	0.64	.524	-154.291	301.911	
Printed materials	21.444	73.453	0.29	.771	-123.336	166.224	
Pictures	6.714	82.07	0.08	.935	-155.051	168.48	
Videos	133.196	146.952	0.91	.366	-156.455	422.848	
Voice recording	42.479	125.483	0.34	.735	-204.856	289.813	
Internet	181.031	97.091	1.86	.064	-10.34	372.403	*
Text messages	-84.169	69.495	-1.21	.227	-221.148	52.81	
Other	-65.115	137.873	-0.47	.637	-336.871	206.641	
Constant	219.741	116.523	1.89	.061	-9.932	449.414	*
Mean dependent var	291.915	SD dependent var	288.053				
R-squared	0.032	Number of obs	224				
F-test	0.888	Prob > F	0.527				
Akaike crit. (AIC)	3182.486	Bayesian crit. (BIC)	3213.191				

*** p<.01, ** p<.05, * p<.1

Remarkably, 45 % of the respondents stated to be very willing to exchange information on FAW interventions against 3.29 % that were not willing to exchange knowledge. The respondents explained that exchange of information is pertinent to improving productivity and livelihood per household and the community by extension. Further analysis found that the most used method of

exchange is through story telling at 89.38%. Story telling refers to casual/ informal conversations. Outstandingly, less than 1 % of the respondents reported mass communication campaigns as an exchange method used to transfer or share information on FAW interventions.

Similarly, a review of tacit knowledge sharing conducted by Mohajan (2016), concluded that tacit knowledge sharing plays a key role in enhancing performance/productivity as compared to explicit knowledge. However, tacit knowledge is unwritten, unspoken, acquired through various stakeholder interactions and thus it is not easily shared. Moreover, the study outlined meetings, knowledge fairs (farmer field day (s), visits and participation as effective avenues to enhance tacit knowledge sharing to promote organizational performance and/or productivity. Contrary to the respondents' preferences, a linear regression analysis of exchange channels against quantity of maize harvested indicated a significance effect with regard to barazas and workshops with p values of 0.08 and 0.096, respectively.

Table 6. Linear regression of exchange platforms versus quantity of maize harvested

Quantity of harvested maize	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig
Communities of practice	58.722	45.333	1.30	.196	-30.525 147.97	
Story telling	14.487	73.914	0.20	.845	-131.03 160.003	
Farmer field schools	32.676	90.742	0.36	.719	-145.969 211.322	
Barazas	158.21	90.096	1.76	.08	-19.164 335.584	*
Workshops	211.608	126.708	1.67	.096	-37.845 461.061	*
Seminars	-54.877	98.255	-0.56	.577	-248.314 138.559	
Group meetings	-19.743	35.834	-0.55	.582	-90.29 50.804	
Internet	82.753	112.08	0.74	.461	-137.901 303.407	
Other	-4.116	91.832	-0.04	.964	-184.909 176.676	
Constant	247.502	76.71	3.23	.001	96.481 398.524	***
Mean dependent var	274.500	SD dependent var	273.536			
R-squared	0.036	Number of obs	282			
F-test	1.128	Prob > F	0.343			
Akaike crit. (AIC)	3973.793	Bayesian crit. (BIC)	4010.212			

*** p<.01, ** p<.05, * p<.1

Disaggregation of internet as a platform revealed that 41 % of the respondents were very willing to use online tools such as websites, USSD and mobile applications to exchange information on FAW intervention (s). They reported that online tools are great alternatives especially when physical meetings are challenging e.g. during Covid-19 pandemic, geographically dispersed stakeholders but also a challenge when ICT infrastructure is limited. Correspondingly, a study by Tata and McNamara (2018) showed that fluctuating cost of electric power, limited information technology resources and ICT infrastructure are barriers towards effective utilisation of online tools for agricultural extension. Furthermore, Tambo *et al.* (2019) compared radio, videos and text messages used to disseminate FAW management information in Uganda and found that radio, ICT enhanced radio campaign, and had a significant impact on behavioral change of farmers in managing FAW as well as enhancing their knowledge capacity on sustainable FAW management. Further analysis of the online tools as separate platforms found a preference for USSD compared to websites and mobile applications. Respondents cited cost implications and usability as challenges to utilize these platforms. Similarly, a study by Gichamba *et al.* (2017) reported limited technical capacity, internet connectivity and high costs of electricity as obstacles in achieving the full potential of online tools for agricultural extension. Conversely, the study found that 32.1 % and 25 % of the sampled respondents preferred websites via a computer and mobile phone respectively; only 25 % preferred USSD as e-extension tools and/or platforms.

Conclusion

The knowledge management structure and organisation of FAW control interventions revolves around the farming community with fellow farmers, extension officers and radio being the preferred source (s) of information on the account of credibility, validity and reliability. This information is delivered through word of mouth during storytelling, farmer group meetings, farmer field schools, workshops, trainings and/ or seminars. During dissemination, stakeholders use mental memory, note taking and asking questions to retain the information shared. Online tools such as websites, USSD and mobile applications are alternatives that require considerable capital investment with regard to ICT infrastructure to enhance its effectiveness. Nevertheless, FAW identification and control practices information can still be provided with a focus on USSD. Chemical control by using pesticides stands out as the most preferred method and thus is deemed effective by the farmers. However, FAW control interventions that have been proved to be effective through experimental research are less likely to be applied within the area as there is limited information on how to apply such methods. These methods include push- pull technology, use of botanical plants, traps, pheromones and predators. Disseminators should focus on strengthening the capacity of farmers, extension officers through the radio, word of mouth/ storytelling to enhance technology accessibility and application. Research information on FAW control interventions should be shared regularly with farmers and extension officers through group meetings, workshops, communities of practice to enhance technology adoption and eventual maize productivity.

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