International Journal of Agricultural Management and Development (IJAMAD)
Available online on: www.ijamad.com
ISSN: 2159-5852 (Print)
ISSN:2159-5860 (Online)

Effectiveness of Agricultural Training Centers' Curriculum in Promoting Adoption of Agricultural Technologies: Evidence from Small-scale Potato Farmers in Nyandarua County, Kenya

Ronald O. Nyamwamu[1], Justus M. Ombati[2*] and John G. Mwangi[2]

Received: 2 September 2013,
Accepted: 31 January 2014

Abstract

Agricultural Training Centres (ATCs) promote crop and livestock development by providing extension information to farmers and serving as models of improved crop and livestock husbandry practices. Although potato farmers in Nyandarua County were trained on potato production technologies, their average yield was ≤ 16 tonnes per hectare compared to the national potential of 30 tonnes. This study therefore sought to determine the effectiveness of ATCs' curriculum in promoting farmers' adoption of selected potato production technologies in Nyandarua County in Kenya. A survey design was used. Primary data was collected from 136 farmers trained at ATCs on potato production using interview schedules. The respondents were sampled through a five-stage technique. The data was analysed using T-test and ANOVA, then summarized into percentages. Study results showed that adoption of recommended potato production technologies produced high yields compared to traditional technologies. It was therefore concluded that ATCs' curriculum was effective in promoting farmers' adoption of potato seed selection, planting, crop protection and harvesting technologies. It is recommended that ATCs' curriculum prioritise demonstrations that show the influence of clean seed, fertilizer application, timely harvesting and spacing on potato yields. Further, campaigns should be held to educate farmers on the importance of potato dehaulming to promote its adoption. In addition, farmer-based seed production programs should be started in the County aimed at ensuring ready availability of seed.

Keywords:
Adoption, Agricultural Training Centre, Curriculum, Effectiveness, Technology

[1] *Extension Division, Ministry of Agriculture, P.O. Box 30028, Nairobi, Kenya.*
[2] *Department of Agricultural Education & Extension, Egerton University, PO Box 536-20115 Egerton, Kenya.*
** Corresponding author's email: jombati@egerton.ac.ke, jusmotush@yahoo.com*

INTRODUCTION

The agriculture sector is critical for economic development in most developing countries, for increased incomes, better living standards, poverty reduction and increased food security (Andriese *et al.*, 2007). The agricultural sector provides good opportunities for rural-economic development for most Sub-Saharan countries (Gildemacher, 2012). Agriculture-based economic growth has a stronger effect on poverty reduction than non-agricultural growth (International Fund for Agricultural Development (IFAD, 2010). Kenya's economy relies heavily on agriculture's significant contribution in income generation, employment creation, foreign exchange generation, food security, and provision of raw materials for industries (Ministry of Agriculture, 2010b; GoK, 2007). The economy of Kenya is strongly correlated to agricultural growth and development, as evidenced by the agriculture sector's growth from negative 2.9% in 2009 to 6.3% in 2010, thus increasing the Gross Domestic Product (GDP) from 2.6% by 5.6% in the same period (Kenya Bureau of Statistics, 2011). About 68% of Kenyans living in rural areas rely on agricultural activities for their livelihood (Wambugu and Muthamia, 2009).

Potato is a main tuber crop and third most important food crop in the world after rice and wheat (International Potato Centre, 2008). It is grown in Latin America, Europe, Asia and Africa (Bohl and Johnson, 2010; FAO, 2009). The crop is critical in achieving food security, employment creation and income generation, poverty reduction and economic development (Gildemacher, 2012; Kipkoech *et al.*, 2010). Asia is the world's leading potato producer (48%), second is Europe (33%), third is Africa (7%), with China accounting for more than 20% of the global production (FAO, 2009). Malawi leads in Africa's potato production by producing 20% of the total production in 2007 (FAO, 2009).

The world's average potato yield in 2007 was 16.8 ton/ha, where Africa had 10.8 ton/ha, Malawi 11.9 ton/ha while Kenya had 6.7 ton/ha (FAO, 2009). In Europe and Noth America, the average yield is 40 ton/ha while the developing countries obtain 5-25ton/ha (FAO, 2009). Netherlands produced an average yield of 44.7 ton/ha in 2009 (FAO, 2009; Jansky *et al.*, 2009).

In Kenya, potato is ranked second most important food crop after maize (Kasina and Nderitu, 2010; Abong *et al.*, 2012). About 500,000 Kenyan farmers grow potatoes in over 108,000 ha but obtain low yields due to limited use of high quality seeds and inputs, pest and disease attack (Abong *et al.*, 2012; Kaguongo *et al.*, 2008). The crop is grown mainly for food although it generates employment and income (Lung'aho *et al.*, 2010). This shows that this crop contributes significantly to Kenya's economy. The crop is agro-ecologically suited for high altitude areas (1500-3000 metres above sea level) such as Nyeri, Murang'a, Kiambu and Nyandarua Counties (Lung'aho *et al.*, 2010; Wang'ombe, 2008). In Kenya, potato production is mostly done by small-scale farmers on average land sizes of 2ha (Ogola *et al.*, 2011; Ayieko and Tschirley, 2006). Kenya contributes about 6.5% of Africa's total potato production (Nyagaka *et al.*, 2010). Despite an increase in potato acreage in Kenya, production has not proportionately increased, due to inadequate use of certified seeds, pests and diseases, and poor crop husbandry practices (Mwangi *et al.*, 2008). Potato production involves land preparation, seed acquisition, planting, 1st earthing up, weeding, pest and disease control, 2nd earthing up and lastly harvesting (Bohl and Johnson, 2010). Since Nyandarua County is one of the major potato producing areas in Kenya, it produced 18% and 42% of the total potatoes produced in Kenya in 2009 and 2011 respectively (MoA, 2010a). The county achieved 24% and 25% of the national potato acreage in 2010 and 2011 respectively (MoA, 2012a, b). In Nyandarua, potatoes are produced in two seasons (April-May and October-December) with harvesting being done after 4 months after planting (Ogola *et al.*, 2010).

Agricultural extension started back in the 1900s (World Bank, 2010). In Kenya, much of the agricultural extension is public although it is also provided by the private sector (Anderson, 2008; Christoplos, 2010). According to Abegunde and Ogunsumi (2011), agricultural extension transfers skills between farmers, extension agents and researchers with an aim of promoting technology adoption. The information disseminated in form of advice, skills, and education promotes food security, wealth and employment creation and poverty reduction (ASCU, 2012). The extension service is therefore perceived as a form of non-formal education (Rajalahti and Swanson, 2010), which improves agricultural yield (Maguire *et al*., 2011). This is because farmer education can influence technology adoption (Anderson, 2008). In Kenya, public extension services are provided by extension agents in the field, at Agricultural Training Centres and parastatals such as Horticultural Crops Development Authority and National Cereals Produce Board (MoA, 2009).

Farmer Training Centres are found in different countries in the world such as Ethiopia (Mengistu, 2009), Tanzania, Kenya, Namibia and Turkey (Nyamwamu, 2013). The Agricultural Training Centers were set up to offer extension services and for durations ranging from 1day to 2 weeks (Desmarais, 2010). Kenya has 28 ATCs distributed in different agro-ecological areas with Olojoro Orok and Njabini found in Nyandarua County (MoA, 2012a). In Kenya the ATCs were formed in 1950s to promote adoption of high yielding technologies. At the start, 11 ATCs were formed in Kenya and were later increased to 28 by the year 2011 (Isinika *et al*., 2002; MoA, 2012b). Since their formation up to 2006, the ATC training was held without curricula but currently formal curricula are used (MoA, 2006). For crop husbandry, curriculum content includes fertilizer application, seed selection, weed, and pest and disease control, planting and thinning. For potatoes it also includes harvesting, storage and processing (MoA, 2006). Potatoes make a significant contribution to food security, poverty reduction and rural economic development because majority of the producers are smallholder farmers (Gildemacher, 2012).

According to Natumaya (2009), small-scale farmers experience low food reserves due to low yields caused by inefficient crop production practices, poor crop pest and disease management. Low agricultural productivity is reflected by low yields obtained per unit area (Kenya Institute for Public Policy Research and Analysis (KIPPRA, 2009). Adoption of modern farming practices can increase production obtained by small-scale farmers (MoA, 2004). Agricultural extension is an educational process which causes desired changes in people through training (Mengistu, 2009). The extension service shares agricultural knowledge and technology between researchers, extension workers and farmers (ASCU, 2012; Qtaishat and AL-Sharafat, 2012). Since agricultural extension is a form of education, an educated and trained labor-force adapts and easily, utilizes new technologies in production, thus increasing efficiency and productivity (Kenya Institute for Public Policy Research and Analysis (KIPPRA, 2009). The curriculum for the ATCs should therefore motivate the farming population who need skills to chart their destiny out of rural poverty. This paper advocates for farmer training to improve production so that they can earn a productive life through agriculture and regard it as a dignified and profitable occupation. Data for this study was collected in Nyandarua County which is a major potato producing County in Kenya. The aim of this paper was to help in identifying possible areas of intervention in agricultural extension and curriculum development so as to improve potato production in Nyandarua County and also in Kenya through ATCs' curriculum.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Nyandarua County which is served by two ATCs located in Njabini and Oljoro Orok, major potato producing areas in Kenya (MoA, 2010a). Nyandarua County falls within the Aberdare ranges in Kenya, at an altitude of 1,800-3,000 metres above sea level. The average annual temperature is 220c and an average annual rainfall of 1,000 mm, which is bimodal; long rains are received in March-July and the short rains in October-December (Jaetzol *et al.,* 2006). The County has 143, 879 households with 596, 268 persons out of which 82% live in rural areas (KNBS, 2010). Land ownership is freehold with majority of the farmers owning an average of 2 ha (Wang'ombe, 2008). Dairy cattle cattle keeping is the dominant livestock production activity followed by potato production (Nyagaka *et al*., 2010). Potato production is the major crop production activity in the County (Ministry of Land and Settlement, Ministry of Planning and National Development and United Nations Centre for Regional Development, 2003; Mwakubo *et al*., 2010).

Other cash crops include wheat and pyrethrum while horticultural crops include cabbage, carrots and garden peas (Obare *et al.*, 2010). The potato is a major crop produced in Kenya with Nyandarua County producing about 18% of the total tonnage (ASCU, 2012; MoA, 2010c).

Sampling and data collection

Primary data for this study was collected from 136 small-scale potato farmers using an interview schedule. To ascertain the reliability of the schedules, they were pre-tested in the field while validity was ascertained through discussions with experts in the Agricultural Education and Extension department of Egerton University. The sample of farmers was obtained using a five-stage technique from farmers who were trained at ATCs between 2009 and 2010. The first stage involved listing all farmers trained at ATCs in Nyandarua County. The second, third, fourth and fifth stages respectively, involved selecting potato farmer groups based on their district, division and location from which they hailed from. Data was collected on farmers' adoption of potato seed selection, planting, crop protection and harvesting technologies after being trained at ATCs. In addition, farmers' socio-economic data was collected on age, gender, education level of potato farmers, reasons for growing potatoes as well as sources of agricultural information for potato farmers.

Data analysis

The proportion of farmers who obtained agricultural information from different sources was expressed as a percentage. The proportion of potato farmers who are knowledgeable and adopting potato seed selection, crop protection, planting and harvesting technologies were expressed as a percentage of the total sample. The independent t-test was used to test the four null hypotheses that stated that: There was no statistically significant difference in yield between farmers adopting and those not adopting the recommended potato seed selection, crop protection, planting and harvesting technologies respectively after being trained at ATCs in Nyandarua County on potato production. The ANOVA was used to determine the difference in yields obtained by potato farmers trained for different number of days at the ATCs. Spearman's rank correlation was used to establish the relationship between the number of times potato farmers were trained at ATCs versus the yield obtained and adoption of certified potato seed.

RESULTS AND DISCUSSION

More males (66%) than females were engaged in potato production in the County. Perhaps this could negatively affect potato production as men participated in agricultural training than women who provided most of the farm labour. This agrees with Kiura (2011) who found that women provide 75% of farm labour while men benefit from most of the agricultural extension services. The United Environmental Programme report of 2008 said that men produce most cash crops while women provide most of the farm labour (United Environmental Programme, 2008). Similarly, the Food Agricultural Organisation of the United Nations report of 2011 also found that agricultural women have limited access to agricultural extension services (FAO, 2011). Of the 136 respondents, 30% of them were aged 40 years and below, while 70% were aged 41years and above. This implied that over two thirds of the potato producers were aging, while the youth were few in potato production. Potato yields may not increase as a result of potato training at the ATCs because most trainees are females whereas it is the males who make most decisions on the farm and also control resources. This means that the knowledge acquired through training may not be put into use on the farm. This also means that if an aging population is involved in training, production may not increase significantly because the individuals are getting less active, may not provide the labour and skill required and acquired through training. In addition, succession may not be possible because the young population is not prepared to take over farming activities by participating in agricultural training. Most of the respondents (97%) reported to have attained at least primary education, while 3% had no formal schooling (Table 1). This means that most potato farmers were educated and literate. Involvement of a literate and educated population in training and farming could increase their understanding of the subject matter, thus increas-

Table 1: Gender, age and education level of potato farmers in Nyandarua County

Variable	Percent
Gender	
Male farmers (n=90)	66
Female farmers (n=46)	34
Age (years)	
Farmers aged 40≤ (n=41)	30
Farmers aged ≥41 (n=95)	70
Education level	
Farmers who had completed at least primary school (n=132)	97
Farmers who had no formal schooling (n=4)	3

Table 2: Farmers' use of potatoes

Variable	Percent
Use	
Farmers who grow potatoes as a business (n=114)	84
Farmers who grow potatoes for home consumption (n=116)	85

ing the adoption of innovations and technologies. This is consistent with KIPPRA (2009) and Nyagaka *et al.* (2010), who found that an educated labour-force easily understands, interprets new information and adopts new technologies such as the use of fertilizers, certified seed and control of crop and insect pests and diseases. A literate farmer is likely to understand easily the technical terms used during training, read the labels on fertilizer bags, follow directions on the operation of machines and tools and other items in order to work out the best system for his farm.

Of the 136 respondents, 84% of them indicated growing of potatoes as a business, while 85% said that they grew potatoes for home consumption as well (Table 2). This could also mean that most farmers who grow potatoes do so for the purpose of providing food for their household members and also as an economic activity. This may also mean that potatoes are critical in the achievement of food security, employment creation and income generation in Nyandarua County. This is consistent with Gianessi and Ashley (2011) and Abong' *et al.* (2012), whose findings show that potato production is done as a food and cash crop, and is significant in Kenyan economy. In order to obtain potato yields enough for food and sale, potato farmers seek training on production technologies that can increase yields. During these training, they are trained on potato seed selection, planting, crop protection and harvesting technologies.

Potato production curriculum

Potato seed selection techniques

Study results showed that 85% of the respondents knew the correct potato seed size to plant while 70% knew the correct minimum number of sprouts per seed tuber, and 96% knew the meaning of 'clean potato seed' tubers of the recommended size that have the correct number of sprouts. However, 47% of the respondents indicated that they obtain potato seed from their own farms, 24% from farmer groups, 14% from ATCs, 9% from Kenya Agricultural Research Institute (KARI), 4% from neighbouring farmers while 20% from Molo Agricultural Development Corporation (ADC) (Figure 1). This meant that majority (75%) of the farmers do not obtain potato seed from recommended sources, despite their good knowledge of potato

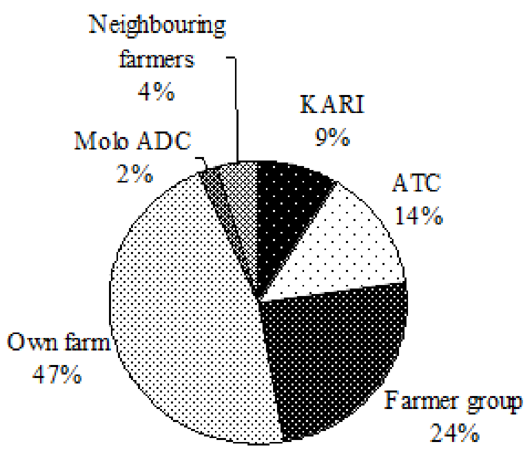

Figure 1: Sources of potato seed in Nyandarua County.

Table 3: Farmers' knowledge of clean potato seed, use of volunteer crop and crop rotation.

Variable	Percent
Clean Potato Seed	
Farmers who understand clean potato seed as being 'disease-free'(n=131)	96
Farmers who understand clean potato seed as being 'free from dirt' (n=5)	4
Use of volunteer crop	
Farmers who eat volunteer potato crop (n=94)	69
Farmers who sell volunteer potato crop (n=22)	16
Farmers who use volunteer crop as fodder (n=7)	5

seed selection technologies. This was against Kirkwyland and Thomas (2012) who recommend the use of certified potato seed when planting potatoes. Gildemacher (2012) observes that potato seed quality is important in sustainably improving potato production. Potato yields can be increased by using the recommended potato seed. If potato farmers are knowledgeable on potato seed selection technologies and practise them, yields obtained from their farms can increase. This is because they will select a seed tuber of correct size, pure, true to type, that is healthy and has at least 3 sprouts, from certified sources.

Potato crop protection techniques

Study results showed that 96% of the respondents understood that clean potato seed was disease-free, 69% eat volunteer potato crop while 89% practice crop rotation (Table 3). This meant that most farmers were knowledgeable on potato crop protection technologies, although about 75% did not use certified potato seed and 69% ate volunteer potato crop. This could imply that majority of potato farmers do not practice most of the recommended potato crop protection technologies. This is consistent with Gildemacher (2009) who found that only 1% of potato farmers in Kenya obtain their potato seed from licensed seed growers. Ogola *et al.* (2010), established that most farmers recycle seed tubers or obtain it from neighbours. Gildemacher (2012) observed that the use of uncertified potato seed significantly reduces potato yields. Potato farmers' failure to use certified potato seed gives them difficulties in controlling potato pests, diseases and weeds. This will be either through introducing new diseases onto their farms or multiplying the already existing diseases. In addition, if the farmers do not practise crop rotation and field sanitation, then they will experience difficulties in controlling insect pests and diseases. This agrees with Wang'ombe (2008) who found that few potato farmers in Nyandarua County use clean potato seed. This is supported by Kwambai and Komen (2012) who found that farmers' use of previous crop or buying potato seed from local markets or from neighbours increases disease build up and spread. Mwangi *et al.* (2008), also established that farmers' failure to practise crop rotation increases disease incidences while the use of clean potato seed and crop rotation helps in controlling weeds, insect pests and diseases (Gildemacher, 2012).

Potato planting techniques.

Study results show that 69% and 54% of the respondents use correct spacing within and between rows for planting potatoes respectively.

Table 4: Potato spacing, ridging and fertilizer application.

Variable	Percent
Spacing	
Farmers using recommended spacing within rows (n=94)	69
Farmers using recommended spacing within rows (n=73)	54
Ridging	
Farmers who practice ridging (n=131)	96
Fertilizer application	
Farmers using recommended fertilizer rates (n=79)	58
Farmers using recommended fertilizer type (n=131)	96

Table 5: Potato maturity indicators and adoption of dehaulming.

Variable	Percent
Potato maturity indicators	
Farmers who check if the plant is dry (n=78)	33
Farmers who check if flowers have dropped (n=19)	67
Farmers who check if the plant has turned yellow (n=31)	57
Farmers who check if tuber skin is hard (n=4)	14
Farmers who use age of crop plant since planting time (n=4)	23
Farmers who do not practise crop rotation (n=15)	3
Dehaulming	
Farmers who do not dehaulm potatoes (n=45)	3
Farmers who dehaulm potatoes (n=91)	11

Further, 96% reported that they prepared ridges, 96% used correct fertilizer rates during planting of potatoes (Table 4). This implied that most farmers used the recommended planting technologies. This was in line with Wang'ombe (2008) who had established that 82% of the farmers in Nyandarua County use fertilizers and FAO (2012), who recommend Di-Ammonium Phosphate (DAP) fertilizer for planting potatoes. Whereas Ogola *et al*. (2011) observed that potato yields can be increased through using correct inputs, Schulte-Geldemann *et al.* (2012), found that application of correct amounts of fertilizers increases potato yields. The spacing used during planting potatoes will determine the plant population which ultimately influences yields. If correct spacing, correct type and amount of fertilizer is used, the correct plant population is obtained per init area, having a healthy crop. This is likely to produce high yields. Further, if a farmer prepares ridges during planting and successively earths up, this practice induces tuber formation as well as prevents pests and diseases. This increases the quantity and quality of potato yield.

Potato harvesting techniques.

Further, study results showed that 57% of the respondents checked whether the plants had dried, 14% if flowers had dropped, 23% checked if the plants had turned yellow/brown, and 3% used age of the crop since planting time, while 3% checked if tuber skin had hardened.

Further, 67% of the respondents dehaulmed potatoes, while 79% used the recommended dehaulming method (Table 5). This implies that majority of potato farmers use the recommended potato harvesting technologies, which is consistent with FAO (2012) recommendation that potatoes should be harvested when stalks are dry, and be dehaulmed 2-3 weeks prior to harvesting (Kirkwyland and Thomas, 2012). Correct diagnosis and interpretation of potato maturity indicators by farmers can significantly affect yields. This is because some maturity indicators resemble pest and disease manifestations or malnutrition for example yellowing and drying of the plant and falling of flowers. Therefore potato farmers need skills for distinguishing between a disease manifestation and a mature potato plant by grasping the maturity indicator for the varieties commonly grown. Mature tubers have higher dry matter content, and therefore are of high quality. If farmers mistaken a disease for maturity and harvest the crop, the total yield may be low and of low quality. Further, the farmers need to prepare for harvest by dehaulming their crop and perform it at the right stage of growth, using the correct method. Dehaulming hardens the tuber skin and therefore reduces bruising and skinning. Harvesting potatoes at the right stage and dehaulming before harvesting can increase yields and quality of tubers.

Sources of agricultural information

A comparison of various sources of agricultural information showed that 83% of the respondents preferred to get information about potato production from ATCs than from other sources (17%). The other sources of agricultural information are; 56% consider the radio, 53% sought from extension officers, 50% got it from field days, and 29% from other farmers (Figure 2). This means that radios, agricultural exten-

Table 6: Independent t-test on yield difference between farmers using and farmers not using certified seed and crop protection technologies.

Variable	Mean Yield (ton/ha)	S.D.	S.E.	t-test	p-value
Crtified seed					
Farmers who plant certified seed after being trained at ATC (n=71)	19	23.89	2.84	5.42	0.00
Farmers who do not plant certified seed after being trained at ATC (n=65)	13	26.36	3.27		
Crop protection					
Farmers using recommended crop protection practices after being trained at ATC (n=113)	17	27.33	2.57	2.05;	0.04
Farmers not using recommended crop protection practices after being trained at ATC (n=23)	13	27.10	5.65		

sion officers and field days are major sources of agricultural information to potato farmers, second to ATCs. This could be attributed to the systematic delivery of subject matter during farmer trainings using radio programs, agricultural extension officers and field days. Further, there is a high likelihood of completing a teaching session in ATCs', radio programs and in farmer training sessions than in other sources. This could mean that more potato farmers listen to agricultural radio programs than they meet agricultural extension officers or attend field days. It could also imply that radio programs are more frequently and regularly used in the County to disseminate agricultural information compared to the frequency of visits by agricultural extension agents and field days. These findings are supported by Mumero (2013) who reported that a radio is a dominant source of agricultural information in Nakuru, Nyanza, Nyeri, Machakos, Makueni and Webuye, although the information provided is inadequate ans sometimes require translation into simple forms usable by local farmers. Mumero (2013) also established that most farmers (44%) trust the public extension service although it is less available as expected, probably due to their ratio of one extension agent to 1,470 farmers agaist the recommended one officer to 400 farmers. Wanzala (2014) also reported that at one time in Kenya's history every village had an extension agent, unlike the situation currently. Consequently, other sources

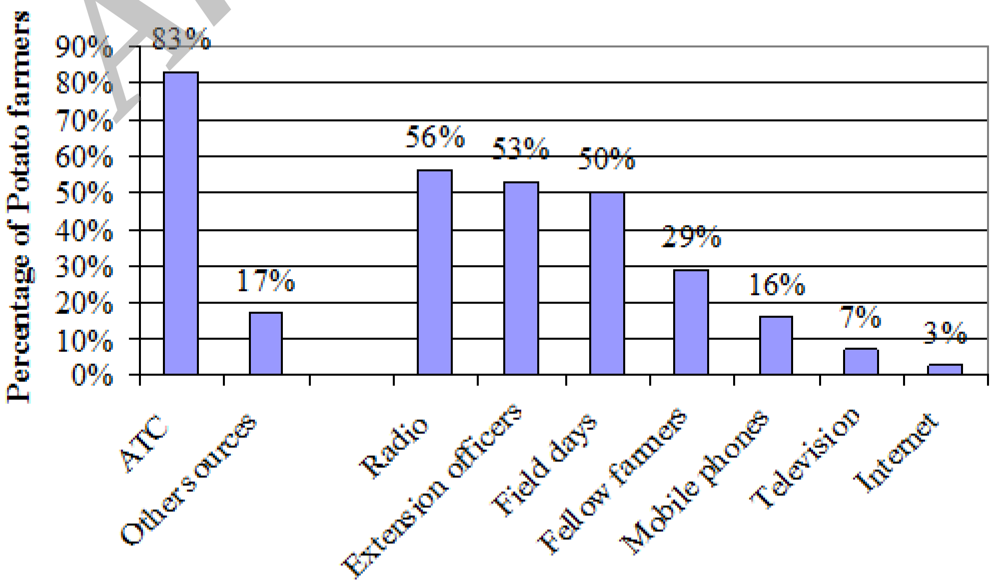

Figure 2: Sources of agricultural information for potato farmers.

Table 7: Independent t-test on yield difference between farmers using and farmers not using recommended harvesting technologies.

Variable	Mean Yield (ton/ha)	S.D.	S.E.	t-test	p-value
Planting technology					
Farmers using recommended potato planting practices after training at ATC (n=108)	17	26.95	2.59	2.73;	0.01
Farmers not using recommended potato planting practices after training at ATC (n=28)	13	27.04	5.11		
Harvesting technologies					
Farmers using recommended potato harvesting practices after training at ATC (n=92	17	26.55	2.77	2.72;	0.00
Farmers not using recommended potato harvesting practices after training at ATC (n=44)	14	27.87	4.20		

Table 8: ANOVA Descriptive statistics on Number of Times Trained versus Potato Yield.

Variable	Mean Yield (ton/ha)	S.D.	S.E.
Descriptive statistics			
Farmers trained on potato production at ATC for one day (n=67)	10	16.41	2.01
Farmers trained on potato production at ATC for two days (n=42)	19	7.63	1.18
Farmers trained on potato production at ATC for three days (n=27)	26	18.05	3.47

of agricultural information such as Farmer Field Schools are used. Mumero (2013) also found that about 11% farmers in Nakuru, Nyanza, Nyeri, Machakos, Makueni and Webuye obtain agricultural information from mobile phones. Mumero (2013) added that some farmers get agricultural information from fellow farmers, through field days and agricultural shows.

The null hypotheses were not supported by the data collected as shown by the t-test results on yield differences between potato farmers adopting and potato farmers not adopting technologies after being trained at ATCs on potato production. The t-test was done on potato seed selection ($p<0.01$), crop protection ($p<0.05$), planting ($p<0.01$) and harvesting technologies ($p<0.01$) as shown in table 6 and 7. The hypotheses were therefore rejected and conclusions drawn that potato farmers who had adopted potato technologies obtained higher yields than those who had not adopted after they were trained at ATCs on potato production.

ANOVA of the number of times trained versus potato yield

The potato farmers trained thrice at the ATC on potato production obtained an average of 26 ton/ha, the farmers trained twice obtained 19 ton/ha, while the farmers trained once obtained

Table 9: ANOVA on the number of times a farmer is trained versus potato yield.

Variable	Sum of Squares	df	Mean Square	F	p-value
Between groups	76061.575	2	38030.787	176.648	0.00
Within groups	28633.829	133	2.01	215.292	

Table 10: Relationship between the number of times potato farmers were trained at ATC versus potato yield and adoption of certified seed.

Variable	rho	p-value
Number of Times trained versus potato yield	0.880	0.000
Number of times trained versus adoption of certified see	0.13	0.13

10 ton/ha (Table 8). The high difference in potato yield between groups than within groups could mean that potato yields obtained by farmers increased with an increase in the number of times that the farmers attended training on potato production (Table 9). This may imply that adoption of potato production technologies by potato farmers may not increase with increase in the number of times farmers attended training at ATCs for example on certified seed and use of fertilizers.

The relationship between the number of times potato farmers were trained at the ATCs and the potato yield was 0.88 (p-value ≤0.00) while the relationship between the number of times potato farmers were trained at ATCs and adoption of potato certified seed was 0.13 (p-value ≤0.13) (Table 10). This means that there was a strong relationship between potato yield and the number of times farmer were trained at the ATCs whereas there was no relationship between the number of times trained at the ATC on potato production and adoption of certified potato seed. This implies that the number of times a potato farmer was trained at the ATC on potato production could influence potato yield, but not the adoption of certified seed. For training to be effective adequate time is required for the farmer trainees to internalize the skills and where possible, when field practicals are carried out.

CONCLUSION

This study concluded that ATCs' curriculum is effective in promoting small-scale farmers' adoption of potato selection, crop protection, planting and harvesting technologies. Adoption of potato technologies increases yields. This therefore implies that ATCs' curriculum significantly contributes towards national development through food security improvement, wealth and employment creation and poverty reduction.

RECOMMENDATIONS

We recommend that ATCs' curriculum prioritize demonstrations that showcase the influence of clean seed, timely harvesting and fertilizer application on potato yields. Further, campaigns should be used to educate on the effect of correct spacing and dehaulming on yields. The County should start farmer-based seed production programs to ensure that clean seed is readily available.

ACKNOWLEDGEMENT

We most sincerely thank the extension workers and farmers in Nyandarua County for their contribution during this study.

REFERENCES

1- Abegunde, B.O., & Ogunsumi, L.O. (2011). Evaluation of agricultural extension and delivery services in South-West Nigeria. International Journal of Agriscience, 1 (4), 581-591.

2- Abong, G.O., Shibairo, S.I., Kabira, N.J., & Aguk, J.A. (2012). Enhancing food security through increased potato production in Kenya. Retrieved from http://www.plantscience. unobi. ac. ke/ node/1039 on 8/7/2012.

3- Agriculture Sector Coordinating Unit. (2012). National Agricultural Sector Extension Policy, (NASEP). Nairobi, Kenya: Kilimo House.

4- Anderson, J.R. (2008). Agricultural advisory services: Background Paper for the World Development Report, 2008. Retrieved from siteresources. worldbank.org/.../ Anderson _AdvisoryServices.pdf on 21/5/2013.

5- Andriesse, W., Giller, K., Jiggins, J., Loffler, H., Oosterveer, P., & Woodhill, J. (2007). The role of agriculture in achieving millennium development Goal 1. A Review of leading Reports. Wageningen International, Wageningen: The Netherlands. Retrieved from http://www. edepot.wur.nl/23281 on 22/7/ 2012.

6- Ayieko, M.W., & Tschirley, D. (2006). Enhancing access and utilization of quality seed for improved

food security in Kenya. Tegemeo Institute of Agricultural Policy and Development, Egerton University. Nairobi. Working paper No. 27/2006.
7- Bohl, W.H., & Johnson, B.S. (Ed.). (2010). Commercial potato production in North America. (2nd. Rev. ed). American Potato Journal, supplement (57).
8- Christoplos, I. (2010). Mobilising the potential of rural and agricultural extension. The Global Forum for Rural Advisory Services: FAO, Rome. Retrieved from http:// www.g-fras.org/fileadmin/.../Mobilizing_the_potential_of_extension .pdf on 21 /5/ 2013.
9- Desmarais, P. (2010). Kasisi Agricultural & Training Centre. Retrieved from http://www. canadianjesuitinternational.ca/.../zambia_ka on 17/10/2012.
10- Food Agricultural Organization of the United Nations. (2009). Human Wildlife Conflict in Africa-Causes, Consequences and Management Strategies. FAO Forestry Paper 157. Rome.
11- Food Agricultural Organisation. (2011). The State of Food and Agriculture 2010-11: Women in Agriculture. Rome, FAO. Retrieved from http:// www.feedtheFuture.gov/.../Clinton%20women %20 and the agriculture report…pdf on 10/11/2012
12- Food Agricultural Organisation. (2012). Importance of potato production and consumption in Kenya. Retrieved from http:// www.fao.org/wairdocs/x5420E/x5420e04 on 6/7/2012.
13- Gianessi, L., & Ashley, W. (2011). Fungicide spraying is critical for increasing potato production. International Pesticide Benefits. Case Study No.48. Crop Protection Research institute. Croplife Foundation, Washington DC. Retrieved from http// www. croplifefoun dation.org.
14- Gildemacher, P.R., Demo, P., Barker, I., Kaguongo, W., Woldegiorgis, G., Waguire, W., Wakahiu, M., Leeuwis, C., & Struik, P. C. (2009). American Journal of Potato Research. 86:373-38.
15- Gildemacher, P.R. (2012). Innovations in potato seed systems in East Africa. (Doctoral dissertation, Wageningen University, United Kingdom). Retrieved from http://www. edepot.wur.nl 212110.pdf on 8 /8/2012.
16- GoK. (2007). Kenya Vision 2030; A Globally Competitive and Prosperous Kenya. Ministry of Planning and National Development and the National Economic and Social Council (NESC), Nairobi, Kenya: Government Printers
17- International Fund for Agricultural Development. (2010). Rural Poverty Report 2011: New Realities: New Challenges: New Opportunities for Tomorrow's Generation. International Fund for Agricultural Development, Rome.
18- Isinika, A., Temu, A., Kitalyi, A., & Ngugi, D. N. (2002). Agricultural Education in Kenya and Tanzania (1968-1998). Nairobi; Kenya: Regional Land Management Unit, (RELMA).
19- International Potato Centre (CIP). (2008). The International Year of the Potato. Retrieved from http:// www.cip. org/pressroom /facts_ figures/ 2008 _international_year of the potato.
20- Jaetzol, R., Schmidt, H., Hornetz, B., & Chisanya, C. (2006). Natural Conditions and Farm Management Handbook of Kenya. Central Kenya, Vol. II (2nd. ed). Nairobi; Kenya: Ministry of Agriculture.
21- Jansky, S.H., Jin, L.P., Xie, K.Y., Xie, C.H., & Spooner, D.M. (2009). Potato production and breeding in China. Potato Journal. 52,57-65. doi: 10. 1007 /s/11540-008-9121-2. Retrieved from www.vcru. wisc.edu/spoonerlab/pdf/Potatoes%20in% 20 China. pdf on 22/ 5/ 2013.
22- Kaguongo, W.P., Gildemacher, P., Demo, P., Wagoire, W., Kinyae, P., Andrade, J., Forbes, G., Fuglie, K., & Thiele, G. (2008). Farmer practices and adoption of improved potato varieties in Kenya and Uganda. Social Sciences Working Paper 2008-5. CIP, Lima, Peru.
23- Kasina, M., & Nderitu, J. H. (2010). Policy Implementation and its Economic Impact on Potato Marketing Value chain in Kenya. KARI: Nairobi. Retrieved from http//www. kari.org/ …/pdf.
24- Kenya National Bureau of Statistics. (2010). The 2009 Kenya Population and Housing Census Volume 1. Nairobi; Kenya: Ministry of Planning and National Development
25- Kenya National Bureau of Statistics. (2011). Kenya Economic Survey Highlights presented during Kenya Economic Survey 2011 on 17th May 2011 by Wycliffe Ambetsa Oparanya, Nairobi; Kenya.
26- Kenya Institute for Public Policy Research and Analysis, (KIPPRA). (2009). Kenya Economic Report 2009. KIPPRA. Nairobi, Kenya. Retrieved from http:/ www.kippra.org on 22/7/2012.
27- Kipkoech, D.N., Mburu, J., Ritho, C.W., Ng'ang'a, N.W., & Lung'aho, C. (2010). Technical Efficiency among Small-scale Ware Potato Producers in Kenya.
28- Kirkwyland, M., & Thomas, E. (2012). Production Guide for Organic Potatoes. NYS IPM publication no. 138. New York. Retrieved from http:// www.

nysipm.cornell.edu/organic_ guide/potato.pdf. on 13/ 6/2012.
29- Kiura, L. (2011). Women in agriculture. Retrieved from http://icar.org in/.../12-women %20I N%AGRI...PPT on 15/11/2012.
30- Kwambai, T.K. & Komen, S.K. (2012). Multinational partnership to promote certified potato seed Production and Distribution in the North Rift Region of Kenya. Retrieved from http:// www. kari. org /.... MULTI....pdf on 16/7/ 2012
31- Lung'aho, C., Nderitu, S.K.N., Kabira, J.N., El-Bedewy, R., Olanya, O. M., & Walingo, A. (2006). Yield Performance and Release of Four Late Blight Tolerant Potato Varieties in Kenya. Journal of Agronomy, 5, 57-61.doi:10.3923/ja.2006.57.61.
32- Maguire, C., Rivera, W., Gary, A., & Pierson, M. (2011). Building the base for global food security. Agricultural Education and Training. United States of America: United States Agency for International Development (USAID).
33- Mengistu, F. T. (2009). Problems and prospects of farmers training centers: The Case Study of Ada'a Woreda, East Shewa, Oromia Region (Masters Thesis). Available from http:// www. ipms-ethiopia. org/ Final Thesis
34- Ministry of Lands and Settlement, Ministry of Planning and National Development, United Nations Centre for Regional Development, & University of Nairobi. (2003). Nyandarua District Regional Development Plan (2001-2030). An Integrated Plan for Sustainable Regional Development. Nairobi; Kenya: United Nations Centre for Regional Development, UNCRD.
35- Ministry of Agriculture and Ministry of Livestock and Fisheries Development. (2004). Strategy for Revitalizing Agriculture (2004-2014). Nairobi; Kenya: Ministry of Agriculture.
36- Ministry of Agriculture. (2006). Review of the Status of Agriculture Training Centres' Task-force Report. Nairobi; Kenya: Unpublished.
37- Ministry of Agriculture. (2009). Agricultural Training Centers' 2009 Annual Report. Nairobi; Kenya: Ministry of Agriculture.
38- Ministry of Agriculture. (2010a). National Root and Tuber Crops Policy. Nairobi; Kenya: Ministry of Agriculture.
39- Ministry of Agriculture. (2010b). Agricultural Sector Development Strategy (2010-2020). Nairobi; Kenya: Government Printers.
40- Ministry of Agriculture. (2010c). National Horticulture Policy. Nairobi; Kenya: Ministry of Agriculture.
41- Ministry of Agriculture. (2012a). Economic Review of Agriculture. Prepared by the Central Planning and Monitoring Unit. Nairobi; Kenya: Ministry of Agriculture.
42- Ministry of Agriculture. (2012b). Kilimo News (Jan.-March 2012). Journal of the Ministry of Agriculture. Nairobi; Kenya: Ministry of Agriculture. Available at http://www.kilimo. go.Ke.
43- Mumero, M. (2013, November 12th). Radio: Still the Heartbeat of Farming. The People, online.
44- Mwakubo, S.M., Nguyo, W., Nyagaka, D. O., & Obare, G. A. (2010). Are Kenyan small-holders allocatively efficient? Evidence from Potato Producers in Nyandarua North District. Journal of Agricultural Economics, 2 (3), 078-085.
45- Mwangi, J.K., Nyende, A.B., Demo, P., & Matiru, V.N. (2008). Detection of latent infection by ralstonia solanacearum in potato (Solanum tuberosum) Using Stems Instead of Tubers. African Journal of Biotechnology, 7 (11), 1644-1649. Available at
46- Natumaya, D. (2008). Farmer Training Increases Productivity and Income in Uganda. Retrieved from http://www.acdvoca.org September 2011.
47- Nyagaka, D. O., Obare, G. A., Omiti, J. M., & Nguyo, W. (2010). Technical Efficiency in Resource Use: Evidence from Smallholder Irish Potato Farmers in Nyandarua North District, Kenya. African Journal of Agricultural Research, 5 (11), 1179-1186.
48- Nyamwamu, R.O. (2013). Effectiveness of Agricultural Training Centers' Curriculum in Promoting Small-scale Farmers' Adoption of Selected Potato Technologies in Nyandarua County, Kenya. (Unpublished Masters' Thesis). Egerton University. Egerton, Kenya.
49- Obare, G.A., Nyagaka, D.O., Nguyo, W., & Mwakubo, S. M. (2010). Are Kenyan small-holders allocatively efficient? Evidence from Irish Potato Producers in Nyandarua North District. Journal of Agricultural Economics, 2 (3), 78-85.
50- Ogola, J.B.O., Ayieko, M.W., Orawo, A.O., & Kimani, F.W. (2011). Analysis of fFertilizer use in potato production in Nakuru district, Kenya. African Journal of Agricultural Research. 6 (16), 3672-3677.
51- Ogola, J., Odette, G., & Ondego, N. (2010). Small-holder horticultural marketing programme. Draft report for Value Chain Study on Potato, Cabbage and Garden peas in Nyandarua North. Nairobi; Kenya: Unpublished.

52- Qtaishat, T., & AL-Sharafat, A. (2012). Attitudes of vegetable farmers towards public agricultural extension service. American Journal of Agricultural and Biological Sciences, 7(3), 370-377.doi: 10.3844/ajabssp. 2012. 370. 377.
53- Rajalahti, R., & Swanson, B.E. (2010). Strengthening agricultural extension and avisory Systems. Procedure for Assessing, Transforming and Rural Development Discussion Paper 45. The World Bank.Washington, D.C. Retrieved from http:// www.g-fras.org /.../ M... /Strengthening-Agricultural-Extension-and-AS.pdfon 21/5/2013.
54- Schulte-Geldemann, E., Gildemacher, P.R., & Struik, P.C. (2012). Improving seed health and seed performance by positive selection in three Kenyan potato varieties: A paper accepted for publication by the American Journal of Potato Research. 13/04/2012.
55- United Nations Environmental Programme. (2008).Women Farmers' Productivity in Sub-Saharan Africa. Retrieved from http://www.unep.org / ...Agriculture/.../women farmers.. pdf on 20/11/2012
56- Wambugu, P.W. & Muthamia, Z.K. (2009). The state of plant genetic resources for food and agriculture in Kenya. KARI, Kenya. Retrieved from http:/ www.fao.org/docrep/013/i15 00 e/Kenya.pdf on 6/7/2012.
57- Wang'ombe, J. G. (2008). The potato value Chain in Kenya and Uganda. Maastricht School of Management, Netherlands. Retrieved from http// www.roundtableafricanet/media/uploads/file/ joseph%20 gichuru % wangombe-the %20 potato% 20 value % 20 chain% inkenya 20 and % 20% uganda pdf on 5/7/2012.
58- Wanzala, O. (2014, February 22nd). Information is power and farmers here know exactly that. Saturday Nation, online.
59- World Bank. (2010). A brief history of public extension policies, Resources and Advisory Activities in Kenya: Extension and Advisory Services in Kenya. Retrieved from http://www.worldwide-extension.org/africa/kenya/s-kenya on 19/5/2013.