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EFFECTIVENESS OF AGRICULTURAL TRAINING CENTERS' CURRICULUM IN PROMOTING ADOPTION OF AGRICULTURAL TECHNOLOGIES: EVIDENCE FROM SMALL-SCALE POTATO FARMERS IN NYANDARUA COUNTY, KENYA

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ABSTRACT

Agricultural Training Centers (ATCs) train farmers, public and private sector staff on agricultural technologies. Although the potato farmers in Nyandarua County are trained on production technologies, their average yield is ≤16 tones per hectare compared to the national potential of 30 tones per hectare. This study sought to determine the effectiveness of ATCs' curriculum in promoting farmers' adoption of selected Irish potato production technologies in Nyandarua County. Data was collected from 136 farmers trained at ATCs on potato production, using interview schedules, sampled through a five-stage technique. Data was analyzed using T-test and ANOVA, then summarized into percentages. Results showed that adoption of recommended potato production technologies produced higher yields. It was concluded that ATCs' curriculum was effective in promoting adoption of potato seed selection, planting, crop protection and harvesting technologies by farmers. Campaigns should be intensified on the influence of spacing, fertilizer, clean seed, dehaulming and use of correct maturity indicators on potato yield.
Keywords: Adoption, Agricultural Training Centre, Curriculum, Effectiveness, Technology.

INTRODUCTION

The agriculture sector is critical for economic development in most developing countries, 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, 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, 2010; Ministry of Planning, National Development and Vision 2030, 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 GDP from 2.6% by 5.6% in same period (Kenya National Bureau of Statistics 2011).

Potato is the main tuber crop and third most important food crop in the world after rice and wheat (International Potato Centre, 2008). The crop is critical in achieving food security, employment creation and income generation, poverty reduction and economic development (Gildemacher, 2012; Kipkoech, Mburu, Ritho, Ng'ang'& Lung'aho, 2010). In Kenya, potato is ranked second most important food crop after maize (Kasna & Nderitu, 2010; Abong, Shibairo, Kabira, & Aguk, 2012). About 790,000

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

Kenyan farmers grow potatoes in two seasons but obtain low yields due to limited use of high quality seeds and inputs, pest and disease attack (Kaguongo et al., 2008). This shows that this crop contributes significantly to Kenya's economy. The crop is suited for high altitude areas (1500-3000 m above sea level) like in Nyandarua County (Wang'ombe, 2008). Potato production is mostly done by small-scale farmers on average land sizes of 2ha (Ogola, Ayieko, Orawo & Kimani, 2011). Kenya contributes about 6.5% of Africa's total potato production (Nyagaka, Obare, Omiti & Nguyo, 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, Nyende, Demo, & Matiru, 2008). Potato production involves land preparation, seed acquisition, planting, 1st earthing up, weeding, pest and disease control, 2nd earthing up and lastly harvesting (Bohl & Johnson, 2010).

In Nyandarua, potatoes are produced in two seasons (April-May & October-December) with harvesting being done after 4months after planting (Ogola, Odette & Ondego, 2010). 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; the county achieved 24% and 25% of the national potato acreage in 2010 and 2011 respectively (MoA, 2010; MoA, 2012). In the county, potato is a major food and cash crop grown by small-scale farmers (Obare, Nyagaka, Nguyo & Mwakubo, 2010). The yields obtained range between 8-14 tons/ha against a national average of 24ton/ha and national potential of 30ton/ha (MoA, 2012). Civil society organizations augment the public sector which dominates extension service provision in Kenya (Agriculture Sector Coordination Unit, ASCU, 2012).

The Agricultural Training Centres were formed in 1950s following the Swynnerton plan which advocated for the adoption of high yielding technologies, fronted by the green revolution (MoA, 2009). The 27 Agricultural Training Centres in Kenya train farmers, public and private sector staff on agricultural technologies (MoA, 2012). Two out of the 27 ATCs are found in Nyandarua County. About 68% of Kenyans living in rural areas rely on agricultural activities for their livelihood (Wambugu & Muthamia, 2009). 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 by small-scale farmers (MoA, 2004). Extension is an educational process which causes desired changes in people through training (Mengistu, 2009). The extension service promotes adoption of agricultural technologies aimed at increasing productivity and production (Amir, Zaid & Zaikulla, 2005; Bokor, 2005; MoPND 1994). The extension service shares agricultural knowledge and technology between researchers, extension workers and farmers (ASCU, 2012; Qtaishat & AL-Sharafat, 2012).Recent developments in world food demand calls for greater urgency of farmers accessing appropriate agricultural skills as away of ensuring sustainable food supplies both for the rural communities and satisfying rising urban food demands. The curriculum for the ATCs should motivate the young farming population who need skills to chart their destiny out of rural poverty. 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 Agricultural Training Centers were set up to offer extension services and training for farmers in durations ranging from 1day to 2 weeks (Desmarais, 2010). This study sought to determine the effectiveness of ATCs' curriculum in promoting small-scale farmers' adoption of potato technologies and skills after being trained at ATCs on potato production.

This paper similarly calls for setting farmers to earn productive life by giving them opportunities to appreciate that agriculture is a dignified and profitable and profitable occupation.
Data was collected from Nyandarua County, a major potato producing county in Kenya. The primary objective was to provide insights into the effectiveness of ATCs' curriculum in promoting farmers' adoption of potato seed selection, planting, crop protection and harvesting technologies. This could help in the identification of possible areas of intervention in extension and curriculum development so as to improve potato production. Limited studies have enquired into the effectiveness of ATCs' curriculum in promoting farmers' adoption of potato production technologies in Kenya, and this study therefore sought to fill that knowledge gap.

METHODOLOGY OF RESARCH

The study was conducted in Nyandarua County, which is served by two Agricultural Training Centers (Njabini and Oljoro orok) and is a major Irish potato producing county in Kenya (MoA, 2010). The county falls within the Aberdare ranges of Kenya, at an altitude 1800-3,000m above sea level. The annual average temperature is 22^{o}C and an average annual rainfall of 1,000mm, which is bi-modally distributed; long rains in March-July and short rains in October - December (Jaetzol, Schmit, Hornetz & Chisanya, 2006). The county has 143, 879 households with 596, 268 persons out of which 82% live in rural areas (KNBS, 2010). Land ownership is free-hold with majority of farmers owning an average of 2ha (Wang'ombe, 2008). Dairy farming is the dominant followed by Irish potato production (Nyagaka, *et al*., 2010). The other cash crops include wheat, pyrethrum, and horticultural crops like cabbages, garden peas and carrots (Obare, *et al*., 2010). Irish potato is a major vegetable produced in Kenya, and Nyandarua County produces about 18% of the national annual tonnage (ASCU, 2012; MoA, 2010).
The adoption of Irish potato production technologies by potato farmers trained at the Agricultural Training Centers in Nyandarua County between 2009 and 2010 was surveyed in September, 2012. Data was collected from 136 small-scale potato farmers, sampled using a five-stage technique. At the first stage, all farmers trained at Agricultural Training Centers in Nyandarua County on various agricultural skills including potato production technologies were listed. At the second, third, fourth and fifth stages respectively, farmer groups to which the selected farmers had membership were traced to the districts, divisions and locations they hailed from. Primary data was collected using interview schedules which were developed and pre-tested in the field to ascertain their reliability, in line with the study objectives. Validity was ascertained through discussion with experts in Agricultural Education and Extension Department of Egerton University. Data was collected on farmers' adoption of the potato seed selection, planting, crop protection and harvesting technologies after being trained at the ATCs on potato production. The ATCs' curriculum on potato production skills included; seed selection, planting technics, crop protection and harvesting technologies. Its effectiveness was measured as a percentage of the farmers trained and had adopted the technologies on potato production. In addition, data was collected on age, gender, education level of the potato farmers, reasons for growing potatoes as well as sources of agricultural information for potato farmers. The age and gender variables were included so as to guide in decision making regarding the beneficiaries of extension programs. Age and education level could be used to determine their relationship with the receptiveness of learners to innovations and technologies, which could positively impact on yields. Reasons for growing potatoes could indicate the role of the crop in food security and economy in the study area, while data on sources of agricultural information could guide on the relevance of various extension service providers. Education level was measured by the number of years in formal schooling.

The proportion of farmers obtaining agricultural information from different sources was expressed as a percentage. The proportion of potato farmers knowledgeable and adopting the 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 4 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 the 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 (34%) are engaged in potato production. This could negatively affect production because men participate in agricultural training while women provide most of the farm labor. This agrees with Kiura (2011) who found that women provide 75% of farm labor while men benefit from most of the agricultural extension services. United Environmental Programme (2008) reported that men produce most cash crops while women provide most of the farm labor. Food Agricultural Organization (2011) also found that agricultural women have limited access to extension services. About 30% of the potato farmers were aged 40 years and below while 70% were aged 41 years and above. This implies that majority of the potato producers are aging while the youth are not involved in agriculture. About 97% of the potato farmers had acquired 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 trainings and farming could increase their understanding of the subject matter, thus increase adoption of innovations and technologies. This is consistent with KIPPRA (2009) and Nyagaka et al., (2010) who found that an educated labor-force easily understands, interprets new information and adopts new technologies like use of fertilizer, certified seed and control of pests and diseases.

Table 1
Gender, Age and Education Level of Potato Farmers in Nyandarua County

Variable	Percentage
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 reached at least primary school (n=132)	97
Farmers who had no formal schooling (n=4)	3

About 84% of the farmers grow potatoes as a business while 85% grows potatoes for home consumption as shown in Table 2. This may mean that potatoes are critical in the achievement of food security, employment creation and income generation in Nyandarua County. This is consistent with Gianesi and Ashley (2011) and Abong' et al., (2012) who found that potato production is done as a food and cash crop, and is significant in Kenya's economy.

Table 2
Farmers' Use of Potatoes in Nyandarua County

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

Potato Curriculum Production Technologies.
Irish Potato Seed Selection Techniques.

Results showed that 85% of farmers knew the correct potato seed size while 70% knew the correct minimum number of sprouts per seed tuber and 96% knew the meaning of 'clean potato seed'. This could imply that potato farmers select clean potato seed tubers of the recommended size, having the correct number of sprouts. However, 47% of the farmers obtain potato seed from their own farms, 24% from farmer groups, 14% Agricultural Training Centres (ATCs), 9% Kenya Agricultural Research Institute (KARI), 4% from neighboring farmers while 20% obtain seed from Molo Agricultural Development Corporation, ADC (Figure 1). This could mean that majority (75%) of the farmers do not obtain potato seed from recommended sources, despite their good knowledge of potato 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.

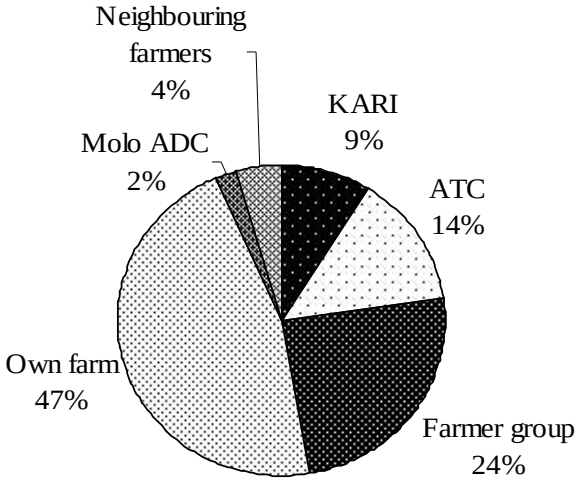

Figure 1. Sources of Potato Seed for Farmers in Nyandarua County

Irish Potato Crop Protection Techniques

Results showed that 96% of the farmers understand that clean potato seed is disease-free, 69% eat volunteer potato crop while 89% practice crop rotation, as shown in Table 3. About 47% of these farmers obtain seed from own farms, 24% from farmer groups, 14% ATCs, 9% KARI, 4% neighboring farmers while 20% obtain seed from Molo ADC as shown in Figure 1. 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) found that most farmers recycle seed tubers or get it from neighbors. 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 control of potato pest, disease and weeds. This agrees with Wang'ombe (2008) who established 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 neighbor's increases disease build-up and spread. Mwangi *et al*., (2008) found that farmers' failure to practice crop rotation increases disease incidences while the use of clean potato seed and crop rotation helps in controlling weeds, pests and diseases (Gildemacher, 2012).

Table 3

Farmers' Knowledge of Clean Potato Seed, Use of Volunteer Crop and Crop Rotation in Nyandarua County

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 potato crop as fodder(n=7)	5
Farmers who do not use volunteer potato crop in any way (n=14)	10
Crop rotation	
Farmers who practice crop rotation (n=121)	89
Farmers who do not practice crop rotation (n=15)	11

Irish Potato Planting Techniques.

Results showed that 69% and 54% of the farmers use correct spacing within and between rows for planting potatoes, respectively. A further 96% prepare ridges, 96% use correct type of fertilizer while 58% use correct fertilizer rates during planting potatoes (Table 4). This implied that most farmers used the recommended planting technologies. This was in line with Wang'ombe (2008) who found that 82% of farmers in Nyandarua use fertilizers and Food Agricultural Organization, 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, Gildemacher and Struik (2012) found that application of correct amounts of fertilizer increases potato yields.

Table 4

Potato Spacing, Ridging, and Fertilizer Application by Farmers in Nyandarua County

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

Irish Potato Harvesting techniques.

The results showed that 57% of the farmers check whether the plant is dry, 14% if flowers have dropped, 23% check if the plant has turned yellow / brown and 3% use age of the crop since planting time while 3% check if tuber skin has hardened.

A further 67% dehaulm potatoes while 79% use the recommended dehaulming method (Table 5). This implies that majority of potato farmers use the recommended potato harvesting technologies. This is consistent with Food and Agricultural Organization, FAO (2012) recommendation that potatoes should be harvested when stalks are dry, and be dehaulmed 2-3 weeks prior to harvesting (Kirkwyland & Thomas, 2012).

Table 5
Adoption of Potato Dehaulming and Maturity Indicators by Potato Farmers in Nyandarua County

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

Sources of Agricultural Information for Potato Farmers

A comparison of various sources of agricultural information showed that 83% of the farmers prefer Agricultural Training Centers (ATCs), to the other sources (17%). Among the other sources of agricultural information, 56% consider the radio as important, 53% extension officers, 50% field days, 29% other farmers, as shown in Figure 2. This may mean that radios, extension officers and field days are major sources of agricultural information to farmers, besides ATCs. This could be attributed to the systematic delivery of subject matter during farmer trainings in radio programs, extension officer-farmer training and field days. Furthermore, there is a higher likelihood of curriculum completion during ATCs', radio programs and extension-farmer training than from other sources. The indication that farmers obtain agricultural information from radios than from extension officers, field days and other sources, could mean that more farmers listen to agricultural radio programs frequently than they meet extension officers, attend field days or obtain information from the other sources. It could also imply that radio programs teach more frequently and regularly than extension officers visit farmers and field days are held.

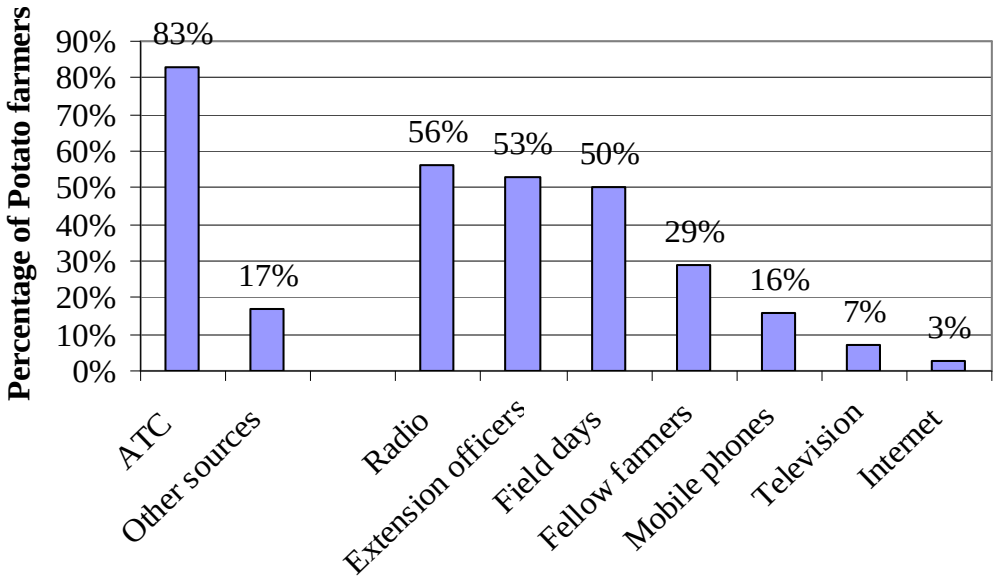

Figure 2. Potato farmers' sources of agricultural information

The null hypotheses were not supported by the data collected as shown by the t-test results on yield difference 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 (t=5.42; df=134; p=0.00), crop protection (t=2.05; df=134; p=0.00), planting (t=2.73; df=134; p=00) and harvesting technologies (t=2.72; df=134; p=0.00) 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.

Table 6

Independent T-test on Yield Difference between Farmers Using and Farmers Not Using Recommended Certified Seed and Crop Protection Technologies

Variable	Mean Yield	Std. Deviation	Std. Error Mean	T-test
Certified seed				
Farmers who plant certified seed after being trained at ATC (n=71)	69.96	23.889	2.835	T=5.417; df =134; p=0.000
Farmers who do not plant certified seed after being trained at ATC (n=65)	46.62	26.361	3.270	
Crop protection				
Farmers using recommended crop protection practices after being trained at ATC (n=113)	60.96	27.326	2.571	T=2.049; df =134; p=0.042
Farmers not using recommended crop protection practices after being trained at ATC (n=23)	48.17	27.097	5.650	

Table 7
Independent T-test on Yield Difference between Farmers Using and Farmers Not Using Recommended Planting and Harvesting Technologies

Variable	Mean Yield	Std. Deviation	Std. Error Mean	T-test
Planting technologies				
Farmers using recommended potato planting practices after training at ATC (n=108)	62.02	26.954	2.594	T=2.732; df =134;
Farmers not using recommended potato planting practices after training at ATC (n=28)	46.39	27.044	5.111	p=0.007; df =134
Harvesting technologies				
Farmers using recommended potato harvesting practices after training at ATC (n=92)	63.15	26.545	2.768	T= 2.719; df = 134;
Farmers not using recommended potato harvesting practices after training at ATC (n=44)	49.70	27.873	4.202	p =0.004

The ANOVA of the number of days potato farmers were trained at the ATCs versus potato yield produced an MS of 38030.17 between groups, 215 within groups, an SS of 76061.58 between groups and 28633.83 within groups at df of 2 and 133, respectively (Table 8). The potato farmers trained for 3 days obtained an average yield of 97.78 bags (SD=18.05), 2 days obtained 70 bags (SD=7.63), while those trained for 1 day obtained 37.75 bags (SD=16.41) as shown in Table 9. The higher difference in potato yield between groups than within groups could mean that potato yields obtained by farmers increased with an increase in number of days the farmers were trained on potato production, although to a definite level. This may imply that adoption of some Irish potato production technologies by potato farmers may not increase with an increase in the number of times farmers are trained at ATCs for example certified seed and fertilizer.

Table 8
ANOVA on Farmers' Number of Days Trained versus Potato Yield

Variable	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	76061.575	2	38030.787	176.648	.000
Within Groups	28633.829	133	215.292		

Table 9
ANOVA Descriptive Statistics on Days Trained versus Potato Yield

Descriptive statistics	Mean Yield	Std. Deviation	Std. Error
Farmers trained on potato production at ATC for one day (n=67)	37.75	16.413	2.005
Farmers trained on potato production at ATC for two days (n=42)	70.19	7.633	1.178
Farmers trained on potato production at ATC for three days (n=27)	97.78	18.046	3.473

The relationship between the number of times potato farmers were trained at the ATCs and the potato yield was 0.887 (p=0.000) while the relationship between the number of times potato farmers were trained at ATCs and adoption of potato certified seed was 0.132 (p=0.127) as shown in 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, field practicals are carried out.

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 potato farmers are trained at ATC versus potato yield	887**	.000
Number of times potato farmers are trained at ATC versus adoption of Certified Seed	0.132	.127

CONCLUSIONS

This study concludes that ATCs' curriculum is effective in promoting potato farmers' adoption of potato seed selection technologies in Nyandarua County. This is because the potato farmers trained on potato production at the ATCs were able to select potato seed as recommended during trainings. The potato farmers who adopted recommended potato seed selection technologies obtained higher average yields (69bags/acre) compared to lower yield (46bags/acre) obtained by potato farmers who were not adopting the technologies after being trained at ATCs. Secondly, the ATCs' curriculum was found to be effective in promoting potato farmers' adoption of recommended crop protection technologies. Consequently, potato farmers adopting the technologies obtained higher average yields (60bags/acre) compared to lower yields (48bags/acre) obtained by farmers not adopting crop protection technologies after being trained at ATCs on potato production. Thirdly, the ATCs' curriculum is effective in promoting potato farmers' adoption of Irish potato planting technologies. This was evidenced by higher average yield (62bags/acre) obtained by potato farmers adopting compared to lower yields (46bags/acre) obtained by farmers not adopting recommended potato planting technologies after being trained at the ATCs. Lastly, ATCs' curriculum is effective in promoting farmers' adoption of potato harvesting technologies. This was shown by the higher average yields (63bags/acre) obtained by farmers adopting, compared to lower yields (49bags/acre) obtained by potato farmers not adopting recommended potato harvesting technologies after being trained at ATCs on potato production. Farmer campaigns should be intensified on the effect of correct spacing, fertilizer application, clean seed dehaulming and maturity indicators on potato yield. Starting a farmer-based seed production program can ensure that clean potato seed is readily available. The experiences gained in this study are an indication of the need to provide appropriate skills to farmers involved in various agricultural production enterprises and a way of ensuring knowledge based economy.

REFERENCES

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

Agriculture Sector Coordinating Unit (2012). National horticulture policy. Nairobi , Kenya: Kilimo house.

Agriculture Sector Coordinating Unit (2012). National agricultural sector extension policy, (NASEP). Nairobi , Kenya: Kilimo house.

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*

Bohl, W. H ., & Johnson, B . S . (Ed.). (2010). Commercial Potato production in North America. (2nd . Rev. ed). *American Potato Journal*, supplement (57).

Bokor, R . K . (2005). Agricultural Extension: Its Role in National Development: Retrieved from http://www. modernghana.com October 2011

Desmarais, P . (2010). Kasisi Agricultural & Training Centre. Retrieved from http://www.canadianjesuitinternational.ca/.../zambia_ka on 17/10/2012.

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%20and the agriculture report…pdf on 10/11/2012

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

Gianessi, L ., & Ashley, W . (2011). Fungicide spraying is critical for increasing potato production. International pesticide benefits. Case study no.48. Crop protection research institute. Crop life foundation, Washington Dc. Retrieved from http// www.croplifefoundation.org.

Gildemacher, P . R ., Demo, P ., Barker, I ., Kaguongo, W ., Woldegiorgis, G ., Waguire ,W . W .,Wakahiu, M ., Leeuwis, C ., & Struik, P . C. (2009). *American journal of potato research.* 86:373-382

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

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.

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.

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.

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.

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.

Kenya National Bureau of Statistics (2010). The 2009 Kenya Population and Housing Census Volume 1. Nairobi; Kenya : Ministry of Planning and National Development

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.

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

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

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

Kiura, L . (2011).Women in agriculture. Retrieved from http://icar.org.in/.../12-women%20IN%AGRI...PPT on 15/11/2012.

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

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 www.ipms-ethiopia.org/ Final Thesis

Ministry of Agriculture (2004). Farmers Training Centers, Demonstration Farms Fund Operations Manual. Nairobi; Kenya : Ministry of Agriculture.

Ministry of Agriculture and Ministry of Livestock and Fisheries Development (2004). Strategy for Revitalizing Agriculture (2004-2014). Nairobi; Kenya : Ministry of Agriculture

Ministry of Agriculture (2009). Agricultural Training Centers' 2009 Annual Report. Nairobi; Kenya: Ministry of Agriculture

Ministry of Agriculture (2010). National Root and Tuber Crops Policy. Nairobi; Kenya : Ministry of Agriculture

Ministry of Agriculture (2010). Agricultural Sector Development Strategy (2010-2020). Nairobi; Kenya : Government Printers.

Ministry of Agriculture (2010). National Horticulture Policy. Nairobi; Kenya : Ministry of Agriculture

Ministry of Agriculture (2012). Economic Review of Agriculture. Prepared by the Central Planning and Monitoring Unit. Nairobi; Kenya : Ministry of Agriculture.

Ministry of Planning and National Development (1994). National Development Plan (1997-2001), 8th Development Plan. Nairobi; Kenya : Government Printer.

Ministry of Planning, National Development and Vision 2030 (2007). Kenya Vision 2030. Nairobi; Kenya : Government Printers.

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* vol.7 (11), pp.1644-1649. Available at http://www.academicjournals.org/AJB

Natumanya, D . (2008). Farmer Training increases Productivity and Income in Uganda. Retrieved from http://www.acdvoca.org September 2011

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.

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), 078-085.

Ogola, J . B . O . , Ayieko, M . W . Orawo , A . O . , and Kimani, F . W . (2011). Analysis of fertilizer use in potato production in Nakuru district, Kenya. *African journal of agricultural research.* 6 (16), 3672-3677. Doi: 10.5897/AJAR10.464. Retrieved from http://www.academicjournals.org/AJAR on 13/10/2012

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 : Capital guardians.

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. Retrieved from http://www.thescpub.com.ajabbs.toc on 28/9/2012

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

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

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/i1500e/Kenya.pdf* on 6/7/2012

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% inkenya20and%20%uganda pdf on 5/7/2012.

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