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Research Application Summary

Adoption and impact of improved pigeon peas on household poverty in South East Kenya

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Abstract

About 60% of the population in South Eastern Kenya is estimated to be below the poverty line, with majority of the poor living in rural areas, where agriculture is the main source of livelihood. Most of the impoverished areas are largely semi-arid with a predominant smallholder, rain-fed agricultural production system. Farming is perennially constrained by low and erratic rainfall, low soil fertility and use of poor seeds which results in low yields, aggravating poverty. Improved pigeon pea varieties have been developed and disseminated in South Eastern Kenya to increase productivity and reduce household poverty. However, its adoption has been low and there is paucity of information on the impact of its adoption on household poverty. The objectives of this study were to assess the factors influencing adoption of improved pigeon peas in Machakos, Kibwezi west and Mutomo sub-Counties and to evaluate the impact of adoption on households' poverty. Cross sectional data were collected from which determinants of adoption were established. Propensity score matching approach was used to assess the impact of adoption on poverty. The results showed that farmers' access to improved pigeon pea seed, contact with agricultural extension service providers and access to market information significantly influenced adoption ($p < 0.001$). Adopters and non-adopters got an average net farm income of KES 27,570 and 12, 790 per acre per year, respectively. Adoption resulted in a decrease of head count poverty by 0.24% and a reduction in poverty gap and poverty severity by 0.30% and 0.20 %, respectively. The results suggest that farmers adopt a technology when there is easy access to the required inputs, technical advice on implementation and reliable market information for the output. The results also showed that adoption of improved pigeon pea was associated with reduction in household poverty.

Key words: Kenya, pigeon peas adoption, poverty reduction, propensity score matching, smallholder

Résumé

About 60% of the population in South Eastern Kenya is estimated to be below the poverty line, with majority of the poor living in rural areas, where agriculture is the main source of livelihood. Most of the impoverished areas are largely semi-arid with a predominant smallholder, rain-fed agricultural production system. Farming is perennially constrained by low and erratic rainfall, low soil fertility and use of poor seeds which results in low yields, aggravating poverty. Improved pigeon pea varieties have been developed and disseminated in South Eastern Kenya to increase productivity and reduce household poverty. However, its adoption has been low and there is paucity of information on the impact of its adoption on household poverty. The objectives of this study were to assess the factors influencing

adoption of improved pigeon peas in Machakos, Kibwezi west and Mutomo sub-Counties and to evaluate the impact of adoption on households' poverty. Cross sectional data were collected from which determinants of adoption were established. Propensity score matching approach was used to assess the impact of adoption on poverty. The results showed that farmers' access to improved pigeon pea seed, contact with agricultural extension service providers and access to market information significantly influenced adoption ($p< 0.001$). Adopters and non-adopters got an average net farm income of KES 27,570 and 12, 790 per acre per year, respectively. Adoption resulted in a decrease of head count poverty by 0.24% and a reduction in poverty gap and poverty severity by 0.30% and 0.20 %, respectively. The results suggest that farmers adopt a technology when there is easy access to the required inputs, technical advice on implementation and reliable market information for the output. The results also showed that adoption of improved pigeon pea was associated with reduction in household poverty.

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Introduction

About 60% of the population in South East Kenya (SEK) is estimated to live below the poverty line, with the majority of the poor residing in rural areas, where agriculture is the main source of livelihood (KNBS, 2015).South Eastern Kenya region is largely semi-arid having two rain seasons with an annual mean of 700mm (Jaetzold *et al*., 2010). The rain seasons have substantial variation in onset, intensity and cessation which perennially affects agricultural production. Most farmers depend on rain-fed agriculture for their livelihood that is characterized by low agricultural productivity induced by use of poor quality seeds, limited use of soil fertility enhancing inputs and dependence on low and erratic rainfall which aggravates household poverty. Pigeon pea (*Cajanus cajan*) is one of the staple crop grown by smallholder farmers in Machakos, Kibwezi West and Mutomo Sub-counties. However, use of local landrace seed material has led to low yields and farm income.

The International Crops Research Institute for the Semi-Arid Tropics collaborated with Kenya Agricultural Research Institute (now Kenya Agricultural and Livestock Research Organization), Winrock International and the University of Nairobi in developing and releasing a number of improved pigeon pea varieties (Olubayo *et al*., 2007). The varieties have high-yielding, drought-tolerance and disease resistance traits intended to improve pigeon pea production in semi-arid areas of Kenya. Some of the varieties released included KARI Mbaazi1 which has short maturing period of 3-4 months, KAT 60/8, a medium-duration variety maturing in 5-6 months and ICEAP 00777 that matures in 8-9 months. The yields from the improved pigeon peas range from 1.5 tons to 3 tons per hectare per year compared to the local landraces that yield 0.3 to 0.7 tons per hectare (Kwena *et al*., 2017). However, smallholder pigeon pea farmers have persistently grown the lower yielding local landraces (Simtowe, 2012).

There is literature on adoption and impact of agricultural technologies on household poverty (Claessens *et al*., 2013). Even so, there is a considerable knowledge gap on impact of adopting leguminous crops in semi-arid areas of Africa as most of impact studies are related to modern agricultural technologies

conducted for cereal crops such as maize, wheat and rice which are largely grown in high potential areas. The objectives of this study were to (i) assess the factors influencing adoption of improved pigeon peas in Machakos, Kibwezi West and Mutomo Sub-Counties in South East Kenya, and (ii) evaluate the impact of adoption of the improved varieties on households' poverty.

The annual population growth rate is estimated at 2% in Machakos, 2.35% in Kibwezi West and 2.1% in Mutomo Sub-counties (KNBS, 2015). This means that the proportion of children in households is increasing which necessitates efforts to increase food production to meet nutritional needs for the growing population and increase income to cater for other household needs. Hence the need for analysis of adoption of agricultural technologies that increase food supply and income to alleviate household poverty.

Methodology

The study was conducted in South Eastern Kenya region that is made up of Machakos, Makueni and Kitui Counties. Pigeon pea is one of the major staple crops, and it is the second most produced legume in the region after the common bean. The study purposively focused on semi-arid zone producing pigeon pea namely: Mwania watershed area along river Mawnia that represented Machakos Sub-county, Kalii watershed area along river Kiboko for Kibwezi West Sub-County and Mutomo watershed area along river Tiva for Mutomo Sub-County.

Primary data were gathered through a semi structured questionnaire. Following Kothari (2004) the sample size used in the study was derived as:

$$N= (z^2pq)/d^2$$

Where: N is the desired sample size; z was set at 1.96 representing 95 % confidence interval; p is the proportion of the population estimated to have improved pigeon pea on their farms which was assumed to be 30 percent in this study (0.3). q = 1- p, and is the proportion of households considered not growing improved pigeon peas on their farms (0.7), d is the degree of accuracy. In the study, N= [3.841(0.3)(0.7)]/0.0025; N=323.

A multi-stage sampling technique was adopted where two Wards were selected from each Sub-county from which four villages were selected. Fourteen households were selected from each village through a simple random sampling approach making a total sample size of 336.

A binary logit model was used to assess the determinant of adoption. Following Greene (2003) Logit model was based on cumulative logit probability function. The logit distribution function of the adoption was specified as:

$$P_i = \frac{1}{(1+e^{-z_i})} = \frac{e^{z_i}}{(1+e^{z_i})} \quad \text{.....(1)}$$

Where: P_i is the probability that the ith household will adopt improved pigeon pea varieties which is a binary variable taking the value of 1 for adopters and 0 for non-adopters. The ratio of the probability of adopting to not adopting (odds ratio) was defined by:

$$\frac{P_i}{1-P_i} = \frac{1+e^{zi}}{1+e^{zi}} = e^{zi}$$, taking the natural log gives:

$$Z_i = In\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + U_t \quad \text{.....(2)}$$

Where Z_i is a function of n-explanatory variables which are expressed as:

$$Z_i = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + U_t.$$

Z_i is ith value of the dependent variable and is the ith value of the independent variable which can be a dummy or a continuous variable. Household, i = 1, 2,…. n, are observations on variables for the adoption model and n being the number of explanatory variables used in the study. is an intercept and are unknown parameters to be estimated in the adoption model. is unobserved error term.

Following Foster (2005) poverty was computed as:

$$P_v = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{Gp_i}{z}\right]^v \quad \text{.....(3)}$$

Where : P_v is the poverty measure , N represents the total number of households, z is poverty line. The poverty gap for individual i is = with = 0 when, . is the expenditure of household i. The different measures of poverty were (= 0, 1, and 2) that show the varying range of inequality among the poor. The study evaluated = 0,1,2 with as the poverty head count ‘ that reflected the percentage of households with household below the poverty line, the poverty line was set at US $1.90 per adult equivalent expenditure per day which was equivalent to KES 5,700 per month. The poverty gap was represented by the extent to which an individual falls below the poverty line and the poverty severity which represents the weighted sum of poverty gaps. Overall, the measure shows a decline in living standard this impling that the higher one’s standard of living, the lesser the poor one is deemed to be.

The impact of adoption on poverty was estimated by the Average Treatment of the Treated (ATT) approach using matching of the adopting and non-adopting units. The matching was based on two assumptions that selection into adopting group was solely based on observable characteristics and that there was an overlap of observable characteristics between the adopters and non-adopters in the sample. Matching on every covariate is difficult when the set of covariates is large. Propensity scores were estimated to overcome the problem. The conditional probability that the ith individual will adopt improved pigeon pea conditional on observed characteristics was defined by the propensity score, P() and expressed as:

P()=P(=1|()) ...……... (4)

Where =1 is when the ith individual adopts while =0 means no adoption.

Following Rosenbaum and Rubin (1983) the Average Treatment Effect on the Treated (ATT), which is the average gain from adoption for individuals who actually adopted is expressed as:

$$ATT = E\left(y_{1i} - y_{01} \middle| p(x_i)\right) = E(y_{1i}|p(x_i), A_i = 1) - E(y_{0i}|p(x_i), A_i = 0) \quad \text{.....(5)}$$

$ATT = E(y_{1i}|A_i=1) - (y_{0i}|A_i=1)$, where $E(y_{1i}|A_i=1)$ represents the average outcome of adoption in terms of poverty reduction as observed in survey data while 5Ø8Ü (|=1) is the average outcome of adoption had the farmer not adopted.

Results and discussions

In the study 34% of the farmers had adopted improved pigeon peas. The results in Table 1 show that variables capturing households access to agricultural extension services, improved pigeon pea seed and marketing information had a 1% level statistical significant influence on adoption. Years of farming experience of household head, access to climate change information and membership in farmer's association had significant influence on adoption of improved pigeon pea production at 5 % level.

The results in Table 2 reveal that the adopters got KES14,780 (US$ 134.30) per acre per year more than the non-adopters. About 53.07% and 53.33% of adopters and non-adopters of improved pigeon pea, respectively, were below the poverty line. This means that non-adopters were 0.263 percentage points lower in poverty than non-adopters. Poverty head count provided information on the proportion of adopters and non-adopters that were living on less than KES 190 (US$1.9) per day but did not show how far below the poverty line the poor were. The headcount did not show changes when every poor person became less poor, nor did it change when a poor person became even poorer.

When considering the poverty gap, adopters had an average of 5.47 percentage points lower than the poverty line while the non-adopters were deeper in poverty by a 5.83 percentage points. The results were generated by dividing the total sum of all the poverty shortfalls below the poverty line by the total adult equivalent in the sample. Poverty severity for adopters was 2.47 percentage points among adopters and 2.7 percentage points in non-adopters.

Discussion

The results revealed that years of farming experience of household's head coefficient was positive and significantly influenced adoption. This is because with increasing years of farming, it is expected that farmers acquire more experience, knowledge and skills about the appropriate use and operation of the technology which translates into higher productivity. The increased productivity translates into improved agricultural income and reduction of household poverty as higher productivity means higher yields, more food, more livestock feed from crop residues and more marketable surplus from own harvest.

Farmers' access to agricultural extension services positively influenced adoption. The agricultural extension staff provide farmers with information on seeds suited to the various agro-ecological zones, availability of farm inputs and good crop husbandry. The results imply that public agricultural extension service provision is a strong conduit for providing both information and technical skills on improved agricultural production especially among those who cannot afford to pay for the private service provision.

Access to pigeon pea seed positively influenced adoption of the technology. This implies that access to seed is a necessary condition to adoption of improved pigeon peas. The recurrent drought in South East Kenya region and resultant crop failure is a precursor to exhaustion of seed stock in most resource-poor households. This is due to the tendency of the households converting the seed into food whenever there is drought and hunger. Frequent replenishment of seed stock by increasing its availability and

improving farmers' access in terms of location and affordability is thus inevitable if production of improved pigeon pea varieties in South East Kenya is to be increased.

Table 1. Factors influencing farmers' adoption of improved pigeon pea production

Variables	Coefficient	t-statistic
Age of household head	0.017	3.06
Gender of household head	0.032	1.01
Farming experience of household head	0.01**	1.15
Education level of household head	-0.02	2.35
Family size	0.32	1.88
Non-farm income	0.034	1.27
Farm size	0.067	-1.66
Access Extension	0.042***	1.18
Access seed	0.06***	0.97
Access credit	0.013	0.68
Access climate information	0.056**	0.92
Access market information	0.031***	1.26
Distance market	-0.043	-0.57
Membership in farmers' association	0.037**	3.06
Log likelihood	-43.01	
LR chi square	62.4**	

Notes: The dependent variable is the decision to adopt improved pigeon pea, which equals one, zero otherwise. ***, **, * denote statistical significance at the one percent, five percent and ten percent levels, respectively

Table 2. Impact of adopting improved pigeon pea on household poverty

Outcome	Mean outcome		ATT
	Adopters	Non-adopters	
Net farm income	27,570	12,790	14,780 (38.6)
Head count poverty	53.07	53.33	-0.263 (0.156)
Poverty depth	5.47	5.83	-0.363 (0.196)
Poverty severity	2.47	2.7	-0.23 (0.095)

t-statistics in parenthesis; ATT=

Farmers' access to climate change information is crucial especially in in an area with erratic rainfall. This could be because farmers need information on onset and cessation of rainfall and the distribution to be able to plan their farming activities. Information on expected temperature range is also important for farmers to prepare on the pigeon pea husbandry. During very high temperatures the pest infestation is high and farmers need to be aware of the likely weather changes to prepare for such eventualities like high pest infestation and how to reduce the damage by setting aside money to purchase pesticides, or reduce their investment in crop if it predicted to be adversely affected by the projected weather changes.

Farmers' access to market information had a positive coefficient and significantly influenced adoption. This could be because farmers are usually receptive of a technology when they are informed on how to sell what is produced in excess of home consumption or when they are sure that what they produce has ready market. Market information is inevitable for farmers who aspire to practice farming as a business to increase farm income and not farming as a hobby. Information on how much to produce, when, where to sell what quantities and which price is usually needed by farmers to make informed decision on production.

The coefficient on membership in farmers' association was positive and significant. This could be attributed to farmer group meetings that are local fora for interactive knowledge exchange which enhance adoption of agricultural technologies. Membership in farmers associations enables farmers benefit from economies of scale by purchasing farm inputs in bulk at a discounted rates and marketing in bulk that reduces the marketing transaction cost and increase their marketing margins.

The reduction in poverty head count, poverty gap and poverty severity in adopting households relative to the non-adopters suggests that production of improved pigeon pea varieties had aquantifiable impact of reducing the percentage of farmers below the poverty line, narrowing the gap of the poor below the poverty line (depth of poverty) and reducing the inequality of the poor below the poverty line (severity). The results are an indication of adoption of the technology contributing towards improving the farmers' wellbeing through poverty reduction.

Conclusion

Farmers adopt a technology when there is easy access to the required inputs and reliable market information for the output. The results also showed that adoption of improved pigeon pea was associated with reduction of household poverty which raises the need to find mechanisms for extending improved pigeon pea production to other semi-arid areas in Kenya.

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References

Claessens, L., Antle, J. M., Stoorvogel, J. J., Valdivia, R. O., Thornton, P.K. and Herrero, M. 2012. A method evaluating climate change adaptation strategies for small-scale farmers using survey, experimental and modeled data. *Agricultural Systems* 111: 85–95.http://dx.doi.org/10.1016/j.agsy.2012.05.003

Foster, J. E. 2005. Poverty indices. pp. 41–66. In: de Janvry, A., Kanbur, R. (Eds.). Poverty, inequality and development: Essays in honor of Erik Thorbeck. Kluwer Academic Publishers, Norwell, MA.

Greene, W.H. 2003. Econometric analysis. Fifth Edition. Prentice Hall International Upper Saddle River, USA. http://qed.econ.queensu.ca/jae/

Jaetzold, R., Schmidt, H., Hornetz, B. and Shisanya, C. 2010. Farm management handbook of Kenya. Vol II. Natural Conditions and Farm Management Information. 2nd Edition, Part II/C. East Kenya.

Kenya National Bureau of Statistics. 2015. Spatial dimensions of wellbeing in Kenya. Where are the poor? From counties to wards. Government Printers. Nairobi.

Kothari, C.R. 2004. Research Methodology: Methods and Techniques. Second revised edition. New Age International (P) Ltd, Publishers, New Delhi, India

Kwena, K., Ayuke, F.O., Karuku, G.N. and Esilaba, A.O. 2017. The curse of low soil fertility and diminishing maize yields in semi-arid Kenya: Can pigeon peas play saviour? *Tropical and Sub-Tropical Agroecosystems* 20: 263-278.

Olubayo, F.M., Mwang'ombe, A. and Kimani, P. 2007. Dissemination and adoption of improved pigeon pea technologies among dryland communities in Kenya. A paper presented at the Agricultural Innovation in Dryland Africa (AIDA) Conference held at Accra, Ghana, 22-24 January, 2007.

Rosenbaum, P.R. and Rubin,D.B. 1983. The central role of the propensity score in observational studies for causal effects. Biometrika Journal, 70: 41-55. http://links.jstor.org/sici?sici=0006-3444%28198304%2970%3A1%3C41%3ATCROTP%3E2.0.CO%3B2-Q

Simtowe, F., Muange, E., Munyua, B. and Diagne, A. 2012. Technology awareness and adoption: The case of improved pigeonpea varieties in Kenya. Paper presented at the International Association of Agricultural Economists Triennial Conference in Brazil, Foz do Iguaçu August. pp. 18-24.