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COST EFFECTIVENESS OF PRE-HARVEST TECHNOLOGIES AND THEIR ADAPTABILITY AMONG SMALLHOLDER VEGETABLE FARMERS IN SRI LANKA

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Abstract

Agriculture has changed intensely over the past years. It has succeeded in reducing food costs (through technology and labour reduction), meeting the demand for increasing population and year round production. Technology has played a major part in these developments despite some environmental and social issues. However adoption of technologies in the developing world occurs at very slow pace and Sri Lanka is not an exception. As a result of series of experiments conducted, an application of extra doses of potassium fertilizer and half burnt rice hull were found to be effective in controlling postharvest losses of vegetables. This study attempted to investigate the cost effectiveness of these pre-harvest technologies and to study the factors affecting the adaptation of new technologies by the vegetable farmers. Net marginal revenues were calculated using the data obtained from the field experiments conducted at different locations using the custom rates and the subsidized prices of fertilizer. A structured questionnaire survey was conducted during the month of April 2017 in administrative divisions of NuwaraEliya district in Sri Lanka. A binomial logit regression model was employed to analyse the data. The cost analysis shows that both technologies are cost effective. The survey results show that despite irrigation and integrated pest management (IPM) technologies other technologies are well received by the farmers. It is revealed that most farmers are well aware of new varieties introduced and adhering to the recommendation of fertilizers by the Department of Agriculture. The results of the logit regressions show that application of extra doses of potassium and application of silicon as half burnt rice hull, as new technologies, are significantly affected by the income, experience in farming and the availability of credits. This study implies that extension services are needed in IPM and irrigation techniques.

Keywords: Cost Effectiveness, Technology Adoption, Vegetable Farmers, Logit Regression.

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1. Background and Literature Survey

The structure of agricultural production has changed intensely over the years both in the developed and developing world. It has succeeded in reducing cost of production of food meeting the demand for increasing population and year round production. Rapid development of the agriculture sector and the improved productivity, particularly in the developed world, can largely be attributed to technological innovations during the last few decades. Much of the agricultural innovations originated in developed countries and however some of these technologies are difficult to apply in developing countries or the process of adaptation has been very sluggish (Mwangi & Kariuki, 2015; Bandira & Rasul, 2002). Nevertheless, the adoption of new technology remains a crucial requirement for the positive transformation of the agriculture sector.

With rapid population growth and demand for more food, the need for the adoption of novel technologies in agriculture has been emphasized (Cole, 1999; Devi et al., 2014; Diiro & Sam, 2015). There is a large pool of literature on adaptations of new technology by farmers and farmers' learning behavior (Conley & Udry, 2010). In this strand of literature, the discovery of agricultural technologies and their adoption have been identified as an engine of growth in agriculture (Eklund, 1983; Sunding & Zilberman, 2001; Thornton, 1973).

In general, technology adoption is determined by economic, social, physical and technical aspects of farming (Abay & Assefa, 2004). More specifically, agricultural technology adoption decisions are determined by human capital (education and experience), wealth (income and assets), basic services (infrastructure, extension and credit), imperfect information, risk and uncertainty, institutional constraints, input availability and infrastructural problems (Kohli and Singh 1997).

This study focuses on two technologies which were found to be very effective in reducing postharvest losses of vegetables tested through a series of greenhouse and field experiments predominantly vegetable growing areas of Sri Lanka. The two technologies were extra doses of potassium application (EDKA) and the application of half-burn rice hull (HBRH) as a low-cost supplement of silicon. They were field tested in low altitude (less than 350m above MSL) districts of *Mathale* and *Dambulla* where vegetables such as tomato and capsicum are predominantly grown and in the high altitude (more than 1500m above MSL) district of NuwaraEliya where carrot, leeks, beetroot and cabbage are predominantly grown. The effectiveness of the EDKA and HBRH in controlling postharvest losses in vegetables has been already established by previous studies (Somapala et al 2015 & 2016). The National Science Foundation (NSF) of Sri Lanka currently provides funding to pilot test and to disseminate the technologies among the farmers.

The objectives of the present study are twofold. The first is to compute cost effectiveness of the two technologies namely EDKA and HBRH. The second is to investigate the factors affecting the adoption of these two technologies by the rural smallholder farmers in the districts of Mathal, Dambulla and NuwaraEliya of Sri Lanka.

2. Empirical Approach

Net marginal revenues were calculated using the data obtained from the field experiments conducted at different locations using the custom rates and the subsidized prices of fertilizer. The factors affecting the adoption of technologies were investigated using cross sectional primary data collected through semi-structured questionnaire administered on 50 randomly selected smallholder farmers during *Yala* season of 2016 in two administrative divisions (*Thalathuoya and Phathahewaheta*) of the *NuwaraEliya* district of Sri Lanka. The questionnaire was pre-tested and enumerators were trained prior to the survey. The current level of adoption of various technologies was elicited through the questionnaire and the factors affecting the adoption of the two technologies were determined by estimating a binomial-logit regression model.

2.1 Empirical Specification for Technology Adaptation

In this study, the probability of adapting a strategy was hypothesized to be influenced by the socio-economic characteristics of the farmer and farm characteristics. Accordingly, a binomial-logit model was used to analyze the factors which influence the decision to adapt the two

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technologies. The dependent variable was treated as "1" if a certain farmer adopts the technology and "0" otherwise.

In such a situation, according to Greene (1993), the logit equation can be written as:

$$P_r(Y = 1) = \frac{e^{\beta' x}}{1 + e^{\beta' x}} \qquad (1)$$

Where β is the vector of parameters associated with factor "x" (socio-economic and farm characteristics) influencing the decision of adopting the technology.

Then the cumulative distribution function can be given by

$$F(\beta' x) = \frac{1}{1 + e^{\beta' x}} \qquad (2)$$

Assuming the probability that farmer n will adopt the technology (EK or HBRH) is equal to the proportion of farmers using that technology, the individual empirical models to be estimated can be given by

$$T_i = \beta_0 + \sum_{j=1}^{n} \beta_j x_j + \varepsilon_j \qquad (3)$$

Where Ti = the technology (EK or HBRH)
β_o = intercept
β_j = coefficient of independent variables
ε_j = random error term

3. Results and Discussion

3.1 Cost Effectiveness of The Two Technologies

Table 1 shows the cost effectiveness of applying extra dosage of MOP on tomato at one location and on leeks at two locations. Net marginal revenues were calculated both at the subsidized price and the commercial price of MOP and assumed that application cost of extra amounts of MOP is zero. Results show that the extra cost on double or triple dosage than the DOA recommendation can be overcome by the increased yield of tomato and leeks. However, since these values have been extrapolated from 2.7 m² plots this has to be tested on large fields for recommendations.

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Table 1: Cost effectiveness of application of extra doses of MOP

Crop	MOP dosage	Yld (kg/plot)	Plot Size (square meters)	Gross Marginal Revenue* (Rs³/plot)	Cost of MOP (Rs/plot)		Marginal Cost (Rs/plot)		Marginal Revenue net of MOP cost (Rs/plot)		Marginal revenue (Rs/ha)	
					At subsidized rate	At commercial Rate	At subsidized rate	At commercial Rate	At subsidized rate	At commercial Rate	At subsidized rate	At commercial Rate
Tomato	DOA Rec. (130kg/ha)	29.22	27.91		0.18	1.78						
	Double dose (195kg/ha)	36.52	27.91	314	0.35	3.55	0.175	1.775	314	312	76,240	75,851
	Triple Dose (260kg/ha)	40.35	27.91	165	0.53	5.33	0.175	1.775	165	163	40,014	39,626
Leeks 1	DOA Rec. (150kg/ha)	40.33	2.79		0.32	3.20						
	Double dose (250kg/ha)	42.65	2.79	100	0.88	8.88	0.56	5.68	99	94	365,540	353,959
	Triple Dose (350kg/ha)	45.23	2.79	111	1.26	12.78	0.385	3.905	111	107	408,158	400,196
Leeks 2	DOA Rec. (150kg/ha)	40.33	2.79		0.32	3.20						
	Double dose (250kg/ha)	42.97	2.79	113	0.88	8.88	0.56	5.68	113	108	415,679	404,098
	Triple Dose (350kg/ha)	44.33	2.79	59	1.26	12.78	0.385	3.905	58	55	215,518	207,557

* Prices of tomato and leeks were rupees 43 and 90 per kilogram respectively

Table 2 shows the cost effectiveness of applying PBRH as Si supplement on leeks. Results show that application of PBRH at a rate of 7168 kg per hectare could significantly increase the yield of leeks. Even though doubling of PBRH application further increases the yield the marginal improvement is very minimal.

Table 2: Cost effectiveness of application of PBRH

	Yld (kg/plot)	Gross Marginal Revenue (Rs/plot)	Kilogram of PBRH applied per plot (kg/ha)	Cost of PBRH* (Rs/plot)	Marginal Cost (Rs/plot)	Marginal Revenue net of PBRH (Rs/plot)	Marginal Revenue net of PBRH (Rs/ha)
Only DOA recommendation	40.33						
Applying HBRH at a rate of 7168kg/ha	44.40	285	2 (7168)	6	6	279	58557
Applying HBRH at a rate of 14337kg/ha	44.53	9	4 (14337)	12	6	3	700

* Cost of PBRH (burning and application) was calculated as rupees three per kilogram

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3.2 Factors affecting the two technologies

Table 3 shows the demographic characteristics of the households interviewed at two administrative divisions. On average 73% of the *Thalathuoya* and more than 95% of the P*hathahewaheta* are malefarmers. In both GN divisions majority of the farmers have done schooling upto GCE (O/L) and 27% of the famers in *Thalthuoya* and 15% of the farmers in *Phathahewaheta* farmers have the education beyond GCE (O/L). The income levels lower and around Rs. 20,000 per month in both GN divisions and more than 50% of the households are receiving "*Samurdhi*". Farmers in both divisions are well experienced and land holding size of *Pahathahewaheta* is higher than that of *Thalathuoya*.

Table 3: Demographic characteristics

		Unit	Thalathuoya	Pahathahewahata
Gender	Male	%	73.91	96.43
	Female	%	26.09	3.57
Education	Upto grade 5	%	21.74	28.57
	Grade 5 to O/L	%	50.43	66.43
	O/L	%	17.39	7.14
	A/L	%	4.35	0.00
	More than A/L	%	6.09	7.86
Family members	Male	%	59%	60%
	Female	%	49%	47%
Monthly income		Rs.	18,815	21,873
Samurdhi beneficiaries		%	52.17	60.71
Land area		Acre	0.93	1.32
Year of farming experience		Number	24.74	26.75

3.3 *Institution and Services for Farming*

Institutions, technological services available and their utilization are given in Table 4. All the farmers in *Thalathuoya* are members of the FO while in *Pahathahewaheta* only 85% of the farmers are members. It is very unusual that only 9% were provided with machineries from the FO *Thalathuoya* and 25% in *Pahathahewaheta*. Majority of farmers in both divisions get advices on new technologies from FOs and extension officers. However, little support is given on marketing for farmers by these institutions in both divisions. The use of credit facilities is higher in *Pahathahewaheta* than *Thalatuoya*.

Table 4: Services available for farmers
(% of farmers having these services out of total 50 farmers)

Service	Benefits	Thalathuoya	Pahathahewahata
Farmer organization	Membership	100.00	85.71
Benefits	Machineries	8.69	25.00
	Marketing	17.39	0.00
	New technologies	82.61	53.57
Extention services	Availability	82.61	85.71
Benefits	New Technologies	82.61	82.14
	Marketing	17.39	10.71
Use of credit facilities		43.48	60.71

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3.4 Level of Technology Adaptation by Farmers

The level of level of adaptation of various technologies in two GN divisions is given in table 5. Despite irrigation and IPM technologies in *Pahathahewaheta* other technologies are well received by the farmers. It seems most farmers are well aware of new varieties introduced. Adhering to the recommendation of fertilizers of the DOA of the farmers is almost 80%. Use of irrigation techniques like drip irrigation and sprinkler irrigation is at a very low level.

Table 5: Level of adaptation of technologies

Technology	Thalathuoya (%)	Pahathahewahata (%)
New varieties	60.87	64.29
Application of DOA recommendation	78.26	82.14
Use of soil conservation methods	78.26	60.71
Mulching	52.17	60.71
Use of IPM techniques	65.22	17.39
Use of Irrigation technologies	17.39	32.14

3.5 Factors Affecting Extra K Application and Half Burnt Rice Hull Application

Logit regression model specified in equation 3 was estimated separately for each technology results are given in Table 6. The results shows that except the monthly income of the household head other variables do not significantly affect adoption of extra K application. In contrast application of HBRH is significantly affected by the monthly income, years of experience in farming and availability of credit facilities.

Table6: Factors Affecting the Adoption of New Technologies

	Application of extra K doses			Application of half burnt rice hull		
	Coefficient	S.E.	Significance Pr>|z|	Coefficient	S.E.	Significance Pr>|z|
Monthly income (Rs.)	0.001	0.001	0.03**	0.001	0.001	0.05*
Land extent ac)	0.85	0.84	0.31	-0.83	0.72	0.25
Experience in farming (years)	-0.06	0.04	0.09	0.10	0.05	0.03**
Land Ownership (Own = 1, 0 otherwise)	0.31	1.48	0.84	-0.32	2.15	0.88
Service EOs (available = 1, 0 otherwise)				-0.73	1.57	0.64
Availability of Credit (available = 1, 0 otherwise)				5.68	2.32	0.01**
Education (Higher than O/L =1, 0 otherwise)	1.33	1.28	0.29	-0.66	1.17	0.57
Constant	-0.41	1.42	0.78	2.48	1.27	0.05
Log likelihood		34.52			43.56	
Cox & Snell R Square		0.36			0.32	
Nagelkerke R Square		0.47			0.45	
Sample size		51			51	

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It is evident from the results that farmers should have a financial capacity to adopt these technologies since the adaptation incurs extra cost. It seems that the farmers are aware of the impacts of using HBRH to control the postharvest losses through many years of experience in cultivation. In addition, availability of credit facilities also enhances the application of HBRH.

Conclusions

It can be concluded that the application of extra doses of potassium fertilizer and the half burnt rice hull is cost effective can be disseminated to the farmers after repeating the experiments in larger scale.

This study concludes that farmers in the survey areas are quite experienced in vegetable cultivation. Majority of them have the services of extension officers and the farmer organizations and are the members of the farmer organizations. However, they have a very little support in farm machineries and marketing facilities. Majority of the farmers are already adopting technologies like new varieties, soil conservation and adhering to the fertilizer recommendation by the DOA. However, they are very poor in adopting new irrigation techniques which may be attributed to the high initial costs of materials. Farmers are still not willing to accept high cost technologies like application of extra doses of K fertilizer since they are not aware of the net returns. Therefore, the awareness programme should be carried out to convince the farmers. To increase the financial capacity credit facilities should be increased and thereby technology adoption can be improved.

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