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Full Length Research Paper

Round potato (*Solanum tuberosum*) profitability and implications for variety selections in the Southern Highlands of Tanzania

Hosea Mpogole* and Reuben M. J. Kadigi

Department of Agricultural Economics, Sokoine University of Agriculture, Tanzania.

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According to the standard economic theory that treats a person as a maximising agent of short run profit, it would be expected that farmers would select round potato varieties with the highest profit potential. However, previous studies treated round potato as one variety and other adoption studies often assumed that profitability was not important in the adoption of improved varieties. Therefore, this study analysed the profitability of round potato and the implications for variety selections by using a sample of 510 farmers drawn from three districts of the Southern Highlands of Tanzania. The main question was whether smallholder round potato farmers considered profit potentials or are there other factors in variety selections? The results showed that *Kagiri* was the most profitable variety and there were significant differences in profitability among varieties. However, not many farmers produced *Kagiri* because they used their own criteria in order to make profit. Such criteria included the availability of seed tubers, preferences of the local consumers and processors, common practices, yield, and suitability for home consumption. It was recommended that the role of plant breeders should go beyond the crop characteristics, such as, yield potential, response to inputs, and tolerance to diseases, so as to include both farmers and consumers' preferences.

Key words: Irish potato, potatoes, profitability, smallholder farmers, variety selection.

INTRODUCTION

Round potato (*Solanum tuberosum*) is the main root and tuber crop and the third most important food crop in the world after rice and wheat, which grows in over 125 countries, and is consumed by over a billion people [International Potato Centre (CIP), 2008]. Annual production exceeds 320 million tons, where China, which is the world's biggest producer of round potato, produces over 70 million tons a year (FAOSTAT, 2008). Both production and consumption of the crop has been increasing. For example, round potato production in the world is increasing at an annual rate of 4.5% and area planted at 2.4% (CIP, 2008; FAOSTAT, 2008). Tanzania produces about 504,000 tons annually and most of this output comes from the Southern Highlands of Tanzania (SHT) (URT, 2007). Studies have shown that round potato produces remarkable quantities of calories comparable to cereals and that it is more profitable than many other food crops (Scott et al., 2000; CIP, 2008; FAOSTAT, 2008). This means that the crop can serve both for food as well as for income to the rural population.

However, round potato is not just one as there are many different varieties. Those varieties have different characteristics such as dry matter content, taste, yield, response to inputs, and tolerance to diseases (UARC, 1990; Goossens, 2002). The variations in round potato varieties indicate that there could be different markets for respective varieties, and hence, different profitability. Nonetheless, previous studies on round potato production and marketing in Tanzania, such as, the work of Anderson (1996, 2008), Koizumi (2007), Mwakasendo et al. (2007), Kabungo (2008), and Namwata et al. (2010), treated round potato as one variety. Also,

*Corresponding author. E-mail: hmpogole@yahoo.com, hosea.mpogole@tumaini.ac.tz. Tel: +255(0)262720900, +255(0)713492528. Fax: +255(0)262720904.

adoption studies often assumed that profitability was not important in the adoption of production technologies such as improved varieties (Mafuru et al., 2007). As such, there was a dearth of knowledge regarding the criteria that farmers consider in selecting the round potato varieties they produce.

According to the standard economic theory that treats a person as a maximising agent of short run profit, it would be expected that farmers would select round potato varieties with highest profit potential (Rudra, 1983; Ellis, 1988). Therefore, this study analysed the profitability of round potato and the implications for variety selection. The main question was whether smallholder round potato farmers in SHT considered profit potentials in variety selections. Also, if profit does not matter, then what are the factors that do? An understanding of the reasons why farmers select the crops or crop varieties they cultivate will help the private and government institutions to identify the appropriate strategies and the support required to stimulate commercial production (Lukanu et al., 2004). It will also help plant breeders to know the farmers' considerations in variety selections rather than developing crop varieties using yield, response to inputs and tolerance to diseases as the sole criteria.

EMPIRICAL ANALYSIS

Analytical techniques

In carrying out profitability analyses, a number of studies use gross margin (GM) and net margins as indicators to estimate crop and farm profitability (Al Said et al., 2007). Usually, net margins are different from net returns because the cost of management, cost of capital, and the opportunity cost of the land are not accounted for (Takele, 2001; Maredia and Minde, 2002; Al Said et al., 2007; Ortega-Ochoa et al., 2007; Moniruzzaman et al., 2009; Ojo and Ehinmowo, 2010; Sulumbe et al., 2010). For example, Al Said et al. (2007) used the GM (1) to estimate the crop and farm profitability of farms specialising in vegetable production.

$$GM_i = Yield_i \times \mathrm{Pr}ice_i - Variable\cos ts_i \qquad (1)$$

Where, $yield_i$ is output in kg/unit of land for crop i; $price_i$ is the price of output i in units of money/kg; *variable costs*$_i$ are the cost of seeds, fertilisers, agrichemicals, occasional labour and transport to market for crop i in units of money/unit of land.

In this study, GM analysis was used to determine the profitability of round potato production. The fundamental advantages of GM analysis as an economic tool include, its easiness to understand and utilise the logical interrelations of economic and technological parameters, and its ability to forecast rational variants for the operational structure of an enterprise or individual farmer. Although, GM analysis does not include fixed and/or overhead costs, it does give a clear indication of financial direction. Equation 1 was further disentangled into (Equation 2):

$$GM = P_Q Q - P_i X_i \qquad (2)$$

Where P_Q is the price of output Q, P_i is the price of ith input, and X_i is the ith input. It was assumed that Q is a function of inputs X_i and a technology parameter, T, defined by round potato variety, fertiliser use, and agrochemicals, $Q = f(X,T)$. In this study, GM was first analysed by location because the use of inputs and prices differ among the three study Districts. Second, GM was also used in the model of analysis of variance (ANOVA) from regression viewpoint to determine differences in profitability among varieties.

In ANOVA, the dependent variable is a continuous or metric variable, while the independent variable has two or more categories (Gujarati, 2006; Hair et al., 2006; Gujarati and Sangeetha, 2007). Hence, if the variety for example, has two or more categories, that is, the different varieties of round potato, then ANOVA can be used to assess whether significant differences exist in mean profitability as measured by GM.

According to Pindyck and Rubinfeld (1991), Hair et al. (2006), and Gujarati and Sangeetha (2007), a problem that can be approached using ANOVA can be approached very well using regression analysis. In fact, they argue that ANOVA and regression analysis are an illuminating and complementary way of looking at the statistical inference problem. This implies that one can study ANOVA from the regression point of view. Hair et al. (2006) and Gujarati and Sangeetha (2007) define ANOVA model as a regression model in which all regressors are exclusively dummy or qualitative in nature. Thus, an ANOVA model with one continuous dependent variable and one qualitative variable with three or more categories can be expressed as in Equation 3.

$$Y_j = \beta_0 + \sum_{i=2}^{n} \beta_{ij} D_{ij} + \mu_j \qquad (3)$$

Where Y_j is the (average) GM of agricultural produce for variety, j and D_{ij} are dummy variables. The intercept value (β_0) represents the mean value of the benchmark category and β_{ij}'s for $i \geq 2$ are differential intercept coefficients, and μ is the stochastic error term.

One can observe from Equation 3 that there are $m-1$ dummy variables. This is always the case in order to avoid perfect collinearity. According to Gujarati and Sangeetha (2007), where there is a dummy variable for each category or group and also an intercept, there is always a case of perfect collinearity, that is, exact linear relationship among the variables. Thus, the rule of thumb states that if a categorical variable has m categories, then one should introduce $(m-1)$ as dummy variables. In other words, for each qualitative regressor the number of dummy variables introduced must be one less than the categories of that variable. The category for which no dummy variable is assigned is known as the base, benchmark, control, comparison, reference, or omitted category (Pindyck and Rubinfeld, 1991; Gujarati and Sangeetha, 2007).

The ANOVA model (Equation 3) from regression point of view for the effect of variety on profitability was developed into Equation 4.

$$GM_i = \beta_0 + \beta_1 D_{1i} + \beta_2 D_{2i} + \beta_3 D_{3i} + \beta_4 D_{4i} + \beta_5 D_{5i} + \beta_6 D_{6i} + \beta_7 D_{7i} + \beta_8 D_{8i} + \beta_9 D_{9i} + \mu_i \qquad (4)$$

Where, β_0 is the (average) GM of *Kikondo* variety and μ_i is the error term.

D_{1i} = 1 if *Kikondo* variety and = 0 if otherwise;
D_{2i} = 1 if *Arka* variety and = 0 if otherwise;

D_{3i} = 1 if *Kagiri* variety and = 0 if otherwise;
D_{4i} = 1 if *Kidinya* variety and = 0 if otherwise;
D_{5i} = 1 if *Tigoni* variety and = 0 if otherwise;
D_{6i} = 1 if *Malita* variety and = 0 if otherwise;
D_{7i} = 1 if *Msafiri/Mtega* variety and = 0 if otherwise;
D_{8i} = 1 if *Sasamua/Baraka* variety and = 0 if otherwise;
D_{9i} = 1 a mixture of two or more varieties and = 0 if otherwise;
β_i for $i = 1, 2, 3, 4, ..., 9$ are the differential intercept coefficients.

Since the variable variety has nine categories as shown, Equation 4 should contain only eight dummy variables so as to avoid the incidence of perfect collinearity as pointed out by Pindyck and Rubinfeld (1991) and Gujarati and Sangeetha (2007). In this case, we let $\beta_1 = 0$ so that Equation 4 becomes:

$$GM_i = \beta_0 + \beta_2 D_{2i} + \beta_3 D_{3i} + \beta_4 D_{4i} + \beta_5 D_{5i} + \beta_6 D_{6i} + \beta_7 D_{7i} + \beta_8 D_{8i} + \beta_9 D_{9i} + \mu_i \tag{5}$$

In Equation 5, *Kikondo* variety is the control or the benchmark. The intercept (β_0) represents the mean value of the benchmark that is the mean GM of the *Kikondo* variety. The coefficients attached to the dummy variables in Equation 5, that is, β_2 through β_9 are differential intercept coefficients because they tell by how much the value of the intercept that receives the value of 1 differs from the intercept coefficient of the benchmark category (Pindyck and Rubinfeld, 1991; Gujarati and Sangeetha, 2007).

Assuming that the error term in Equation 5 satisfies all the ordinary least squares (OLS) assumptions, on taking the expectation of Equation 5 on both sides, we have the following.

Mean GM of the round potato of the *Arka* variety:

$$E(GM_i | D_{2i} = 1,\ D_{ji} = 0 \ for\ j = 3, 4, 5, ..., 9) = \beta_0 + \beta_2 \tag{6}$$

Mean GM of the round potato of the *Kagiri* variety:

$$E(GM_i | D_{3i} = 1,\ D_{ji} = 0 \ for\ j = 2, 4, 5, 6, 7, 8, 9) = \beta_0 + \beta_3 \tag{7}$$

Mean GM of the round potato of the *Kidinya* variety:

$$E(GM_i | D_{4i} = 1,\ D_{ji} = 0 \ for\ j = 2, 3, 5, 6, 7, 8, 9) = \beta_0 + \beta_4 \tag{8}$$

Mean GM of the round potato of the *Tigoni* variety:

$$E(GM_i | D_{5i} = 1,\ D_{ji} = 0 \ for\ j = 2, 3, 4, 6, 7, 8, 9) = \beta_0 + \beta_5 \tag{9}$$

Mean GM of the round potato of the *Malita* variety:

$$E(GM_i | D_{6i} = 1,\ D_{ji} = 0 \ for\ j = 2, 3, 4, 5, 7, 8, 9) = \beta_0 + \beta_6 \tag{10}$$

Mean GM of the round potato of the *Msafiri/Mtega* variety:

$$E(GM_i | D_{7i} = 1,\ D_{ji} = 0 \ for\ j = 2, 3, 4, 5, 6, 8, 9) = \beta_0 + \beta_7 \tag{11}$$

Mean GM of the round potato of the *Sasamua/Baraka* variety:

$$E(GM_i | D_{8i} = 1,\ D_{ji} = 0 \ for\ j = 2, 3, 4, 5, 6, 7, 9) = \beta_0 + \beta_8 \tag{12}$$

And the mean GM of the round potato of the mixture of two or more varieties:

$$E(GM_i | D_{9i} = 1,\ D_{ji} = 0 \ for\ j = 2, 3, 4, ..., 8) = \beta_0 + \beta_9 \tag{13}$$

Similarly, the mean GM of the round potato of the *Kikondo* variety which is the benchmark category, is β_0 or:

$$E(GM_i | D_{ji} = 0,\ for\ j = 2, 3, 4, ..., 9) = \beta_0 \tag{14}$$

Equations 6 through 14 tell us that the mean GM of round potato of the *Kikondo* variety is given by the intercept β_0, and the slope coefficients, β_2 through β_9 tell by how much the mean GM of round potato of the *Arka*, *Kagiri*, *Kidinya*, *Tigoni*, *Malita*, *Msafiri/Mtega*, *Sasamua/Baraka*, and the mixture of two or more varieties differ from the mean GM of round potato of the *Kikondo* variety.

The ANOVA model (Equation 5) from the regression point of view was run using STATA. Although, such model could also be run in SPSS 16.0, STATA provides concise results in just one table (Rabe-Hesketh and Everitt, 2007).

Study location

This study was carried out in three districts of the Southern Highlands of Tanzania namely, Njombe in Iringa region, Mbeya Rural in Mbeya region, and Nkasi in Rukwa. Njombe and Mbeya Rural districts were purposively selected because they were the leading producers of round potato in their respective regions, and the characteristics of their farmers and farming practices differed. Njombe produced predominantly one variety of round potato, which is *Kikondo* (CIP 720050) while Mbeya produced a number of varieties including *Kikondo*, *Arka*, *Kidinya*, *Kagiri*, and *Tigoni*. Also, in Mbeya Rural, it is possible to cultivate round potato throughout the year, while this is not the case in Njombe.

Njombe and Mbeya Rural Districts have better transport networks than Nkasi District. They have more access to input and output markets as well as to extension services than Nkasi District. Although, Nkasi produced only small quantities of round potato, the District was chosen for comparison purposes, to compare profitability and farmers' variety selections in areas with high and low potential (in terms of access to input and output markets).

Sampling and data collection

Data collected was purposively selected from 15 villages based on the volume of production of round potato. In those villages, respondents were randomly selected from farmers' meeting called by village executive officers (VEOs). The VEOs were informed at least a day prior to the visit, and they were requested to call for round potato farmers' meeting on the day of the visit. In total, 510 farmers (170 from each District) were included in this study. However, the proportion of women who showed up to the meetings was relatively small. This phenomenon is not uncommon for it has been well documented that the gender division of labour which allocates all childcare, household activities, and water and wood carrying to women, constraints the capacity of women to participate in market based production irrespective of opportunities (Kaaria et al., 2007; World Bank, 2009).

A pilot survey to pre-test data collection instruments and to gain familiarisation with the study areas was conducted in two villages, one in Njombe and the other in Mbeya Rural. Using a closed- and open-ended questionnaire, data was then collected on demographic and socio-economic characteristics; number and names of round potato varieties produced; farmers' preferences for certain varieties; main reasons for selected round potato variety(ies), production costs per acre; round potato output; volume of round potato sold; and selling price of variety(ies) produced in the current and previous seasons. Questionnaires were administered by five trained enumerators together with the researcher in two seasons from March 2010 to June 2011 as part of the principal researcher's PhD study.

RESULTS AND DISCUSSION

Characteristics of the surveyed round potato farmers

In a sample of 510 round potato farmers, about 70% were male while 30% were female (Table 1). As stated previously, more men show up to the round potato farmers' meetings than women. However, statistics show that in Tanzania, female constitute about 51% of the total population (NBS, 2010). Thus, it can be inferred that the higher percentage of men in this study might be a reflection of the commercial nature of round potato production in the study areas. This follows the fact that the majority of round potato farmers were doing so for commercial purposes, and it is likely that more men would be involved in it, leaving women with other food crops for home consumption and other household activities. According to Kaaria et al. (2007) and World Bank (2009) in Africa, studies have shown that when a crop is perceived as commercial, men are more likely to take over from women.

With regard to age, Table 1 shows that farmers of the age range between 30 to 44 years accounted for 56.5% of the total respondents, followed by the 45 to 64 (26.3%) and the 14 to 29 year age group (15.5%). This result indicates that few youths, for example, primary and secondary school leavers were involved in round potato production. Quite often, age is used as an indicator of farming experience. This experience makes certain informational and search costs to be easier (Luh, 1995).

Other characteristics measured were education level and marital status as shown in Table 1. About 86% of the respondents had primary education, 8% had secondary education, and nearly 5% had no formal education. It is expected that farmers with higher levels of education would be more profit-oriented than those with lower levels of education. Other studies such as Hawassi (2006) and Nkumba (2007), found that education level influenced productivity and market access. It also influences the cost of information seeking and negotiation, as well as, profit orientation (Von Braun and Kennedy, 1994; Pingali et al., 2005; Asrat et al., 2009).

Round potato productivity

Round potato productivity was measured in terms of yield per acre. Figure 1 shows yield levels of round potato for the three districts. The crop yield varied greatly in the three districts reflecting the level of inputs used. In Njombe District the minimum yield per acre was 8 (100 kg) bags and the maximum was 107 bags with the average of 44 bags (11 tons per hectare). In Mbeya Rural District the minimum yield was 4 bags per acre and the maximum was 100 bags with the average of 33 bags (8.25 tons per hectare). Nkasi District had the lowest yield, where the minimum was 1 bag per acre and the maximum was 33 bags with the average of 12 bags (3 tons per hectare).

The productivity of round potato farmers in SHT was very low. According to FAOSTAT (2008), more yields would be expected under optimal conditions. For example, the round potato yield in South Africa is 34 and in Egypt is 25 tons per hectare. This means that potential still exists for improvement of productivity by proper use of inputs such as fertilisers and herbicides and the use of clean and improved seed tubers.

Common varieties produced in the study areas

Common varieties produced in the study areas include *Kikondo*, *Arka*, *Kagiri*, *Kidinya*, and *Tigoni, Malita, Mtega, Sasamua, Baraka,* and *Msafiri*. Others include *Tana*, *Loti*, *Kala*, *Ngolofu, Subira* and *Bulongwa*. *Kikondo* is predominantly grown in Njombe while *Arka*, *Kagiri*, *Kidinya* and *Tigoni* are mostly grown in Mbeya and *Malita*. *Mtega*, *Sasamua*, and *Baraka* are some of the old varieties that are still grown mostly at Nkasi District. As it can be seen from Table 2, Njombe District produced only one variety that is *Kikondo*, which is produced mainly for commercial purposes. *Kikondo* is said to have high dry matter content suitable for boiling, baking, and processing into chips and crisps. It was also reported that farmers in Njombe grew other local varieties such as *Loti* and *Kala* for home consumption. These round potatoes for home consumption were grown in the maize fields as they were not formally planted but germinated automatically from the previous year's tubers, which remained in the fields.

Farmers in Mbeya Rural grow a number of varieties including *Kikondo*, *Arka*, *Kagiri*, *Kidinya* and *Tigoni*. However, as seen in Table 2, many farmers in Mbeya grow two or more varieties in separate fields. This is so for three main reasons. First, it is because of the fragmented nature of the family plots as characterised by steep mountain slopes and valleys. Second, it is due to the shortage of seed tubers. Unlike Njombe District, where seed tubers can remain or be stored in the field until the next season, the case of Mbeya was different. Generally, soil at Mporoto area in Mbeya Rural was moist almost throughout the year. Hence, seed tubers remaining in the field usually sprout and germinate in no time. So, farmers had to buy seed tubers almost every season from villages near the Kitulo Conservation Area

Table 1. Sex, age, education, and marital status of farmers visited.

Parameter	Njombe		Mbeya rural		Nkasi	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Sex						
Female	64	37.6	35	20.6	56	32.9
Male	106	62.4	135	79.4	114	67.1
Total	170	100.0	170	100.0	170	100.0
Age (Years)						
14-29	14	8.2	32	18.8	33	19.4
30-44	99	58.2	91	53.5	98	57.6
45-64	52	30.6	44	25.9	38	22.4
≥65	5	2.9	3	1.8	1	.6
Total	170	100.0	170	100.0	170	100.0
Education level						
No formal education	6	3.5	13	7.6	6	3.5
Primary education	139	81.8	145	85.3	157	92.4
O-level secondary education	24	14.1	9	5.3	7	4.1
A-level secondary education/certificate	1	0.6	3	1.8	0	0.0
Total	170	100.0	170	100.0	170	100.0
Marital status						
Married	146	85.9	148	87.1	157	92.4
Single	7	4.1	9	5.3	6	3.5
Separated/widowed	17	10.0	13	7.6	7	4.1
Total	170	100.0	170	100.0	170	100.0

At this area the soil conditions are said to be similar to that of Njombe. The third reason is that Mbeya is within the catchment of Uyole Agricultural Research Centre (UARC), which sometimes distributes improved seed tubers.

Profitability of round potato by location

Profitability analysis for round potato production was carried out using the GM analysis as in Equation 2. The GM analysis was segregated by district. Results showed that round potato production in the study areas was highly profitable as indicated by the GM in Table 3. As mentioned previously, the yield per unit of land was highest in Njombe followed closely by Mbeya Rural. However, the selling price was lowest in Njombe. This was due to the fact, that almost all farmers in Njombe produced the round potato at about the same time, thus lowering their bargaining power and farm gate prices. Round potato production in Mbeya Rural was practiced throughout the year thus fetching higher prices especially at times when there was little or no production in Njombe. The average selling prices per 100 kg bag were 17,000 Tanzanian shillings (TZS) in Njombe, 22,000 TZS in Mbeya Rural, and about 26,000 TZS at Nkasi. The high farm gate prices at Nkasi District were due to the low production in this

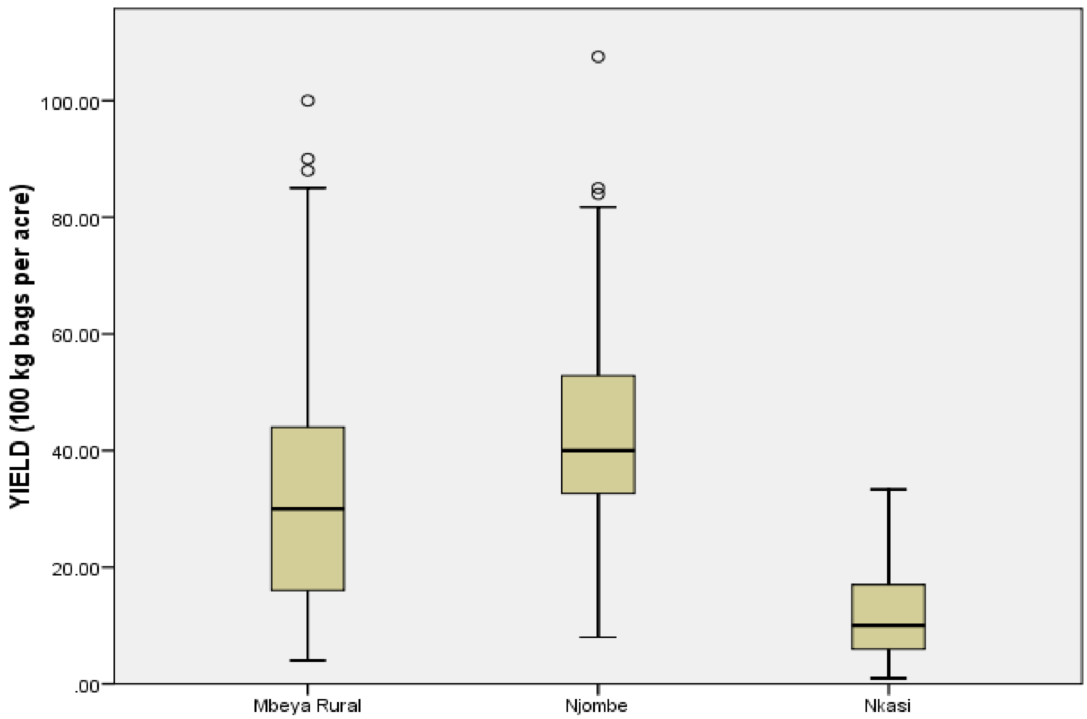

Figure 1. Round potato productivity in the study areas.

Table 2. Common varieties grown in the study areas.

Variety	Mbeya Rural		Nkasi		Njombe	
	Frequency	%	Frequency	%	Frequency	%
Kikondo (CIP 720050)	24	14.1	0	0.0	170	100.0
Arka	43	25.3	33	19.4	0	0.0
Kagiri	17	10.0	0	0.0	0	0.0
Kidinya	13	7.6	0	0.0	0	0.0
Tigoni	12	7.1	0	0.0	0	0.0
Malita	0	0.0	43	25.3	0	0.0
Msafiri/Mtega	0	0.0	29	17.1	0	0.0
Sasamua/Baraka	0	0.0	15	8.8	0	0.0
Two or more varieties on separate plots	61	35.9	8	4.7	0	0.0
Mixed varieties in same plot	0	0.0	42	24.7	0	0.0
Total	170	100.0	170	100.0	170	100.0

area. However, because of high yield per unit area, Njombe obtained the highest gross revenues.

In terms of operating costs, farmers in Njombe District store their own seed tubers for the next farming season while in Mbeya Rural, farmers purchased seed tubers almost every other farming cycle. At Nkasi District, majority of the farmers does not buy the seed tubers and most of the farm work are done by themselves with only a few cases of hired labour. As such, operating costs were minimal at Nkasi because of low or non-use of inputs and hired labour.

Results of the ANOVA model from regression viewpoint

ANOVA from regression view point Equation 5 was carried out to determine if significant differences existed in mean GM by varieties. The results of the model are given in Table 4. The results showed that all varieties were profitable since $\beta_0 + \beta_i > 0$ for $i = 2,3,4,...,9$. However, significant differences existed in profitability among the round potato varieties. The most profitable varieties were *Kagiri*, followed by *Tigoni*, *Kikondo* and *Arka*. The

Table 3. Round potato profitability analysis by districts.

S/N	Description	Mbeya Rural		Njombe		Nkasi	
		Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
1	Acres under round potato production	1.93	1.50	1.92	1.12	1.03	0.66
2	Total output (100 kg bags)	103.68	311.48	91.39	83.99	12.94	13.40
3	Output per acre (100 kg bags/acre)	33.13	21.70	43.96	17.26	11.74	6.92
4	Selling price (TZS per 100kg bag)	21,661.00	5,594.53	17,042.00	4,412.61	25,899.00	4,670.44
5	Gross Income (TZS/acre)	742,320.00	543,722.00	758,170.00	364,100.00	307,200.00	193,715.00
6	Seed buying (TZS per acre)	168,510.00	53,260.78				
7	Farm clearing (TZS per acre)	7,915.30	9,654.89	11,204.00	13,277.08		
8	Tillage (TZS per acre)	47,413.00	37,169.67	28,571.00	4,756.67	13,309.00	4,666.38
9	Sowing (TZS per acre)	30,276.00	9,199.18	24,608.00	5,151.63		
10	Weeding (TZS per acre)	34,010.00	11,673.61	31,260.00	10,907.80	18,245.00	7,444.21
11	Fertilisers (TZS per acre)	109,020.00	49,653.89	119,370.00	47,546.24		
12	Chemicals (TZS per acre)	17,644.00	12,138.33	25,101.00	10,519.09		
13	Spraying (TZS per acre)	14,012.00	5,834.19	12,888.00	4,376.80		
14	Harvesting and carriage (TZS per acre)	75,054.00	48,464.39	44,121.00	15,635.59	22,840.00	19,335.65
15	Total operating costs (TZS/acre)	338,670.00	231,779.00	284,420.00	83,502.29	51,695.00	23,416.17
16	Gross Margin (TZS/acre)	458,210.00	454,244.00	489,600.00	358,418.00	262,550.00	193,183.00
17	Return per shilling invested (16)/(15) (TZS)	1.35		1.72		5.08	
18	Return per bag harvested (16)/(3) (TZS)	13,829.75		11,137.96		22,370.00	

GM of the *Kikondo* variety was about 484,900 TZS as represented by β_0. This GM is quite comparable with that of 489,600 TZS in Table 3 for Njombe District, which produced *Kikondo* variety only. The GM of other varieties was found by taking $\beta_0 + \beta_i$ for $i = 2,3,4,...,9$. For instance, the mean GM were 794,889 TZS for *Kagiri*, 618,167 TZS for *Tigoni*, and 377,743 TZS *Arka*.

It was reported that *Kagiri* was sold in Zambia and Malawi where it was mostly preferred and fetched at higher prices. However, not many farmers produced it as it was not very much preferred by the local consumers and processors. *Tigoni*, the variety which is increasingly popular because of its comparable taste to *Kikondo* and higher yields, was the second profitable variety after *Kagiri*.

Farmers selections of round potato varieties they produce

Given the empirical results in Table 4, it was expected that majority of round potato farmers were producing *Kagiri*, which is the most profitable variety. However, the result of Table 2 was contrary that, in which only a very small proportion of farmers produces *Kagiri*. This is also contrary to the standard economic theory that farmers are maximisers of short run profits, and that they would grow such crops or crop varieties that have a promise of yielding higher profits. This incident leads us to further examine what then are the criteria that farmers considered in selecting the varieties they produced.

The results as shown in Table 5 indicated that the criteria considered in variety selection varied among the three Districts. In Njombe District, about 38% reported that the main criterion in variety selection was the market demand, while those who reported availability of tubers at their local level was 19.4%, selling price was 16%, common practice was 11%, and yielding variety was 11%. In Mbeya Rural, those who said that

Table 4. Results of the ANOVA model from regression viewpoint.

Variety	Proxy parameter	Coefficient	Std. error	t
Arka	β_2	-107157.30**	44854.87	-2.39
Kagiri	β_3	309989.30***	93000.60	3.33
Kidinya	β_4	-183788.50*	103266.50	-1.78
Tigoni	β_5	133267.00	107609.50	1.24
Malita	β_6	-183754.50***	67003.15	-2.74
Msafiri/Mtega	β_7	-231251.60***	73656.99	-3.14
Sasamua/Baraka	β_8	-193626.90*	107609.50	-1.8
Mixed varieties	β_9	-220923.40***	79664.46	-2.77
_cons	β_0	484899.60***	24283.99	19.97

***, Significant at 1%; **, significant at 5%; *, significant at 10%.

Table 5. Farmers' criteria for variety selections.

Main reason for variety selections	Njombe		Mbeya		Nkasi	
	Frequency	%	Frequency	%	Frequency	%
High selling price for the variety	27	15.9	40	23.5	0	.0
High yielding variety	19	11.2	4	2.4	18	10.6
Most demanded in the market	64	37.6	56	32.9	12	7.1
Resistant to pests and diseases	1	.6	1	.6	1	.6
Seed tubers availability/most available	33	19.4	56	33.0	108	63.5
Recommended by extension officers	2	1.2	0	.0	2	1.2
Suitability for home consumption	5	2.9	13	7.6	6	3.5
Common practice	19	11.2	0	.0	23	13.5
Total	170	100.0	170	100.0	170	100.0

seed tubers availability was the main criterion in variety selection was 33% and those who said market demand was also about 33%, while selling price was 23.5% and suitability for home consumption was about 8%. Lastly, at Nkasi District those who stated that the main criterion was seed tubers availability at their locale was 63.5%, while common practice was 13.5%, yield was about 11%, and market demand was about 7%.

As mentioned previously, Njombe District produced only one variety partly because of market demand and availability of seed tubers. The majority of the farmers reproduced the seed tubers hence having same variety in all farming seasons. Also, it was reported that *Kikondo* has high dry matter content suitable for boiling, baking, and processing into chips and crisps making it the most preferred variety by local consumers and processors.

Availability of seed tubers and market demand were the main criteria in variety selection in Mbeya Rural District. Seed tubers created a great challenge because of the year round moist soil and the lack of storage facilities made the storage of the tubers for the next season to be difficult. Hence, majority of the farmers had to purchase the seed tubers from some distant villages, because such tubers were not available in abundant, quite often farmers had to purchase the varieties that were available. This is evidenced by the fact that farmers in Mbeya produced many different varieties at the same time (Table 2) because of the difficulty in obtaining enough tubers of one preferred variety.

Round potato variety selection at Nkasi District was mostly based on availability of tubers and the varieties that were traditionally popular in their locale. Incidences of mixed varieties in one plot were very common in this District. As such, a good proportion of farmers were not able to name the varieties they produced.

The behaviour of smallholder farmers making use of more production criteria than profit criteria in variety selections is not uncommon. For example, other studies such as Bekele et al. (2011), Hemachandra and Kodithuwakku (2010), Kudi and Abudlsalam (2008), Beckford (2002), and Rudra (1983) generally indicate that farmers had greater inclination towards production orientation than profit orientation. This leads us to conclude that farmers are not irrational, they have their own important criteria for the production decisions they make. This conclusion is however not completely new. According to Beckford (2002), smallholder farmers should be treated as a special case, because in their farming decisions they consider many factors perhaps more important than profit.

Conclusion

The study found that *Kagiri* was the most profitable variety and that there were significant differences in profitability among varieties. According to the standard economic theory which treats farmers as maximising agents of short run profit, it was expected that many farmers would produce *Kagiri*. However, this was not the case because farmers were proved to have their own criteria other than profit. Such criteria included the availability of seed tubers, preferences of the local consumers and processors, common practices, yield, and suitability for home consumption. It is therefore, recommended that the role of plant breeders should go beyond the crop characteristics such as yield potential, response to inputs, and tolerance to diseases so as to include both farmers and consumers' preferences.

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