THE INFLUENCE OF FARMERS' ADOPTION BEHAVIOUR ON MAIZE PRODUCTION EFFICIENCY

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ABSTRACT

Although problems normally addressed in agricultural development are concerned with some form of production efficiency, most adoption studies do not focus much on the contribution of adoption behaviour to the production efficiency. Instead, they concentrate more on the determining factors and their influence on adoption of recommended practices. This study was therefore designed to determine the contribution of farmers' adoption of recommended maize production practices, namely maize varieties, seed spacing, fertilization and weeding on production efficiency in order to assess the soundness of the advice given to farmers. The research was conducted in the Njombe district, using a structured questionnaire to collect data from 113 farmers, randomly selected and representing five percent samples of four villages. The results show that most of the farmers (97.3 percent) production efficiency falls well below the achievable maize yield of about 40 bags per acre. The overall low level of adoption of the recommended and investigated practices as well as their highly significant correlation with yield goes a long way in explaining the low production efficiency. However the fact that these practices explain only 55 percent of the yield variation leads to the conclusion that extension and research haven't all the answers, either in terms of the nature and completeness of recommended practices or in terms of the appropriate criteria for their measurement.

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1. INTRODUCTION

Agriculture is the backbone on the Tanzanian economy accounting for about half of the national income and slightly more than half of merchandise exports. The importance of agriculture is further emphasized by the fact that about 80 percent of Tanzanians depend on agriculture as a source of food and income (World Bank, 2001). This implies that progress in reducing poverty, malnutrition and food insecurity in Tanzania depends greatly on the performance of the agricultural sector.

The issue of improving agriculture in order to increase its productivity has been given due emphasis and attention in Tanzania. For example after the independence in 1961, the government adopted a number of approaches towards agricultural development, which include the Transformation Approach (1962-1966), the Improvement Approach (1963-1966), the Commodity Approach (1978-1983). Besides this various projects were initiated such as the Sasakawa Global 2000 (1989-1998), the National Agricultural Extension Program (NALERP-1989-1996), the Southern Highlands Extension and Rural Finance Project (1994-2001), the National Agricultural Extension Project Phase II (NAEP-1996-2001), and the FAO Special Program for Food Security (1995 -) (Sicilima & Rwenyagira, 2001).

The main cash crops grown in the country include coffee, sisal, cashew, cotton, tobacco and pyrethrum, while the main food crops include maize, sorghum, millet, rice, wheat, pulses (mainly beans), cassava and potatoes. Among these food crops, maize is the most important cereal food crop, and implies that a shift towards self-sufficiency in food production in Tanzania depends to a greater extent on the improvement of maize production.

Njombe district is one of the districts that is famous for the production and supply of maize in the country. Most of the extension programmes like Sasakawa Global 2000 and others were initiated and introduced in areas particularly suited for maize production, with the object of promoting recommended maize production practices in a package form.

A package consists of the combined use of recommended maize varieties, fertilizers, seed spacing, pesticides application and weed control. Although numerous practices are being recommended to farmers, very little is known about their direct influence on maize production efficiency, which represents the goal of the majority of extension programmes. This could be partially attributed to the fact that different disciplines or sub-disciplines are involved in the agricultural-technical or production research, which is not necessarily conducive for a holistic approach. But also from an extension point of view the focus is seldom on the influence of behaviour (practice adoption) on the results of adoption behaviour, namely efficiency. Instead, most adoption studies (Bwana, 1996; Temu, 1996; Semgalawe, 1998; Kalineza, 2000) concentrate more on the influence of behaviour determinants on the adoption of recommended practices, although the ultimate concern is efficiency or more efficient production. This is understandable in the context of Düvel's (2004) assertion, namely that the problems in agricultural development ultimately revolve around issues of efficiency and effectiveness. These are normally the result of certain behaviour (practice adoption) and usually imply the non-adoption or incorrect adoption of certain recommended practices.

The objective of this paper is therefore to assess the role of farmers' adoption of some of the practices recommended to farmers, of which the more important ones are maize varieties, seed rate, fertilization and weeding.and to establish whether the advice offered to farmers by extension workers can be improved.

2. METHODOLOGY

A validated, pre-tested structured questionnaire was used to collect data through personal interviews from 113 farmers. These were randomly drawn, representing five percent samples of four villages selected to represent the biggest variation in terms of bio-climatic conditions within the Njombe district. The collected data were coded, computer-captured, cleansed and then analyzed using the statistical package for social sciences (SPSS). Correlations, chi-square and regressions were used to determine the relationship between the adoption of the recommended practices and production efficiency.

3. RESULTS AND DISCUSSION

3.1 Production efficiency

In this study, yield, expressed in terms of bags[3] per acre, is used as a criterion for evaluating the level of production efficiency of maize farming. The reason for choosing yield as a criterion is due to the fact that it is easy to get reliable information regarding the total harvest from which the mean yield per acre can be calculated. The same does not apply to, for example, financial criteria such as the marginal return or net income per acre, because few farmers keep accurate records and are, therefore, not in a position to provide accurate or reliable responses. Yields for the 2003/2004 season are shown in Figure 1

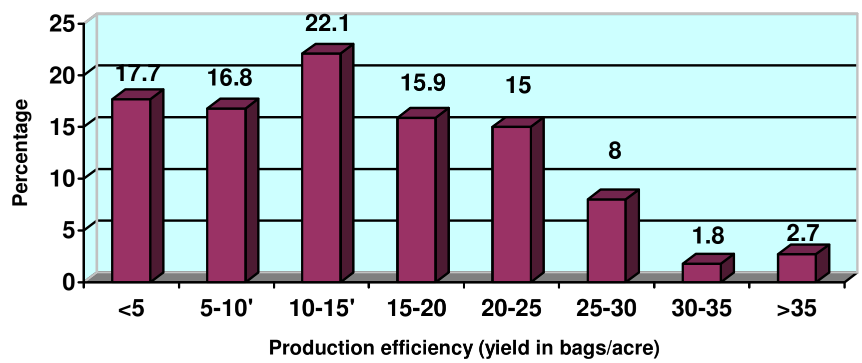

Figure 1: Percentage distribution of the respondents according to their production efficiency as reflected in yield (bags per acre) (N=113)

Measured against the achievable yield of about 40 bags per acre (Liana, 2005) it is clear that the current production falls well below it. Evidence of this is the skew distribution shown in Figure 1, with 72.5 percent of the respondents falling below the halfway mark and only 2.7 percent having accomplished the desired level.

3.2 Adoption of recommended maize production practices

The recommended maize production practices investigated in this paper include the use of recommended maize varieties, seed spacing

3 *One bag is equivalent to 100 kg.*

and weed control and fertilization. Each of these practices is assessed individually in the following subsections to determine the general level of adoption and the influence on production efficiency.

3.2.1 Seed

The recommended maize varieties for the study area include UH 615, UH 625, H 614, H 628, SC 627, S 627 and P 67. Although different varieties of improved maize seeds have been recommended, most farmers do not buy recommended hybrids but use local varieties or select from previous planted hybrid instead. This pattern of behaviour regarding seed varieties is reflected in Table 1.

Table 1: Distribution of respondents according to maize seed adoption and production efficiency as reflected in yield (bags/acre) (N=113)

Type of seed	Yield categories (bags/acre)							
	<10		10-20		>20		Total	
	(n)	(%)	(n)	(%)	(n)	(%)	(N)	(%)
Replanted hybrid (1)	20	43.5	18	39.1	8	17.4	46	40.7
Local varieties (2)	17	36.2	19	40.4	11	23.4	47	41.6
Recommended hybrid (3)	2	10.0	6	30.0	12	60.0	20	17.7
Total	**39**	**34.5**	**43**	**38.1**	**31**	**27.4**	**113**	**100.0**

χ^2 = 14.716; d.f.=4; p=0.005 *r = 0.392; p=0.000*

According to Table 3.2 only 17.7 percent of the interviewed farmers buy the recommended hybrids. The consequence of this poor adoption of the recommended varieties is expected to find expression in the level of production efficiency. The results in Table 1 reveal a highly significant correlation (r=0.392; p=0.000) between the seed used and the maize yield, implying that the better the seed choice is, the higher the yield tends to be. For example 60 percent of those respondents using the recommended hybrids had yields of more than 20 bags per acre, while the percentage of those replanting hybrid seed or using local varieties was only 17.4 percent and 23.4 percent, respectively.

To establish whether the local varieties contribute more to the maize yield than replanted hybrids or the *visa versa*, the scale items and scale points were inversed. Although the results still revealed a significant relationship (r = 0.249; p=0.00), the fact that correlation is significantly less, seems to indicate that the use of local varieties is a better practice than the replanting of hybrids. This is potentially valuable information for extension, but should be further researched to verify these findings, and also to be able to differentiate more specifically between the influence of different local varieties and replanted hybrids.

3.2.2 Seed spacing

The recommended spacing for full season varieties of maize is 25-30 cm by 75-90 cm with one plant per hill and 50 by 90 cm with two plants per hill. Respondents' adoption behaviour regarding the seed spacing is summarized in Table 2 below.

Table 2: Distribution of respondents according to the adoption of seed spacing and production efficiency (bags/acre)

No of seeds	Seed spacing (cm)	Population/ acre (x 1000)	Yield categories (bags/acre)							
			<10		10-20		>20		Total	
			n	%	n	%	n	%	N	%
1	<20 x <60	40-45	2	66.7	1	33.3	0	0.0	3	3.2
	20-25 x 60-75	30-35	16	32.0	26	52.0	8	16.0	50	52.6
	25-30 x 75-90	20-25	14	33.3	12	28.6	16	38.1	42	44.2
	Total		**32**	**33.7**	**39**	**41.1**	**24**	**25.3**	**95**	**100**
1,2[4]	20-25 x 60-75	30-35	2	50.0	1	25.0	1	25.0	4	40.0
	25-30 x 75-90	20-25	3	50.0	2	33.3	1	16.7	6	60.0
	Total		**5**	**50.0**	**3**	**30.0**	**2**	**20.0**	**10**	**100**
2	<25 x <75	> 50	1	100.	0	0.0	0	0.0	1	12.5
	25-50 x 75-90	30-35	1	16.7	1	16.7	4	66.7	6	75.0
	50 x 90	20-25	0	0.0	0	0.0	1	100	1	12.5
	Total		**2**	**25.0**	**1**	**12.5**	**5**	**62.5**	**8**	**100**

One seed/hill (r= 0.182; p= 0.078)
One, two seeds/ hill (r= -0.052; p= 0.886)
Two seeds/hill (r= 0.583; p= 0.129)

The majority of respondents (84 percent) plant only one seed per hill and there are no indications that planting alternatively one and two or planting two seeds per hill leads to higher yields. The high rainfall

[4] *In a row for example, if the first hill is planted with one seed then the second hill is planted with two seeds. This is repeated for the whole row.*

conditions suggest that moisture is no limiting factor and that higher plant populations could be associated with higher yields. However, this does not seem to be the case. On the contrary, in the case of one seed and two seeds per hill the findings in Table 2 indicate significant correlations at 7.8 and 12.9 percent probability respectively. Although not highly significant, there is again a recognisable tendency for higher yields to be associated with smaller plant populations. For example among the group of farmers planting one seed per hill not a single respondent using the high plant population (more than 40 000 plants per acre) harvested more than 20 bags per acre, while as many as 38.1 percent with a plant population of 20 000 to 25 000 plants achieved more than 20 bags per acre.

From these findings it appears that there has been an over-adoption regarding the seeding rate or that the recommendation going out to farmers has not been adequately tested and verified. Another possibility is that the interaction between seeding rate and weeding and fertilization has not yet been clearly disentangled.

3.2.3 Weeding

Weeds interfere with crop growth through competition for water, light and nutrients. Some weeds may also harbour insect pests and diseases that directly infect the crop plants, consequently causing losses in yield (Temu, 1988). In the Southern Highlands of Tanzania where the study area was located, yield reductions resulting from weeds have been recorded to range from 60-75 percent of the potential yield (Croon *et al.,* 1984).

Table 3 shows the distribution of respondents according to the weed infestation and maize yield. The weed infestation was based on the occurrence of three types of weeds that are important because of their drastic effect on maize yields, namely "Wandering Jew", couch grass and nut grass. An occurrence of all three types was assessed as "heavy", while a light infestation referred to the occurrence of only one of the three serious weeds.

Although maize fields should be free of weeds, the weed infestation in general is very high with 55.7 percent of the respondents having weed infestations assessed as medium to high. The highly significant correlation (r= -0.587; p=0.000) between the degree of weed infestation and yield suggests that this is one of the reasons for the poor overall yields in the survey area.

Table 3: Distribution of respondents according to weed infestation and production efficiency (yield in bags/acre)

Weed infestation	Yield categories (bags/acre)							
	<10		0-20		>20		Total	
	n	%	n	%	n	%	N	%
None	0	0.0	5	38.5	8	61.5	13	11.5
Low	7	18.9	14	37.8	16	43.2	37	32.7
Medium	10	25.6	23	59.0		15.4	39	34.5
High	22	91.7	1	4.2	1	4.2	24	21.2
Total	**39**	**34.5**	**43**	**38.1**	**31**	**27.4**	**113**	**100.0**

χ^2 =58.110; df=6; p=0.000 *r= -0.587; p=0.000*

To overcome weed infestation, the recommended weeding frequency in the study area is three times or more, but, according to Table 4, which gives an overview of the weeding frequency, the percentage respondents weeding twice or three times are more or less the same. No single respondent weeds more than three times.

Table 4: Distribution of respondents according to weeding frequency and production efficiency (yield in bags/acre)

Weeding frequency	Yield categories (bags/acre)							
	<10		10-20		>20		Total	
	n	%	n	%	n	%	N	%
Twice	22	40.0	18	32.7	15	27.3	55	48.7
Thrice	17	29.3	25	43.1	16	27.6	58	51.3
Total	**39**	**34.5**	**43**	**38.1**	**31**	**27.4**	**113**	**100.0**

χ^2 = 1.734; df = 2; p = 0.42 *r = 0.82, p = 0.386*

The findings in Table 4 provide no evidence in support of a relationship between weeding frequency and production efficiency (r = 0.82, p = 0.386). A possible reason for the low relationship between the weeding frequency and yield is that the weeding frequency is a function of weed infestation, which, as has been shown in Table 3, is negatively correlated with yield. It is assumed that farmers with a higher weed infestation are inclined to weed more frequently. However, this assumption is not supported by the data (r = -0.151, p = 0.111) If anything, the opposite seems to be case, namely that farmers with the lower degree of weed infestation tend to weed more frequently, perhaps because they are more convinced of the harmful effects of weeds. The fact that the weeding frequency not necessarily becomes manifested in higher yields, may be attributed to the fact that the measures that are used in this study to measure the influence of weeding on production efficiency are not very accurate or fail to differentiate between different levels of weeding effectiveness. A more refined measure of weeding is therefore required to shed more light on the causality relationship between weed control and production efficiency.

3.2.4 Fertilization

Maize plants have a relatively high demand for nutrients, particularly for nitrogen, phosphorus and potassium for obtaining high yields. These important nutrients can be supplied through application of inorganic fertilizers or farmyard manure (TARO, 1987). The measures used for assessing fertilization were the application of phosphate and nitrogen fertilizer and the time of nitrogen application, viz. whether as basal application or as topdressing. The relationships between these measures and production efficiency (yield per acre) are shown in Table 5.

The general adoption rate is low, with only 10,6, 30,1 and 25.7 percent meeting the recommendation for phosphate application, nitrogen application and the time of nitrogen application. In all cases there is a highly significant correlation with production efficiency (yield), with nitrogen fertilization probably contributing most towards higher production (r=0.685; p=0.000) This is understandable in view of the high annual rainfall (1200 to 1600 mm per annum) and the tremendous leaching effect. It is for this reason that the time of application has a significant influence on the yield and the findings clearly show that, if only one application of nitrogen is made, it is better to apply it all as top-dressing rather than at planting.

Table 5: Distribution of respondents according to their adoption of fertilizer practices and production efficiency as reflected in yield (bags/acre) (N=113)

Fertilization	Yield categories (bags/acre)							
	1-10		10-20		>20		Total	
	n	%	n	%	n	%	N	%
1. Phosphate fertilization								
<30 kg per acre	34	49.3	26	37.7	9	13.0	69	61.1
30-50 kg per acre	4	12.5	14	43.8	14	43.8	32	28.3
>50 kg per acre	1	8.3	3	25.0	8	66.7	12	10.6
r=0.551; p=0.000								
2. Nitrogen fertilization								
<25 kg per acre	19	90.5	2	9.5	0	0.0	21	18.6
25-50 kg per acre	13	37.1	20	57.1	2	5.7	35	31.0
50-75 kg per acre	4	17.4	12	52.2	7	30.4	23	20.4
>75 kg per acre	3	8.8	9	26.5	22	64.7	34	30.1
r=0.685; p=0.000								
3. Time of N_2 application								
All at planting (1)	3	75.0	1	25.0	0	0.0	4	3.8
All as topdressing (2)	27	36.5	33	44.6	14	18.9	74	70.5
At planting and topdressing (3)	1	3.7	9	33.3	17	63.0	27	25.7
r=0.479; p=0.000								

3.2.5 Maize production practices as package

The importance of the various practices is evident from the above findings, but the question as to whether they explain all or enough of the variation found in terms of production efficiency remains unanswered. An indication of this can be obtained from regression analyses of which the results are shown in Table 6.

According to Table 6, the influence of the recommended maize production package on the maize yield is significant (R^2 = 0.560, p = 0.000) but explains only 56 percent of the yield variation. This suggests that there are still many unanswered questions in terms of the appropriateness of currently recommended practices or in terms of their measurement.

Table 6: Regression analysis of the various maize production practices on production efficiency (Yield in bags/acre) (N = 113)

Variable	Beta	t	p
(Constant)		-3.070	0.003
Maize variety	0.054	0.633	0.528
Phosphate fertilizers	0.201	2.316	0.023
Nitrogen fertilizers	0.395	4.567	0.000
Time of Nitrogen fertilization	0.238	3.091	0.003
Seed spacing	0.175	2.503	0.014
Weeding frequency	0.013	0.182	0.856
Number of seeds per hill	0.079	1.099	0.274

$R^2 = 0.550$, $p = 0.000$

4. CONCLUSION AND EXTENSION IMPLICATIONS

The findings confirm the close and significant relationship between the various practices and production efficiency (yield) thereby justifying their promotion through extension. Judging from the degree of adoption of the various practices, which is on average less than 25 percent, there is still tremendous scope for improvement. Noteworthy is that the total contribution of all included practices towards the explanation of yield variation is only about 55 percent, which suggests that there are clear limitations regarding the increase of yields that can be accomplished with the promotion of these practices.

This implies a tremendous challenge still resting with extension and research in terms of the development and refinement of extension messages. This could imply the identification of further practices, a refinement of the current ones and/or a refinement of assessment scales.

It is meaningful that the mere inclusion of weed infestation as an independent variable already increases the regression (R^2) or explanation of variation from 55 to 72 percent and contributes more than any of the included practices. The fact that weed control, measured as weeding frequency, did not significantly contribute towards the regression, clearly shows that the measure used is inappropriate and that much work needs to be done in order to come up with appropriate and practical measures for assessing the level of weed control for baseline or for extension output purposes. The same applies, albeit to a lesser degree, to other recommended practices and it would appear that this is an area frequently overlooked by research, thereby largely failing in its knowledge support function. A further complication of the fact that extension often lacks appropriate criteria and scales and no absolute standards of adoption behaviour, is that an analysis of behaviour determinants becomes very difficult with no clear independent variable.

All this calls for closer collaboration between extension and research in the area of message development, refinement and outcome evaluation.

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