CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Chapter three begins by providing a brief description of the Njombe district, where the study was conducted. This is followed by the description of the population and sampling procedures, instrumentation and data collection, definition of the study variables and finally the statistical analyses procedure used.

3.2 DESCRIPTION OF THE STUDY AREA

The study was confined to the Njombe district in the Iringa Region of the Southern highlands of Tanzania. The district is located between 8.8^0 and 9.8^0 South of the equator, and 34.5^0 and 35.8^0 Longitudes. Its altitude is between 1000 and 2000m above sea level; and hence has a cool climate with the possibilities of frost during the months of June and July, causing scorching of some crops that are still in a vegetative stage. The district receives up to 1600mm of rainfall per annum mainly from November/ December to April/ May. The dry season is from June to October.

The main activity carried out by people in the Njombe district is Agriculture. The major food crops grown include maize, beans, wheat and potatoes where as the major cash crops are maize, potatoes and pyrethrum. This means that the district depends largely on maize as food as well as cash crop. Several types of livestock like goats, sheep, pigs, local (indigenous) chicken and small numbers of cattle are kept.

3.2.1 Reasons for choosing Njombe district.

The reasons why Njombe was chosen as survey and study area are the following:

- It is one of the districts where the improved agricultural packages for grain production like maize has been introduced.

- It is famous and important for the production of maize and is one of the areas that the country mainly depends on for supplying food grains like maize.

- It was easily accessible for the researcher and thus more affordable as far as traveling expenses are concerned. The area also has good roads that are passable throughout the year.

3.3 THE POPULATION AND SAMPLING PROCEDURE

In view of limited financial resources placing limitations on the number of interviews, the survey sample was ultimately restricted to 113 maize growers, which were randomly drawn and represented five percent samples of four [1]villages selected to represent the biggest variation in terms of climatic conditions within the Njombe district of Tanzania. Justification for the compromise between the sample percentage and the number of villages was based on the contention of Boyd *et al.,* (1981), namely that a sample size of about five percent is a fairly representative one.

3.4 INSTRUMENTATION AND DATA COLLECTION

Primary data collection began by a preliminary/reconnaissance survey that involved familiarization visits, introduction of the study objectives and informal discussion with farmers, village leaders and extension staffs in the study area. The main objective was to get a better understanding of the study area that helped in refining the research problem, identifying the major information gaps and guiding the sampling process. In addition the questionnaire was thoroughly discussed with researchers and extension officers, then pre-tested and thereafter the main survey commenced where by the final version of the pre-tested questionnaire (Appendix 1) was used to collect data from sampled respondents.

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[1] The villages were purposefully selected on the basis of their accessibility

Secondary data for this study were obtained from books, journals, reports and other documents from Library at the University of Pretoria, Sokoine University of Agriculture, Regional and District agricultural offices, Internet and other related sources.

3.5 VARIABLES AND THEIR MEASUREMENT

3.5.1 Independent variables

Some of the independent variables considered in this study are among the ones that have been identified as important in determining the adoption behaviour by numerous studies (Rogers, 1983; Mattee and Mvena, 1988; Gass and Bigs, 1993; Lyatuu, 1994; Machumu, 1995; Amir and Pannel, 1999; Sicilima and Rwenyagira, 2001). These include the individual socio-economic and personal characteristics of farmers like age, sex, formal education, farm size and area under maize.

Age:

Age of the respondent was measured in terms of the total number of years one had lived from his/her birth to the period when the survey was conducted. The respondents' ages were then categorized into three age groups namely; young (less than 36 years), middle (36-56 years) and old (more than 56 years).

Sex:

Sex was measured by grouping the respondents into their state of being a male or a female therefore two categories were used.

Formal education:

Measured in terms of the number of years of formal schooling attained by the time of the survey. These were then categorized into the following categories:

1. Those who had not attended formal schooling at all
2. 1-7 years of schooling
3. More than 7 years of schooling

Farm size:

Farm size was determined by asking the respondents to indicate the size of the land they own. Most of the farmers in the study area, and Tanzania in general, are subsistence farmers with small farm sizes, which were categorized as small (<3 acres), medium (3-6 acres) and large (>6 acres).

Farm sizes were measured in acres because this is the unit that is commonly used in the study area. Since the majority of respondents have mall farms the conversion of acres to hectares was thought of not importance because it could have resulted into fractions that are very difficult for some people to grasp the clear picture of farm sizes.

Area under maize:

This refers to the part of the land used to grow maize at the time of the survey. The categorization applied ranged from small (<=1 acre) to medium (1.1-3 acres) to large (>3 acres).

3.5.2 Intervening variables

The intervening variables explored in this study include those which have been found to be important in the prediction of behaviour based on extensive research done in South Africa and Ethiopia by researchers like Düvel, 1975; Louw and Düvel, 1993; Düvel and Scholtz, 1986; Botha, 1986; Düvel and Botha, 1999; Habtemariam, 2004.

These are need related aspects (efficiency misperception, need tension, need compatibility), knowledge (awareness of the solutions) and perception (prominence, advantages and disadvantages).

Efficiency misperception

Closely associated with the perceived current efficiency is the efficiency misperception or the degree to which individuals incorrectly (usually overrate) their efficiency (Düvel, 2004). To establish this, farmers were asked to estimate their own efficiency. The enumerator also did a similar rating based on objective (researched) guidelines or criteria. In both cases a five-point scale was used in order to assist in calculating farmers' degree and percentage of misperception. For this the following formula was used.

Degree of overrating/underrating = Farmers' scale point - Enumerators scale point

Percentage overrating/underrating = (A – B)-1)/4*100 where as,
A = represents farmer's own assessment (scale point)
B = represents enumerator's assessment (scale point) based on research findings
1 is the first figure in the five-point scale, and has to be subtracted in order to make the lowest point on the scale = 0
4 is the difference between the highest and the lowest scale points (5 - 1).

The percentages obtained were then categorized into [2]underrating, slightly underrating, assess correctly, slightly overrating, overrating

[2] Underrating/slightly underrating and overrating/slightly overrating are presented by negative and positive signs respectively while a correct assessment is presented by a zero implying that both farmers and enumerator have the same assessment. In other words the farmer assessed his/her situation of practice adoption correctly.

Need tension:

The NT or problem perception refers to the perceived discrepancy between the present situation and the desired situation or level of aspiration (Düvel, 2004). Based on this definition, farmers were asked to indicate their present and aspired level (or goals) of practice adoption. It is expected that the higher the goal or level of aspiration the higher the need tension. Farmers were then grouped into [3]three categories namely; low, medium, and high need tension.

Need compatibility:

Since need compatibility is a measure of whether the recommended solution fits into the need situation of an individual or contributes towards the attainment of his/her needs, this variable was measured by requesting the respondents to estimate the level of production efficiency they would have attained if they had used (or not used) the suggested practices. The percentage changes in production efficiency were then calculated using the formula below. Based on the obtained results the respondents were categorized into low, medium and high need compatibility.

$A = C – B/B*100$

Where A = Percentage change in production efficiency

B= Current production efficiency

C= Production efficiency they would have attained if not used the suggested practices

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[3] With exception of efficiency misperception and awareness, the categorization of the intervening variables into low, medium and high was based on how one was assessed in a given scale. Low category represented those respondents that were assessed in low scale levels; medium category represented those that were assessed in medium scale levels while high represented those who were in high scale levels. For example, in a 5-point scale, 1-2 level could represent low, 3-4 could represent medium while 5 could represent high.

Awareness

It refers to an awareness of recommended solutions or the optimum that is achievable in terms of efficiency. In this case awareness refers as the knowledge of recommended maize production practices in the study area. Based on this definition awareness was measured by requesting farmers to indicate the recommended maize production practices that they are aware of in their area and making an assessment on the following scale: 1) Not aware 2) Aware

Perceived total attributes of Innovation:

Where needs relate to all positive or driving forces which in total constitute the attractiveness, perceptions are understood to be of a more specific nature and are analyzed on the basis of attributes of innovations (Düvel, 2004). The Perception aspects looked at in this study include prominence, relative advantages and disadvantages of the maize production practices.

Prominence

According to Düvel (2004) prominence is synonymous with Rogers' (1983) concept of relative advantage, which he defines as the degree to which an innovation is perceived as being better than the idea it supersedes. Based on this definition farmers were asked to indicate what they regarded to be the best practice(s) or to compare their own practice with the recommended one. According to the perceived prominence, individuals were categorized into three groups namely, low prominence, medium prominence and high prominence.

Relative advantages/disadvantages of recommended practices

These attributes were captured by requesting the respondents to (a) list the advantages and disadvantages and (b) to assess their importance on a five-point semantic scale. The former was assumed to refer to the number of positive and negative forces, while the latter, namely the weightings, served as an indication of their strength. Both these measures were used in an analysis of the influence of the perceived advantages and disadvantages on adoption behaviour. Due to the time consuming nature and scope of these questions, they were only posed in respect of certain practices, namely maize varieties and fertilization.

It was of interest also to evaluate the role of individual advantages (positive forces) and disadvantages (negative forces) on the adoption behaviour. To achieve this some of the advantages and disadvantages perceived to be more important were considered. It is noteworthy that some of the advantages were regarded as negative forces while some of the disadvantages were considered as positive forces. Due to this the advantages were categorized as 1) Negative force 2) Low positive force 3) Medium positive force 4) High positive force. The disadvantages were categorized as 1) Positive force 2) Low negative force 3) Medium negative force 4) High negative force

3.5.3 Dependent variables:

These include production efficiency and recommended maize production practices, although the latter do assume independent character in Chapter 4 where the focus is on influence of practice adoption on production efficiency.

Production efficiency

Yield in terms of bags per acre for the 2004/2005 season was used to measure the production efficiency. Since the overwhelming majority of the respondents harvested below the optimum or achievable yield of about 40 bags per acre, the following classification was used:

1) <10 bags/acre 2) 10-20 bags/acre 3) >20 bags per acre

Recommended maize production practices

Maize varieties:

This variable was measured by asking the respondents to indicate maize varieties they used for the 2004/2005 season. Most of the respondents grew replanted hybrid, local varieties and recommended hybrids and so the categorization was according to the variety used.

Phosphate fertilization

This practice was measured by requesting respondents to indicate the rate of phosphate fertilization used in the 2004/2005 season. The responses were then categorized into: 1) <30 kg/acre 2) 30-50 kg/acre 3) >50 kg/acre

Nitrogen fertilization

The measurement of nitrogen fertilization was based on the amount of nitrogen applied as well as the time of application. The responses given to the amount of nitrogen applied were categorized into an adoption scale consisting of

1) <25 kg/acre 2) 25-50 kg/acre 3) 50-75 kg/acre 4) 75 kg/acre.

For responses regarding the time of fertilizer application, provision was made for the following categories: 1) At planting only 2) As top dressing only 3) At planting and as top dressing.

The scale for total nitrogen fertilization was a combination of the rate and time of application scales, and resulting in the following adoption scale: 1) low adoption (<5 scores) 2) Medium adoption (5-7scores) 3) High adoption (>7 scores).

Total fertilization package

The recommended fertilization package for the Njombe district involves the use of all the fertilization practices discussed above. The scale used to assess the adoption of fertilization as a whole, consisted of a summation of all the scores and the following categorizations were used: 1) low adoption (<6 scores) 2) Medium adoption (6-10 scores) 3) High adoption (>10 scores).

Seed spacing

The recommended number of maize seed per hill is one or two but in 2004/2005 season the overwhelming majority of the surveyed respondents used one seed per hill. Due to this the analyses and discussion on the factors influencing the adoption of this practice focused on those farmers who used one seed only. Seed spacing was obtained by asking the respondents to indicate which spacing was used in maize production for 2004/2005. The responses were classified into:

1) <20 x <60 2) 20-25 x 60-75 3) 25-30 x 75-90.

Each category of seed spacing was then used to compute the plant population per acre.

Weeding

Weeding is a practice assumed to have a major influence on yield, because weeds compete with the crop for nutrients and moisture. The approach used to differentiate between the effectiveness of weed control and thus its adoption was based on how often they weed their maize fields. It was assumed that this can vary between one and three times, but ultimately the variation allowed for only two scale points: two times (1) and three times (2).

The degree of weed infestation was also thought to have a tremendous influence on the production efficiency. The measurement of weed infestation was based on the occurrence of three most important types of weeds that are most harmful because of their drastic effect of maize yields namely; *tradescantia fluminerisis* (wandering jew), *cynodon dactylon* (cough grass) and nut grass. An occurrence of all three types was assessed as high infestation, while low and medium infestation referred to the occurrence of one and two serious weeds, respectively.

3.6 DATA ANALYSIS

The data collected through means of coded questionnaires was – captured, cleansed and analyzed using the statistical package for social sciences (SPSS). Descriptive statistics such as frequencies, percentages and means were done as a first step towards determining the distribution of the variables (general findings). Graphics like bar charts were used to summarize large amounts of information while correlations, chi-square, and regressions were used to determine the relationship between the independent and the dependent variables.

Chi-square analyses were used in combination with two-dimensional contingency tables to establish whether significant differences occurred between the various categories or groups. This also allowed for the identification of relationship other than linier correlations, which are normally not detected with correlation analyses.

Bivariate correlation analyses were employed to assess the existence, magnitude (strength or degree) and kind (negative or positive) of relationship that exist between the independent and the dependent variables. This was achieved by computing the correlation coefficients and significance or probability. According to De Vos (1998), Morgan and Grego (1998), Mallery & George (2003), the correlation coefficient, *r* range in value from –1 to +1. A correlation coefficient of +1 designates a perfect, positive relationship implying that one variable is precisely predictable from the other variable and as the one increases in value (or decreases) the other similarly increases (or decreases).

A correlation coefficient of 0 indicates no relationship between the two variables whatsoever, while that of –1 represent a perfect, negative correlation. Negative indicate that as one variable increases in value, the other variable decreases in value.

Mallery and George, 2003 assert that perfect correlations (positive or negative) exist only in mathematical formulas and direct physical or numeric relations. The non-perfect positive ($0<r<1$) and non-perfect negative ($-1<r<0$) are common types of correlation or relationship that exist between two variables. In the interpretation of analyses a probability of less than 5 percents ($p<0.05$) was interpreted as statistically significant.

Multiple linear regression analysis were used to investigate the effect of various independent variables (predictors) on the dependent (an outcome) variable. The regression analysis is also an indicator of how well one or more independent variables predict the value of a dependent variable (Lugole, 2005). Due to this fact the model was also used to assess the degree to which the various independent and intervening variables contribute towards explaining the dependent variable variance. According to Tabachnick and Fidell (2001), the regression model is based on the following:

$$Y = A + B_1X_1 + B_2X_2 + \ldots + B_kX_k$$

Where Y is the predicted value on the dependent variable, A is the Y intercept, the Xs represent the various independent variables (of which there are k), and the Bs are the coefficients assigned to each of the independent variables during regression.

CHAPTER 4

PRODUCTION EFFICIENCY AND ADOPTION OF RECOMMENDED MAIZE PRODUCTION PRACTICES

4.1 INTRODUCTION

Although production efficiency is the function of the adoption of recommended practices and the most important goal of developing and promoting the practices, most of the adoption studies (Bwana, 1996; Temu, 1996; Semgalawe, 1998; Kalineza, 2000) 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. Düvel (2004) asserts that the problems normally addressed in agricultural development are concerned with some form of production efficiency. These are normally the result of a certain behaviour (practice adoption) and usually imply the non-adoption or incorrect adoption of certain recommended practices. Düvel's (1991) behaviour analysis model, that this study is based on, accommodates the concept of production efficiency as the consequence of adoption behaviour.

This chapter provides an overview of the status of maize production efficiency in the study area. Also the influence of each practice adoption as well as total adoption of recommended maize production package on production efficiency will be assessed in this chapter.

4.2 PRODUCTION EFFICIENCY

In this study yield in terms of [4]bags per acre is used as a criterion for evaluating the status of production efficiency of maize farming. The motive behind choosing yield as a criterion is due to the fact that it is easy to get reliable information regarding the total yield from which the mean yield per acre can be calculated. Yields for the 2003/2004 season are shown in Table 4.1.

[4] One bag is equivalent to 100 kg

Table 4. 1: Distribution of the respondents according to their production efficiency as reflected in yield (bags per acre)

Yield categories (bags/acre)	Respondents	
	N	%
<5	20	17.7
5-10	19	16.8
10-15	25	22.1
15-20	18	15.9
20-25	17	15.0
25-30	9	8.0
30-35	2	1.8
>35	3	2.7
TOTAL	113	100.0

Seen against the research findings (Liana, 2005) that the optimum maize yield per acre in the study area is judged to be 36-40 bags, it is evident that most (97.3 percent) of the farmer's production efficiency falls well bellow that level. The target of 36-40 bags is not unrealistic as one of the surveyed farmers managed to get a yield of 42 bags per acre.

4.3 ADOPTION OF RECOMMENDED MAIZE PRODUCTION PRACTICES

The recommended maize prodcc varieties, use of fertilizers (phosphate, nitrogen, time of nitrogen fertilizer application), spacing and weed control. Each of these practices will be assessed individually in the following subsections to determine the general level of adoption and its influence on production efficiency.

4.3.1 Seed

The recommended maize varieties in 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 instead they use local varieties or select from previous planted hybrid. The latter is discouraged because it is likely to result in a drastic decrease in yield and uniformity and farmers are thus recommended to obtain fresh supplies of hybrid maize seed every season. Respondents' adoption behaviour regarding the seed used is summarized in Table 4.2.

Table 4. 2: Distribution of respondents according to maize seed adoption and production efficiency as reflected in yield (bags/acre)

Seed adoption	**Yield categories (bags/acre)**							
	1-10		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

$\chi^2 = 14.716$; df=4; p=0.005

r = 0.392; p=0.000

According to Table 4.2 only 17.7 percent of the interviewed farmers buy the recommended hybrids. Some of the reasons for the non-adoption of recommended hybrids, as reported by the respondents, are fake seeds, poor resistance to diseases, poor milling quality of the grain, high seed costs, low storability and poor taste. These reasons for the non-adoption of recommended maize varieties will be explored in more detail later.

The consequence of non - and or low adoption of recommended hybrid maize is expected to find expression in the level of production efficiency. The results in Table 4.2 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. The results are in line with hypothesis of the study, which states that there is a relationship between adoption of recommended practice and production efficiency.

Data were further analyzed to check whether the local varieties contribute more to the maize yield than replanted hybrids or the *vise versa*. This was achieved by interchanging the scale points of the two seed categories. Local varieties were assigned a score of one instead of two and replanted hybrids were assigned a score of two instead of one as indicated in Table 4.3.

Table 4. 3: Distribution of respondents according to maize seeds adoption and production efficiency as reflected in yield (bags/acre)

Seed adoption	Yield categories (bags/acre)							
	1-10		10-20		>20		Total	
	(n)	(%)	(n)	(%)	(n)	(%)	(N)	(%)
Local Varieties (1)	17	36.2	19	40.4	11	23.4	47	41.6
Replanted hybrid (2)	20	43.5	18	39.1	8	17.4	46	40.7
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; df=4; p=0.005

r = 0.249; p=0.008

Although the results in Table 4.3 reveal a significant correlation (r= 0.249; p=0.008) between the seed use and the maize yield, the correlation is lower than when the scores of seed categories were not interchanged, implying that local varieties contribute more to maize yield than replanted hybrids.

4.3.2 Fertilization

The 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 recommended fertilizers for maize production in the study area are phosphate fertilizers like tri-super phosphate (TSP), di-ammonium phosphate (DAP), Minjingu rock phosphate (MRP) and nitrogen fertilizers like urea, CAN (calcium ammonium nitrate), NPK (nitrogen, phosphate, potassium) and farm yard manure (FYM). Among these, the commonly used fertilizers are TSP, DAP, Urea, CAN and FYM.

The following sections will evaluate individually the influence of adoption of phosphate, nitrogen and time of application of nitrogen fertilizers in production efficiency. Furthermore, the influence of the adoption of the total fertilizer package on production efficiency will be assessed.

4.3.2.1 Phosphate fertilizers

The recommended application of phosphate fertilizer is more than 50kg/acre at planting. In Table 4.4 the respondents' rate of fertilizer application is summarized. Although farmers are advised to apply the recommended rate of phosphate fertilizer, the adoption rate is still low. Most of the respondents (61.1 percent) apply less than 30kg/acre of phosphate fertilizers with only 10.6 percent of respondent farmers applying more than 50 kg/acre.

Table 4. 4: Distribution of respondents according to phosphate fertilizer adoption and production efficiency as reflected in yield (bags/acre)

Phosphate fertilization (kg/acre)	Yield categories (bags/acre)							
	1-10		10-20		>20		Total	
	n	%	n	%	n	%	N	%
<30	34	49.3	26	37.7	9	13.0	69	61.1
30-50	4	12.5	14	43.8	14	43.8	32	28.3
>50	1	8.3	3	25.0	8	66.7	12	10.6
Total	39	34.5	43	38.1	31	27.4	113	100

χ^2 =27.092; df=4; p=0.000

r=0.551; p=0.000

The results reveal a highly significant correlation (r=0.551; p=0.000) between phosphate fertilizer application and the maize yields, implying that the higher the amount of phosphate fertilizers application is, the higher the yield tends to be. For example 66.7 percent of those respondents using more than 50kg/acre of phosphate fertilizers had yields of more than 20 bags per acre, while the percentage of those applying less than 30kg/acre of phosphate fertilizers was only 13 percent.

4.3.2.2 Nitrogen fertilizers

The recommended rate of nitrogen fertilizer is at least 75 kg/acre. As in the case of phosphate fertilizer the adoption rate of the nitrogen fertilizer, summarized in Table 4.5, is still low. For example, about 70 percent of interviewed farmers do not apply the recommended rates of nitrogen fertilizer.

Table 4.5: Distribution of respondents according to nitrogen fertilizer adoption and production efficiency as reflected in yield (bags/acre)

Nitrogen fertilization (kg/acre)	Yield categories (bags/acre)							
	1-10		10-20		>20		Total	
	n	%	n	%	n	%	N	%
<25	19	90.5	2	9.5	0	0.0	21	18.6
25-50	13	37.1	20	57.1	2	5.7	35	31.0
50-75	4	17.4	12	52.2	7	30.4	23	20.4
>75	3	8.8	9	26.5	22	64.7	34	30.1
Total	39	34.5	43	38.1	31	27.4	113	100

r=0.685; p=0.000

The results reveal a highly significant correlation (r=0.685; p=0.000) between nitrogen fertilizer application and the maize yield, implying that the higher the amount of nitrogen fertilizer application is, the higher the yield tends to be. For example 64.7 percent of those respondents using more than 75kg/acre of nitrogen fertilizer had yields of more than 20 bags per acre, while not a single farmer applying less than 25kg/acre of nitrogen fertilizers had a yield of more than 20 bags/acre. The findings are in agreement with hypothesis of the study.

4.3.2.3 Time of nitrogen fertilizer application

In the study area it is recommended that about 33 percent of nitrogen fertilizers should be applied at planting and about 66 percent as topdressing. However according to Table 4.6, which gives an overview of the time (stage) of nitrogen application, the larger majority of the farmers apply all of it as top dressing only. Of the 105 respondents who use nitrogen fertilizer few farmers (25.7 percent) apply nitrogen fertilizer at planting and as topdressing as it is recommended.

Table 4.6: Distribution of respondents according to time of nitrogen fertilizer application and production efficiency as reflected in yield (bags/acre)

Time of Nitrogen fertilizer application	Yield categories (bags/acre)							
	1-10		10-20		>20		Total	
	n	%	n	%	n	%	N	%
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 as topdressing (3)	1	3.7	9	33.3	17	63.0	27	25.7
Total	31	29.5	43	41.0	31	29.5	105	100.0

χ^2 =25.211; df=4; p=0.000

r =0.479; p=0.000

The results show a highly significant correlation (r=0.479; p=0.000) between the time of nitrogen fertilizer application and yield. For example 63.0 percent of those respondents using nitrogen fertilizer at plating and as topdressing had yields of more than 20 bags per acre, while not a single farmer applying nitrogen fertilizer at planting only had a yield of more than 20 bags/acre.

The scale used to measure nitrogen application assumes that if only one nitrogen fertilization is applied, it is better to apply all the nitrogen as topdressing than to apply it all at planting. The findings in Table 4.6 seem to justify this, because 75 percent of the respondents who applied all their nitrogen at planting had low yields (less than 10 bags) while among those who apply all nitrogen fertilizer as top-dressing only 36.5 percent fall into the low yield category. This conclusion that, if only one application of nitrogen is made, it is better to apply it all as top-dressing rather than at planting is also supported by a lower correlation (r = 0.401) if these two items on the scale are interchanged. The likely reason for the better effect of nitrogen when applied as topdressing rather than at planting is the high degree of leaching due to the high rainfall that is 1200-1600mm per annum.

4.3.2.4 Fertilizer package

The scores for the adoption of the total fertilization package were obtained by adding the scale points of the individual fertilizer practices[5] already discussed. The scores were then categorized into three groups namely, <6 scale points for low adoption, 6-10 for medium adoption and 11-15 for high adoption. The survey results in respect to the adoption of the total fertilizer package are summarized in Table 4.7.

Table 4.7: Distribution of respondents according to fertilizer package adoption and production efficiency as reflected in yield (bags/acre)

Total fertilization package	**Yield categories (bags/acre)**							
	1-10		10-20		>20		Total	
	n	%	n	%	n	%	N	%
<6	23	82.1	5	17.9	0	0.0	28	24.8
6-10	12	26.1	26	56.5	8	17.4	46	40.7
11-15	4	10.3	12	30.8	23	59.0	39	34.5
Total	39	34.5	43	38.1	31	27.4	113	100

χ^2 =57.183; df=4; p=0.000

r=0.632; p=0.000

According to Table 4.7, the minorities of respondents fall into the low adoption category. For example, 24.8 percent fall under this category while 75.2 percent fall under the medium and high adoption score categories. The results also reveal a highly significant correlation (r=0.632; p=0.000) between fertilizer package adoption and the maize yield, implying that the higher the package adoption score is, the higher the yield tends to be.

[5] The scale points for total fertilization package were obtained before the individual fertilizer practices were re-categorized

For example 59.0 percent of those respondents with high adoption score (11-15 scale points) had yields of more than 20 bags per acre, while not a single farmer with a low adoption score (less than 6) had a yield of more than 20 bags/acre. The results are in agreement with those from maize fertilizer demonstrations conducted by the *Kilimo*/FAO fertilizer program, which proved that poor fertilization generally results in poor yields (United Republic of Tanzania, 1991).

4.3.3 Seed Spacing

The recommended spacing for full season varieties of maize is 25-30 cm by 75-90 cm with one plant per hill. In the Southern Highlands area (where the study area is located) with an altitude of over 1,500 m and reliable rainfall, planting two plants of maize per hill at 50 by 90 cm gives the same yields as a single plant per hill at 25-30 cm by75-90 cm (TARO, 1987). Respondents' adoption behaviour regarding the seed spacing is summarized in Table 4.8 below.

Table 4. 8: Distribution of respondents according to seed spacing adoption and production efficiency as reflected in yield (bags/acre)

Number of seeds	Seed spacing (cm)	Yield categories (bags/acre)							
		1-10		10-20		>20		Total	
		n	%	n	%	n	%	N	%
One	<20 x <60	2	66.7	1	33.3	0	0.0	3	3.2
	20-25 x 60-75	16	32.0	26	52.0	8	16.0	50	52.6
	25-30 x 75-90	14	33.3	12	28.6	16	38.1	42	44.2
	Total	32	33.7	39	41.1	24	25.3	95	100.0
One, two[6]	20-25 x 60-75	2	50.0	1	25.0	1	25.0	4	40.0
	25-30 x 75-90	3	50.0	2	33.3	1	16.7	6	60.0
	Total	5	50.0	3	30.0	2	20.0	10	100.0
Two	<25 x <75	1	100.0	0	0.0	0	0.0	1	12.5
	25-50 x 75-90	1	16.7	1	16.7	4	66.7	6	75.0
	50 x 90	0	0.0	0	0.0	1	100.0	1	12.5
	Total	2	25.0	1	12.5	5	62.5	8	100.0

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)

According to Table 4.8 there is no significant relationship between seed spacing and the maize yield (r = 0.182, p= 0.078; r= -0.052, p= 0.886 and r= 0.583; p= 0.129) indicating that seed spacing has little effect on yield. The results might be inaccurate either because of 1) the wrong estimations of the seed spacing used due to the fact that most of the respondents use step or foot measures estimations instead of the recommended rope or stick. 2) The inappropriateness of the seed spacing recommendations 3) the scale used for its measurement.

[6] 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

4.3.4 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 is located, yield reductions resulting from weeds have been recorded to range from 60-75 percent of the potential yield (Croon *et al.,* 1984).

As said earlier, the most important types of weeds that are believed to contribute to a drastic decrease in the maize yield in the study area are *tradescantia fluminerisis* (wandering jew), *cynodon dactylon* (cough grass) and nut grass. The prevalence of these weeds was used as a criterion for weed infestation. These were categorized into four categories namely, "no weed infestation" for farmers who had none of the mentioned types of weeds; "low weed infestation" for farmers who had one type of weed; "medium weed infestation" for farmers who had two types of weeds and "high weed infestation" for farmers who had all three types of weeds. Table 4.9 shows the distribution of respondents according to the weed infestation and maize yield.

Table 4.9: Distribution of respondents according to weed infestation and production efficiency as reflected in yield (bags/acre)

Weed infestation	**Yield categories (bags/acre)**							
	1-10		10-20		>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	6	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

Although the prevalence of weed infestation is believed to have a significant decrease in yield, Table 4.9 shows that only few respondents have no weed infestation. Most of the respondents (91.7 percent) with the high weed infestation had a low maize yield of 1-10 bags per acre. The results reveal a highly significant negative correlation (r= -0.587; p=0.000) between the degree of weed infestation and the maize yield, which implies that the lower the degree of weed infestation, the higher the maize yield tends to be. For example 61.5 percent of those respondents without a single type of weed infestation had yields of more than 20 bags per acre, while the percentage of those with high weed infestation was only 4.2 percent.

To overcome weed infestation, the recommended weeding frequency in the study area is three times or more but, according to Table 4.10, which gives an overview of the weeding frequency, the majority of the respondents weed three times. No single respondent weeds more than three times.

Table 4.10: Distribution of respondents according to weeding frequency and production efficiency as reflected in yield (bags/acre)

Weeding frequency	Yield categories (bags/acre)							
	1-10		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

$\chi^2 = 1.734$; df = 2; p = 0.420

r = 0.82, p =0.386

According to the distributions there is a slight tendency for an increased frequency of weeding to increase yields, but this only applies below the 20 bags/acre threshold, but is not statistically significant ($\chi^2 = 1.734$; df = 2; p = 0.420; 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 4.9, is negatively related to yield.

A further analysis of the relationship between weeding frequency, degree of weed infestation and the yield is shown in Table 4.11. According to the results there is a highly significant relationship (r= -0.593; p= 0.000 and r= -0.574; p= 0.000) between degree of weed infestation and the maize yield within the weeding frequency categories.

Table 4. 11: Distribution of respondents according to weeding frequency, weed infestation and production efficiency as reflected in yield (bags/acre)

Weeding Frequency	**Weed infestation**	**Yield categories (bags/acre)**							
		<10		10-20		>20		Total	
		n	%	n	%	n	%	N	%
Twice									
	None	0	0.0	2	33.3	4	66.7	6	10.9
	Low	2	14.3	6	42.9	6	42.9	14	25.5
	Medium	7	35.0	9	45.0	4	20.0	20	36.4
	High	13	86.7	1	6.7	1	6.7	15	27.3
	Total	22	40.0	18	32.7	15	27.3	55	100.0
Three times	None	0	0.0	3	42.9	4	57.1	7	12.1
	Low	5	21.7	8	34.8	10	43.5	23	39.7
	Medium	3	15.8	14	73.7	2	10.5	19	32.8
	High	9	100.0	0	0.0	0	0.0	9	15.5
	Total	17	29.3	25	43.1	16	27.6	58	100.0

Twice: r= -0.593; p= 0.000

Three times: r= -0.574; p= 0.000

For example, 66.7 percent of those without any weed infestation and weed two times had yields of more than 20 bags per acre, while the percentage of those with high weed infestation was only 6.7 percent. The trend is the same in the case of those who weed three times. For example, 57.1 percent of those without any weed infestation had yields of more than 20 bags per acre, while not a single farmer with high weed infestation had yields of more than 20 bags/ acre.

However there is a little support for the assumption that farmers who weed less are the ones with lower weed infestations. The fact that 63.7 percent of the respondents weeding twice had a medium or high infestation of weeds as opposed to 48.3 percent of those weeding three times, rejects the view that weeding is a function of the degree of infestation in the survey area. This might 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 realistic 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.

4.4 MAIZE PRODUCTION PACKAGE

The previous section assessed the influence of individual maize production practice on production efficiency. This section will go further to evaluate the influence of maize production package in totality on production efficiency. The linear regression model was used to assess the relationship. The model results are summarized in Table 4.12.

Table 4.12: Relationship between maize production packages and production efficiency as reflected in yield (bags/acre)

Variable	Beta	t	p
(Constant)		0.003	0.998
Maize variety	0.073	1.071	0.287
Phosphate fertilizers	0.189	2.137	0.035
Nitrogen fertilizers	0.295	3.354	0.001
Time of Nitrogen fertilization	0.126	1.944	0.055
Fertilizer Package	-0.025	-0.210	0.834
Seed spacing	0.095	1.637	0.105
Degree of weed infestation[7]	-0.476	-7.609	0.000
Weeding frequency	-0.032	-0.580	0.563
Number of seeds per hill	0.110	1.918	0.058

$R^2 = 0.720$, $p = 0.000$

The total contribution of all included practices toward the explanation of yield variation is only about 55 percent. It is meaningful that the mere inclusion of weed infestation as an independent variable increases the regression (R^2) or explanation of variation from 55 to 72 percent (Table 4.12).

The degree of weed infestation explains more than any of the practices studied followed by the use of nitrogen and then the use of phosphate fertilizers. The degree of weed infestation is however, not a practice, but the findings regarding its importance do suggest that with better and more appropriate measures and indicators, degree of weed infestation would have emerged as a much more important yield or efficiency determining factor.

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[7] The degree of weed infestation is not a practice but it has been included in the model because it has an influence on yield and it was expected to have an influence on weeding frequency and consequently on the yield. Also, there is no other measure in this study found to measure the influence of weeding on production efficiency.

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.

These findings represent convincing evidence in support of the widely accepted causal relationship between practice adoption and production efficiency. More importantly, the evidence provides the basis for the behaviour analysis model, which focuses on the adoption of recommended practices as the means of increasing efficiency, in this case the yields.