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ECONOMICS OF MILLET PRODUCTION UNDER DIFFERENT CROPPING SYSTEMS IN BORNO STATE OF NIGERIA

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DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY, FACULTY OF AGRICULTURE, AHMADU BELLO UNIVERSITY, ZARIA.

April, 2000

DECLARATION

I hereby declare that this thesis was written by me and it is a record of my own research work, except where reference is made to published literature and duly acknowledged. It has not been presented before in any application for a degree.

3-6-2000

Andrew C. Iheanacho — Date

The above declaration is confirmed.

3-6-2000

Dr. D. O. A. Phillip — Date

Chairman, Supervisory Committee.

CERTIFICATION

This Thesis entitled "ECONOMICS OF MILLET PRODUCTION UNDER DIFFERENT CROPPING SYSTEMS IN BORNO STATE OF NIGERIA" by A.C. Iheanacho meets the regulations governing the award of the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

To my beloved wife, Agnes, and sons, Chigozie, Uche and Neme, for their patience, love and care during the study.

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ABSTRACT

The purpose of the study was to determine the economics of millet production under different cropping systems in Borno State of Nigeria. The specific objectives were to identify the socio-economic characteristics of the millet growing farmers; determine the resource use in the cropping systems; determine the relationship between socio-economic variables and agricultural outputs of the farmers; determine differences in cost and returns among millet crop mixtures; estimate production functions for millet cropping systems; compare relative importance and resource use efficiency of common resources used in millet crop mixtures; and identify the major technical and socio-economic problems of the millet growing farmers.

Data for the study were collected using questionnaire and interview schedules administered to 180 farmers growing millet in mixtures. Thirty six (36) farmers were randomly selected from each of the stratum of the five major millet crop mixtures grown in the study area, namely; millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut. Analysis of data was achieved by means of simple descriptive statistics, gross margin analysis, multiple regression, analysis of variance (ANOVA) and chi-square statistic (X^2).

The major findings of the study indicate that educational level of the farmers, resident household size and number of extension workers visits were the major socio-economic variables which positively and significantly affected their outputs as indicated by the linear regression model. Age and farming experience were inversely related to output. Millet/cowpea mixture was the most profitable, with gross margin of ₦20,689.03. Food security objective, however, was the major reason for growing millet in mixtures.

The semi-log production function gave the best fit for the millet-based cropping systems. Farm size was significant at 5% in all the cropping systems, except millet/groundnut. Except for millet/sorghum mixture, seed rate was found to be significant in all the crop mixtures. Fertilizer was insignificant at 5% in all the mixtures, while labour was insignificant in millet/sorghum/cowpea and millet/sorghum/groundnut production. A measure of the relative importance of the resources in production shows that land ranked first in all the mixtures, except in millet/groundnut where it ranked second, perhaps due to the extensive rather than intensive land use in peasant agriculture. Comparison of economic efficiency of resource use based on the ratio of the marginal value product (MVP) and marginal factor cost (MFC) indicates that all the inputs were under-utilized, in all the cropping systems. Millet/cowpea mixture had the highest return to scale (2.93), followed by millet/groundnut mixture (2.92), both exhibiting increasing return to scale. This implies that 1% increase in the set of inputs for millet/cowpea and millet/groundnut mixtures would increase output by 2.93 and 2.92 percent respectively. High cost of inputs was ranked as the most important agronomic problem by 50% of the farmers. This was followed by lack of finance, soil infertility, drought and erosion. Based on the findings of the study, it was recommended that farm support and tractor of animal traction services aimed at supplying adequate inputs and labour should be rendered to the farmers, while the extension service should be revitalised to ensure more visits to them. The use of organic manure to complement artificial fertilizer should be encouraged and dry planting (sene) discouraged to reduce losses due to drought.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Introduction

Nigeria is endowed with abundant physical and human resources necessary to provide ample food and export. Ogungbile and Olukosi (1992) indicated that Nigeria is furtunate to have a substantial base of agricultural research infrastructure, knowledge as well as resources, and occupies a land mass of over 90 million hectares of which about 75 percent is suitable for agriculture.

Inspite of the tremendous human and land resources in Nigeria, food supply has continued to fall below demand level. Nigeria has been finding it difficult to feed its population without recourse to massive importation of food (Fabiyi and Idowu, 1991). Estimates of the per capita food production index in grain equivalent by Food and Agricultural Organization (1992) and the Central Bank of Nigeria (1992) separately and independently show that as at 1992, the average Nigerian had less than 350 of grain equivalent weight of food available to him for the year, if he could afford to buy it. The food import bill, for instance, increased from ₦15.7 billion in 1987 to ₦375.3 billion in 1996, while the per capita caloric food intake showed a deficit of -11.3 and -9.1 percents in the same years (Tables 1 and 2).

Table 1.1: Estimated Output and Caloric Intake of Major Staple Crops in Nigeria: 1987-1992

Year	Staple Crops ('000 kg)						Per-capita caloric intake
	Cassava	Maize	Millet	Rice	Wheat	Yam	
1987	na	1357	808	138	139	4889	-11.3
1988	15540	5268	5136	2081	565	9132	-15.7
1989	17404	5008	4770	3303	554	9609	-11.3
1990	19043	5768	5136	2500	554	13624	-9.1
1991	20000	5810	4109	3185	455	16000	-9.1
1992	21320	5578	3986	3074	432	18578	-9.1

Source: Central Bank of Nigeria Economic and Financial Review Vol. 3 No. 2 June, 1993.

Table 1.2: Values of Food and Total Imports in Nigeria: 1987 - 1996 (₦' million)

Year	Food*	Total imports
1987	1704.2	15695.3
1988	1298.9	13831.3
1989	2178.8	30860.2
1990	3703.2	45717.9
1991	6622.0	89488.2
1992	13742.2	143151.2
1993	21870.0	181924.1
1994	13364.8	98747.8
1995	34837.9	254701.6
1996	50156.5	375293.1

Source: Central Bank of Nigeria, 1994; Federal Office of Statistics (FOS), Annual Abstract of Statistics (AAS), 1997. In Phillip, D.O.A. (1997)
* Including animal and Vegetable Oils.

In the past, strategies adopted for realization of food policy objectives in Nigeria emphasized mobilization of small-holders to adopt and utilize improved productive resources. Among the programmes and projects designed to achieve this policy strategies include Operation Feed the Nation (OFN), National Accelerated Food Production Programme (NAFPP), The Green Revolution and the Agricultural Development Programmes (ADPs).

To meet the food need of the rapidly growing population of Nigeria, however, increased production will have to come from overall increased yield per hectare. This can be achieved not only through the use of productive resources, but also mixed cropping of the major food crops in Nigeria. One of such major food crops is the pearl millet.

1.2 Economic Importance of Millet

The pearl millet is an important staple food crop across sub-sahara Africa and consumed by 75 percent in northern Nigeria. In the northern Guinea Savanna and Sudan Zones, it is second to sorghum, but supercedes sorghum in Sahel region (Nwasike et al., 1982). Of the 14 million hectares grown in West Africa, Nigeria (28%) is the largest producer, while the country's output represents 31% of the African output of the crop (Spencer et al., 1987). The output of millet in Nigeria was estimated at 5.136 million tones in 1990, but decreased to 3.986 million tones in 1992 (CBN, 1993). Also, the total demands for millet in Nigeria in 1997 and the year 2000 have been projected as 6.454 and 7.454 million tones respectively (Table 1.3). This is against the actual production of 5.90 million tones in 1997 and projected production of 5.96 million tones in 1999 (FAO, 1999).

Table 1.3: Projected Demand for Millet in Nigeria: 1985-2000 ('000 metric tonnes).

Year	Human Consumption per annum	Industrial Requirement	Seed Requirement	Wasted	Total Requirement
1985	4,068	511	64	142	4,785
1987	4,315	526	68	151	5,076
1989	4,578	575	72	161	5,385
1991	4,857	610	76	171	5,713
1993	5,153	647	81	180	6,061
1995	5,466	686	86	192	6,430
1997	5,799	728	91	204	6,822
2000	6,337	795	99	223	7,454

Source: Wudiri, B.B. and I.O. Fatoba (1992).

Millet is used in preparation of varieties of local dishes such as masa (millet cake), tuwo (foofoo), kunu (pap), fura and dankwali (sweets) (Iheanacho and Amos, 1996). It can also be boiled as rice. The straw is important building material for granaries and as fencing materials in areas where millet is the staple food. It is also used as livestock feed, especially during the dry season. Industrially, millet is used in preparation of alcoholic and non-alcoholic beverages, sour and Opaque beers, fermented and unfermented bread and snack foods (Rooney and McDonough, 1987; Subramanian and Jambunathan, 1980; Perten, 1983).

Sorghum and millet constitute the major food base of Sokoto, Kebbi, Katsina, Kano, Jigawa, Borno, Yobe, Bauchi, Kaduna and Plateau States of Nigeria to the tune of 80-90% of the total food need of 50 million people (Wudiri and Fatoba, 1992). Analysis of nutritive value of 180 in-bred lines of pearl millet grown at the same time in a moderately fertile soil showed protein content ranging from 8.8 to 20.9 percent, with a mean of 16% (Burton et al., 1972). According to Teriba (1994), millet is a crop that is grown where no other cereal can consistently produce harvest on sandy, infertile soils, where rainfall is low and erratic.

Inter-cropping is the dominant cropping system for millet among the small-holders in the drought prone, semi-arid tropics of West Africa, and covers 75% of the cultivated area in the region (Steiner, 1974). In northern Nigera, Norman (1974) recorded 156 different associations of crops with 40% of the areas devoted to 2-crops mixtures such as millet/sorghum and millet/cowpeas.

1.3 Problem Statement

Millet production and intercropping research are abundant (Norman, 1977; Baker, 1980; Fussel and Serani, 1985; Natare and Williams, 1992; and Baidu-Forson, 1994), yet the aggregate food supply in Nigeria has remained deficit. For example, while Nigeria's population grows at an average annual rate of about 3%, total food production in Nigeria rises by no more than 1.5% per annum on the average (United Nations, 1987; World Bank, 1990). This means that at the present level of production, the food production gap might continue to widen with time, if unchecked.

Several factors have been identified as the causes of the food shortage problem in Nigeria. Some of these are natural disasters such as drought or flood; high population growth rate; inefficiency in the use of available farm resources and wrong choice of enterprise combination or cropping systems among others. Of these problems, inefficiency in the use of available resources and choice of enterprise combination and cropping system constitute the major constraints to increased food production in Nigeria (Ogunfowora et al., 1994; Mijindadi, 1980; Okorji and Obiechina, 1985). It is on this basis that this study was aimed at examining the economics of millet production under different crop mixtures in Borno State towards increasing the level of aggregate food supply in Nigeria, to solve the food deficit problem.

The questions which the study was intended to provide answers to were:-

i. What are the millet-based cropping systems in the study area, and the socio-economic characteristics of the millet growing farmers?

ii. Do the socio-economic characteristics of the farmers affect their agricultural productivity?

iii. Are there differences in relative importance and resource use efficiency for common resources used in millet mixtures?

iv. Are there differences in profitability among the different millet cropping systems?

v. What are the major agronomic and socio-economic problems of the millet growing farmers?

1.4 Objectives of the Study

The main objective of the study is to compare economics of millet production of different crop mixtures in Borno State of Nigeria.

The specific objectives were to:

i. identify the socio-economic characteristics of the farmers growing millet mixtures;

ii. examine resource use in the cropping systems;

iii. determine the relationship between socio-economic variables and agricultural outputs of the farmers growing millet mixtures;

iv. determine the differences in costs and returns among millet crop mixtures;

v. estimate production function for millet-based cropping systems;

vi. compare relative importance and resource use efficiency for common resources used in millet crop mixtures; and,

vii. identify the major technical and socio-economic problems of the millet farmers.

1.5 Hypotheses

The following hypotheses were postulated for testing:

i. There is no relationship between the socio-economic characteristics of the farmers and the value of farm output of millet-based systems;

ii. There is no difference in profitability among the millet-based mixtures.

iii. There is no relationship between the output and inputs used in production.

iv. The resources are not efficiently utilized.

v. There is no relationship between farm size and millet-based cropping systems.

1.6 Justification of the Study

Despite the popularity of millet crop mixtures in northern Nigeria and West Africa in general, there was more emphasis on developing sole crop technologies rather than mixtures, while research endeavours were mostly centered on sole cropping. There has been a long-standing tendency to associate progressive agriculture with sole cropping (Norman, 1974). Additionally, the major focus in millet research for both sole and mixtures has remained studies on the effects of such agronomic factors as variety, density and geometry, planting dates, harvesting dates and added fertility on total productivity or physical yield (Nwasike and Egharevba, 1981; Singh, 1987; Natare and Williams, 1992 and Affholder, 1995). Little or no studies exist, especially in Borno State, where over 70% of the arable land is devoted to millet production, to compare millet crop mixtures based on economic and social considerations such as associated costs and returns, and efficiency of resource use. There is need for a bridge in the millet research gap.

Second, economists are of the view that in the face of risk and uncertainty, small-holder farmers should consciously select crop combinations that facilitate sufficient food and income for the family's need. This situation was described by Simon (1955) and Cyert and March (1968) as a "Survival algorithm". In allocating their resources, however, Nerlove (1988) has shown that farmers are finely attuned to marginal costs and returns. Thus, farmers take into consideration their production goals as well as associated costs and returns in arriving at crop combination and resource allocation. Millet inter-croppings are already closely associated with most farmers in Nigeria, and Borno State in particular. There should, therefore, be little difficulty in stimulating small-holder farmers into training and accepting millet crop mixtures based on well-validated research findings for increased productivity and profit maximization. This study provides information for research design and extension messages aimed at urging small-holder farmers to adopt millet crop mixtures that are cost effective, efficient in resource use, and one that ensures increase in aggregate yield per hectare. It provides the current information that would guide millet growers in decision making regarding crop mixtures to adopt, the government in formulating relevant policies towards the solution to food crisis in Nigeria. The uniqueness of the study lies in the use of production function for analysis of crop mixtures.

CHAPTER TWO

LITERATURE REVIEW

2.1 Agronomy of Millet

In Nigeria, three varieties of millet are distinguishable based on maturity date and method of planting. These include gero, maiwa and dauro (Ajayi and Labe, 1990). Gero is early maturing and the most widely spread, being cultivated in the southern Guinea, northern Guinea, Sudan and Sahel savanna ecological zones. Maiwa and dauro millets are late maturing. Maiwa is mostly grown in the southern and northern Guinea Savanna areas, while dauro, the transparent millet, is grown in the Southern Guinea Savanna in the altitude areas of Jos Plateau, where it is a very important part of the cropping system. Only the gero and maiwa are grown in Borno State. Maiwa is grown in the Southern and gero in the Northern parts of the State. Both forms of millet are late-maturing.

The gero is the most extensively grown form of millet in Nigeria. It is commonly grown in the low-rainfall Sahel zone, Sokoto, Borno and Katsina States. With the first rains, the field is prepared often manually, into broad beds and furrows at 50 to 100cm apart. About 10-25 seeds are dibbled in each hill spaced at 50 to 100cm apart. After 3-5 weeks, the crop is thinned to 3-7 seedlings in each hill.

The maiwa millet is strongly photo-period sensitive, late-maturing, produces long heads, and often grown mixed with sorghum (Appa Rao et al., 1994). It is grown in relatively high rainfall areas in heavy soils. Maiwa, like gero, is directly planted in the field where 5-20 seeds are dibbled in each hill. Often gap filling is done after removing the excess seedlings from adjacent hills. In some areas, an early maturing maize is planted with the first rains and after harvesting maize, maiwa and cowpea are planted in August. The maiwa form matures late and plants grow to over 3 metres tall.

The pearl millet is usually inter-cropped with a variety of crops. Around Zaria, for instance, 24 crops were observed in 174 combinations. However, groundnut, sorghum and cowpea are the most common inter-crops (Nwasike et al., 1982). Yield obtained by farmers can be increased under good management condition and by the use of fertilizers at optimum use of 13kg Nha and 12kg P_2O_5ha (Goldsworthy, 1965).

The most serious disease of millet is downy mildew, which is responsible for approximately 8% yield losses annually (Slevaraji, 1978). Other major disease of millet include ergot and smut. Ergot is generally restricted to the wetter millet growing areas and the disease is not yet of economic significance. The disease is characterized by the presence of small droplets of pinkish sugary fluid (honey dew) on the spikelets. As the disease progresses these droplets become thicker and coaleasce to form sticky dark patches on the ear. Smut develops under conditions of high atmospheric humidity when flowers are replaced by dark green smut sori. Some measures of control of stem borers disease has been achieved with the chemical furadan when applied as granules at sowing.

The three major insect pests of millet in Nigeria are stem borer, millet grain midge and Bishop birds, causing the greatest total loss of grain. Use of pest and disease resistant millet varieties is usually recommended.

2.2 Millet Sole Versus Mixed Cropping Systems

Inter-cropping, the growing of two or more crops stimultaneously in the same field is the dominant cropping system used by small-holder farmers in the drought prone, semi-arid tropics of West Africa. It covers 75% of the cultivated areas in the region (Steiner, 1994). In northern Nigeria, Norman (1974) recorded 156 different associations of crops with 40% of the areas devoted to 2-crop mixtures such as millet with sorghum and millet with cowpeas. Also, Nwasike and Egbarevba (1981) found out that a large proportion of millet in Nigeria is mixed with crops like sorghum, cowpea, and groundnut, while 30% are grown sole in the Sudan and Sahel zones.

Until recent, agricultural researches, however, have been largely confined to improving sole crop performance through increased population, seed rate, seed depth and planting date. Despite a lot of extension activities to recommend sole cropping, however, a large proportion of the land in some parts of the country are devoted to mixed cropping (Abalu, 1976; Ogungbile et al., 1991).

The yield advantage of millet inter-croppings over the sole has remained topical. Fussel and Serafini (1985) indicated that inter-cropping systems in West Africa as a whole, have yield advantages over the component crops grown as sole crops. They observed that while yield advantage of 20-30% are the most common, total yield advantages range from 10-100% for common cereal/legume associations such as millet/cowpea, sorghum/cowpea, cereal/groundnut and cereal/cereal associations like maize/millet, maize/sorghum and millet/sorghum.

Comparing productivity of millet-based cropping systems for unstable environment, Baidu-Ferson (1994) observed that millet yields were generally 50% lower than typical on-station yield. He, however, attributed this to an attempt to mimic crop protection conditions of farmer fields, where there is minimal or no crop protection. In a similar study in West Africa, however, Baker (1980) found no difference between the yield stability of inter-crops over sole crops in northern Nigeria. Nonetheless, when he compared the probabilities of failure, based on disaster level of income, inter-cropping systems were found to be more stable.

In addition to high overall productivity resulting from inter-cropping, Harwood (1979) has stressed other objectives that could be achieved. These include high labour productivity, weed control, control of insect pests and diseases, soil nutrient use efficiency, insurance against adverse agro-climatic conditions, and minimum tillage requirement for long-duration inter-crops during growing period. According to Baker (1979), mixing a shorter season millet with sorghum not only allows a second grain harvest but also reduces water stress on the sorghum during grain maturation by halving the total crop density.

Norman (1977) summarized the four principal reasons for inter-cropping as (i) tradition; (ii) the need for security; (iii) the need to maximize the return from a factor which is most limiting, such as labour, and; (iv) the beneficial effect of legumes on other crops. Abalu (1977) concluded that farmers of northern Nigeria use inter-cropping to diversify activities and as an insurance against biological and economic risks.

2.3 Farm Profitability Analysis

Cost-return analysis usually forms the basis for farm profitability analysis. This involves itemizing the costs and returns of production , and using them to arrive at such estimates as the return to one unit of the resources used, the gross margin, as well as the gross and net returns. In some instances, these values are subjected to tests of statistical significance to verify differences between them. According to Libero (1977), monetary units should be used as basis for measuring all inputs and outputs in cost and returns analysis for cropping systems.

Gomez (1975) developed a farm level model to evaluate alternative cropping mixtures and patterns. These include: (i) profitability measured as the difference between value of yield and cost of production; and, (ii) net return defined as the difference between value of yield and cash input cost, including hired labour. In choosing economic indicators on the basis of production factors affected by potential innovation, Werner (1993) suggested the use of (i) the the gross margin and returns to variable costs, where only capital is affected; (ii) yield/labour ratio, where only labour is affected; and, (iii) gross margin, return to variable costs and monetary returns to labour, where capital and labour are affected.

The major problems associated with cost-return analysis as basis for profitability assessment are: (i) it does not indicate the relative importance of each of the resources in production; and, (ii) it is location bound and specific in applicability due to use of money as the common unit of measurement and the prevailing price for the estimates. Inspite of the limitations, cost-return analysis is a useful tool in enterprise comparison and in indicating a profitable pattern of aggregate input use. This method was used by Olagoke (1991) in Anambra State, Osifo and Anthonio (1970) in Western Nigeria, and Nweke and Winch (1980) in South-eastern Nigeria.

2.4 Farmers and Production Goals

Orthodox production economic theory begins with the assumption of the existence of pure competition, which rests on the atomicity of buyers and sellers, the freedom of entry and exit, and homogeneity of product from the sellers and buyers view points. It contended that the entrepreneur's motive for producing any given product is that of attainment of maximum profit while the consumer's or buyers motive for purchasing is that of maximizing utility (Olayide and Heady, 1982).

There is no unanimity among small-scale farmers themselves, however, on what the goals of production are, what they ought to be or how they are to be attained. According to Harwood (1979), the fundamental goal of assuring enough food for the community and for the individual family is common to farmers in all rural societies. Beyond meeting basic food needs, he observed, the goals of families and societies become individual. He pointed out that farmers are utility maximizers and purposive in making decisions, and at extremely low subsistence levels understandably tend to think more in terms of immediate returns and less in terms of future consequencies. In a study by Smith and Capstick (1976), farmers ranked the following goals in order of importance: stay in business, stabilize income, increase efficiency and production, provide a college education, increase time off, increase net-worth, and increase farm size.

Olayide et al. (1982), however, contended that the two motives of enterprises in peasant production are: (i) that of a family unit striving to satisfy its consumption demands with given levels of resources (labour and technology); (ii) that of a miniature businessman or entreprenuer in a partially monetized market economy. These two goals, he indicated, amount to saying that the peasant farmer, although producing primarily for family consumption, often produces a marketable surplus of his particular product, so long as the market value is higher than his cost of production. This tendency was earlier confirmed by Schultz (1964) in his analysis of production responses of peasant small-holders in Africa, as well as the rapidity with which these farmers increased their production of cash crops such as cocoa, rubber, cotton, coffee etc.

Although profit maximization and food security are the essential ingredients of the multiple goal objective of small-scale farmers, profit maximization alone has continued to be used as the closest approximation of production behaviour of the farmers. This is due to the difficulty in operationalizing multiple goal objective and the ease of subjecting profit maximization to mathematical manipulation.

2.5 Risk and Uncertainty in Production

Farmers attitude towards risk and uncertainty is one of the major factors which affect production decisions with respect to cropping patterns, cropping systems and use of technology. Olayide (1982) described risk as variability or outcomes which are measurable in an empirical or quantitative sense, while uncertainty is an outcome whose probability cannot be established in an empirical or quantitative manner. He identified the major sources of uncertainty in agriculture as price, technical or yield, technological and socio-legal uncertainties. He pointed out that pure risks need not have an impact of serious nature as to affect decision making and/or farm resources, since it involves near-complete knowledge of the mean and modal outcome, range and dispersion of outcomes. Losses and gains which are due to risk phenomena, he opined, can be incorporated into the firms schedule and impact on decision making considerably reduced or nullified. He suggested measures such as diversification, multipe or mixed cropping; and multile or scattered and non-contiguous farm plots as means of minimizing variability or bearing on future plans, yields, prices and net income.

Phillip (1980) observed that uncertainty about yield arises because some input variables are not under the decision maker's control and their levels of utilization are not known at the time decisions have to be made concerning the level of the controlled inputs. Farmers, he pointed out, are known to differ in their risk preferences and profitability judgements, and these in turn influence the level at which a given input is used.

Comparing technology options on the basis of risk, Idachaba (1993), identified production and income risks as relevant, and are related to yield risk. Yield risk, he indicated, consists of risk created by a trend toward genetic uniformity resulting to increased vulnerability to disease epidemics, risk by errors occuring during the transition from old to new agronomic practices, and risk arising from fluctuations in the supply and distribution of seeds, fertilizers, pesticides and tractor services. The more responsive new varieties are to fertilizer and more dependent they are on pesticide application, the more yield vary and the more risk farmers face, as the availability of these inputs changes from year to year. He observed that small-scale farmers employ practice of inter-cropping and adoption of modern input on a limited scale as risk-minimizing strategies.

The attitude of farmers towards risk differs and affects their production decision. Studies (Muscardi and DeJanvry, 1977; Dillon and Scandizzo, 1978; Bingwanger, 1980 and Oglethorpe, 1994) have shown that the risk-averse farmer, who adopts a utility maximizing farm plan, will produce at a level of intensity significantly lower than that which would be adopted under profit maximizing. For such farmers, they observed, only minor reductions in expected income, at sub-optimal profit levels, can greatly reduce income variance.

2.6 Resource Use and Allocative Efficiency

One of the strategies for increasing agricultural productivity is a combination of measures designed to increase the level of farm resources, as well as make efficient use of the resources already committed to the farm sector. The degree of efficiency with which resources are used on farm depends on a large number of interacting factors constituting an agricultural system, and may be internal or external to the farm. A measure of efficiency which avoids the problems associated with traditional average productive measures, was first introduced by Farrel (1957). He introduced the distinction between (in)efficiency and allocative (in)efficiency. He observed that technical inefficiency arises when less than maximum output is obtained from a given bundle of factors and allocative inefficiency arises when factors are used in proportions which do not lead to profit maximization. Efficient use and allocation of resource thus, implies that a redistribution or re-allocation of resource to further increase output or use less of the input to produce the same output is impossible.

Farrel's early work on efficiency has remained topical. Kirzner (1979) pointed out that efficiency has meaning only when goals have been defined. Also, Pasour (1981) argued that performance standards derived by assuming profit maximization should not be used to measure the performance of economic agents whose objective functions involve elements other than profit. According to Russell and Young (1983), inefficiency is due solely, to our inability to measure inputs, or inaccurate measurement of land and labour due to ignoring quality differences, and would disappear should proper measures be used. The notion of inefficiency, they suggested, is relevant only within the narrow confines of the perfectly competitive equilibrium and hence irrelevant to analyzing real work problems. Tisdell (1983) indicated that the traditional economic theory of the behaviour of small farms is modeled to a large extent on the economic theory of purely competitive firms. This theory, he pointed out, assumes that an individual firm can buy, if it wishes, a virtually unlimited supply of any resource at the prevailing market price of the resource, and in particular that the firm faces no supply restrictions in hiring the amount of resources that maximizes its profit. He regretted that farmers in developing countries, often find that funds available to them for buying inputs are limited, and this restricts their ability to buy inputs such as fertilizer. This means that available supply of an input at the farm level is less than that required to maximize profit or the surplus.

A number of suggestions have been made on how to measure the relative efficiency of different group of farms or inputs. Jabbar (1977) suggested that tenural classification is more apropriate than size classification on the basis of land or any other single input category, in measuring relative efficiency of different groups of farms. Brinkman and Gellner (1977) pointed out that the rate of return of resources in agriculture presents the earnings per unit of resource (Labour, management, capital and land), rather than the level of total earnings. They suggested that comparisions of rates of return to various resources in different sectors should be used to provide a measure of relative efficiency of resource use, and can be used to determine whether farmers are underpaid. Olukosi and Erhabor (1988), however, indicated that among the measures of efficiency there is none that could be described as the best, as the most appropriate measure depends on the type of farm and the most important factor of production. If labour is the most important factor of production, for instance, labour efficiency can be measured.

On resource allocative efficiency, Nerlove (1988) pointed out that in allocating their own time along with material goods, within the domain of the households, farmers are timely attuned to marginal costs and returns. Allocative efficiency is determined by calculating the ratio of the marginal value product (MVP) to the Marginal Factor Cost (MFC) (Olukosi and Ogungbile, 1989). The MVP is calculated from the respective regression coefficient using the appropriate formular depending on the lead equation or functional form, while the market price of one unit of the input concerned is the MFC. A ratio of 1.0 is interpreted to mean economic optimum allocative efficiency, while a ratio less than 1.0 implies that the input is being over-used. When the ratio is greater than 1.0, it means the input is under-used. Heady (1948) suggested that we compare the MVP of each resource (as worked out at the geometric mean) with its corresponding price and test the difference statistically for significance with the help of t-test.

The MVP and MFC or price of input approach to resource allocative efficiency has been criticized by Rudra (1973). He indicated that the use of the market price to compare with the average MVP directly implies that a section of the farmer is over-using resources while the other is under-using it. In other words, every individual farmer is inefficient. Singh (1975), however, pointed out that inspite of this and other limitations of this approach, it provides a useful guide in deciding whether or not the level of agricultural production in a given environment could be profitably increased by making adjustment in the pattern of resource allocation. The approach was used by Reedway (1976) and Mijindadi and Norman (1982).

Relating efficiency of resource allocation to the farmer's production goals, Phiri (1992) observed that where the profit maximization and household approaches have applied to small-scale agriculture, the results have almost always been at odds with each other. Measures of farmers' performance based on the profit maximization approach, he noted, invariably leads to conclusions that small-scale farmers allocate resources inefficiently and that they are lazy and irrational decision-makers. On the other hand, measures based on the household objectives approach leads to the conclusion that farmers allocated resources efficiently according to their subjective judgement of future outcome.

2.7 Production Function Analysis

Production function explains the physical relationship between one or more inputs or factors and the output obtained from them. It helps in the estimation of the marginal productivity of productive inputs and their use efficiency in production process.

The units to adopt in expressing the input-output relationship, and the criteria for selection of functional forms have always been a subject of controversy among researchers. This is because most of the input and output variables are often heterogeneous in nature with no common physical unit of measurement. Heady and Dillon (1961) suggested some form of aggregation and measurement in value terms for computational convenience. Three major approaches to this idea of aggregation commonly reported in literature are use of money, use of caloric equivalent and use of grain equivalent. Output from mixed cropping and farming enterprises as well as input of heterogenius capital items are expressed in monetary terms (Flini and Zuckerman, 1979; Mijindadi, 1980; Russell and Young, 1983). The limitation of this method is that the results obtained cannot be easily generalized since they apply strictly to the particular price regime on which they were based (Heady and Dillon, 1961). The conversion factors provided by FAO (1964) have been widely used for caloric equivalent. This method has been criticized by Upton (1973) on the main basis that it has limited applicability having excluded such agricultural products as cotton, rubber and jute which have no nutritive value. He noted that unlike the caloric equivalent method which is limited to those agricultural products that have caloric values, the grain equivalent method has conversion factors for all the major agricultural products, land rents and even transport costs in terms of grain equivalents. The conversion factors for grain equivalent most commonly used are well documented by Clark and Haswell (1970).

On criteria for selection of functional form, Heady and Dillon (1961) outlined some useful principles that could guide in the selection of the appropriate functional forms as:

(i) the consistency of the chosen function with the study objectives;

(ii) knowledge of the relationship that exists between variables;

(iii) a consideration of the existing theories of the science involved.

Mijindadi (1980) reviewed the guiding principles as outlined by Heady and Dillon (1961) and concluded that the quadratic, square root, Cobb-Douglas and transcendental forms are the most appropriate forms for Nigerian traditional agriculture.

Despite all a priori theoretical and practical considerations, however, Griffin et al., (1987) have pointed out that the researcher may never be able to know the true functional form, especially with the growing number of forms. They suggested choice of functional form based on statistical and econometric criteria. Some of such statistical and econometric criteria according to Olayemi and Olayide (1981) are:

i) The goodness of fit which is judged by the magnitude of the coefficient of multiple determination (R^2);

ii) Statistical significance of the regression coefficients; and,

iii) 'Correctness' of the signs of the regression coefficient.

The researcher, they suggested, must understand the assumptions underlying the use of the various functional forms and to ensure that those assumptions conform with his perception of reality in the context of his study.

2.8 Problems of Production Functions

There are two major problems associated with the use of production function analysis. These are multi-collinearity and auto-correlation. Multi-collinearity implies that there is linear relationship between two or more of the independent variables. The effect is that the standard errors of the estimated coefficients of the regressors become large thus resulting in non-significance of the coefficients even when they may in actual fact be significant. This problem is often caused by the natural phenomenon that certain economic or production variables tend to move together. For example, seed quantity and labour input move together with farm size. According to Olayemi and Olayide (1981), multi-collinearity constitutes a problem only when the purpose of the study is to use the regression coefficients for estimating such values as marginal value products and elasticity, and does not affect the overall influence of the regressors on the dependent variable. As long as interests lies in forecasting and the forces operating during the period for which data were collected are expected to continue, multi-collinearity does not pose any problem (Johnston, 1963; Leser, 1969). Heady and Dillon (1961) maintained that it is not possible to completely avoid multi-collinearity.

On reduction of multi-collinearity, Goldberger (1964) suggested that the functional form be changed or transformed. For instance, in a quadratic equation, when a second degree regressor (X^2) is collinear with the first (X), a linear equation that excludes X^2 would probably eliminate most of the problem. Heady and Dillon (1961) opined that the quickest method is the removal of the collinear variables, if there would be no adverse effects on the purpose of estimation. Another method suggested by Hossain (1974) is to use the value of the collinear variable to divide the other variables, and to estimate the regression coefficient of the collinear variable by subtracting the sum of the coefficients of the other variables from one.

The second major problem associated with the use of production function is auto-correlation. This implies a condition of non-zero covariance between the error terms, ei. In times series data, for example, it implies that an error et is correlated with another error et-1, while in cross-sectional data, it impies that an error ei, associated with a value Yi is correlated with one or more of the errors associated with Yi values in the same series. Auto-correlation has been associated with mis-specification of functional form and omission of relevant variables among other causes (Olayemi and Olayide, 1981). It reduces the precision of parameter estimates and renders F- and t-statistics test of significance invalid. The Durbin-Watson (DW) statistic which is usually obtained from the computer prints-out of most regression analysis is most commonly used to test auto-correlation.

Evidence from the literature reviewed shows that millet is adaptive to the sahel zone of Nigeria, and mostly grown in mixtures. The advantages of mixtures over sole are, however, depends on the yardsticks for assessment, such as adaptability to adverse weather condition, efficiency of resource use and cost-benefit analysis among others. Though the use of cost-benefit analysis, using money as common unit of measurement and the prevailing price for the estimates has been criticised, it has remained widely employed by researchers, because of the ease of application. However, the production goals of the farmer, and the specific objectives of a research may influence the choice of analytical technique. In this study, cost-benefit analysis using gross margin analysis will be adopted for assessing profitability, while production function analysis will be used to compare efficiency of resource use.

CHAPTER THREE

METHODOLOGY

3.1 The Study Area

The study was conducted in Borno State of Nigeria. Borno State is one of the 36 States in Nigeria. It is located in the north-east corner of Nigeria, between Latitude 10°2' N and Longitude 13°4' E. The State has a population of about 2.6 million based on the 1991 census, and a variety of ethnic groups with Kanuri, Hausa, Shuwa and Fulani as the widely spoken vernacular. Hausa is widely spoken throughout the State as secondary language.

The major occupations of the people are farming, herdsmanship and fishing. Cash crops grown in the State are mainly groundnut and cotton, while food crops include millet, maize, guinea corn, rice, cowpea, wheat and cassava. Estimated area of 0.7 million hectares of the arable lands are extensively grown to millet annually as rain-fed crop by subsistent farmers (Bababe et al., 1994), representing 86% of the total arable land in the State. The major millet based cropping systems as identified through diagnostic survey by Borno State Agricultural Development Programme (BOSADP) include millet/cowpea, millet/sorghum, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures (BOSADP, 1992). These mixtures formed the basis for the study in Konduga, Kaga and Jere Local Government Areas of the state.

The two major vegetational zones in the State are Sudan and Sahel. The Sahel zone consists of Firgi soil on which most of the wetlands of Borno State are situated, while the

Sudan zone is made up of scrubby vegetation interspersed with tall trees. Farming in the State commences usually in the month of June.

3.2 Sampling Frame

The sampling population was millet growing farmers. A three-stage random sampling was employed in selecting the study farmers. The first stage was random selection of 3 of the 27 Local Government Areas (LGAs) in the State, while the second involved random selection of 3 villages from each of the LGAs. Millet growing farmers from the selected villages were then stratified into those growing millet/cowpea, millet/groundnut, millet/sorghum, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures, based on BOSADP (1992) diagnotic survey. The third stage of random sampling involved selection of 4 millet growing farmers from each millet mixture stratum. A farmer who fell into more than one mixture stratum was also interviewed in the others, if the number of farmers in any of the strata was insufficient. The use of stratified random sampling was to ensure representation of each millet based crop mixture in the study.

A total of 3 LGAs, 9 villages and 180 millet growing farmers, comprising 36 farmers from each of the five crop mixtures, were, therefore, selected for the study. The list of millet growing farmers and their crop mixtures compiled with the help of the village extension agents (VEAs) in the respective locations served as the sampling frame.

3.3 Data Collection

The primary data for the study were collected based on the 1997/98 cropping season, using structured questionnaire and oral interview schedules. Variables on which data were collected include socio-economic and production variables. The socio-economic variables of interest include farmers age, resident household size, educational level, contact with extension workers, farming experience, production goals, land tenure, millet-based mixtures, reasons for crop mixtures, farm size, farm and non-farm incomes. Data collected on production variables include land area cultivated (ha) for millet-based crop mixtures; output of millet and that of the component crops in the mixtures (kg); prices of millet and the component crops (₦/kg); labour use for land preparation, planting, weeding, fertilizer application, harvesting, and threshing (man-day); prices of labour (₦/man-day), and quantity (kg/ha) and price (₦/kg) of seeds for planting.

Secondary sources of data include journal, BOSADP reports, books and government reports. Variables on which data where collected include national food output, caloric intake and import bills.

3.4 Analytical Technique

The techniques used for data analysis to achieve the objectives of the study were simple descriptive statistics, budgetary technique, the multiple regression technique, analysis of variance (ANOVA) and chi-square statistic (X^2).

3.4.1 Simple Descriptive Statistics

The simple descriptive statistics include percentages, means, ranking etc. This technique was employed to analyze and discuss the millet based mixtures, the socio-economic characteristics of the respondents and the problems of the farmers, to achieve specific objectives 1 and 5.

3.4.2 Budgetary Technique

The budgetary technique was used to analyse the costs and returns of the crop mixtures, to achieve specific objective 4. The technique was used to estimate and compare gross margins (Gms) per hectare and man-day for the different millet crop mixtures. The model was expressed as follows:

$$GM = GR - TVC$$

where,

GM = Gross margin

GR = Gross revenue

TVC = Total variable costs

All estimations were based on per hectare. The gross margin analysis was used because the fixed costs of the farmers were negligible.

3.4.3 Multiple Regression Analysis

This technique was used to estimate the influence of socio-economic variables on agricultural output of the farmers, and to develop a production function for millet crop mixtures. This satisfied specific objectives 3 and 5 respectively.

3.4.3.1 Socio-economic Variables and Agricultural Ouput

The regression model for the socio-economic variables influencing the farmers agricultural output was implicitly expressed as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_5, U)$$

where,

Y = Value of output (₦/ha)

X_1 = Age of the Farmer (years)

X_2 = Farming experience (years)

X_3 = Number of years of formal education (years)

X_4 = Resident household size (number of persons)

X_5 = Number of visits by extension workers during the cropping season

U = Stochastic term

The linear, semi-log and double-log functions were tried for the different millet crop mixtures. The functions were explicitly expressed as follows:

$$Y = bo + b_1X_1 + b_2X_2 + b_3X_3 + b_4b_4 + b_5b_5 + e_i \text{ - - - - Linear}$$

$$Y = \log bo + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + b_5\log X_5 + e_i \text{ - - - Semi-log}$$

$$\log Y = \log bo + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + b_5\log X_5 + e_i \text{ - - - Double-log}$$

The bo's are constants, while, b_1 - b_5 are the coefficients. Based on the coefficient of multiple determination, (R^2), a priori expected signs of the coefficients and significance of the coefficients, the linear function was chosen as the lead equation for all the crop mixtures. The a priori expectation was that age (X_1) and farming experience (X_2) would be negative, while that of educational level (X_3), resident household (X_4) and contact with extension workers (X_5) would be positive. Pair-wise correlation was used to check for the presence of multi-collinearity.

3.4.3.2 Production Function Analysis

Production function was developed to determine the physical relationship between inputs and output, and used to compare the relative importance and resource use efficiency for common resources used in millet crop mixtures. A separate regression model was fitted for each of the crop mixtures. The implicit form of the model is as follows:

$$Y = f(X_1, X_2, X_3, X_4, U)$$

where,

Y = Crops output in grain equivalent weight (GEW)

X_1 = Farm size in hectare

X_2 = Labour in man-days

X_3 = Fertilizer in kilogram (kg)

X_4 = Seeds in grain equivalent weight

U = Stochastic term.

The expression of outputs and seeds in grain equivalent weight (GEW) was to standardize the heterogeneous outputs and seeds quantities in the mixed cropping, by multiplying them with given conversion factors based on the grain values of the crops. The conversion factors provided by Clark and Haswell (1970) was used for the purpose of standardization. The conversion factors and method are presented in Appendix III

Different functional forms, the linear, semi-log and double-log functions were tried. The models were explicitly expressed as follows:

$$Y = bo + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + e_i \quad \text{----} \quad 1$$

$$Y = \log bo + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + e_i \quad \text{----} \quad 2$$

$$\log Y = \log bo + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + e_i \quad \text{----} \quad 3$$

The semi-log function was selected as the most fitted on the basis of the statistical and econometric criteria, as well as the a priori expectation. The a priori expectation was that all the coefficients, X_1 - X_4, would be positive. Pair-wise correlation was also used to check for the presence of multi-collinearity.

(i) Measuring Resource Importance and Use Efficiency

The estimated regression coefficients (bi's) were used to compute the Beta coefficients.

(Bi*s) for each resource as follows:

$$B_1^* = b_i \frac{\delta_{xi}}{\delta_y}$$

where.

B_i^* = βeta coefficient

δ_{Xi} , δ_y = Standard deviations of the given input and of the dependent variable respectively.

The magnitudes of the Bi*s were used to rank the relative importance of each of the common resources in the millet-based crop mixtures. This method was used by Mijindadi and Norman (1982). Input with the highest positive Beta coefficient was the most important in production.

(ii) Determining Efficiency of Resource Use

The efficiency of using resources in production of millet crop mixtures was determined and compared using marginal value productivity and technical efficiency for the different mixtures. These methods were used by Ogungbile and Sanni (1991). The marginal value product (MVP) of each of the resources was estimated using the estimated regression coefficients and the prices of the outputs. The MVP was then compared with the cost of one unit of the particular resource's marginal factor cost (MFC) to make inference on economic efficiency of resource use. The following ratio was then estimated to determine the relative efficiency of resource use (r).

$$r = \frac{MVP}{MFC}$$

If r = 1, resource is efficienctly used.

r > 1, resource is under-used.

r < 1, resource is excessively used.

The values of MVP and MFC based on the semi-log function (equation 2) were estimated as follows:

MPP = bi/ $\overline{X}$

MVP = MPP.Py

MFC = Pxi

where.

$\overline{X}$ = Arithematic mean value of the input being considered.

bi = The estimated regression coefficient of input X_i

Py = Unit price of the output of the crop mixture being considered.

MPP = Marginal physical product of input.

MVP = Marginal value product of the crop mixture being considered.

MFC = Pxi (unit price of the input Xi).

The relative percentage change in MVP of each resource required in order to obtain r = I, or MVP = MFC, which represents optimal allocation of resources was obtained as follows:

$$D = \left| 1 - \frac{MFC}{MVP} \right| 100 = \left| 1 - \frac{1}{r} \right| 100$$

where, D = The absolute value of the percentage change in MVP of each resource (Mijindadi, 1980).

Technical efficiency in the use of resources for the different millet crop mixtures was compared using their returns to scale. This method was adopted by Ogungbile and Sanni

(1991). Technical efficiency is a measure of a firms success in producing maximum output from a given set of inputs (Farrel, 1957). The elasticity of production (Ep) was estimated and the sum of the elasticities were used to estimate the return to scale for the different crop mixtures as follows:

$$E_{P_{x_i}} = \frac{d_y}{d_{xi}} \cdot \frac{\bar{x}_i}{\bar{y}_i}, \qquad i = 1, 2 \ldots \quad k$$

$$\sum_{i=1}^{k} E_{P_{xi}} = RTS$$

3.4.3.3 Hypothesis Testing of Statistical Difference in Gross Margins Using ANOVA

Analysis of variances (ANOVA) was used to test the hypothesis that there is no statistical difference in profitability among the millet mixtures. The gross margins of the crop mixtures from the individual farmers were considered together. The five millet-based mixtures were used as treatments. There were 36 replications.

The results obtained after the estimation were presented in a format for the analysis of variance (Table 3.1), as used by Freund, (1984).

Table 3.1 Format for Analysis of Variance.

Source of Variation	Degree of freedom	Sum of squares	Mean square	F
Cropping Systems	K-1	SS(Tr)	MS(Tr)	$\frac{MS(Tr)}{MSE}$
Error	K(n-1)	SSE	MSE	
Total	Kn-1	SST		

Source: (Freund, 1984).

where,

F = MS(Tr) = Variance ratio

MS(Tr) = $\frac{SS(Tr)}{MSE}$ = Treatments mean square

MSE = $\frac{SSE}{MSE}$ = Error mean square

SS(Tr) = Treatment sum of squares

SSE = Error sum of squares

SST = Total sum of squares

K = Number of treatments

n = Number of replications

The chi-square statistic was used to test the relationship between farm size and millet-based mixtures.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of the Study Farmers

The socio-economic characteristics of the study farmers were examined with respect to their age, farming experience, formal education, farm size, household size, contact with extension workers, reasons for growing millet in mixture, production goals, and land tenure system.

4.1.1 Age Distribution of Respondents

The mean age of the respondents was 40.7 years, with the majority of the farmers (51.1%) in the age group of 31 to 40 years (Table 4.1). Respondents in the age bracket of 41 to 50 years constituted 38.9% of the study farmers, while only 3.9% were above the age of 50 years. The maximum age of the respondents was 58 years, with a minimum of 23 years.

Table 4.1: Distribution of Respondents According to Age.

Farmers Age (Years)	Number of respondents	Percentage
21 - 30	11	6.1
31 - 40	92	51.1
41 - 50	70	38.9
Above 50	7	3.9
Total:	180	100

Source: Field Survey data, 1997/98.

Mean = 40.7; Minimum = 23; Maximum = 58.

The age of 31-40 years for majority of the respondents is a very active and virile age for farming. The respondents fall within the age range (15-64 years) defined by FAO (1992) as economically productive. The age of a farmer affects the type of farm operation he or she could undertake. Younger farmers could embark on more energy requiring farm operation such as land tilling and tree felling than older farmers.

4.1.2 Farming Experience of Respondents.

The farming experience of farmers to a large extent affects their managerial know-how and decision making. Besides, it influences the farmer's understanding of climatic and weather conditions, as well as socio-economic policies and factors affecting farming.

Table 4.2 presents the number of years of farming experinece of the respondents. It shows that majority of the respondents (62.8%) had farming experience of between 1 and 10 years. Only 31.1% of the respondents had 11 to 20 years farming experience. The mean years of farming experience for the respondents was 10.3 years, with a minimum of 3 years and maximum of 30 years. With a mean of 10.3 years, the farmers could be categorized as inexperienced.

Table 4.2: Farming Experience of Respondents.

Farming Experience (Years)	Number of respondents	Percentage
1 - 10	113	62.8
11 - 20	56	31.1
21 - 30	11	6.1
Total:	180	100

Source: Field Survey data, 1997/98

Mean = 10.3; Minimum = 3; Maximum = 30.

4.1.3 Respondents' Educational Background.

The respondents were asked to indicate their levels of formal education and the result is presented in Table 4.3. It indicates that majority of the respondents (61.1%) had secondary education, while (17.8%) had primary education. About 21% of the respondents did not attend any formal educational institution. Only about 1% had post secondary education. In all 79.4% had one form of formal education or the other.

The educational background of a farmer is an important determinant of his adoption behaviour and managerial ability. It helps him to understand government policies and agricultural programmes.

From the findings, it is obvious that graduates of higher institutions in ths State had not really gone into farming. Perhaps, the production incentives were not provided, or that they preferred white-collar jobs.

Table 4.3: Level of Education of Respondents

Level of Formal Education	Number of respondents	Percentage
No formal education	37	20.6
Primary education	32	17.8
Secondary education	110	61.1
Post secondary	1	0.5
Total:	180	100

Source: Field survey data, 1997/98

4.1.4 Farm Size of Respondents.

All the farms studied were between 1 and 3.5 hectares. The mean farm size was 1.4ha, with most farms being from 1ha to 1.99ha for 77.8% of the respondents (Table 4.4). Only 7.2% of the respondents had farm size between 3 and 3.99 hectares, while 15% had between 2 and 2.99 hectares for millet cropping systems. The respondents were all, therefore, small-scale farmers, based on Olayide et al. (1980) classification that farmers with holdings between 0.10 hectares and 5.99 hectares belong to this category. This is in consonance with the documentation of the Federal Ministry of Agriculture and Natural Resources (FMANR, 1985) that small-scale farmers in Nigeria form the bulk of farming populace. Farm size is a very important factor in farming and affects not only the output, but also the level of input use.

Table 4.4: Farm Size Distribution of Respondents

Farm Size (Hectare)	Number of respondents	Percentage
1 - 1.99	140	77.8
2 - 2.99	27	15.0
3 - 3.99	13	7.2
Total:	180	100

Source: Field survey data, 1997/98.

Mean = 1.4ha; Minimum = 1ha; Maximum = 3.5ha.

4.1.5 Household Size of Respondents.

Information was solicited on the household size of the respondents. The result is presented in Table 4.5. Majority of the respondents (58.9%) had household size between 1 and 4 persons, while those with household size of 5-8 persons constituted 35.6%. Only a family had a household size of more than 12 persons. In all, therefore, 94.5% of the respondents had household size of 1 to 8 persons.

The mean household size for the respondents was 3.8 persons, while the minimum and maximum household sizes were 1 and 13 persons respecitvely. Household size is an important factor in traditional agriculture and affects farm labour sources and supply.

Table 4.5: Household Size Distribution of Respondents.

Household Size	Number of respondents	Percentage
1 - 4	106	58.9
1 - 8	64	35.6
9 - 12	9	5.0
Above 12	1	0.5
Total:	180	100

Source: Field survey data, 1997/98.

Mean = 3.8; Minimum = 1; Maximum = 13.

4.1.6 Respondents' Contact with Extension Agents.

The extension contact in terms of the frequency of visits of the extension agents to the farmer and vice versa plays important role in adoption of agricultural technology. The respodents were asked to indicate the number of contacts with extension agents and the result is presented in Table 4.6. The result reveals that 50% of the respondents had no contact with extension agents during the cropping season. About 20% had one or two contacts with extension agents, while 23.9% had three or four contacts. The maximum number of contacts had by farmers was five, with the minimum of one and mean of 1.5.

Farmers' contacts with extension agents are necessary, at least, during land preparation, planting and harvesting. These are the three main farm operations during which farmers need information and guidance most.

Table 4.6: Distribution of Respondents According to Number of Contacts with Extension Agents.

Contact with Extension Workers	Number of respondents	Percentage
No contact	90	50.0
1 - 2	37	20.5
3 - 4	43	23.9
5 - 6	10	5.6
Total:	180	100.0

Source: Field survey data, 1997/98.
Mean = 1.5; Minimum = 1; Maximum = 5.

4.1.7 Respondents' Reasons for Growing Millet in Mixtures.

The respondents were asked to indicate their major reasons for growing millet in mixture and the result is prsented in Table 4.7. About 44% of the respondents grew millet in mixture with other crops because it is their traditional practice, while 20% intended to ensure food security by growing millet in mixture. The least reason given for growing millet in mixture was to obtain high yield as indicated by only 10.6% of the respondents. Other reasons given were to ensure more efficient use of land (13.3%) and because of shortage of land (11.7%). It could be deduced, therefore, that the traditional practices and yield security objectives of the farmers were the major factors affecting their decision to grow millet in mixture. Worthy of note is the traditional practice of the farmers.

The practice of millet inter-cropping is as old as millet farming in the areas. This stems from the subsistent nature of farming in the areas, which suggests or demands that the farmer produces most of his food needs such as millet or sorghum for preparing foofoo (tuwo) and pap (kunu); cowpea or groundnut for boiling and eating and for soup making. Additionally, farmers, recognising the importance of farming in their livelihood, embark on mixed cropping to ensure yield security. Some of the farmers interviewed disclosed that inter-cropping millet with cowpea mulches the soil against excessive loss of water, improving the ground and yield of millet in the event of abrupt stopping of the rainy season, a major characteristic of rainfall in the area.

Table 4.7: Respondents' Reasons for Growing Millet Mixtures.

Reasons	Number of respondents	Percentage
It is the traditional practice	80	44.4
To obtain high output	19	10.6
Because of shortage of land	21	11.7
Ensures more efficient use of land	24	13.3
Ensures yield security	36	20.0
Total:	180	100.0

Source: Field survey data, 1997/98.

4.1.8 Production Goals of Respondents.

The production goal of a farmer is an important factor in his decision making regarding what to produce, how to produce, and for whom it will be produced. This applies also in peasant agriculture, where productive resources pose constraints.

The distribution of the respodents according to production goals are presented in Table 4.8. The analysis shows that 45% of the respondents were producing to ensure food security, while 37.2% and 17.8% were producing for profit maximization/food security and profit maximization only, respectively. Thus, food security objetive, a major characteristic of the small-holders, ranked first among the study farmers. The result is obvious. Millet is a staple food for majority of the rural inhabitants in Borno State, though the components of millet crop mixtures such as groundnut and cowpea are sometimes aimed at profit maximization.

Table 4.8: Distribution of Respondents According to Production Goals

Production goal	Number of respondents	Percentage
Profit maximization	32	17.8
Food security	81	45.0
Profit maximization/food security	67	37.2
Total:	180	100.0

Source: Field survey data, 1997/98.

4.1.9 Distribution of Respondents According to Land Tenure Systems.

Table 4.9 shows the distribution of the respondents according to land tenure or ownership. The result indicates that majority of the millet mixture growers (67.88%) inherited their lands while 20.5% rented. Only 11.7% of the respondents purchased land for farming.

The land tenure system affects the farmers adoption behaviour and land improvement practices embarked upon. Chikwendu et al. (1994) noted that non-land owners adopted the minisett technique for seed yam multiplication than land owners. He attributed this to the fact that non-land owners may wish to maximize whatever benefits they can derive from the available land. On the contrary, Njoku (1991) indicated a positive relationship between land ownership and adoption level. Farmers who owned the land on which they cultivated oil palm adopted more techniques than those who were tenants on the land. Famoriyo (1978) related this relationship to insecure tenure of tenants which frequently prevents permanent investment on land. This later feeling was also expressed by some of the non-land owners in the study area for not using fertilizer. According to this group of farmers, the residual effect of any chemical fertilizer on soil extends to the next cropping season, and they might not be allowed to use the land during the next cropping season. The situation was made worse by the high cost of fertilizer.

Table 4.9: Land Tenure Systems in the Area of study

Land tenure	Number of respondents	Percentage
Inherited	122	67.8
Rented	37	20.5
Purchased	21	11.7
Total	180	100

Source: Field survey data, 1997/98.

4.2 Resource Use for the Millet-based Cropping Systems

The types, amount, utilization and prices of the various resources used by the farmers for the millet cropping systems were examined. These resources include land, labour, seeds and fertilizer.

4.2.1 Land Resource

Land forms a very important resource in both subsistance and large-scale farming. The total area of farm land devoted to the production of a crop is an important measure of the size of that enterprise. The total area of land cultivated by the respondents were estimated as 47.9, 48, 52, 58.5, and 50.5 hectares for farmers growing millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures respectively, making a total of 256.9 hectares. The mean farm sizes were, therefore, 1.33, 1.33, 1.44, 1.62 and 1.40 for the mixtures in the same order. Land acquisition was mainly through inheritance. No farmer had more than two farm plots devoted to the same millet-based mixture. The result is presented in Table 4.10.

Table 4.10: Land Use in Hectares According to Millet-based Cropping Systems of Sampled Farmers in the Study Area

Cropping System	Total Area	Mean	Minimum	Maximum
Millet/Sorghum	47.9	1.33	1	3.5
Millet/Cowpea	48	1.33	1	3
Millet/Groundnut	52	1.44	1	3.5
Millet/Sorghum/ Cowpea	58.5	1.62	1	3.5
Millet/Sorghum/ Groundnut	50.5	1.40	1	2.5

Source: Field survey data, 1997/98.

Significant relationship was found between farm size and millet-based cropping system (Table 4.11). This is contrary to the hypothesis that there is no relationship between farm size and millet-based cropping system. The result is not surprising. Among the reasons given by the farmers for growing millet in mixtures were shortage of land and to ensure more efficient use of land (Table 4.7). Table 4.11 shows the relationship between farm size and cropping millet-based systems.

Table 4.11: Relationship Between Farm Size and Millet-based Cropping Systems (df = 8)

Cropping Systems	Farm size			Chi-square X^2	Level of significance
	1-1.99	2-2.99	3-3.99		
Millet/sorghum	30	5	1		
Millet/cowpea	31	2	3		
Millet/groundnut	28	4	4	14.44	Significant
Millet/sorghum/cowpea	24	7	5		
Millet/sorghum/groundnut	26	10	0		

Source: Field survey data, 1997/98.

4.2.2 Labour Resource

Family labour constituted the major type of labour among the study farmers. The labour was provided by the respondents and their relatives or dependants. Hired labour was provided by paid workers on daily basis, and represented a major source of labour to most of the respondents. The average wage rate per man-day was ₦150.00 at the period of the study. The mean labour use were estimated at 36, 39.28, 46.97, 51 and 59.7 man-day per hectare

(Table 4.12), for millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/cowpea/groundnut respectively. Labour demand was, therefore, higher in the 3-crop millet mixtures than 2-crop mixtures. According to the farmers, each component crop in a millet mixture requires a separate harvesting period, since the crops do not mature at the same time. This explains the higher labour requirement in the three crop mixtures than two crops.

Table 4.12: Labour Resource Use in Man-day Per Hectare According to Millet-based Cropping Systems in the Study Area.

Cropping System	Total Labour in man days	Mean	Minimum	Maximum
Millet/Sorghum	1724.40	36	22	76
Millet/Cowpea	1884.85	39.28	21.30	57.33
Millet/Groundnut	2442.55	46.97	20.75	67.67
Millet/Sorghum/ Cowpea	2996.30	51.00	29.65	81.75
Millet/Sorghum/ Groundnut	3014.85	59.7	25	86.25

Source: Field survey data, 1997/98.

4.2.3 <u>Seed Resource</u>

The most common variety of millet used by farmers in Borno State was the Ex-Borno, while Chakalori, Borno Brown and Ex-Dakar were the common varieties of sorghum, cowpea and groundnut respectively. The average seed rates for millet in millet/sorghum, millet/cowpea and millet/groundnut mixture were 2.87, 3.84 and 3.77 kg per hectare respectively. The weights of the component crops, namely, sorghum, cowpea and groundnut were 6.12, 19.08 and 26.46 kg per hectare in the same order.

In the 3-crop mixtures, the average seed rates per hectare for millet were 2.49 and 2.34 kg for millet/sorghum/cowpea and millet/sorghum/groundnut mixtures respectively. Thus, the three-crop millet mixtures required less millet seed rate per hectare than the two-crop mixtures. Seed rate per hectare for the component crops, sorghum, cowpea and groundnut were 13.9kg (sorghum), 4.75kg (cowpea) for millet/sorghum/cowpea mixture, and 5.17kg (sorghum), 15.66kg (groundnut) for millet/sorghum/groundnut mixtures (Table 4.13). The seed rates were below the recommended rate by BOSADP. Most of the study farmers used the previous years harvest as seeds. The prices of millet, sorghum, cowpea and groundnut per kilogram during the cropping season were ₦25, ₦24, ₦47 and ₦43 respectively. Compared in grain equivalent weight (GEW) per hectare, the seed rates per hectare for millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut were 5.69, 24.88, 52.06, 19.82 and 35.08 respectively. The GEW factors estimated by Clark and Haswell (1978) were used. Based on the estimates of the GEW, millet/groudnut mixture required the highest seed rate, followed by millet/sorghum/groundnut.

Table 4.13: Seed Rate Per Hectare and Common Varieties for Component Crops in Millet-based Cropping Systems in the Study Area.

Cropping System/ Variety	Seed rate (kg/ha)				Seed rate (GEW/ha)*
	Millet	Sorghum	Cowpea	Groundnut	
Millet/Sorghum	2.87	6.12	-	-	5.69
Millet/Cowpea	3.84	-	19.08	-	24.88
Millet/Groundnut	3.77	-	-	26.46	52.06
Millet/Sorghum/Cowpea	2.49	13.90	4.75	-	19.82
Millet/Sorghum/Groundnut	2.34	5.17	-	15.66	35.08
Common Varieties of Seeds	Ex-Borno	Chakalori	Borno-Brown	Ex-Dakar	-

Source: Field survey data, 1997/98
* GEW = Grain equivalent weight.

4.2.4 Fertilizer Resource

Compound fertilizer (N.P.K. - 15.15.15.) was used by the farmers. The mean rates of fertilizer application were 28.90, 24.79, 57.00, 39.23 and 39.11 per hectare for millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut respectively (Table 4.14). These were below the recommended rate per hectare by BOSADP for all the millet crop mixtures.

The under-utilization of fertilizer was expected, in view of the high cost of fertilizer in the 1997 cropping season. The cropping season coincided with the withdrawal of the fertilizer subsidy by the Federal Government. This resulted in the price of fertilizer skyrocketing from the official rate of ₦450 per 50kg bag to ₦1,200 for the same bag. The respondents revealed that the withdrawal of fertilizer subsidy came to them as a surprise, as no prior arrangement was made, even for the use of organic manure, because of the cheapness and availability of fertilizer before the withdrawal. Only 41.67, 33.33, 47.22, 50 and 33.33 percents of the farmers growing millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut respectively, used fertilizer during the cropping season. The minimum rates of fertilizer application were 50kg/ha for each of millet/cowpea and millet/groundnut; and 43.33 kg/ha and 45kg/ha for millet/groundnut and millet/sorghum/cowpea mixtures respectively. Maximum rate for all the cropping systems was 100kg/ha, except for millet/sorghum/groundnut and millet/sorghum with maximum rate of 133.33 kg/ha and 83.33 kg/ha respectively. Millet/sorghum mixture had a minimum rate of 41.67 kg/ha of fertilizer application.

Table 4.14: Fertilizer Application Situation of the Farmers According to Millet-based in the Study Area

Cropping Systems type	Total Quantity (kg)	Mean rate per Farmer (kg)	Mean rate (kg/ha)	Percentage of Users (%)	Minimum rate (kg/ha)	Maximum Rate (kg/ha)	Fertilizer Used
Millet/sorghum N:P:K:15:15:15	1384.25	38.45	28.90	41.67	41.67	83.33	
Millet/cowpea N:P:K:15:15:15	1190.00	33.06	24.79	33.33	50	100	
Millet/groundnut N:P:K:15:15:15	2983.00	82.86	57.00	47.22	43.33	100	
Millet/sorghum/ N:P:K:15:15:15 cowpea	2295.00	63.75	39.23	50.00	45	100	
Millet/sorghum N:P:K:15:15:15	1975.00	54.86	39.11	33.33	50	133.33	

Source: Field survey data, 1997/98.

4.3 Productivity and Profitability of Millet Cropping Systems

The yield of component crops and the accruing revenues were examined in this section. costs and returns of the millet-based cropping systems were estimated and compared as a measure of profitability, while the statistical difference in gross margins was examined using t-test on Analysis of Variance (ANOVA).

4.3.1 Yield of Component Crops

The yield per hectare of the component crops in the millet-based cropping systems are presented in Table 4.15. Analysis of the yields shows that millet/cowpea mixture (676.04 kg/ha) had the highest millet yield, followed by the millet yield from millet/groundnut (574.42 kg/ha). Millet yields from millet/sorghum, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures were 365.34, 300.00, and 319.41 kg/ha respectively. The yield of millet as a component crop in millet-based cropping system was, therefore, found to be higher in two crop-based mixtures than in 3-crop mixtures.

In millet-based mixture, millet/sorghum (432.15 kg/ha) yielded more sorghum than millet/sorghum/cowpea (352.04 kg/ha) and millet/sorghum/groundnut (360.40 kg/ha). In general, it was observed that the yields of the component crops were higher in 2-crop mixtures than 3-crop mixtures. This could be attributed to competition for nutrients among the crops. The higher the number of component crops, the more the competition and consequently, the lower the yield.

When the yields were however, converted to grain equivalent weights (GEW) per hectare, as a standard for comparison, millet/groundnut mixture with GEW/ha of 856.19 was found to have the highest yield, followed by millet/cowpea with GEW/ha of 728.22. Millet/sorghum/groundnut ranked third with GEW/ha of 710.70, while millet/sorghum mixture with GEW/ha of 507.72 was the least. The higher GEW/ha of 2-crop measures compared with 3-crop mixtures especially for crop mixture contraining cowpea or groundnut as a component crop can be explained in terms of their higher GEW/kg, higher yields in 2-crop than 3-crop mixtures (Table 4.15). Groundnut or cowpea is planted at higher seed rate per hectare in 2-crop mixture than 3-crop mixture (Table 4.13), and consequently more yield.

Table 4.14: Mean Yields of Component Crops in Kilogramme and Grain Equivalent Weight per Hectare for Millet Cropping Systems the study Area.

Cropping Systems	Yields of Component Crops (kg/ha)				Total Yield (GEW*/ha)
	Millet	Sorghum	Cowpea	Groundnut	
Millet/sorghum	365.34	432.15	-	-	507.72
Millet/cowpea	676.04	-	239.74	-	728.22
Millet/groundnut	574.42	-	-	254.42	856.17
Millet/sorghum/ cowpea	300.00	352.04	138.63	-	570.49
Millet/sorghum/ groundnut	319.41	360.40	-	151.51	710.70

Source: Field survey data, 1997/98

* GEW = Grain equivalent weight : Millet (0.68 GEW/kg), Sorghum (0.60 GEW/kg); Cowpea (1.12 GEW/kg) Groundnut (1.83 GEW/kg)

4.3.2 Revenue of Component Crops in Mixtures

Output revenues of the different cropping systems were valued at the prevailing market prices in the 1997 farming season. The average market prices for millet, sorghum, groundnut and cowpea were ₦25, ₦43 and ₦47 per kilogram respectively. The highest total revenue per hectare (₦28,168.75) was generated from millet/cowpea mixture. This was followed by millet/groundnut mixture with total revenue of ₦23,300.77 per hectare. Millet/sorghum inter-crop had the least revenue of ₦19,505.22 per hectare (Table 4.16). Thus, for the 2-crop millet-based mixtures, millet/cowpea mixture was found to be the most revenue-yielding, followed by millet/groundnut mixtures. Millet/sorghum/groundnut with total revenue of ₦23,149.78 generated more revenue than millet/sorghum/cowpea under the 3-crop mixtures. The total revenue per hectare for a crop mixture is a function of the yields and prices of the component crops.

Table 4.16: Average Revenue of Component Crops Per Hectare for Millet-based Cropping Systems in the Study Area.

Cropping systems	Component Crops Revenue (₦/ha)*				
	Millet	Sorghum	Cowpea	Groundnut	Total revenue (₦/ha)
Millet/ sorghum	9133.61	10371.61	-	-	19505.22
Millet/ cowpea	16901.04	-	11267.71	-	28168.75
Millet/ Groundnut	14360.58	-	-	10940.19	23300.77
Millet/ sorghum/ cowpea	7500	8448.92	6515.73	-	22464.65
Millet/ sorghum/ groundnut	7985.15	8649.50	-	6515.13	23149.78

Source: Field survey data, 1997/98
* Millet (₦25/kg), Sorghum (₦24/kg), Groundnut (₦43/kg) and Cowpea (₦47/kg).

4.3.3 Costs and Returns Analysis.

The results of the budgetary analysis in Table 4.17 indicate that the average cost of production for millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures were ₦6,312.23, ₦7,479.72, ₦8,634.71, ₦9,243.62 and ₦10,749.60 per hectare respectively. The analysis reveals that the production cost for millet/sorghum/groundnut mixture was the highest, followed by the millet/sorghum/groundnut mixture. The use of more labour in the 3-crop mixtures could have accounted for the higher production costs, vis-a-vis the 2-crop mixtures. Each component crop of a mixture had particular planting, harvesting and threshing periods. This explains the higher labour requirement and cost in the 3-crop than 2-crop millet mixtures.

Millet/cowpea mixture attracted the highest gross margin per hectare of ₦20,689.03. This was followed by millet/groundnut and millet/sorghum/cowpea with gross margins of ₦14,646.06 and ₦13,221.03 per hectare respectively. Millet/sorghum mixture generated second to the lowest gross margin per hectare of ₦13,192.99, inspite of the least variable cost per hectare (₦6,312.23). This may be attributed to the low total revenue obtained by the farmers, resulting from the low market prices of millet (₦25/kg) and sorghum (₦24/kg) during the production year, as against ₦43 and ₦47 per kilogramme for groundnut and cowpea respectively. All things being equal, millet cropping systems with groundnut and cowpea as component crops were, therefore, bound to generate more revenue.

Analysis of gross margin per man-day, however, showed that millet/sorghum (₦366.47) mixture ranked second to millet/cowpea mixture which had gross margin of ₦526.59/man-day. Millet/sorghum/groundnut (₦207.71) and millet/sorghum/cowpea (₦258.03) had the least gross margin per man-day. The gross margin per man-day could be used as a measure of return to labour, especially in peasant agriculture where fixed costs are negligible, as applied to this study.

Table 4.17: Estimated Production Costs and Returns Per Hectare of Millet-based cropping Systems in the Study Area.

Item/ha	Value (₦/ha)*				
	Millet/Sorghum	Millet/cowpea	Millet/G/nut	Millet/sorghum /Cowpea	Millet/sorghum /groundnut
Gross Revenue (GR)	19505.22	28168.75	23300.77	22464.65	23149.78
Variable Costs:					
Labour	5400	5892	7045.80	7683	8955
Fertilizer	693.60	594.96	1376.88	941.52	938.64
Seed	218.63	992.76	232.03	619.10	855.96
Total Variable Cost (TVC)	6312.23	7479.72	8634.71	9243.62	10749.60
Gross Margin (GR-TVC/ha)	13,192.99	20689.03	14646.06	13221.03	12400.18
Gross Margin/Man-day+	366.47	526.59	316.73	258.13	207.71

Source: field survey data, 1997/98.
*Market Prices: Sorghum (₦24/kg); Millet (₦25/kg); Groundnut (₦43/kg); Cowpea (₦47/kg).
+ Gross margin per man day = Gross margin per ha/Total labour per ha

4.2.4 Gross Margin Statistical Test of Significance.

The different gross margins of the millet-based cropping systems were subjected to statistical test of significance, to check whether they were different. The test of the gross margins shows that there was difference statistically (at 5%) among the gross margins. The null hypothesis (H_O) was, therefore, rejected and the alternative hypothesis (H_a) which means that there was difference in profitability (as measured by the gross margin) among the millet cropping systems was accepted. The ANOVA table is presented in Table 4.18.

Table 4.18: The ANOVA of Gross Margin For Millet-based Mixtures in the Study Area

Source	df	ss	Ms	F-cal	F-tab 5%
Treatments	4	1078250985	269562746	9.88*	3.48
Error	175	4776250466	27292860		
Total	179	5854501452			

Source: field survey data, 1997/98

* = Significant at 5%.

4.4 Regression Analysis of Socio-economic Variables and Output.

A multiple regression analysis was used to determine the socio-economic factors that affect the value of agricultural outputs of the millet mixture growing farmers. The linear function was chosen because it had the highest magnitude of $\bar{R}^2$ and conformed to the a priori expectations of the signs of the coefficients. The estimated regression coefficients, the standard errors and the t-values are presented in Table 4.19.

Analysis of the result shows that resident household size (X_4) was significant at 5%, and positively related to the agricultural output value of the farmers. This implies that the more the resident household size of the farmer, and the number of visits paid to him by the agricultural extension agents, the more likely his agricultural output would increase. This conforms with the a priori expectation. The reasons are obvious. Family labour supplied on the farm, Ceteris paribus, varies directly with the number of resident members during the cropping season, while the level of crop output varies directly with the amount of family labour supplied on the farm. A household with many productive members would probably contribute to the extra-labour requirements of millet mixture farm operations, leading to the positive relationship.

Table 4.19: Estimated Coefficient of Regression Analysis of Socio-economic Determinants of Output Value in Millet Cropping Systems (Linear Function).

Variables	Coefficient	Standard Error	T-Value
Farmers age	-598.482	422.107	-1.418[NS]
Farming experience	-298.697	453.636	-0.658[NS]
Educational level	498.273	471.412	1.057[NS]
Resident household size	2697.915	1124.574	2.399[*]
Extension visit	2299.054	1172.834	1.960[**]
Constant	41979.705		
R	0.58		
$\bar{R}^2$	0.54		

Source: Field survey data, 1997/98
* Significant at 5%; ** Significant at 10%, N
S = Not significant at the specified levels.

Also, farmers who are in frequent contact with the extension agents are likely to be relatively more enlightened and aware of benefits of adopting agricultural innovations. Frequent contact with extension workers is also likely to minimise doubts among farmers and ensure timely procurement of inputs. This would most probably encourage sustained adoption of the agricultural innovation.

The coefficient of educational level, though insignificant, was positively related to millet mixture output and in consonance with the a priori expectation. This means that as the level of education of the farmer increased, the output level also increased. All things being equal, a literate farmer would likely keep written records and so try to avoid past mistakes in current production. Additionally, the level of awareness of government programme and improved farming practices which contribute positively to crop output is enhanced through formal education. The statistical insignificance of this variable, however, means that educational attainment of the farmers was not a determinant of their agricultural output.

Age and farming experience of the farmers were expected to be negatively related to millet mixture output, as perhaps the more the age and experience of the farmer, the more likelihood that he would be conservative in adopting innovation. Also, such farmers appear to be less adventurous compared with the younger ones and depend more on past experience. The variables, age and farming experience were, however, not statistically significant, implying that they were not determinants of millet mixture output.

4.5 Production Function Analysis

The semi-log production function was employed in the analysis of input-output data to measure the contribution of each input to production, when the inputs interacted together to produce output. The selection was based on the comparison of coefficient of multiple determination (R^2), the a priori expectation and the statistical significance of the estimated regression coefficient (Table 4.20). The semi-log had the best fit and was selected as the lead equation for analysis of input-output relationship. Output was expressed in grain equivalent weight (GEW) to standardize the component crops of the mixtures as used by Umeh and Ikejimba (1991) and Olagoke (1991).

About 66 and 90 percents of the variations in yields from millet/sorghum and millet/cowpea mixtures respectively were explained by the specified factor inputs, as indicated by the R^2s. The corresponding R^2 for millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures were 49, 77 and 93 percents. These are reasonably high percentage considering that other important factors, such as differences in soil fertility, weather conditions and farmers' management abilities, were not included in the model.

The coefficients for farm size ($X_{1's}$) in all the cropping systems were positive and significant. Apart from millet/groundnut mixture, all others were significant at 5%. The positive coefficients of farm size suggests that a unit increase in the variable, in each of the five cropping systems, when other explanatory variables are held constant, is consistent with increased output level. This is in consonance with the a priori expectation, and contrary to the hypothesis that there is no relationship between output and input used in production. Ceteris paribus, increase in farm size means that more inputs would be required, and consequently more output expected, under good management. The significance of farm size in all the cropping systems highlights the importance of this factor in the peasant agriculture, where the commonest mode of production is extensive, as opposed to intensive pattern.

The coefficients of labour (X_{2s}) for millet/cowpea and millet/groundnut mixtures were positive and significant at 5%, and disproves the hypothesis of no relationship between inputs and outputs . The positive coefficients are in agreement with the hypothesized expected sign, and implies that as the amount of labour in the farms were increased, the outputs also increased. This type of relationship is, however, expected where the available labour is efficiently managed, along with the other resources to avoid redundancy and diminishing return to labour.

Millet/sorghum/cowpea and millet/sorghum/groundnut mixtures had insignificant labour coefficients at any of the specified levels, indicating lack of relationship between output and labour in the mixtures. A likely reason for the insignificance of the coefficients of labour could be insufficient labour supply or inefficiency in the use of labour, since 3-crop mixtures are more labour demanding.

The coefficient of fertilizer in millet/sorghum (X_3) mixture was positive and in accordance with the expected sign. This means that the quantity of fertilizer applied was directly related to output. The negative coefficients of fertilizer in most of the millet cropping systems could be attributed to the expensiveness of the input and the consequent reduction in the number of users and application rate. Also, inefficiency in fertilizer application methods, or the nitrogen-fixing effects of the component crops (cowpea and groundnut) which were capable of increasing soil fertility, or lead to excessive vegetation and low yield when combined with artificial fertilizer at high rate, could be responsible for the negative coefficients. The statistical insignificance of the coefficients implies that fertilizer was not a determinant of output in the cropping systems.

Seed input coefficients (X_{4s}) for millet/cowpea, millet/groundnut and millet/sorghum/cowpea mixtures were positive and significant at 5%, thereby disproving the hypothesis of no relationship between output and input in production. The positiveness of the seed coefficients is in line with the expected sign, in all the millet cropping systems. All things being equal, higher seed rate in kg/ha implies greater number of component crop stands per hectare and consequently higher yield, except where there is over-crowding leading to competition for nutrients and low yield.

Table 4.20: Estimated Regression Coefficients of Inputs in Millet-based Cropping systems with Semi-log Production Function.

	Estimated Parameters +							
Cropping systems	Constant	Land	Labour	Fertilizer	Seed	F-ratio	R^2	$\bar{R}$
Millet/sorghum	968.731	1548.896* (419.615)	250.058** (129.333)	62.242** (31.590)	110.513^{NS} (392.386)	14.745*	0.655	0.6
Millet/cowpea	748.676	1844.488* (336.055)	270.398* (132.745)	-10.571^{NS} (27.805)	744.755* (245.414)	66.127*	0.895	0.8
Millet/groundnut	1120.999	1329.390** (751.137)	1490.566* (667.304)	-12616^{NS} (116.126)	536.670* (242.038)	9.151*	0.550	0.4
Millet/ sorghum/cowpea	594.865	1597.871* (358.268)	-78.823^{NS} (428.068)	-26.398^{NS} (51.455)	939.949* (285.504)	30.477*	0.797	0.7
Millet/sorghum/ groundnut	341.935	2239.325* (230.709)	115.453^{NS} (138.062)	19.396^{NS} (20.400)	223.8329** (117.190)	121.111*	0.940	0.9

Source: Field survey data, 1997/98
* = Significant at 5% , ** = Significant at 10%,
NS = Not significant at specified levels,
\+ = Figures in parentheses are standard errors

The result of the pooled data for the semi-log function was also found to give the best fit, judging from the R^2 and other econometric criteria. Farm size, labour and seed were all positive and significant at 5%, while fertilizer was negative and insignificant (Table 4.21). The postiveness of the coefficients of farm size, labour and seed is in consonance with the a priori expectation. The insignificance of the fertilizer coefficient in the pooled data further lends credence to the fact that fertilizer is not an important determinant of output in millet-based cropping systems, as evident in the separate models for the cropping systems.

Table 4.21: Semi-log Regression Estimates for Production of Millet-based Mixtures (Pooled Data).

Variables	Coefficients	Standard Error	T-value
Farm size	484.900	106.344	4.560*
Labour	806.645	145.564	5.542*
Fertilizer	-9.728	33.443	-0.291^{NS}
Seed	414.167	78.288	5.292*
R^2	0.519		
$\bar{R}^2$	0.508		
Constant	1144.125		

Source: Field survey data, 1997/98
* = Significant at 5%
NS = Not significant at 5%

4.5.1 **Relative Importance of Productive Resources.**

The relative importance of common resources used in production could be determined by ranking the magnitudes of their positive Beta coefficients as indicated by the production function. The resource with the highest Beta coefficient is the most important. This method was employed by Mijindadi and Norman (1982). The relative importance of resources in the millet crop mixtures as determined by the semi-log production function is presented in Table 4.22.

Analysis of the result shows that land was the most important resource in all the millet cropping systems, except in millet/groundnut mixture, where it ranked second. The reason for relative importance of land resource over others is obvious. Peasant agriculture is usually based on extensive rather than intensive land use. Land is, therefore, expected to be the most important resource. Seed (planting material) ranked second in millet/cowpea and millet/sorghum/cowpea, while labour was second in millet/sorghum and fertilizer in millet/sorghum/groundnut mixtures. Labour input was ranked as the third most important resource in the production of millet/cowpea and millet/sorghum mixtures but first and second in millet/groundnut and millet/sorghum mixtures respectively.

In general, millet crop mixtures with cowpea as one of the component crops had the same resource ranking, with land as the most important, followed by seed, labour and fertilizer. Perhaps, the nitrogen-fixing ability of the roots and the mulching effect of the leaves of cowpea as component crops in millet/cowpea and millet/sorghum/cowpea helped to improve soil fertility and rendered the use of fertilizer less important.

On the aggregate, land ranked as the most important resource with total descending rank order of 6, and followed by labour (10). Fertilizer was the least important with total rank order of 18, confirming the general agronomic finding that millet grows where no other cereal can consistently produce harvest on sandy, infertile soils, where rainfall is low and erratic (Teriba, 1994).

Table 4.22: Rank Order of Relative Importance of Resources in Millet-based Cropping Systems.

	Beta Coefficient				Rank Order of resources*			
Cropping systems	Land	Labour	Fertilizer	Seed	Land	Labour	Fertilizer	Seed
Millet/sorghum	0.81	0.222	0.182	0.062	1	2	3	4
millet/cowpea	0.6	0.143	-0.023	0.307	1	2	3	2
Millet/groundnut	0.34	0.485	-0.015	-0.066	2	1	3	4
Millet/sorghum/ cowpea	0.64	0.032	-0.051	0.395	1	3	4	2
Millet/sorghum/ groundnut	0.87	0.061	0.044	0.051	1	2	4	3
Aggregate Rank Order:					6	11	18	15
Rank order of pooled data:	0.266	0.374	0.018	0.317	3	1	4	2

Source: Field survey data, 1997/98
* Ranks are in descending order of resource importance.

When the result of the pooled data was however considered, labour ranked first as the most important resource. This was followed by seed input, while fertilizer still remained the least important.

4.5.2 Marginal Value Product and Economic Efficiency of Resource Use.

Economic efficiency of resource use in the various millet-based cropping systems was compared using the ratios of their Marginal Value Products (MVPs) and the Marginal Factor Costs (MFCs). The MVP for each input was calculated by multiplying the Marginal Physical Product (MPP) of each input by the arithematic mean price of the millet crop mixture outputs. An input is said to be efficiently used if its MVP is just sufficient to cover acquisition cost, that is, there is no difference between MVP and the MFC. The MVPs and their ratios to MFCs of the significant variable resources in millet cropping systems are presented in Tables 4.23 and 4.24.

According to the MPP and MVP figures for the millet/cowpea mixture, on average, and with all other factors held constant, an increase of man-day of labour would increase output by 5.16 grain equivalent weight (GEW) and revenue by ₦199.59. Similarly, an additional GEW of seed would increase output by 22.45 GEW and revenue by ₦868.37. The MVP of an additional man-day of labour in millet/groundnut mixture would be ₦597.36 with MPP of 21.97 GEW. Millet/sorghum/cowpea mixture had MVP of ₦1,149.12 for seed, while the MVP for millet/sorghum mixture labour and fertilizer were ₦200.55 and ₦62.24 respectively.

Based on the MVP figures, therefore, an additional man-day of labour in millet/groundnut mixture would bring the highest return (₦597.36) than in millet/sorghum and millet/cowpea mixtures. An additional GEW of seed in millet/sorghum/cowpea would bring the highest return (₦1,149.12) compared with millet/cowpea (₦868.37) and millet/groundnut (₦194.4) mixtures.

Table 4.23: Estimated Marginal Physical Products (MPPs) and Marginal Value Product (MVPs) of Millet-based Cropping Systems.

Cropping systems	MPP (GEW/Unit input)				MVP (₦/Unit input)[+]			
	Land	Labour	Fertilizer	Seed	Land	Labour	Fertilizer	Seed
Millet/sorghum	1164.58	5.222	1.62	*	44778.10	200.55	62.24	*
millet/cowpea	1386.83	5.16	*	22.45	53323.61	199.59	*	868.37
Millet/groundnut	923.19	21.97	*	7.14	25101.54	597.36	*	194.4
Millet/sorghum/ cowpea	980.29	*	*	29.18	38603.82	*	*	1149.12
Millet/sorghum/ groundnut	1599.52	*	*	4.55*	56894.93	*	*	148.19

Source: Regression results, field survey data, 1997/98
* Estimate not derived because coefficient was insignificant.
\+ Unit price/Grain equivalent Weight: Millet\sorghum (₦38.45/GEW); Millet\cowpea (₦38.45/GEW);Millet\groundnut(₦27.19/GEW); Millet\sorghum/cowpea (₦39.38/GEW); Millet\sorghum/groundnut (₦35.57/GEW)
Unit price/GEW (Py) = Total value of output/Total GEW of output, of a crop mixture

Table 4.24: Ratios of MVP to MFC.

Cropping Systems	MFC(P_x)				MVP/MFC(P_x)			
	Land	Labour	Fertilizer	Seed	Land	Labour	Fertilizer	Seed
Millet/sorghum	800	150	24	*	55.97	1.34	2.59	*
millet/cowpea	960	150	*	39.9	55.45	1.33	*	21.76
Millet/groundnut	780	150	*	23.7	32.18	3.9836	*	8.19
Millet/sorghum/ cowpea	838	*	*	31.2	46.07	*	*	36.76
Millet/sorghum/ groundnut	1035	*	*	32.6	54.97	*	*	4.58

Source: Field survey data, 1997/98
* Estimate not derived because coefficient was insignificant.

Comparison of the ratios of the MVP and MFC shows that all resulting ratios were greater than unity for land, labour, fertilizer and seed, indicating that the inputs were under-used on the study farms during the cropping season. This confirms the hypothesis that resources are not efficiently utilized. Under the assumptions of the model, therefore, it is likely that outputs and revenues would have been higher if more of inputs had been utilized.

4.5.3 Adjustment in Marginal Value Products (MVPs) for Optimal Resource Allocation.

Optimality in resource allocation requires that the marginal value product be equal to the marginal factor cost or the unit price of the input. Analysis of the MVP - MFC ratios indicates that all the variable resources were under-utilized. The necessary percentage adjustments in the MVPs required, therefore, to obtain optimal resource allocation are presented in (Table 4.25).

Table4.25: Required Adjustment in Marginal Value Products (MVPs) (in percentage) for Optimal Resource allocation of Variable Inputs.

	Percentage Adjustments in MVPs			
Cropping Systems	Land	Labour	Fertilizer	Seed
Millet/sorghum	98.21	80.85	61.4	*
Millet/cowpea	98.20	24.8	*	95.4
Millet/groundnut	96.89	74.9	*	87.8
Millet/sorghum/cowpea	97.83	*	*	97.3
Millet/sorghum/groundnut	98.18	*	*	78.0

Source: Field survey data, 1997/98

* Coefficient was insignificant and, therefore, not determined.

The results indicate that for optimal allocation of land in all the cropping mixtures, more than 96% increase in MVPs was required, while labour in the millet/sorghum, millet/cowpea and millet/groundnut mixtures, required increase in MVPs by 80.85, 24.8 and 74.9 percents respectively. About 61 percent increase in MVP for millet/groundnut, was necessary for optimality in fertilizer application. This could be achieved through increase in fertilizer application rate. Seeds were grossly under-used leading to percentage deficits of 95.4, 87.8, 97.3 and 78 in MVPs for optimal allocation, for millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut respectively. For increase in the use of the inputs to produce any effect in the percentage adjustment of the MVPs for optimal resource allocation, such resources must be purchased in competitive market, to ensure fair prices. In the alternative, higher prices have to be obtained for the outputs.

4.5.4 **Production Elasticity and Technical Efficiency in Resource Use.**

The sum of the elasticity of production of the semi-log function indicates the nature of return to scale, that is, the degree of responsiveness of the output when all inputs are varied (Olagoke, 1991; Ogungbile and Sanni, 1991). These sums amounted to 2.92, 2.93, 2.70, 2.70 and 2.64 for millet/sorghum. millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures respectively (Table 4.26). This implies that if all inputs included in the model for farmers growing millet-based mixtures were increased by 1%, output would have increased by 2.92, 2.93, 2.70, 2.70 and 2.64 percent for millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures respectively.

The sum of elasticities were higher than unity in all the crop mixtures, thus the production for the mixtures was characterised by an increasing return to scale. The highest value observed in millet/cowpea mixture compared with others indicates that it had the highest output to a proportionate change in all the inputs during the cropping season. This was followed by millet/sorghum mixture.

Table4. 26: Elasticity of Production and Returns to Scale of Inputs in Millet-based Cropping Systems.

	Elasticity of Production				
Cropping systems	Land	Labour	Fertilizer	Seed	Return to Scale
Millet/sorghum	2.29	0.3738	0.0931	0.165	2.92
Millet/cowpea	1.90	0.2785	-0.0109	0.767	2.93
Millet/groundnut	1.07	1.2053	-0.0102	0.434	2.70
Millet/sorghum/ cowpea	1.72	-0.085	0.0555	1.014	2.70
Millet/sorghum/ groundnut	2.25	0.1158	0.0495	0.225	2.64

Source: Field survey data, 1997/98

Thus, millet/cowpea and millet/sorghum mixtures could be said to have the highest return to scale amoung other mixtures. This method was adopted by Ogungbile and Sanni (1991). It indicates the technical efficiency of resource use. Farrel (1957) defined technical efficiency as the measure of a firm's success in producing maximum output from a given set of inputs. The millet/cowpea mixture is important source of carbohydrate and protein to the farmers, thus ensuring good and balanced food diet.

4.6 Technical and Socio-economic Problems of Millet Mixture Growers.

The problems of agriculture in Nigeria are legion. These include social, economic and climatic problems amongst others. The millet growing farmers were asked to rank their five most important agro-socio-economic problems in descending order of magnitude. The greatest problem of a farmer was ranked one (1), followed by 2, 3, 4 etc. The result is shown in Table 4.27.

Table 4.27: Rank Order of Technical Socio-economic Problems of Respondents (n = 180).

Technical and Socio-economic problems	Rank order*	Percentage of Respondents**
High cost of inputs	1	50.6
Lack of finance	2	50.0
Soil infertility	3	30.5
Drought	4	28.3
Erosion	5	23.9
Lack of hired labour at critical period	6	23.0
Pests and diseases	7	14.4
Lack of market for produce	8	12.4

Source: Field survey data, 1997/98
* Ranks are in descending order of magnitude of problems
** Multiple responses existed, hence exceeds 100%.

The result reveals that the major technical and socio-economic problems of the farmers were high cost of inputs, lack of finance, soil infertility, drought and erosion. High cost of inputs was ranked first by 50.6% of the respondents. According to the farmers, the cost of fertilizer, in particular, was very high following the Federal Government withdrawal of fertilizer subsidy in 1997. Consequently, the price of NPK fertilizer increased from the official rate of ₦450 to ₦1,200 per 50kg bag. This was not affordable to most farmers. Perhaps, this accounted for not more than 50% of the respondents in any of the millet cropping systems using fertilizer, as indicated in this study (Table 4.27). The situation was made worse by lack of finance facing the farmers, which ranked second in the problems as indicated by 50.0% of the respondents. Evidence from the study showed that 45% of the farmers were subsistent, producing only for consumption (Table 4.8), as opposed to profit maximization. Given the small holdings of the farmers, therefore, lack of finance is bound to constitute a constraint in production.

Soil infertility was ranked to be the third most important agronomic problems of 30.5% of the study farmers. The farmers pointed out that though millets are tolerant to most soil types, they usually supplement the soil with artificial fertilizer or organic manure. With the availability of fertilizer at affordable price, following the government subsidy over the years, the farmers, however, wholly depended on artificial fertilizer because of its reduced price and bulkiness relative to organic manure, and ease of transportation to the farms. They, therefore, cared less about collection of organic manure for millet production, but for backyard vegetable gardens. The sudden withdrawal of fertilizer subsidy in the study year (1997), therefore, met the farmers with no immediate option and arrangement for fertilizing the soils. The result was soil infertility.

Fourth in the hierachy of agronomic problems of the millet mixture growers (23.8%) was drought. The drought in the 1997/98 cropping season in Borno state was phenomenal. According to the farmers, rainfall established in the second week of July, but became dependable from last week of July through August. There were, however, intermittent droughts from last week of August through the second week of September. On the whole, the onset of rainfall was delayed, the frequency was uneven, and the amount was less compared to the situation in 1996. Low yield and high prices were generally recorded for most crops in 1997 compared to the previous year. Millet farmers who embarked on dry planting of millet were the worse hit by the erratic nature of the rainfall in the study areas, as most of their millet stands were staunted in growth.

About 24% of the respondents ranked erosion as the fifth most important technical and socio-economic problem. Two major types of erosions which devastated farmers' farms during the cropping season were reported. They include wind and flood erosions. According to the farmers, the wind storms which usually preceeded any rainfall during the year were tremendous, breaking tall crops like millet and sorghum. In the case of mixtures, the broken stems trampled the component crops such as cowpea and groundnut. Thus, in addition to loss of millet and sorghum stands, extra labours were required to remove the broken stands.

Some of the respondents revealed that they observed persistent floods in August through September. Rain duration lasted up to the second week of October. The incidence of flood erosion in 1997 and in the recent years has become re-occuring, as some of the farmers noted. During the rainy season, the Lakes Alao and Chad overflow their banks. The resulting floods usually destroy crops grown along their courses. Farmers experienced this in 1997/98 cropping season and perceived it as one of the erosion problems they had. Other problems of the farmers include lack of hired labour at the critical period, incidence of pests and diseases, and lack of market for produce.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

The study examined the economics of millet production under different cropping systems in Borno State of Nigeria. The specific objectives were to identify the millet-based cropping systems and socio-economic characteristics of the millet growers; determine the correlation between socio-economic variables and agricultural outputs of the farmers; determine the differences in profitability among millet crop mixtures; estimate production function for millet cropping systems; compare relative importance and resource use efficiency for common resources used in millet crop mixtures; and identify the major agronomic and socio-economic problems of the millet growing farmers.

Primary data for the study were collected using questionnaire and interview schedules administered to 180 millet mixture growing farmers. Thirty six (36) were randomly selected from each of the stratum of the five major millet mixtures studied, namely; millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut. Analysis of data was achieved by means of simple descriptive statistics, gross margin analysis, multiple regression, Analysis of Variance (ANOVA) and Chi-square statistic.

The major findings of the study indicated that the mean age of the farmers was 40.7 years, with 51.1% in the age bracket of 31 and 40 years. Farming experience for majority

(62.8%) of the farmers was between 1 to 10 years, with mean of 10.3 and minimum of 3 years. Majority (61.1%) of the respondents acquired secondary education. Average farm size for the respondents was 1.4ha, with most farmers (77.8%) having farm size ranging from 1 to 1.99ha. Maximum farm size was 3.5ha, while significant relationship existed between farm size and cropping systems. Lands were mostly acquired through inheritance as indicated by 67.8% of the respondents. Household size for 58.9% of the respondents was between 1 and 4 with a mean of 3.8 persons and maximum of 13 persons. Family labour consitituted the major source of labour. Mean labour uses were estimated at 36, 39.28, 46.97, 51 and 59.70 for millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea, and millet/sorghum/groundnut respectively. Labour wage was N150 per man-day. Contact with extension workers was poor, with mean of 1.5, minimum of 1 and maximum of 5 times during the cropping season. Among the major reasons for growing millet in mixtures by respondents were traditional practice, yield security and efficient use of land as indicated by 44.4, 20 and 13.3 and 11.7 percents were profit maximization, food security and both respectively in the same order. Compound fertilizer (N:P:K: 15:15:15) was commonly used by the farmers at application mean rate of 28.90, 24.79, 57.00, 39.23 and 39.11kg/ha, for millet/sorghum, millet/cowpea, millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut respectively. A 50kg bag of the fertilizer was purchased at N1,200. The common varieties of mixture component crops grown were Ex-Borno for millet, economic variables which positively and significantly affected the agricultural outputs of the farmers as indicated by the linear regression model were educational level, resident household size, and extension visits. Age and farming experience were inversely related to output.

Analysis of the costs and returns of the different millet mixtures revealed that millet/cowpea attracted the highest gross margin per hectare of N20,689.03, followed by millet/groundnut (N14,646.06) and millet/sorghum/cowpea (N13,221.03). In terms of gross margin per man-day, millet/cowpea mixture (N526.59) ranked first and followed by millet/sorghum mixture which also had the gross margin of N366.47 per man-day. Thus, millet/cowpea mixture was the most profitable in terms of gross margins per hectare and per man-day.

The result of semi-log production function indicated that farm size was significant at 5% in all the cropping systems, except in millet/groundnut. Labour was significant at 5% in millet/cowpea and millet/groundnut, while seed was significant in millet/sorghum/cowpea and millet/sorghum mixtures. Fertilizer input was significant in millet/groundnut, millet/sorghum/cowpea and millet/sorghum/groundnut mixtures. A measure of the relative importance of the resources in production based on their beta coefficients showed that land ranked first as the most important resource in all the millet mixtures except in millet/groundnut where it ranked second. Millet/cowpea and millet/sorghum/cowpea ranked seed as the second most important resources, while millet/groundnut and millet/sorghum/groundnut ranked it as the second. Comparison of economic efficiency of resources used based on the ratio of marginal value product (MVP) to marginal factor cost (MFC) showed that all the inputs were under utilized, in all the millet-based cropping systems. Additionally, an assessment of the technical efficiency of resource use based on the return to scale indicated that millet/groundnut mixture had the highests return to scale (1.63).

This was followed by millet/cowpea mixture (1.01), even though both mixtures exhibited increasing return to scale. All the other mixtures were characterised by decreasing return to scale, having less than unity sum of elasticity of production.

High cost of inputs was ranked as the most important agronomic problem by 50% of the farmers. This was followed by lack of finance, soil infertility, drought and erosion, in the same order.

5.1 Conclusion.

Evidence from this study has re-affirmed the claims that inefficiency in the use of available resources poses the major constraints to increased food production in Nigeria. Though all the millet-based mixtures in the study were profitable, the production function analysis revealed under-utilization of all the production resources. The profit motive as opposed to food security for determining why farmers prefer to grow crops in mixture was shown to be secondary, among the millet-based growers.

This has a far-reaching implication for food production. The predominance of food security as the major objective for most of the farmers suggest an inherent tendency or willingness to adopt measures specifically towards increasing their aggregate food supply. Intercropping, which is the dominant cropping system for millet growing farmers, has been proved to be one of such measures. The yield advantage and stability over sole cropping has been established by researchers. Its adoption by millet farmers will, therefore, be a worthwhile practice towards food sufficiency.

Millet and sorghum have been shown to constitute the major food base of most states in northern Nigeria, including Borno State to the tune of 50 million people. The objective of attaining food sufficiency and security through millet-based mixtures, however, can only be achieved if productive resources such as land, fertilizer, labour and seeds are efficiently utilized, timely and adequately provided, and if conscious efforts are made to select crop combinations that facilitate food and income for the family's need. This is in addition to addressing the technical and socio-economic problems such as drought, erosion, soil fertility, among others, militating against increased output. The future holds promise for increased food production through millet-based mixtures especially millet/cowpea and millet/groundnut mixtures for sufficient and balanced food crop diet in Nigeria.

5.2. Recommendations.

The following recommendations are made based on the findings of the study.

(i) With regards to the small holdings of the farmers, the relatively small household size, and lack of finance, perhaps resulting to under-utilization of productive input, there is need for an integrated approach to the problems. In this regards, the experience of the National Agricultural Land Development Authority (NALDA) in the state is quite instructive. Its management, by pursuing a farm support service programme aimed at ensuring quick access to productive inputs and social infrastructures, and discouraging land fragmentation should be extended to greater number of millet growing farmers, who produce the major staple food in the state. The range of supports to farmers should include land development, provision of grants, credits, social infrastructure such as storage facilities, roads, potable water, health care and so on, as well as institutional and organizational supports in form of monitoring and evaluation services.

ii. The extension services in the state should be revitalized and made more effective. A situation where 50% of the study farmers had no single access to extension agents, while 44.4% had just 1 to 4 visits during the cropping season does not augur well for effective and efficient farm communication. The fortnightly visits of the Agricultural Development Programme (ADP) should be made more functional by ensuring greater number of and more effective visits to farmers during the cropping seasons.

iii. Millet-based mixtures are labour demanding. Tractor or animal traction hiring services, if rendered to the farmers will help to ensure adequate supply of labour, thereby reduce under-utilization of labour.

iv. The use of organic manure as a supplement to artificial fertilizer needs to be advised and encouraged through the ADP extension agents, to cushion the effect of high cost of artificial fertilizer and further raise the profit margins of the farmers.

v. Millet-based mixtures with crops of higher economic and monetary values, where possible, should be explored to raise the revenue base of the farmers, for easy procurement of inputs. Research institutes and universities should undertake research in this area.

vi. Erosion control programme should be embarked upon by the State government to complement the afforestation programme and tackle the menace of flood erosion. Also, farmers should be discouraged from planting during the dry season in anticipation of the rain (dry planting) to reduce losses from drought.

vii. Finally, farmers should be encouraged to grow 2-crop mixtures, especially millet/cowpea mixture, which has been proved most profitable

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APPENDIX I.

QUESTIONNAIRE

ECONOMICS OF MILLET PRODUCTION UNDER DIFFERENT CROPPING SYSTEMS IN BORNO STATE OF NIGERIA.

Millet Farmers Questionnaire: No:____________________________

Millet-based crop mixture of interest studied:-------------------------------------

Total number of farmers growing the crop mixture in the study

Area:____

A. SOCIO-ECONOMIC CHARACTERISTICS OF FARMERS

1. L.G.A;________________________Village:_____________________

Farmers Name:______________________________

1. Sex:___________________________
2. Age:___________________________
3. Marital Status:___________________
4. Resident household size:____________
5. a) Number of years in formal school:______________

   b) level of Educ. Completed_______
6. Annual farm income: N___________
7. Annual non-farm income: N_______
8. Farm size (ha):_________________
9. Non-farm activityengaged in:_______
10. Number of years of farming experience:____________

11. Production goal:

(a) Profit maximization ( )

(b) Food security ( )

(c) Profit maximization and food security ( )

(d) Others (Specify):______________________

B. INFORMATION ON MILLET PRODUCTION

12. Indicate the other millet-based crop mixture(s) grown in your farm(s) and the crop ratio (Tick)

Crop mixture	Crop Ratio e.g. 1:2; 1:3:2 etc)
a). Millet/cowpea ( )	
b). Millet/groundnut ( )	
c). Millet/sorghum ( )	
d). Millet/sorghum ( )	
e). Millet/sorghum/groundnut ( )	
f). Others (specify)	

13. Which is the major millet-based crop mixture grown in 1997............
14. How many of the major millet-based farms did you have?
15. Why do you grow millet in mixtures (rank the most important first)

Reasons	Ranks
a). It is our traditional practice	
b). To obtain high output	
c). Because of shortage of land	
d). Ensure yield security	
e). Ensure food security	
f). Others (specify)	

C. INFORMATION ON INPUT USE

i) Land

16. Land for millet production is acquired through (Tick).

a). Inheritance ( )

b). Government ( )

c). Bought from other farmers ( )

d). Leasing ( )

e). Others specify)

17. If the land was bought or leased, state the amount N:__________________

18. Indicate the size of land for the major lmillet-based crop mixtures grown in 1997.......

19. What is the rent value of land per hectare in the area N:__________________

ii) Capital

20. Sources of fund for millet production (Tick)

a). Private ( )

b). Partnership ( )

c). Credit from bank ( )

d). Credit from cooperatives ( )

e). Credit from money lenders ( )

f). Others (specify):____________________

iii). Labour input

21. Sources of labour (Tick)

a). Family labour

b). Hired labour or contract labour ( )

c). Family labour/hired or contract labour ( )

22. Clearing labour.

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult	Female Adult	Child	Male Adult	Female Adult	Child
1. 2. 3. etc.								

23. Ridging labour:

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult	Female Adult	Child	Male Adult	Female Adult	Child
1. 2. 3. etc.								

24. Planting labour:

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult	Female Adult	Child	Male Adult	Female Adult	Child
1. 2. 3. etc.								

25. Replanting labour:

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult	Female Adult	Child	Male Adult	Female Adult	Child
1. 2. 3. etc.								

26. Fertilizing labour.

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult 1 2 3	Female Adult 1 2 3	Child 1 2 3	Male Adult 1 2 3	Female Adult 1 2 3	Child 1 2 3
1. 2. 3. etc.								

NB: 1 = First fertilizer application; 2. Second application
3. = Third application.

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult 1 2 3	Female Adult 1 2 3	Child 1 2 3	Male Adult 1 2 3	Female Adult 1 2 3	Child 1 2 3
1. 2. 3. etc.								

NB: 1 = First fertilizer application; 2. Second application
3. = Third application.

27. How many times did you fertilize each farm?

28. Weeding labour.

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult 1 2 3	Female Adult 1 2 3	Child 1 2 3	Male Adult 1 2 3	Female Adult 1 2 3	Child 1 2 3
1. 2. 3. etc.								

NB: 1 = First weeding; 2 = Second weeding; 3 = Third weeding.

29. How many times did you weed each farm?

30. Harvesting labour.

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult	Female Adult	Child	Male Adult	Female Adult	Child
1. 2. 3. etc.								

31. Threshing labour:

Field No.	Crop mixture	Ha	Family labour (in man-days)			Hired labour (in man-days)		
			Male Adult	Female Adult	Child	Male Adult	Female Adult	Child
1. 2. 3. etc.								

32. Average affected hours spent on the farm per day:____________________

a). Male adult:-____________________

b). Female adult:____________________

c). Child:____________________

33. What are the charges per day?

	Charges per day (N)			
Activities	Male	Female	Adult	Child
Clearing				
Ridging				
Planting				
Replanting				
Fertilizing				
Weeding				
Harvesting				
Threshing				

iv). Fertilizer Input

34. Fertilizer application and cost

Field No	Crop Mixture	Ha	COMPOUND		SULFA		C A N		POTASH		A S H	
			Quantity (kg)	Cost (N)	Quantity (kg)	Cost (N)	Quantity (kg)	Cost (N)	Quantity (kg)	Cost (N)	Quantity (Kg)	Cost (N)

Manure input

Cost of manure

Field No	Crop Mixture	Ha	Poultry		Goat		Sheep		Cattle		Donkey	
			Quantity (kg)	Cost (N)	Quantity (kg)	Cost (N)	Quantity (kg)	Cost (N)	Quantity (kg)	Cost (N)	Quantity (Kg)	Cost (N)

v). Seed Input

37. Cost of seeds

Field No	Crop Mixture	Ha	Millet		Cowpea		Sorghum		Groundnut		Others (Specify)	
			Quantity used (kg)	Cost (₦/kg)	Quantity used (kg)	Cost (₦/kg)	Quantity used (kg)	Cost (₦/kg)	Quantity used (kg)	Cost (₦/kg)	Quantity used (kg)	Cost (₦/kg

N.B. Unit used can be in kg, bag (small, big), basin, basket, tons, etc.

38. Farm tools for millet production.

Farm tool	Number	Cost of purchase	Years of purchase	Years of useful life	Salvage value
Smallhoe					
Big hoe					
Cutlass					
Others (specify)					

D. INFORMATION ON FARM PROBLEMS

39. Which are the five major farm problems you have (rank the most important first).

Farm problems	Rank
a). Lack of finance.	
b). Lack of hired labour at critical periods	
c). High cost of inputs.	
d). Drought problems.	
e). Lack of market for the products.	
f). Soil infertility	
g). Pests and diseases	
h). Erosion	
I). Others (specify)	

40. How many times were you visited by Extension workers in the 1997 cropping?________________________

41. Which is your major source of agricultural information:

(a) ADP ( ) (b) NGOS ( ) 8 Cooperatives ( ) (d) Private Companies ( ) (e) None ( ) (f) Others (specify)____

E. INFORMATION ON OUTPUT AND PRICES:

42. Output of mixture component crops:

Field No.	Crop Mixture	Ha	Yield in kg				
			Millet	Sorghum	Cowpea	G/nut	Others (specify)

43. Distribution and sales of output:

Crop disttribution and sales	Crop Harvest (kg)				
	Millet	Sorghum	Cowpea	G/nut	Others (specify)
a). Total harvest.					
b). Home consumption.					
c). Gift					
d). Reserved for next planting					
e). Marketed					
f). Naira received from sale					
g). Others (specify)					

44. Indicate the market price per kg. for the crops in 1997.

Crops	Market price (₦/kg)
Millet Sorghum Cowpea Groundnut Others (specify)	

Appendix II: PAIR-WISE CORRLEATIONS.

Appendix 2.1 Pair-wise correlation of independentt variables for millet/groundnut/correlation mixture semi-leg production function.

Variables	X_1	X_2	X_3	X_4
Land area (X_1)	1			
Labour input (X_2)	-0.436	1		
Fertilizer Quantity (X_3)	-0.013	-0.174	1	
Seed quantity (X_4)	-0.405	0.037	-0.003	1

Appendix 2.2. Pair-wise Correlation of Independent Variables for Millet/Sorghum/Cowpea Mixture Semi-log Production Function.

Variables	X_1	X_2	X_3	X_4
Land area (X_1)	1			
Labour input (X_2)	-0.428	1		
Fertilizer Quantity (X_3)	-0.052	-0.345	1	
Seed quantity (X_4)	-0.074	-0.499	0.154	1

Appendix 2.3

Pair-wise correlation of independent variables for millet/sorghum correlation mixture semi-leg production function.

Variables	X_1	X_2	X_3	X_4
Land area (X_1)	1			
Labour input (X_2)	-0.155	1		
Fertilizer Quantity (X_3)	-0.251	-0.471	1	
Seed quantity (X_4)	-0.450	-0.419	0.214	1

Appendix 2.4 Pair-wise Correlation of Independent Variables for Millet/Cowpea Mixture Semi-log Production Function.

Variables	X_1	X_2	X_3	X_4
Output (Y)	1			
Land area (X_1)	1			
Labour input (X_2)	-0.407	1		
Fertilizer quantity (X_3)	0.055	-0.214	1	
Seed quantity (X_4)	-0.482	0.119	0.099	1

Appendix 2.5 Pair-wise correlation of independent variables for millet/groundnut mixture semi-leg Production Function.

Variables	X_1	X_2	X_3	X_4
Land area (X_1)	1			
Labour input (X_2)	-0.456	1		
Fertilizer Quantity (X_3)	-0.025	-0.360	1	
Seed quantity (X_4)	-0.062	-0.359	0.206	1

Appendix 2.6 Pair-wise Correlation of Independent Variables for Millet/Cropping Systems Semi-log Production Function (Pooled data)

Variables	X_1	X_2	X_3	X_4
Land area (X_1)	1			
Labour input (X_2)	-0.382	1		
Fertilizer Quantity (X_3)	-0.343	0.442	1	
Seed quantity (X_4)	0.209	0.461	0.132	1

Appendix III

Grain Equivalent Weight Conversion Factors and Calculation Method

Appendix 3.1: Grain Equivalent Wesight (GEWS) of Component Crops in the Studied Millet-based Cropping Systems

Crops	GEW*
Millet	0.68
Sorghum	0.60
Cowpea	1.12
Groundnut	1.83

*Source: Clark, C. and M. Haswell (1970).

Appendix 3.2: Calculation of GEW of Millet-based Cropping Systems

Cropping systems	Yields of Component Crops (kg/ha)				Total yield in GEW/ha
	Millet	Sorghum	Cowpea	Groundnut	
	365.34	432.15	-	-	507.72
	676.04	-	239.75	-	728.22
	574.42	-	-	254.42	856.17
	300.00	352.04	138.63	-	570.49
	319.41	360.40	-	151.51	710.70

Calculation of GEW for Crop Mixtures:

Millet/sorghum : (365.34 x 0.68) + (432.15 x 0.60) = 507.73

Millet/cowpea: (676.04 x 0.68) + (239.75 x 1.12) = 728.22

Millet/groundnut : (574.42. x 0.68) + (254.42 x 1.83) = 856.17

pMillet/sorghum/cowpea: (300 x 0.68) + (352.04 x 0.60) + (138.63 x 1.12) = 570.49

Millet/Sorghum/groundnut: (319.41 x 0.68) + 360.40 x 0.60) + (151.51 x 1.83) = 710.70