PERFORMANCE OF QUALITY PROTEIN MAIZE AT VARYING LEVELS OF NPK FERTILIZER AND PLANT DENSITY IN SAVANNA ZONES OF NIGERIA

BY

HASSAN ADAMU HAMIDU

A thesis submitted to the Postgraduate School, Ahmadu Bello University, in partial fulfillment of the requirements for the award of the Degree of Master of Science in Agronomy

DEPARTMENT OF AGRONOMY
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
ZARIA, NIGERIA

MARCH, 1999

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

HASSAN, Adamu Hamidu
(Candidate)

Date 9/8/199

The above declaration is confirmed;

Dr. A.M Falaki
(Major Supervisor)

Date 9/9/1999

CERTIFICATION

This thesis entitled "THE PERFORMANCE OF QUALITY PROTEIN MAIZE AT VARYING LEVELS OF NPK FERTILIZER AND PLANT DENSITY IN SAVANNA ZONES OF NIGERIA". by Hamidu Adamu HASSAN meets the regulations governing the degree of Master of Science (Agronomy) of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

Dr. A.M. Balaki.
Chairman, Supervisory Committee

Dr. E.B. Amans
Member, supervisory committee and Head of Department

Dr. S.A. Dadari
Member, Supervisory Committee

Dean Postgraduate School

Date 17/08/00

AHMADU BELLO UNIVERSITY
ZARIA

DEDICATION

This work is dedicated to my late parents (Mallam Abdul Hamidu and Khadija), Aisha, Zainab and Nigerian Farmers.

ACKNOWLEDGEMENTS

I wish to express my profound gratitude to Dr. A.M. Falaki, Chairman of my Supervisory Committee for his deligent and untiring supervision of this thesis. The same sincere appreciation is extended to Drs. E.B. Amans (Head of Agronomy Department) and S.A. Dadari, members of my Supervisory Committee for their Valuable contributions during the write up of the thesis. I am indebted to Drs. J.A Valencia (Country Director SG 2000 Nigeria Project), Deola Naibakelao (Africa Resident Representative of Sasakawa Africa Association, Accra Ghana) and Mr Christopher R. Dowswell (Director for Program Coordination, Sasakawa Africa Association) without whom this work could not have materialised.

I am deeply indebted to the late Roychi Sasakawa and his organisation for coming up with the opportunity for one to contribute his potential in agricultural production in Nigeria towards poverty alleviation in Africa.

Special thanks go to Drs. S.G. Ado, B Tanimu, M. Mahmud N.C Kuchinda, and P.D Katung; Prof. V.B. Ogunlela; Mals. S. Miko, I.U. Abubakar, M.A Hussaini, B.A. Babaji, A.M. Mohammed, J. Jibrin, Alh. A. Minna and other members of Agronomy Department and Faculty of Agriculture whose names I am not able to list individually but contributed to the success of this work in one way or the other.

Profound gratitute and thanks also go to Mrs Sa'adatu Kabiru, Madam Binta Bello of IAR Library; Miss Ladi Adaji and

her family members and all my classmates, namely Hamza Mani, John Takura, Ibrahim Haruna (Nasarawa) Rilwanu A. Yahaya, Moses Aderigbe, Adeleke Muftau, Inuwa Bello (Danja) and all staff of Agric. Extension unit IAR for their help and advice.

The author extends sincere appreciation to his wife Aisha and daughter Zainab for their love, understanding, help and patience in the course of this study and Mr. Abraham Nmodu for the excellent job in typing this thesis.

ABSTRACT

Two field experiments were conducted at the Institute for Agricultural Research Farms. The first trial was at Kadawa during the 1997 dry season and the other at Samaru during the 1997 rainy season. Treatments, laid out in split plot design consisted of three plant populations (26,700, 53,300 and 80,000 plants/ha), in sub plots; combination of four fertilizer levels (0-0-0, 60-30-30, 120-60-60, 180-90-90 kg NPK/ha) and two varieties of quality protein maize (Obatanpa (0.P.V) and GH110-28 (Hyb) in main plot.

It was observed that 53,300 plants/ha produced significantly higher grain yield, more stalk lodging, taller plants, higher stover dry weight, arger number of grains/cob, higher cob weight (kg/ha) and harvest index than 26,700 plants/ha (the lowest population) in both seasons. The highest population produced statistically the highest leaf area index and root lodging.

The application of 120-60-60kg NPK/ha produced significantly higher grain yield (kg/ha) and cob weight (kg/ha) than other rates except 180-90-90kg NPK/ha. The fertilizer rate of 60-30-30kg NPK/ha) produced taller plants, larger number of leaves/plant and higher leaf area index. Significantly higher stover weight, weight of cobs/plant, 100-seed weight and harvest index were produced by 120-60-60kg NPK/ha in the rainy season. In the dry season the application of 60-30-30kgNPK/ha gave significantly heavier stover weight,

weight of cobs/plant and 100-seed weight.

The control treatment (0-0-0kg NPK/ha) resulted in significantly longer period to the attainment of 50 percent tasselling and silking. It also caused more stalk and root lodging in both seasons.

GH110-28 (Hyb) was superior over Obatanpa (O.P.V) in terms of grain yield, cob weight, took more number of days to 50 percent tasselling and silking and higher number of leaves/plant, 100-seed weight in the rainy season and higher harvest index in the dry season. Obatanpa was superior to GH110-28 (Hyb) in terms of plant height, leaf area index, dry matter/plant, root and stalk lodging in both seasons.

TABLE OF CONTENTS

Page

Title page i

Declaration ii

Certification iii

Dedication iv

Acknowledgements v

Abstract vii

Table of Contents..... ix

List of Tables.....xiii

List of Abbrevations.....xviii

CHAPTER ONE

1.0 INTRODUCTION 1

CHAPTER TWO

2.0 LITERATURE REVIEW 5

2.1 Effect of Plant population on Maize 5

2.2 Effect of nitrogen on Maize 8

2.3 Effect of phosphorus on Maize 11

2.4 Effect of pottassium on Maize 12

2.5 Effect of variety on Maize 13

CHAPTER THREE

3.0 MATERIALS AND METHODS 14

3.1 Experimental site 14

3.2 Treatment and experimental design 14

3.3 Varieties 15

3.3.1 Obatanpa 15

3.3.2 GH110-28 15
3.4 Cultural practices.....15
3.4.1 Land preperation 15
3.4.2 Sowing 15
3.4.3 Fertilizer application 16
3.4.4 Irrigation 16
3.4.5 Weed control 16
3.4.6 Harvesting 16
3.5 Soil analysis 17
3.5.1 Soil texture 17
3.5.2 Total nitrogen 17
3.5.3 Available phosphorus 17
3.5.4 Exchangeable cations 17
3.5.5 pH and organic carbon 18
3.6 Observations 18
3.6.1 Plant height (cm) 18
3.6.2 Number of leaves per plant 18
3.6.3 Dry matter per plant (g) 18
3.6.4 Number of days to 50% tasselling 18
3.6.5 Number of days to 50% silking 18
3.6.6 Lodging count 18
3.6.7 Weight of cobs per plant 19
3.6.8 Leaf Area index (LAI) 19
3.6.9 Number of grains per cob 20
3.6.10 Harvest index 20
3.6.11 100 seed weight 20
3.6.12 Cob yield per hectare 20
3.6.13 Grain yield per hectare 20
3.6.14 Irrigation frequency 20
3.7 Statistical analysis of data 20

CHAPTER FOUR

4.0 RESULTS 21
4.1 Plant height 21
4.2 Number of leaves per plant 24
4.3 Leaf area index 27
4.4 Total dry matter per plant (g) 34
4.5 Stover dry weight (kg/ha) 37
4.6 Number of days to 50% tasselling 43
4.7 Number of days to 50% silking 43
4.8 Stalk lodging 45
4.9 Root lodging 45
4.10 Number of cobs per plant 47
4.11 Weight of cobs per plant 48
12 Number of grains per cob 49
5.13 Grain yield (kg/ha) 51
5.14 Cob weight (kg/ha) 53
5.15 100 seed weight 55
5.16 Harvest index 56
5.17 Correlation analysis 58

CHAPTER FIVE

5.0 DISCUSSION 61
5.1 Effect of season 61
5.2 Effect of varieties..... 61
5.3 Effect of plant population..... 62
5.4 Effect of fertilizer.....64
5.5 Correlation studies.....66

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION 67

REFERENCES 69

APPENDIX (I AND III) 77-80

BIOGRAPHY..... 81

List of Tables

Table — Page

1. Effect of compound fertilizer and population density on plant height (cm) of QPM varieties during 1997 dry season at Kadawa 22

2. Effect of compound fertilizer and population density on plant height (cm) of QPM varieties during 1997 rainy season at Samaru 23

3. Effect of compound fertilizer and population density on number of leaves/plant of QPM varieties during 1997 dry season at Kadawa 25

4. Effect of compound fertilizer and population density on number of leaves per plant of QPM varieties during 1997 rainy season at Samaru 26

5. Effect of compound fertilizer and population density on leaf area index of QPM varieties during 1997 dry season at Kadawa 28

6. Effect of compound fertilizer and population density on leaf area index of QPM varieties during 1997 rainy season at Samaru. 29

7. Interaction of plant population and fertilizer on leaf area index at 12 WAS during the 1997 dry season as Kadawa. 32

8. Plant population and variety interaction as it affected the leaf area index of QPM varieties at 4WAS during the 1997 rainy season at Samaru. 32

9. Plant population and fertilizer interaction as it affected the leaf area index of QPM varieties at 8 WAS during the 1997 rainy season at Samaru. 33

10. Plant population and fertilizer interaction as it affected the leaf area index of QPM varieties at 12WAS during the 1997 rainy season at Samaru. 33

11. Effect of compound fertilizer and population density on dry matter per plant (g) of QPM varieties during 1997 dry season at Kadawa. 35

12. Effect of compound fertilizer and population density on dry matter per plant (g) of QPM varieties during 1997 rainy season at Samaru. 36

13. Effect of compound fertilizer and population density on stover dry weight at harvest of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru respectively 39

14. Interaction of Plant population and variety on stover of maize during 1997 dry season at Kadawa. 40

15. Effect of compound fertilizer and population density on number of days to 50% tasselling & silking on QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru 41

16. Effect of compound fertilizer and population density on stalk and Root lodging of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru. 42

17. Plant population and fertilizer interaction as it affect number of days to 50% silking of(QPM) during the 1997 rainy season at Samaru. 46

18. Effect of compound fertilizer and population density on number of cobs/plant, wt of cobs/plant and number of grains/cob of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru. 50

19. Effect of compound fertilizer and population density on grain yield and cob weight of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru. 53

20. Population and fertilizer interaction as it affect total cob weight of (QPM) during the 1997 rainy season at Samaru. 54

21. Effect of compound fertilizer and population density on grain yield of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru. 57

22. Matrix of correlation Co-efficient between grain yield (kg/ha) and yield characters in 1997 dry season at Kadawa 59

23. Matrix of correlation Co-efficient between grain yield (kg/ha) and yield characters in 1997 rainy season at Samaru 60

List of Appendices

Appendix 1

1a. Meteorological data showing sunshine hours minimum, maximum, mean temperature and Relative humidity at Kadawa during the 1997 dry season. 78

1b. Rainfall, maximum and minimum temperature and Relative humidity at ten day interval during the period of experiment at Samaru, 1997. 79

II. Physical and chemical properties of the soils in which experiments were carried out at Kadawa and Samaru respectively. 80

III. Below is the amino acid composition in normal and quality protein maize (GH110-28 and Obatanpa) using amino acid analyser. 81

CHAPTER ONE

1.0 INTRODUCTION

Maize (Zea mays L.) is a member of the Poiceae family. The origin of maize is controversial. Modern maize probably evolved from wild maize in the Americas. Among the world's cereal crops, maize ranks second to wheat in production. However, maize ranks first in Latin America and Africa (Dowswell et al., 1996).

Maize contains about 10% protein, 70.4% carbohydrate and 2.9% fat (Cortez and Wild-Altmirano, 1972). Quality protein maize has higher levels of lysine and tryptophan. This makes its protein nutritionally superior to other maize varieties (Anon. 1995). The largest maize producing countries (about 20) account for 91% of world production and 80% of the total world maize area (Dowswell et al., 1996). The United States produces 42% of world's maize. From 1950 to 1980, world maize production increased from 145 million tons to 450 million tons, growing at a faster rate than either wheat or rice (Dowswell et al., 1996). World's annual production is currently put at 580 million tons with an average yield of 4.13 t/ha. Nigeria's production in 1997 was 6.2 million tons with an average yield of 1.4 t/ha (FAO, 1997).

Maize is used in more ways than any other cereal (Watson, 1988). It is used for feed, food and in industries and is the staple food in the diets of people in many countries of the world. Hoffman (1965) estimated that some 1,000 million people in the world consume maize. The crop is used mainly as animal

feed in temperate regions, providing over two thirds of total feed grains. Maize occupies the unique position of the "hungry breaker" being the first crop to be put at the dispossal of consumers after the dry season in Nigeria (Edache, 1996). The later further stated that in that condition, maize is mainly consumed fresh as corn on the cob, boiled or roasted. In human nutrition, maize is processed into pap, dried and processed into flour. According to Breth (1998), a special type of maize called quality protein maize (QPM), has the potential to reduce malnutrition where maize is grown because its amino acid balance is comparable to that of milk. Maize is also high in energy, low in fibre and therefore, highly digestible (Miracle, 1972). Besides it is an important raw material in pharmaceuticals, baby food, soft drink and brewery industries.

Maize has a wide range of tolerance to climatic conditions but it is essentially a crop of warm countries with adequate moisture (Obi, 1991). The bulk of its production is in warm temperate regions and in the humid tropics. Temperature, length of growing season and length of day greatly influence production of the crop. The amount, distribution and efficiency of rainfall are also important factors (Jugenheiner, 1976).

Optimum tempertature during tasselling is between 21-30°C. It needs an annual rainfall between 600-900mm distributed evenly during the growing season (Onwueme and Sinha, 1991). It grows on a wide variety of aerated, deep, sandy loams and silty loams containing adequate organic matter

and it can tolerate soil pH from 5-8 but does best under pH 6-7 (Purseglove, 1972).

Maize supplies the highest level of per capita food consumption and is mostly eaten without any protein supplement in most of the Sudan and Northern Guinea savanna areas which proved to have the greatest potential (Edache, 1996). The people in this environment feed mostly on normal maize and other cereals (millet, sorghum) as their staple food. The dependency on traditional maize and other cereals in the savanna ecological zones of Nigeria cannot sustain acceptable growth and adequate health, especially in children, pregnant and lactating mother because of its low protein content. Adults and particularly infants feeding on normal maize and other cereals in this areas without a balanced protein supplement become malnourished and face several health problems or hazards.

In Nigeria responses of maize to application of fertilizers have been reported by many workers. The optimum rates and fertilizer types to be applied in any maize field for production are determined by inherent soil fertility, yield potential of maize variety, and previous crop grown on the land. Current recommendations are based on genotype and agroecological zones.

Research work in the Agricultural Institutions in Nigeria have concentrated on conventional maize. There was little or no report on the effects of NPK fertilizer and plant

population on QPM in the agro-ecological zones of Nigeria. The present study is therefore undertaken with the following objectives:

1. To determine the effect of plant density and varying fertility levels on growth, yield and yield components of open pollinated and Hybrid quality protein maize QPM.

population on QPM in the agro-ecological zones of Nigeria. The present study is therefore undertaken with the following objectives:

1. To determine the effect of plant density and varying fertility levels on growth, yield and yield components of open pollinated and Hybrid quality protein maize QPM.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Effect of plant population on maize

The influence of plant population that gives stability in grain yield in maize crop had recieved serious attention from scientists. Anon (1992) in the United States observed that the average ear weight decreased from 216g at a plant population of 15,000 plants/ha to 182g and 126g at a populations of 30,000 and 45,000 plants/ha respectively. Anonymous (1992) observed that ear weight depends on genetic, environmental and cultural practices. Shubeck and Caldwell (1955) reported that increasing number of maize plants per unit area up to a maximum (50,000 plants/ha) increased crop yield after which further increase in number of plants per unit area resulted in yield reduction. In a review work, Drowney (1971) concluded that the optimum plant density for maize hybrid is in a range of 44,000 to 66,000 plants/ha. Increasing plant population beyond this range resulted in mutual shading, induced barrenness, which in turn limited grain yield. It was also observed that grain yield was significantly increased with increase in plant population from 24,000 to 43,000 plants/ha, but decreased at 72,000 plants/ha (Chinwuba, 1976). Agboola and Kayode (1981) reported that grain yield was not affected by plant population. However, seed yield per ear and number of ears per plant tend to decrease with increase in plant population. This reduction in yield components is due, among

other factors, to increased environmental stress resulting from greater competition among plants.

Agboola and Kayode (1981) working with 37,000 and 62,000 plants/ha at Mokwa and Samaru reported, no significant difference in grain yield. They observed that yields from the lowest population (37,000) compared favourably with that from highest population (62,000 plants/ha). Ologunde and Ogunlela (1984) obtained significantly higher grain yield from a higher plant population at Mokwa and Omu-Aran. They obtained 48 and 53% increase in grain yield at Makwa and Omu-Aran respectively, when plant population was increased from 24,000 to 48,000 plants/ha. They noted that a further increase in plant population to 72,000 plants/ha resulted in 10 percent and 18 percent yield reductions at the respective locations. They suggests that a plant population of about 50,000 plants/ha may be regarded as being adequate for maximum yield in the southern Guinea Savanna ecological zone of the country. This suggested that plant density should be higher than the current officially recommended plant population of 36,000 plants/ha for maize in the Nigerian savanna ecological zone (Anon, 1973).

The general low yields of maize at low plant densities have been associated with low light interception resulting from poor ground cover (Haggar and Cooper, 1972) while the decline in yield occuring at levels above the optimum plant population has been attributed to inter-plant competition for

moisture, nutrient, light and carbondioxide.

Plant population has been known to affect plant height. Nordem (1965) found that increasing plant population from 12,000 to 62,000 plants/ha increased plant height by 17 percent, while Abdullahi (1975) observed that plant height was not significantly affected by plant population. However, within the plant population (17,570 - 78,282) adopted, plant height tends to increase with increase in plant population.

Many workers have studied the effect of plant densities on the yield components of maize. Bunting (1973) observed that the number of ears per plant producing ripe grain decreased with increasing plant density. He observed an average of more than one fertile ear per plant at densities below 70,000 plants/ha. At a higher plant density of 200,000 plants/ha, however, he observed an average of 0.8 fertile ear/plant. Similar observations were made by Filev and Pan'kin (1976) and Rathore et al., (1976).

Wilson and Allison (1978) observed that the size of grain, the number of grains/ear and the length of ear decreased with increasing plant population. Similarly, Ologunde (1974) observed that weight/ear, number of kernels/ear, weight/1,000 kernels and length of ear decreased by 36.8, 23.4, 12.7 and 19.8 percent, respectively, when the rate of planting was increased from 40,000 to 80,000 plants/ha.

Chinwuba (1976) in Nigeria found that percentage loss in stand at harvest and percentage barren plants increased linearly as plant population increased from 24,00 to 72,000 plants/ha.

Kohnke and Mike (1951) observed that silking date was delayed by one day for each increament of 8,750 to 10,000 plants/ha. These data are close to that obtained by Shubeck and Caldwell (1955), showing a 5-day delay in silking associated with increase in plant population from 8,900 to 45,500 plants/ha. Contrary to this, Zuber and Grogan (1956) could not associate any variation in silking date with increase in planting rate.

2.2 Effect of nitrogen on maize

Response of maize to nitrogen application was studied (Jones, 1973) and 65 kgN/ha rate was recommended for maximum grain yield throughout the Nigerian savanna. Under good management, this recommendation may have to be doubled when growing improved varieties of maize (Jones, 1973). It was observed that increasing application of N at various levels up to 120kg/ha resulted in grain yield increase. Further increase of N to 180 kg/ha leads to yield depression. Optimum N rate for maize in the southern and Northern Guinea savanna zones was suggested to be between 100 to 150kg/ha Chude, 1996). In the Sudan and Northern Guinea Savanna, open polinated maize requires 120kgN/ha; while hybrid maize requires, 150kgN/ha (Chude, 1996).

Maximum plant height and length of ear were produced by maize when 200kg/ha of N was applied (Sattar et al., 1975). Plant height was found to be increased by increasing N from 0-200kg/ha in maize cultivar pera 280, (Gagro, 1978 Muhammed et al., 1978). Increase in stover yield of maize was observed when 126kgN/ha was applied in three split doses (El-sharkawy, 1976). However, increase in N application may not have significant increase in plant height (Reyes et al., 1972). Dave (1976) reported that the peak demand for nitrogen occurs during the period from about three weeks before and two weeks after tasselling. In India Singh et al.,(1978) demonstrated that increasing the rate of nitrogen N from 0 to 60kg/ha significantly increased grain, yield but yield differences between 60 and 90 kgN/ha, were not significant. Such significant increase in grain yield was attributed to significant increase in almost all yield contributing characters, especially number of cobs/ha, grain weight/cob, cob length and grain/row. Similar observations have earlier been made by Shukla and Bhardwaj (1976) and Verma and Singh (1976). However, if the native soil fertility is very high, a non significant response to applied nitrogen would be observed Steel et al., 1982).

Increase in dry mater in response to fertilization was reported by Mikhail and Sheleby (1979), but some researchers have reported little or no response Douglass et al., (1972) have found depressions in dry matter yield with rates greater

than 700kgN/ha (Powell and Webb, 1972). Singh et al., (1979) observed significant increase in Kernel weight, number of Kernels per ear and length with increase in the level of nitrogen application from 0 to 60kg/ha, with these attributes producing 37.3, 52.2 and 33.3 percent increase, respectively.

Nitrogen has been known to affect the number of days to 50% tasselling and silking. Rathore et al., (1976) observed that nitrogen application increased the number of days to tasselling, while Ologunde (1974) observed a decrease in the number of days to 50% tasselling with increasing nitrogen levels. Salame and Aly (1979) reported increases in the number of days to maize silking with nitrogen application. Conversely, however, Sharma (1973) observed that increasing the rate of applied nitrogen decreased the number of days to 50% silking. The variable response in the number of days to 50 percent tasselling and silking to increaments in nitrogen fertilization should be attributed to location effect, the variety used and prevailing climatic conditions.

Ologunde (1974) found that ear weight, number of kernels per ear, weight per 1000 kernels, length of ear, kernel depth, ear diameter and number of ears per plant increased by 35.5, 26.8, 5.8, 19.6, 6.0, 70 and 13.0 percent, respectively, when the nitrogen level was raised from 0 to 336 kg/ha.

2.3 Effect of phosphorus on maize

Increasing levels of phosphorus applied to maize in the presence of nitrogen increases grain yield and some attributes of yield significantly (Lornhard Bory and Nemeth, 1989). Leaf area index in particular was observed to increase by 18-24% when phosphorus was increased from 0-60kgP_2O_5/ha.

A transient deficiency of phosphorus during the early growth of maize might reduce final yield not as a consequence of smaller leaf area but as a result of lower number of grains per cob (Barry and Miller, 1989). Shoot growth rate is retarded by phosphorus limitation and also the formation of reproductive organs. Flower initation is delayed (Rossiter, 1978) and seed formation is restricted in particular (Barry and Miller, 1989). Premature senescence of leaves is another factor limiting yield in phosphorus deficient plants.

A linear response to phosphorus application and a highly significant and positive interaction was observed when Mcphilips (1989) applied two levels of phosphorus (32.5 and 65kgP_2O_5/ha) and three levels of nitrogen (78, 136 and 190kgN/ha) to maize.

Sun et al., (1989) studied the effect of phosphorus and nitrogen on the extent of lodging and yield on maize and observed that, lodging in plots where nitrogen was applied alone was 58.8% as against 56.4% in plots with both nitrogen and phosphorus applied to the plots in plots with no nitrogen, the lodging was as low as 43.8% but grain yield was

significantly higher in nitrogen and phosphorus than in checks. In plants suffering from phosphorus deficiency, reduction in leaf expansion and leaf surface area (Fredeen et al., 1989) and also number of leaves (Lynch et al., 1991), are the most striking effects.

2.4 Effect of potassium on maize

Response to K on farmers' plots were low due to poor husbandry, and low intensity of cropping (Tag et al, 1972). Nye and Greenland (1960) indicated that responses are small and more common in the forest than in the savanna zone of west Africa. Reports by Amon and Adetunji (1970, 1973), Heathcote (1973) and Anderson (1973) have indicated pottassium response of crops in the tropic and maize in particular to depend on the soil parent rock, climate and cropping system adopted. On soils derived from sandstone, using high yielding maize variety and good management, the response can be very dramatic. If soil organic matter is low, rates of K up to 120kg$K_2$0/ha may be required, it could be higher than the economic recommendation of 700kg$K_2$0/ha for the savanna ecological zone of Nigeria (Sobulo, 1973).

When potassium is deficient, growth is retarded and net retranslocation of K^+ is enhanced from mature leaves and stems, and under severe deficiency, these organs become chlorotic and necrotic, depending on the light intensity to which the leaves are exposed (Marschner and Cakmak, 1989). Lignification of vascular bundles is also impaired (Pissarek,

1973) a factor which might contribute to the higher susceptibility of pottassium defficient plants to lodging.

2.5 Effect of variety on maize

Varieties differ in their adaptation to new ecologies, yield potentials, maturity period & canopy architecture (Dowswell, 1996). They also differ in physical and chemical properties of the grain, which affect their suitablitity for various end uses (Kling, 1991).

Elemo (1990) in his evaluation of hybrid maize cultivars for adaptation to the Northern Guinea savanna ecology reported that there was no measurable difference in grain yield and hundred grain weight of hybrid maize tested as compared to the open polinated variety. However, hybrids are clearly higher yielding than the best open pollinated varieties in all ecological zones of Nigeria (Fakorede et al., 1993). Kim et al, (1988) showed in his work that the performance of hybrid maize was 34% higher than what was obtained with improved open pollinated maize varieties.

Averaged over four years of cultivation, Nigerian hybrids yielded 4.4t/ha (4.6t/ha in the forest early, 3.6t/ha in forest late season and 5.1t/h in the savanna region). This yield compares favourably with the average hybrid yield of 4.5t/ha in the USA in 1965 (Steele, 1978) some 30 years after hybrids were introduced.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental site.

Two trials were conducted, one during the 1997 dry season (Nov-May) and the other during the 1997 wet season (June - October). The first trial which was under Irrigation, was sited at the Irrigation Research Station (IRS) of the Institute for Agricultural Research, at Kadawa (11 39'N, 08" 20'E and 500 m above mean sea level) in the sudan Savanna ecological zone. While the second trial, under rainfed condition was sited at the Institute for Agricultural Research Farm, Samaru (11 11' N, 07° 38'E and 686 m above sea level) in the Northern Guinea Savanna ecological zone of Nigeria. Weather data during the trials were recorded from the Meteorological stations at Kadawa and Samaru and are shown in Appendices Ia and b. The physico-chemical data of soils from the two stations are also represented in Appendix II.

3.2 Treatments and Experinmental Design.

The treatments consisted of two varieties of quality protein maize (QPM) (Obatanpa and GH110-28), four levels of NPK compound fertilizer (0-0-0, 60-30-30, 120-60-60 and 180-90 -90 kg NPK/ha) and three plant populations (26700, 53300 and 80000 plants/ha.)

A split-plot design was used for the experiment. The combination of fertilizer levels and varieties were assigned to the main plots. While plant population was allocated to the

sub-plot. The treatment was replicated four times. Each gross plot size was 4.5 metre wide and consisted of 6 rows of 5 metre length, while the net plots consisted of 2 inner rows of 5 metre length.

3.3 Varieties

3.3.1 Obatanpa: is an open pollinated variety of quality protein maize (QPM). It was obtained from the Crop Research Institute Kumasi, Ghana. Its seed is white in colour and dented. The plant possess resistance to maize streak virus disease. It is tall (above 1.5m) and of intermediate duration of maturity (110 days)

3.3.2 GH110-28 is a hybrid quality protein maize, also obtained from the Crops Research Institute Kumasi, Ghana. The seed of this variety is white flint and dented. It also posseses resistance to maize streak virus disease. It is short in stature (less than 1.5m) and of intermediate duration of maturity (110 days).

3.4 Cultural practices

3.4.1 Land preperation

The sites were ploughed and harrowed at a week interval and ridged at 75cm after which land was marked out into the plots.

3.4.2 Sowing

Sowing was done on ridges, on 28th February, 1997 for the dry season trial and 19th June 1997 for the wet season trial. Two seeds were sown per hole at depth of at 50, 25 and 17cm

intra row spacing along the ridges and thinned to one plant per stand at 12 days after sowing to achieve a density of 26,700, 53,300 and 80,000 plants per hectare respectively.

3.4.3 Fertilizer application

Fertilizer was applied at the rate of 0-0-0, 60-30-30, 120-60-60 and 180-90-90kg/ha. Each rate of NPK was applied in two equal split doses. The first half at one week after planting by side placement 8-10cm away from the base of the plant stands. At four weeks after sowing the second dose of NPK (20-10-10) was top dressed by side placement 8cm away from the plant.

3.4.4 Irrigation

This was done at a weekly interval. At each irrigation the soil was brought back to field capacity. The irrigation was stoped two weeks before harvest to allow crops to dry completely in the field.

3.4.5 Weed control

Weeds were controlled by manually by hoe weeding. At Kadawa four hoe weedings were carried out at 2, 4, 6 and 8 weeks after sowing because of the presence of noxious weeds (Cyperus spp). At Samaru trial three hoe weedings were carried out at 2, 4 and 6 weeks after sowing for proper weed control.

3.4.6 Harvesting

Harvesting was done when the cobs were fully mature and dry in the field. The net plot was harvested for yield at

harvest. The cobs were picked dried, and threshed and the chaff was separated from the dry seed by winnowing with trays.

3.5 Soil analysis

Before land preparation, soil samples from the experimental sites were randomly taken at the depths of 0-15cm and 15-30cm, respectively, using a tubular hand auger. The samples were bulked, dried and the composite sample ground, sieved with a 2mm sieve-mesh and analysed for physico-chemical properties using standard procedures (Juo, 1979).

3.5.1 Soil texture

The texture was analysed by hydrometer method (Boyoucus 1951) and textural class determined by texture triangle.

3.5.2 Total nitrogen

Total nitrogen was determined by the Micro-kjehdahl procedure (Bremmer, 1965, IITA, 1975).

3.5.3 Available phosphorus

Available phosphorus was determined by the method described by Trough (1930). The extractable phosphorus was determined by the molybdate blue colours (Bray and Kurtz, 1945).

3.5.4 Exchangeable cations

Exchangeable cations were determined by the acetic acid method (Reith, 1967). Magnesium, calcium and potassium concentrations were determined by the atomic spectrophotometry using Perkin Elmers Model 403.

3.5.5 pH and organic carbon

pH and organic carbon were determined using the standard procedures described by Black (1968).

3.6 Observations

Five plants per plot were used as sample for the collection of the relevant data on each parameter such as:

3.6.1 Plant height (cm)

This was measured at 4,8 and 12 weeks after sowing. The measurements at 4 and 8 weeks after sowing were taken from the ground level to the tip of the innermost whorl leaf. But at 12 weeks after sowing, the reading was taken from the ground level to the tip of the flag leaf.

3.6.2 Number of leaves per plant

The number of open functional green leaves for each of the five plants was counted and average was taken at 4, 8 and 12 weeks after sowing.

3.6.3 Total dry matter (g)

The dry matter was determined at harvest. Five plants were randomly uprooted and oven dried to a constant weight at 70°C and the respective weights recorded.

3.6.4 Number of days to 50 percent tasselling

This was taken as interval between the date of sowing and the time when 50 percent of the plants per plot have tasselled.

3.6.5 Number of days to 50 percent silking

This was taken as days from the date of sowing to the time when 50 percent of the crop plants per plot have silked.

3.6.6 Lodging count

A count of lodged plants was taken at crop maturity. A plant was considered lodged when it is inclined at more than 45° from the vertical position or if the stem is broken below the ear. The number of lodged plants was counted in each plot and expressed as percentage of the total plants in a plot. A plant was considered as rootly lodged if the angle between the stem and the ground level was less than 45°. If the stem was broken below the ear, it was regarded as stem lodged.

3.6.7 Weight of cobs per plant

Five plants were randomly selected and the mean weight of the cobs was recorded.

3.6.8 Leaf Area index (LAI)

Measurements were taken at 4,8 and 12 weeks after sowing. The length and breadth (at its widest point) of a functional leaf blade was measured. The product of length and breadth (apparant leaf area) was multiplied by a factor (K=0.75) to arrive at the actual calculate the leaf area (Watson, 1988). The leaf area index was calculated by using area obtained by the number of plants/m^2 and divided by the land area (Duncan and Hasketh, 1968)

L = Leaf area index

A = Leaf area (cm^2) $L = \frac{A}{P}$

P = Ground area (cm^2)

3.6.9 Number of grains per cob

The average number of seeds per cob from each treatment was recorded by randomly selecting five cobs

3.6.10 Harvest index

It is the ratio of seed to the total plant dry matter (TDM). The calculation was done using the equation:-

$$K\% = \frac{\text{Grain yield from x kg of TDM}}{\text{x kg of TDM}} \times \frac{100}{1}$$

3.6.11 100 seed weight

100 seeds from each treatment were randomly selected and weighed.

3.6.12 Cob yield

Cobs from each plot were removed, dehusked and then sun dried and weighed. The weight of the dehusked cobs/plot was extrapolated per hectare.

3.6.13 Grain yield

The grain yield from each plot after cobs were threshed, and winnowed, weighed and later expressed in kilograms per hectare.

3.7 Statistical analysis of data

The data collected were subjected to statistical analysis of variance as described by Snedecor and Cochran (1967). Significant difference among the treatments means were seperated using Duncans's Multiple Range Test (Duncan, 1955).

CHAPTER FOUR

4.0 RESULTS

4.1 Plant height

Tables 1 and 2 show the effect of treatments on the height of plant at various sampling dates for 1997 dry and rainy seasons, respectively.

The effect of increasing plant density on plant height was only significant at 8 and 12 WAS in 1997 dry and 1997 rainy seasons respectively. At 8 WAS plant population of 53,300 and 80,000 plants/ha produced similar but taller plants than the lowest density of 26,700 plants/ha. At 12 WAS no significant difference in plant height was observed between plants grown at 26,700 and 53,300 plants/ha, although these were found to be significantly shorter than those plants grown at the highest plant population of 80,000 plants/ha.

Obatanpa variety was significantly taller than GH110-28 at all the stages of growth in both seasons.

The effect of fertilizer application was significant at all the growth stages in 1997 dry season and at 8 and 12 WAS in 1997 rainy season. It was observed that application of fertilizer up to 60-30-30kg NPK/ha significantly increased plant height. However, there was no significant difference between the applied rates of 60-30-30 to 180-90-90kg NPK/ha. None of the interaction was found to be significant.

Table 1: Effect of compound fertilizer and population on plant height (cm) of QPM varieties during 1997 dry season at Kadawa.

Treatment	Weeks after sowing 4	8	12
Population (plants/ha) (P)			
26,700	16.9	88.4b	108.0
53,300	17.1	93.8a	113.6
80,000	17.8	95.6a	111.7
SE±	0.7	2.06	1.97
Varieties (V)			
Obatanpa	19.9a	99.0a	114.9a
GH110-28	14.6b	86.2b	107.3b
SE±	0.68	3.42	2.26
Fertilizer Levels (F)			
0-0-0	13.5b	65.6b	87.2b
60-30-30	18.2a	98.3a	117.3a
120:60:60	17.8a	99.0a	119.0a
180:90:90	19.5a	107.4a	120.9a
SE±	0.97	4.84	3.20
Interaction			
P x V	NS	NS	NS
P x F	NS	NS	NS
V x F	NS	NS	NS
P x V x F	NS	NS	NS

Means within a column followed by the same letters do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 2: Effect of compound fertilizer and population on plant height (cm) of QPM varieties during 1997 rainy season at Samaru.

Treatment	Weeks after sowing 4	8	12
Population (plants/ha) (P)			
26,700	21.9	107.3	153.0b
53,300	21.3	102.6	156.6b
80,000	22.4	106.1	160.3a
SE±	0.81	2.43	2.38
Varieties (V)			
Obatanpa	24.4a	114.1a	161.9a
GH110-28	19.3b	96.5b	147.1b
SE±	0.91	3.50	4.02
Fertilizer Levels (F)			
0-0-0	22.9	71.7b	124.5b
60-30-30	22.6	117.4a	164.1a
120:60:60	21.8	116.3a	165.0a
180:90:90	20.1	115.8a	164.0a
SE±	1.28	4.96	5.68
Interaction			
P x V	NS	NS	NS
P x F	NS	NS	NS
V x F	NS	NS	NS
P x V x F	NS	NS	NS

Means within a column followed by the same letters do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

4.2 Number of leaves per plant.

The number of leaves per plant as affected by the treatments are shown in tables 3 and 4.

Plant population had no significant effect on number of leaves at all the sampling periods in both seasons.

Variety had no significant effect on number of leaves per plant at all the sampling periods in 1997 dry season and at 4 WAS in 1997 rainy season. However, at 8 and 12 WAS in 1997 rainy season GH110-28 had significantly higher number of leaves than Obatanpa.

The differences due to fertilizer application were highly significant in both seasons except at 4 WAS in 1997 rainy season. At 4 and 8 WAS in 1997 dry season and 8 WAS in 1997 rainy season, increase in fertilizer level from 0-0-0 to 60-30-30kg NPK/ha increased the number of leaves. But further increase beyond 60-30-30kg NPK/ha was not significant. At 12 WAS in both seasons, progressive increase in number of leaves was observed with every increase in fertilizer level from 0-0-0 to 120-60-60kg NPK/ha, increasing fertilizer rate above 120-60-60kg NPK/ha did not affect this parameter. None of the interaction was significant.

Table 3: Effect of compound fertilizer and population on number of leaves per plant of QPM varieties during 1997 dry season at Kadawa.

Treatment	Weeks after sowing 4	8	12
Population (plants/ha) (P)			
26,700	7.4	12.4	11.3
53,300	7.4	12.4	11.5
80,000	7.5	12.8	11.6
SE±	0.14	0.17	0.22
Varieties (V)			
Obatanpa	7.6	12.5	11.3
GH110-28	7.3	12.5	11.6
SE±	0.17	0.24	0.23
Fertilizer Levels (F)			
0-0-0	6.5b	11.0b	9.5c
60-30-30	7.5a	12.9a	11.4b
120:60:60	7.7a	12.9a	12.4a
180:90:90	8.0a	13.4a	12.6a
SE±	0.25	0.35	0.32
Interaction			
P x V	NS	NS	NS
P x F	NS	NS	NS
V x F	NS	NS	NS
P x V x F	NS	NS	NS

Means within a column followed by the same letters do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 4: Effect of compound fertilizer and population on number of leaves per plant of QPM varieties during 1997 rainy season at Samaru.

Treatment	Weeks after sowing 4	8	12
Population (plants/ha) (P)			
26,700	7.7	11.9	10.3
53,300	7.5	11.7	10.3
80,000	7.6	11.8	10.3
SE±	0.13	0.14	0.10
Varieties (V)			
Obatanpa	7.6	11.4b	9.7b
GH110-28	7.7	12.2a	10.9a
SE±	0.15	0.16	0.22
Fertilizer Levels (F)			
0-0-0	7.6	10.4b	7.6c
60-30-30	7.6	12.0a	10.5b
120:60:60	7.9	12.4a	11.3ab
180:90:90	7.4	12.3a	11.7a
SE±	0.22	0.22	0.34
Interaction			
P x V	NS	NS	NS
P x F	NS	NS	NS
V x F	NS	NS	NS
P x V x F	NS	NS	NS

Means within a column followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

4.3 Leaf area index

Tables 5 and 6 show the effect of treatments on the leaf area index at various sampling dates.

The effect of increasing plant population was highly singnificant at all the sampling periods in both seasons. Each increase in plant population resulted in an increase in leaf area index at all the sampling periods in both seasons.

The difference due to varieties was only significant at 4 WAS in both seasons. At 4 WAS Obatanpa had significantly higher LAI than GH110-28. The differences due to fertilizer levels were highly significant at all the sampling periods in the 1997 dry season and at 8 and 12 WAS in 1997 rainy season. During the 1997 dry season, increase in fertilizer level from 0-0-0 to 60-30-30kg NPK/ha increased the leaf area index significantly but further increase in fertilizer level from 60-30-30 to 180-90-90kg NPK/ha did not affect the LAI at 4 and 8 WAS. While in the 1997 rainy season increase in the rate of fertilizer application from 0-0-0 to 60-30-30kg NPK/ha significantly increased LAI at 8 and 12 WAS, further increase beyound 60-30-30kg NPK/ha did not affect LAI significantly.

There was significant interaction effect of plant population and fertilizer on LAI during the 1997 dry season. During the 1997 rainy season there was significant population and variety interaction at 4 WAS, population and fertilizer interaction at 8 and 12 WAS.

Table 5: Effect of compound fertilizer and population on leaf area index of QPM varieties during 1997 dry season at Kadawa.

Treatment	Weeks after sowing 4	8	12
Population (plants/ha) (P)			
26,700	0.1c	1.1c	1.1c
53,300	0.3b	2.5b	2.2b
80,000	0.4a	3.8a	3.6a
SE±	0.03	0.14	0.01
Varieties (V)			
Obatanpa	0.3a	2.6	2.4
GH110-28	0.2b	2.4	2.2
SE±	0.03	0.18	0.11
Fertilizer Levels (F)			
0-0-0	0.1b	1.5b	1.3c
60-30-30	0.3a	2.6a	2.2b
120:60:60	0.3a	2.6a	2.7ab
180:90:90	0.3a	3.1a	3.0a
SE±	0.04	0.24	0.16
Interaction			
P x V	NS	NS	NS
P x F	NS	NS	*
V x F	NS	NS	NS
P x V x F	NS	NS	NS

Means within a column followed by the same letters do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 6: Effect of compound fertilizer and population on leaf area index of QPM varieties during 1997 rainy season at Samaru.

Treatment	Weeks after sowing 4	8	12
Population (plants/ha) (P)			
26,700	0.1c	1.7c	1.5c
53,300	0.3b	3.1b	3.0b
80,000	0.6a	5.0a	4.7a
SE±	0.03	0.12	0.13
Varieties (V)			
Obatanpa	0.4a	3.3	2.9
GH110-28	0.3b	3.3	3.3
SE±	0.03	0.14	0.14
Fertilizer Levels (F)			
0-0-0	0.4	1.8b	1.4b
60-30-30	0.3	3.7a	3.5a
120:60:60	0.4	3.8a	3.6a
180:90:90	0.3	3.8a	3.9a
SE±	0.04	0.20	0.20
Interaction			
P x V	**	NS	NS
P x F	NS	**	**
V x F	NS	NS	NS
P x V x F	NS	NS	NS

Means within a column followed by the same letters do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 7 shows population and fertilizer interaction at 12 WAS in the 1997 dry season at Kadawa. Considering the fertilizer treatments at each population levels, it was observed that at 26,700 plants/ha increase in fertilizer rate from 0-0-0 to 60-30-30kg NPK/ha significantly increased the LAI, but further increase upto 180-90-90kg NPK/ha showed no significant increase, while at 80,000 plants/ha increased fertilizer rate from 0-0-0 to 60-30-30kg NPK/ha did not affect the LAI, but when the fertilizer level were increased to 120-60-60 and 180-90-90kg NPK/ha a significant increase was observed. When the population was considered in respect to fertilizer levels it was observed that at 0-0-0 and 60-30-30kg NPK/ha each increase in plant population was acompanied with a corresponding increase in LAI. While at 120-60-60 and 180-90-90kg NPK/ha increase in population from 26,700 to 53,300 plants/ha did not affect the LAI. However, further increase in plant population from 53,300 to 80,000 plants/ha significantly increased the LAI.

The interaction between plant population and variety, at 4 WAS is shown in Table 8. Considering the plant population in respect to variety it was observed that Obatanpa. produces higher LAI than GH110-28 at 53,300 and 80,000 plants/ha while at 26,700 plants/ha the LAI of both varieties were statistically similar. The LAI was also observed to significantly increase with every increase in plant population/ha irrespective of variety used.

The interaction between plant population and fertilizer at 8 and 12 WAS are shown in Tables 9 and 10 respectively. Increase in plant population from 26,700 to 53,300 plants/ha at control did not affect the LAI, but further increase in population to 80,000 plants/ha resulted in higher LAI. While at 60-30-30, 120-60-60 and 180-90-90kg NPK/ha, every increase in population level was acompanied by an increase in LAI. When the population was viewed in respect to fertilizer, it was observed that at the lowest population level (26,700 plants/ha) increasing the fertilizer level from 0-0-0 to 60-30-30 kg/ha did not affect the LAI at 8 WAS, further increase to 120-60-60kg NPK/ha significantly increase the LAI. When the fertilizer level was further increased to 180-90-90kg NPK/ha, the LAI was observed to decrease.

Table 7: Interaction of plant population and fertilizer on leaf area index at 12 WAS during the 1996/97 dry season at Kadawa.

Treatment	Fertilizer levels (20:10:10Kg NPK/ha)			
Population	0-0-0	60-30-30	120-60-60	180-90-90
26,700	0.58g	1.14f	1.42df	1.51df
53,300	1.15f	2.12e	2.72d	2.86cd
80,000	2.30c	3.45bc	4.05b	4.87a
SE±		0.24		

Means followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 8: Plant population and variety interaction as it affected the leaf area index of QPM varieties at 4WAS during the 1997 rainy season at Samaru.

Treatment	Variety	
Plant Population (plants/ha)	Obatanpa	GH110-28
26,700	0.23cd	0.15d
53,300	0.44b	0.31c
80.000	0.81a	0.48b
SE±	0.04	

Means followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 9: Plant population and fertilizer interaction as it affect the leaf area index of QPM varieties at 8 WAS during the 1997 rainy season at Samaru.

Treatment	Fertilizer levels (20:10:10Kg NPK/ha)			
Plant Population (plants/ha)	0-0-0	60-30-30	120-60-60	180-90-90
26,700	1.28d	1.81d	2.00c	2.01
53,300	1.52d	3.71b	3.82b	3.40bc
80,000	2.69c	5.72a	5.81a	6.01a
SE±		0.27		

Means followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 10: Plant population and fertilizer interaction as it affected the leaf area index of QPM varieties at 12WAS during the 1997 rainy season at Samaru.

Treatment	Fertilizer levels (20:10:10Kg NPK/ha)			
Plant Population (plants/ha)	0-0-0	60-30-30	120-60-60	180-90-90
26,700	1.86d	1.79c	1.76cd	1.94cd
53,300	1.18d	3.44b	3.83b	3.81b
80,000	2.25c	5.37a	5.30a	6.02a
SE±		0.29		

Means followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

4.4 Dry matter per plant (g)

Tables 11 and 12 show the effect of treatments on dry matter per plant, in 1997 dry and rainy seasons, respectively.

The differences due to plant population on the dry matter per plant was not significant at all the sampling periods in both seasons.

The differences due to variety were highly significant at all the sampling periods except at 9 WAS for both seasons. Obatanpa produced significantly higher dry matter at 3 and 6 WAS than GH110-28.

In the 1997 dry season, a highly significant difference was observed with increased application of fertilizer. At 3 WAS increase in fertilizer level from 0-0-0 to 60-30-30kg NPK/ha did not affect dry matter/plant, further increase to 120-60-60kg NPK/ha increase this parameter. However, when the fertilizer level was increased to 180-90-90kg NPK/ha a non significant difference was observed. At 6 WAS there was a progressive increase in dry matter with every increase in fertilizer level up to 120-60-60kg NPK/ha, further increase did not affect dry matter, while at 9 WAS the highest fertilizer level gave the highest dry matter than others. The differences between dry matter at 60-30-30 and 120-60-60kg NPK/ha was not significant. Plants supplied with no fertilizer gave the lowest dry matter. During the 1997 rainy season, fertilizer significantly ($P>0.01$) affected the plant dry matter at all the stages of sampling. Plant dry matter was found to increase

Table 11: Effect of compound fertilizer and population on dry matter per plant (g) of QPM varieties during 1997 dry season at Kadawa.

Treatment	Weeks after sowing 3	6	9
Population (plants/ha) (P)			
26,700	1.94	29.70	159.90
53,300	2.13	36.30	186.70
80,000	2.27	35.80	160.70
SE±	0.130	2.140	10.570
Varieties (V)			
Obatanpa	2.48a	40.00a	182.90
GH110-28	1.18b	27.80b	155.30
SE±	0.090	1.590	10.100
Fertilizer Levels (F)			
0-0-0	1.66b	12.70c	81.60c
60-30-30	1.95b	28.70b	175.60b
120:60:60	2.34a	45.30a	185.20b
180:90:90	2.61a	49.10a	235.00a
SE±	0.130	2.250	14.280
Interaction			
P x V	NS	NS	NS
P x F	NS	NS	NS
V x F	NS	NS	NS
P x V x F	NS	NS	NS

Means within a column followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 12: Effect of compound fertilizer and population on dry matter per plant (g) of QPM varieties during 1997 rainy season at Samaru.

Treatment	Weeks after sowing 3	6	9
Population (plants/ha) (P)			
26,700	2.86	46.20	347.00
53,300	2.90	42.50	325.00
80,000	2.84	43.50	312.00
SE±	0.180	2.340	29.910
Varieties (V)			
Obatanpa	3.56a	50.00a	353.00
GH110-28	2.17b	38.10b	303.00
SE±	0.130	2.570	25.670
Fertilizer Levels (F)			
0-0-0	2.33b	37.50b	160.00b
60-30-30	2.69a	43.20a	338.00a
120:60:60	3.17a	45.50a	382.00a
180:90:90	3.27a	50.10a	432.00a
SE±	0.180	3.640	36.280
Interaction			
P x V	NS	NS	NS
P x F	NS	NS	NS
V x F	NS	NS	NS
P x V x F	NS	NS	NS

Means within a column followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

with increasing fertilizer rate from 0-0-0 to 60-30-30kg NPK/ha at all the growth stages; further increase in

fertilizer rate did not affect plant dry matter. None of the interaction was significant.

4.5 Stover dry weight (kg/ha)

Table 13 show the effect of treatments on stover dry weight during the 1997 dry and rainy seasons. The differences due to plant population was highly significant at harvest in both seasons. In 1997 dry season increase in plant population from 26,700 to 53,300 plants/ha increased the stover dry weight significantly. Further increase to 80,000 plants/ha resulted in a non significant difference in stover weight at harvest. However, in 1997 rainy season, the highest plant population (80,000 plants/ha) gave the highest stover weight. The differences due to variety were not significant in both seasons.

Fertilizer significantly (P>0.01) affected the stover dry weight at harvest. In the 1997 dry season, increasing fertilizer level from 0-0-0 to 60-30-30kg NPK/ha increased stover dry weight significantly. However, in 1997 rainy season, stover dry weight was found to increase with fertilizer from 0-0-0 to 120-60-60kg NPK/ha, further increase did not increase stover dry weight. All the interactions except for population x variety during the 1997 dry season were not significant. Table 14 shows the interaction of plant population and variety on stover dry weight of quality protein maize during 1997 dry season at Kadawa. Considering the two varieties at various populations, it was observed that the two

varieties have statisticaly the same stover weight at all the population levels. However, when the population levels were considered in respect of the varieties, it was observed that in the case of Obatanpa, increase in plant population level up to 53,300 plants/ha increased the stover weight, further increase produced an insignificant difference. When GH110-28 was looked at, it revealed that increase in plant population from 26,700 to 80,000 plants/ha did not affect the stover weight.

Table 13: Effect of compound fertilizer and population on stover dry weight at harvest of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru respectively.

Treatment	1997 dry season Kadawa	1997 rainy season Samaru
Population (plants/ha) (P)		
26,700	1232b	6,392c
53,300	2301a	8,852b
80,000	2734a	11,418a
SE±	153	590
Varieties (V)		
Obatanpa	2197	8521
GH110-28	1981	9254
SE±	188	610
Fertilizer Levels(F)		
0-0-0	1168b	4,680C
60-30-30	2061a	9,411b
120-60-60	2412a	10,542a
180-90-90	2716a	10,918a
SE±	267	862
Interaction		
P x V	*	NS
P x F	NS	NS
V x F	NS	NS
P x V x F	NS	NS

Means within a column followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 14: Interaction of Plant population and variety on stover weight of maize during 1997 dry season at Kadawa.

Treatment	varieties	
Population	Obatanpa	GH110-28
26,700	1.27b	1.20b
53,300	2.72a	1.88ab
80,000	2.60a	2.87a
SE±	0.52	

Means followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 15: Effect of compound fertilizer and population on number of days to 50% tasselling & silking on QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru.

Treatment	Days to 50% tesselling 1997(DS)	1997(RS)	50% silking 1997(DS)	1997(RS)
Population (plants/ha) (P)				
26,700	65.72a	59.59	68.47	62.94b
53,300	64.13b	59.75	70.28	64.63a
80,000	64.13b	59.72	69.78	64.31a
SE±	0.430	0.080	1.400	0.270
Varieties (V)				
Obatanpa	63.35b	58.44b	67.90b	62.69b
GH110-28	65.96a	60.94a	71.13a	65.29a
SE±	0.590	0.290	1.040	0.510
Fertilizer Levels(F)				
0-0-0	96.08a	60.71a	73.00a	68.04a
60-30-30	63.93b	59.63ab	66.67b	63.29b
120-60-60	63.42b	59.33b	68.50b	62.25b
180-90-90	62.42c	59.08b	67.88b	62.25b
SE±	0.790	0.400	1.470	0.720
Interaction				
P x V	NS	NS	NS	NS
P x F	NS	NS	NS	*
V x F	NS	NS	NS	NS
P x V x F	NS	NS	NS	NS

Means within a column followed by the same letter's do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

Table 16: Plant population and fertilizer interaction as it affect number of days to 50% silking of (QPM) during the 1997 rainy season at Samaru.

Treatment	Fertilizer level (20:10:10) kg NPK/ha			
Plant population	0-0-0	60-30-30	120-60-60	180-90-90
26,700	64.63b	62.88b	62.13b	62.13b
53,300	70.50a	63.38b	62.38b	62.38b
80,000	69.00a	63.63b	62.38b	62.25b
SE±			0.851	

Means followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

4.6 Number of days to 50% percent tasselling

Table 15 shows the effect of treatments on number of days to 50 per cent tasselling. During the 1997 dry season, increased in plant population from 26,700 to 53,300 plants/ha decrease the number of days to 50% tasseling significantly, but further increase to 80,000 plants/ha did not affect it. However, during the 1997 rainy season the differences due to plant population were not significant.

GH110-28 took significantly longer period to reach 50 per cent tasselling than Obatanpa in both seasons.

Number of days to 50 percent tasselling was significantly affected by applied fertilizer in both seasons. There was a highly significant decrease in number of days to 50 percent tasselling with increase in fertilizer level from 0-0-0 to 180-90-90kg NPK/ha, even though there were no significant differences between 60-30-30 to 120-60-60kg NPK/ha in 1997 dry season. In 1997 rainy season, however, a significant decrease in the number of days to tasselling with each increase in the fertilizer from 0-0-0 to 60-30-30kg NPK/ha was observed but a further increase in the rates to 180-90-90kg NPK/ha had no effect on this variable. None of the interaction was found to be significant.

4.7 Number of days to 50 percent silking.

Tables 15 shows the effect of treatments on number of days to 50 percent silking.

The result showed that the difference due to plant population was significnat only in the 1997 rainy season. The attainment of silking was significantly delayed with each increase in plant population from 26,700 to 53,300 plants/ha. However, further increase in plant population to 80,000 plants/ha did not increase this parameter significantly.

GH110-28 took significantly longer time to reach 50 percent silking than Obatanpa in both seasons.

Days to 50 percent silking was affected by applied fertilizer. There was a highly significant decrease in number of days to silking with increase in fertilizer rate from 0-0-0 to 60-30-30kg NPK/ha, and beyond in all seasons.

The population and fertilizer interaction on days to silking was significant in 1997 rainy season (Table 16). Application of fertilizer at 26,700 plants/ha did not affect the number of days to 50 percent silking, but when the plant population was increased to 53,300 and 80,000 plants/ha, the number of days to silking decreased with application of fertilizer from 0-0-0 to 60-30-30kg NPK/ha. Further increase in fertilizer level to 120-60-60 and 180-90-90kg NPK/ha did not affect the number of days to 50 percent silking. When the fertilizer level was considered in respect of plant population, it was observed that at 0-0-0kg NPK/ha number of days to 50 percent silking increased with increased plant population up to 53,300 plants/ha, a further increase in population to 80,000 plants/ha did not significantly increase

the number of days to 50 percent silking. At other levels of applied fertilizer, increase in plant population produced no significant effect on this parameter.

4.8 Stalk lodging

Table 17 shows the effect of treatments on stalk lodging. The differences due to plant population on stalk lodging was significant in both seasons. Increasing plant population from 26,700 to 53,300 plants/ha showed a similar and non statistical difference between the two, but increasing the plant population to 80,000 plants/ha showed a decrease in number of stalk lodging.

There was a highly significant variation in stalk lodging between the two varieties tested, with Obatanpa having more stalk lodging than GH110-28 in both seasons.

Application of 0-0-0 and 180-90-90kg NPK/ha produces more stalk lodging in 1997 dry season. However fertilizer levels of 60-30-30 and 120-60-60kg NPK/ha and 120-60-60 and 180-90-90kg NPK/ha gave statistically similar stalk lodging. None of the interaction was significant in both seasons.

4.9 Root lodging

Table 17 shows the effect of treatments on root lodging. The differences due to plant population on root lodging was significant. Increasing plant population from 26,700 to 53,300 plants/ha did not significantly increase roots lodging, further increase to 80,000 plants/ha showed a highly significant increase in the number of root lodging in both

Table 17: Effect of compound fertilizer and population on stalk and Root lodging of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru.

Treatment	Stalk lodging 1996/97(DS) dry season	Stalk lodging 1997(RS) rainy season	Root lodging 1996/97(DS)	Root lodging 1997(RS)
Population (plants/ha) (P)				
26,700	1.38a	1.56a	2.28b	2.59b
53,300	1.38a	1.50a	2.28b	2.53b
80,000	1.28b	1.28b	2.81a	3.25a
SE±	0.070	0.080	0.180	0.130
Varieties (V)				
Obatanpa	1.50a	1.50a	2.92a	3.35a
GH110-28	1.19b	1.40b	2.00b	2.23b
SE±	0.070	0.060	0.180	0.160
Fertilizer Levels(F)				
0-0-0	1.63a	1.92a	4.33a	4.21a
60-30-30	1.17b	1.42b	2.29b	2.88b
120-60-60	1.13b	1.33bc	1.58b	2.29bc
180-90-90	1.46b	1.13c	1.63b	1.79c
SE±	0.090	0.080	0.250	0.220
Interaction				
P x V	NS	NS	NS	NS
P x F	NS	NS	NS	NS
V x F	NS	NS	NS	NS
P x V x F	NS	NS	NS	NS

Means within a column followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

seasons.

The differences due to varieties were highly significant, Obatanpa was found to be more susceptible to root lodging than GH110-28 in both seaons.

Fertilizer had highly significant effect on root lodging. Increasing the rate from 0-0-0 to 60-30-30kg NPK/ha decreased root lodging, but further increase in fertilizer rate from 120-60-60kg NPK/ha and beyond had no effect in 1997 dry season. However, in 1997 rainy season it was found to decrease with increase in fertilizer rate up to 120-60-60kg NPK/ha. There was no statistical difference between rates of 60-30-30 and 120-60-60kg NPK/ha, further increase to 180-90-90kg NPK/ha did not affect root lodging. None of the interactions was significant in both seasons.

5.0 Number of cobs/plants

Table 18 shows the effect of treatments on number of cobs/plant. Analysed data showed non significant difference in the mean cobs/plant with increase in plant population, in 1997 dry season but a highly significant difference in means of number of cobs/plant in 1997 rainy season. Plant population in 1997 rainy season had a negative effect on number of cobs/plant. Increasing plant population from 26,700 to 53,300 plants/ha decreased the number of cobs/plant. Further increase to 80,000 plants/ha did not affect number of cobs/plant.

GH110-28 has a higher significant number of cobs/plant than Obatanpa in both seasons.

The differences due to fertilizer application was highly signifcant. Increasing fertilizer rate from 0-0-0 to 120-60-60kg NPK/ha, increased the number of cobs/plant in the 1997 dry season with no significant difference between 120-60-60 and 180-90-90kg NPK/ha. However, in 1997 rainy season, the response to fertilizer application was significant up to 180-90-90kg NPK/ha did not increase the number of cobs/plant. None of the interactions was significant in both seasons.

5.1 Weight of cobs/plant

Table 18 show the effect of treatments on number of cobs/plants. Analysed data showed a non significant difference in means of cobs/plant with increased plant population in 1997 dry season. However a signifiant difference in weight of cobs/plant with increased plant population was observed. Plant population had a negative effect on weight of cobs/plant. Increasing plant population from 26,700 to 53,300 plants/ha decrease weight of cobs/plant, further increase to 80,000 plants/ha did not affect weight of cobs/plant.

There was no significant difference in weight of cobs/plant between the two varieties tested in both seasons.

The differences due to fertilizer was highly significant in 1997 rainy season, increasing fertilizer rate from 0-0-0 to 60-30-30kg NPK/ha increased the weight of cobs/plant, but there was no significant difference between 60-30-30 and 120-60-60kg NPK/ha and 120-60-60 and 180-90-90kg NPK/ha, respectively. However, 180-90-90kg NPK/ha showed a significant

difference from 60-30-30kg NPK/ha. In 1997 dry season, increasing fertilizer level from 0-0-0 to 60-30-30kg NPK/ha increased weight of cobs/plant, further increase does not increase the weight of cobs/plant. None of the interactions was significant in both seasons.

5.2 Number of grains/cob

Table 18 shows the effect of treatments on number of grains/cob. Plant population had a significant effect on number of grains per cobs only in 1997 dry season. Increasing plant population from 26,700 to 53,300 plants/ha significantly increased number of grains per cob, further increase up to 80,000 plants/ha did not produce significant increase in number of grains per cob.

There was no significant difference in number of grains per cob between the two varieties tested in both seasons.

The difference due to fertilizer levels was highly significant in both seasons. Increasing fertilizer rate from 0-0-0 to 60-30-30kg NPK/ha increase number of grains per cob significantly while further increase to 120-60-60kg NPK/ha and above produced statistically similar number of grains/cob with 60-30-30kg NPK/ha. None of the interaction was significant in both seasons.

Table 18: Effect of compound fertilizer and population on number of cobs/plant, wt of cobs/plant and number of grains/cob of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru.

Treatmant	No. of cobs/plant 1997(DS)	1997(RS)	Wt. of cobs/plant(g) 1997(DS)	1997(RS)	No. of grains/cob 1997(DS)	1997(RS)
Population (plants/ha) (P)						
26,700	1.09	1.31a	137.30	170.80a	324.70b	532.00
53,300	1.00	0.99b	148.80	150.90b	393.70a	482.00
80,000	1.14	0.95b	151.60	159.20b	360.70a	515.00
SE±	0.051	0.051	5.631	4.861	11.741	24.751
Varieties (V)						
Obatanpa	0.98b	0.95b	140.00	154.40	346.50	478.00
GH110-28	1.17a	1.22a	151.70	167.20	372.90	542.00
SE±	0.041	0.041	5.531	5.151	16.691	26.231
Fertilizer Levels(F)						
0-0-0	0.82c	0.66d	109.00b	91.80c	234.60b	321.00b
60-30-30	1.04b	1.08c	146.90a	171.40b	365.20a	524.00a
120-60-60	1.23a	1.17bc	160.40a	182.10ab	409.00a	601.00a
180-90-90	1.21a	1.43a	167.10a	195.80a	430.00a	593.00a
SE±	0.051	0.051	7.301	7.301	23.601	37.121
Interaction						
P x V	NS	NS	NS	NS	NS	NS
P x F	NS	NS	NS	NS	NS	NS
V x F	NS	NS	NS	NS	NS	NS
P x V x F	NS	NS	NS	NS	NS	NS

Means within a column followed by the same letter's do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.
DS = Dry season.
RS = Rainy season

5.3 Grain yield (Kg/ha)

Table 19 show the effect of treatments on grain yield. Grain yield was found to increase with increasing plant population from 26,700 to 53,300 plants/ha further increase did not affect it in 1997 dry seaons. Plant population has no significant effect on grain yield during the 1997 rainy season.

GH110-28 produce significantly higher grain yield than Obatanpa in both seasons.

Grain yield was found to increase by increaseing fertilizer rates from 0-0-0 to 120-60-60kg NPK/ha in both seasons, further increase in fertilizer rate did not increase grain yield. However, no significnt differences were observed between 60-30-30 and 120-60-60kg NPK/ha and between 120-60-60 and 180-90-90kg NPK/ha in both seasons. None of the interactions was significant in both seasons.

5.4 Cob weight (Kg/ha)

Table 19 shows the effect of treatments on cob weight in 1997 dry and rainy seasons. Cob weight in 1997 dry season was found to increase with increasing plant population from 26,700 to 53,300 plants/ha, further increase does not affect it. However, in 1997 rainy season, plant population had no significant effect on cob weight.

GH110-28 produced significantly higher cob weight than Obatanpa in both seasons.

During the 1997 dry season increasing fertilizer rates from 0-0-0 to 120-60-60kg NPK/ha increased cob weight, further, increase did not effect it. However, no significant differences was observed between 60-30-30 and 120-60-60 and, 120-60-60 and 180-90-90kg NPK/ha.

In 1997 rainy season cob weight was found to increase progressively with increase in fertilizer rates from 0-0-0 to 180-90-90kg NPK/ha. There was no statistically Significant difference between 60-30-30 and 120-60-60kg NPK/ha.

None of the interactions was significant except population x variety on cob weight in 1997 rainy season.

There was a significant population and fertilizer interaction on cob weight (Table 20). In the 1997 rainy season, at 0-0-0 and 60-30-30kg NPK/ha increasing plant population from 26,700 to 80,000 plants/ha did not affect total cob weight. While at higher fertilizer level of 120-60-60 and 180-90-90kg NPK/ha, increasing plant population only up to 53,300 plants/ha significantly increased cob weight. No significant difference was observed between 53,300 and 80,000 plants/ha. When the effect of plant population was considered at varying levels of fertilizer rate, increasing the rate from 0-0-0 to 60-30-30kg NPK/ha had no significant effect on cob yield. However, at higher plant population, (53,300 and 80,000 plants/ha), it was found that increasing fertilizer rate, increased this parameter. It was observed that at the lowest plant population of 26,700 plants/ha increased fertilizer rate

Table 19: Effect of compound fertilizer and population on grain yield and cob weight of QPM varieties during 1997 dry and rainy seasons at Kadawa and Samaru.

Treatmant	Grain yield (kg/ha) 1997(DS)	1997(RS)	Cob weight (kg/ha) 1997(DS)	1997(RS)
Population (plants/ha) (P)				
26,700	1816b	5087	2758b	5990
53,300	3098a	4520	4550a	5774
80,000	3013a	4946	4405a	6391
SE±	220	725	273	278
Varieties (V)				
Obatanpa	2375b	3966b	3569b	5069b
GH110-28	2910a	5737a	4239a	6368a
SE±	161	585	213	319
Fertilizer Levels(F)				
0-0-0	1255c	1400c	2022c	1861c
60-30-30	2707b	4488b	3893b	6035b
120-60-60	2987ab	5606ab	4472ab	7053ab
180-90-90	3621a	7910a	5231a	8926a
SE±	301	827	302	453
Interaction				
P x V	NS	NS	NS	NS
P x F	NS	NS	NS	*
V x F	NS	NS	NS	NS
P x V x F	NS	NS	NS	NS

Means within a column followed by the same letter's do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.
DS = Dry season.
RS = Rainy season.

Table 20: Population and fertilizer interaction as it affect total cob weight of QPM during the 1997 rainy season at Samaru.

Treatment				
		Fertilizer level (20:10:10) kg/ha		
Plant population	0-0-0	60-30-30	120-60-60	180-90-90
26,700	2627c	5255b	5376b	6704b
53,300	1234c	6172b	7716a	7973a
80,000	1721c	6677b	8066a	9102a
SE±			640	

Means followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.

from 0-0-0 to 120-60-60kg NPK/ha had no effect on total cob yield. However at higher plant population of 53,300 and 80,000 plants/ha it was found that increasing fertilizer rate only up to 120-60-60kg NPK/ha significantly increased cob yield/ha, beyond this level no significant response was recorded. The highest cob yield was recorded at higher plant populations of 53,300 and 80,000 plants/ha and fertilizer of 120-60-60 to 180-90-90kg NPK/ha while the least cob yield was recorded at 0-0-0kg NPK/ha at 26,700 plants/ha.

5.5 100-seed weight (g)

Table 21 shows the effect of treatments on 100-seed weight. Plant population had no significant effect on 100-seed weight in both seasons.

GH110-28 produced significantly higher 100-seed weight than Obatanpa only in 1997 rainy season.

In 1997 dry season increasing fertilizer level from 0-0-0 to 60-30-30kg NPK/ha significantly increased 100-seed weight, while further increase to 120-60-60kg NPK/ha and above produced statistically similar 100-seed weight. In 1997 rainy season, however, 100-seed weight was found to increase with increase in fertilizer rates from 0-0-0 to 120-60-60kg NPK/ha. There was no stistical difference between 60-30-30 and 120-60-60kg NPK/ha as well as 120-60-60 and 180-90-90kg NPK/ha, respectively. None of the interactions was significant in both seasons.

5.6 Harvest index

Table 21 shows the effect of treatments on harvest index. In 1997 dry season, harvest index was found to increase with increasing plant population from 26,700 to 53,300 plants/ha, further increase does not affect it. However, in 1997 rainy season, harvest index decreased with increase in plant population from 26,700 to 53,000 plants/ha, further increase in plant population to 80,000 plants/ha does not decrease the harvest index.

GH110-28 was found to have a higher harvest index than Obatanpa in 1997 dry season. However, in 1997 rainy season, no significant difference between the two varieties was recorded.

Fertilizer level has no significant effect on harvest index in 1997 dry season. However, in 1997 rainy season, harvest index was found to increase with increased fertilizer rate from 0-0-0 to 120-60-60kg NPK/ha. There was no statistical difference between 60-30-30 to 180-90-90kg NPK/ha. None of the interactions was significant in both seasons.

Table 21: Effect of compound fertilizer and population on 100-seed weight and harvest index of QPM varieties during 1996/97 dry and 1997 rainy seasons at Kadawa and Samaru.

Treatmant	100 seed wt 1996/97(DS)	1997(RS)	Harvest index 1996/97(DS)	1997(RS)
Population (plants/ha) (P)				
26,700	30.38	29.81	0.41b	0.32a
53,300	31.85	26.24	0.45a	0.28b
80,000	32.64	28.55	0.46a	0.26b
SE±	1.071	0.081	1.001	0.011
Varieties (V)				
Obatanpa	30.09	26.79b	0.39a	0.29
GH110-28	33.16	29.21a	0.44b	0.29
SE±	1.061	0.781	0.021	0.021
Fertilizer Levels(F)				
0-0-0	27.55b	23.00c	0.35	0.20c
60-30-30	31.17a	27.27b	0.41	0.28b
120-60-60	33.14a	29.32ab	0.45	0.32ab
180-90-90	34.64a	32.40a	0.46	0.35a
SE±	1.501	1.451	0.031	0.021
Interaction				
P x V	NS	NS	NS	NS
P x F	NS	NS	NS	*
V x F	NS	NS	NS	NS
P x V x F	NS	NS	NS	NS

Means within a column followed by the same letter(s) do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant.
DS = Dry season.
RS = Rainy season.

5.7 Correlation analysis

The association between grain yield, growth and yield parameters are shown in Tables 22 and 23. A positive and significant correlation was recorded between grain yield and leaf area index at 12 WAS and cob yield per hectare in both seasons. While the relationship between yield and number of cobs per plant and harvest index were significant but negative in the rainy season. The correlation between grain yield and plant height, number of leaves per plant, dry matter per plant, number of days to 50 per cent silking, No of cobs per plant, weight of cobs per plant, No. of grains per cob and 100-seed weight in 1997 dry season were all positive but not significant. Likewise the correlation between grain yield and plant height, number of leaves per plant, No of days to 50% silking and tasselling in 1997 rainy season was positive though not significant. Plant height was significantly correlated with LAI in both seasons and significantly and negatively correlated with number of cobs/plant (in 1997 dry season). In the rainy season yield was negatively correlated with total dry matter/plant, weight of cobs/plant and number of grains/cob.

Table 22: Matrix of correlation coefficient between grain yield (kg/ha) and yield characters in 1997 dry season at Kadawa.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	1.0000												
2.	0.1025	1.0000											
3.	0.0648	0.2664**	1.0000										
4.	0.7055**	0.6051**	0.3162	1.0000									
5.	0.0300	0.2380*	0.2749**	0.6042**	1.0000								
6.	-0.1599	-0.3681**	-0.6517**	-0.8006**	-0.7390**	1.0000							
7.	0.0642	0.0062	-0.4301**	-0.3333**	-0.2551*	-0.3512**	1.0000						
8.	0.0493	-0.0344	0.0422	0.4251**	0.3748**	0.3598**	0.3833**	1.0000					
9.	0.1617	0.2576*	0.2334*	0.5499**	0.4888**	0.4635**	0.4827**	0.5244**	1.0000				
10.	0.1308	0.4259**	0.3817**	0.6875**	0.6848**	0.5204**	0.6891**	0.6222**	0.3433**	1.0000			
11.	0.1641	0.1790	0.2017*	0.4498**	0.4677**	0.3831**	0.4520**	0.3931**	0.2428*	0.3373**	1.0000		
12.	0.3104**	0.5291**	0.2778	0.5952**	0.5471**	0.4597**	0.5280**	0.5744**	0.4852**	0.6186**	0.5673**	1.0000	
13.	-0.0200	0.1950	0.1774	0.4590**	0.4934**	0.4322**	0.4248**	0.3646**	0.1189	0.2029*	0.1616	0.2194*	1.0000

1 Grain yield per hectare (kg); 2 Plant height (cm) 12 WAS; 3 Number of leaves per plant 12 WAS; 4 Leaf area index 12 WAS;
5 Total dry matter per plant (g) 9 WAS; 6 Number of days to 50 percent tasselling; 7 Number of days to 50 percent silking; 8 Number of ears per plant;
9 Weight of cobs per plant (g); 10 No of grains per cob; 11 100 seed weight (g); 12 Total cob yield (kg) 13 Harvest index.
* Significant at 5% level of brobility; ** Significant at 1% level of probility r = 0.200 and 0.26 at 5 and 1% respectively.

Table 23: Matrix of correlation coefficient between grain yield (kg/ha) and yield characters in 1997 rainy season at Samaru

	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	1.0000												
2.	0.1231	1.0000											
3.	0.0796	0.1159	1.0000										
4.	0.6930**	0.6828**	-0.0262	1.0000									
5.	-0.0710	-0.0391	0.0881	0.5250**	1.0000								
6.	0.0596	-0.0363	-0.5330**	-0.6111**	-0.5494**	1.0000							
7.	0.1386	0.0400	-0.2894**	-0.7782**	-0.7385**	-0.1260	1.0000						
8.	-0.2608**	-0.3277**	-0.2485**	0.3564**	0.2853**	0.0421	0.5080**	1.0000					
9.	-0.0533	-0.0119	-0.0737	0.5440**	0.5210**	0.0007	0.6900**	0.6733**	1.0000				
10.	-0.0328	0.0191	-0.2305**	0.4054**	0.4156**	-0.0276	0.5462**	0.6219**	-0.1572	1.0000			
11.	-0.0459	-0.0227	-0.1068	0.2495*	0.1531	0.0046	0.4267**	0.4320**	-0.1292	0.1940	1.0000		
12.	0.2492*	0.2555*	-0.1369	0.5527**	0.4559**	-0.0057	0.6424**	0.7699**	0.0352	0.5720**	0.6411**	1.0000	
13.	-0.2401*	-0.2315*	-0.0745	-0.5053**	0.4513**	0.0446	0.4385**	0.5381**	-0.1975	0.1471*	0.1967	0.1450	1.0000

1 Grain yield per hectare (kg); 2 Plant height (cm) 12 WAS; 3 Number of leaves per plant 12 WAS; 4 Leaf area index 12 WAS;
5 Total dry matter per plant (g) 9 WAS; 6 Number of days to 50 percent tasselling; 7 Number of days to 50 percent silking; 8 Number of ears per plant;
9 Weight of cobs per plant (g); 10 No of grains per cob; 11 100 seed weight (g); 12 Total cob yield (kg) 13 Harvest index.
* Significant at 5% level of brobility; ** Significant at 1% level of probility r = 0.200 and 0.26 at 5 and 1% respectively.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of season

Higher growth and yield parameters particularly plant height, leaf area index, dry matter/plant (g), Stover dry weight (kg/ha), grain yield (kg/ha), weight of cobs/plant, number of grains/cob, cob weight (kg/ha) were observed during the rainy season compared to the dry season. These observations could be attributed to favourable weather climatic conditions recorded during the rainy season trial. The temperature recorded during the vegetative and reproductive stages was optimum for maize (28°C appendix 1b). Maize is known to do well at a temperature range of 21 - 32°C (Kumar et al., 1982, Onwueme and Sinha, 1991). Lower yield and growth parameters recorded during the dry season trial could be attributed to excessively high temperatures recorded at the critical period of pollination and fertilization at Kadawa (37.50°C Appendix 1a). Temperatures above 32°C at the time of pollination have adverse effects on pollination and fertilization, causing reduced seed-set. This has lead to the low yield recorded in the dry season trial. Similar results were reported by (Kumar et al., 1982; Onwueme and Sinha, 1991).

5.2 Effect of varieties

The significantly higher number of leaves/plant, days to 50 percent tasselling and silking, grain yield/ha, 100-seed

weight and cob weight (kg/ha) exhibited by GH110-28 in both seasons over Obatanpa could be attributed to GH110-28 being more responsive to fertilizer and genetic make up of hybrid. While the genetic make up of Obatanpa has expressed its superiority over GH110-28 on plant height, leaf area index, dry matter/plant and lodging. These characters are genetically controlled and could also be influenced by environment to a certain extent. GH110-28 gave higher grain yield (kg/ha) than Obatanpa in both seasons. The difference in grain yield between hybrid and open polinated varieties used could be attributed to greater biomass production, increased harvest index etc noted above. These findings conform with the results obtained by (Kim, et. al., 1988, Fakorede et al., 1993 and Bolanos, 1995) who observed hybrid maize to be higher yielding than open pollinated varieties.

5.3 Effect of plant population

Growth and yield characters were all found to be significantly affected by changes in plant population. The results indicated that increasing the plant population from 26,700 to 53,300 plants/ha and above resulted in significantly taller plants, high LAI, high harvest index, increased days to 50% silking, higher stover dry weight (kg/ha) and grain yield (kg/ha). These observations may be due to the increase in plant population per unit area. When there is an increase in plant population, it may result into competition for sunshine, water, nutrients and even space and if this occurs, it results

into taller plants, delay in silking period, increase in LAI, higher harvest index and grain yield/ha. The increase in grain yield may be due to increase in the number of cobs produced per unit area. This finding was however true only with the dry season trial, this agrees with the findings of Baker (1975) who reported an increase of 11% in grain yield of maize in Samaru when the population was increased from 35,000 to 61,000 plants/ha.

The rainy season trial did not give any significant difference in grain yield of maize. This could probably be due to the fact that the rainy season trials lower population had higher number of cobs/plant, heavier cobs weight/plant and having more grains per cob. This is contrary to expectation since it had been known that grain yield increases with increase in population up to a certain maximum after which, further increase will result in lower yield. However this finding agrees with that of Kayode and Agboola (1981) at Samaru, who found no response in yield obtained from a range of plant populations (37,000 -62,000 plants/ha).

The increase in plant height observed at higher plant population (53,300 plants/ha and above) may be due to fast growth of the plants in trying to compete for sunlight interception. This conforms with the findings of Norden (1965), Shun et.al.,(1989) who observed increased plant height with increased plant population. The increase in LAI may be because of more number of leaves per unit area, which ensured

better light interception and ground cover at higher plant density. This finding is similar to that of Eseche et al (1993) who observed greatest LAI at a plant population of 78,000 plants/ha.

The reduction in number of cobs/plant and weight of cobs/plant observed at 53,300 plants/ha and above could be due to inter-plant competition for water, nutrients and space. A similar result was reported by Bunting (1973) and Rathore et al. (1976) who observed a decrease in number of cobs/plant with increase in plant population.

The delay in the number of days to 50% silking observed during the rainy season trial with increased plant population could be attributed to the effect of competition for environmental resources viz (water, solar radiation and space) which were limited at higher plant population. Thus making the crops to take longer days to attain 50% of silking. At a lower plant population, inter plant competition was minimum, therefore the plant take shorter days to attain 50% silking. This conforms with the findings of Kohnke and Mike (1951), Shubeck and Caldwell (1955) who reported delay in silking associated with an increase in plant population.

5.4 Effect of fertilizer

The significant increase observed in plant height, LAI, number of leaves/plant, dry matter/plant, stover dry weight (kg/ha), number of grains/cob, weight of cobs/plant, grain weight/plant, cob weight/ha, 100-seed weight and harvest index

due to increase in fertilizer application may be due to availability of more plant nutrients in the soil that was able to supply the requirements of the plants thereby causing reduction in competition for nutrients. The increase in fertilizer application also resulted in fast increase in plant growth, the ability of the plants to produce larger leaves and thick canopy for efficient light interception. This result was similar to the findings of Prasad and Singh (1990) who observed a significnat increase in growth and yield parameters of maize with increase in fertilizer application. On the other hand, plants grown with no fertilizer treatment were stunted, spindly and yellowish. The leaves were few with low LAI and the cannopy did not cover the ground completely. With this kind of growth, solar radiation was poorly harvested and photosynthesis reduced; the growth and yield of the crops was thus hampared. Similar observations were reported by Janic et al., (1974), Pamplona et.al., (1988) that the addition of NPK has a positive effect on growth and yield characters, which consequently lead to increased productivity.

The reduction in number of days to 50% tasselling and silking observed with NPK application may be because of nitrogen which is known to delay the plants from reaching reproductive phase due to increase in vegetative growth, however phosphorus counteracted this delay. This conforms to the report of Rathore et. al., (1976) that the number of days to tasselling increases significantly with nitrogen alone but

was not affected by addition of phosphorus. A significant decrease in lodging with increase in fertilizer application observed may be due to addition of phosphorus which gives strength to the crop and therefore prevent them from lodging. Similar results were obtained by Eguchi et.al., (1958) and Sun et.al., (1989).

5.5 Correlation Studies

There was significant positive correlation between grain yield on one hand and most of the yield characters of maize on the other hand. The relationship indicates that the growth characters such as number of leaves/plant and short dry weight and yield attributes such as cob weight, number of cobs/plant, number of grains/cob and 100 seed weight are important determinants of grain yield of maize. Similar observation have been reported by Ologunde and Ogunlela (1984) and Amoruwa (1987).

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

Field experiments were conducted during the 1997 dry season and 1997 rainy season at the Institute for Agricultural Research (IRS) Farms at Kadawa and Samaru, respectively to determine performance of quality protein maize at varying levels of NPK fertilizer and plant density in savanna zones of Nigeria.

Plant density significantly affected grain yield in the and days to 50% tasselling during the dry seasons and number of cobs/plant and weight of cobs/plant in the rainy season. Stalk lodging in both seasons, plant height, stover dry weight, number of grains/cobs, cob weight (kg/ha) and harvest index in the dry season. There was a non significant effect on grain yield in the rainy season, number of leaves/plant, dry matter/plant and 100-seed weight in both seasons. It also had a non significant effect on number of days to 50% silking, number of cobs/plant, weight of cobs/plant in the dry season and number of days to tasselling, number of grains/cob and cob weight in the rainy season.

GH110-28 had higher grain yield, cob weight, number of days to 50% tasselling and silking and number of cobs/plant, in both seasons, 100-seed weight in the rainy season and harvest index in the dry season. While Obatanpa was superior interms of plant height, LAI, dry matter/plant and Root and stalk lodging.

Fertilizer levels 60-30-30kgNPK/ha significantly influence plant height, number of leaves/plant, and LAI, in both seasons, stover dry weight, weight of cobs/plant and 100 seed weight in the dry season and dry matter/plant in the rainy season. However application of 120-60-60kg NPK/ha produced statistically higher grain yield than other rates though at par with 180-90-90kg NPK/ha. Similarly it produced statistically higher dry matter/plant, number of cobs/plant and cob weight/plant in the dry season and higher stover weight, weight of cobs/plant, 100-seed weight and harvest index in the dry season.

Based on the results obtained it can be deduced that both GH110-28 and Obatanpa performed best at 53,300 plants/ha and given 120-60-60kg NPK/ha as recommended for open pollinated maize cultivars. Application of NPK beyond 120-60-60kg NPK/ha gave no advantage. Use of hybrid gave better advantage than open polinated variety in both seasons.

REFERENCES

Abdullahi, A. (1975) Studies of the post flowering development of Maize (Zea mays L.) Unpublished Ph.D Thesis, Ahmadu Bello University, Zaria Nigeria, 110pp.

Agboola, A.A. and G.O. Kayode, (1981). Effect of different nitrogen levels, plant population, and soil nutrient status on yield and yield components of maize (Zea mays L.) in different ecologocal zones of Nigeria. Fertilizer research 2 : 177-191

Amon, B.O.E. and S.A. Adetunji, (1970) Review of soil fertility investigations in Western Nigeria Reseach report No. 55. Ministry of Agriculture and Natural Reseources, Research Divsion, Ibadan, Nigeria.

Amon, B.O.E. and S.A.Adetunji, (1973) The response of Maize,Yam and Cassava to fertilizer in a rotation experiment in the savanna zone of Western Nigeria. Niger. Agric.j.10, 91-98.

Amoruwa, G.M., V.B. Ogunlela and O. Ologunde (1987). Agronomic Performance and Nutrient concentration of maize (Zea mays L.) as influenced by N fertilization and plant density Journal of Agronomy and Crop Science 1159: 226 - 231.

Anderson, G.D (1973). Potassium response of Various crops in East Africa. Proc. 10th coll. Int. Pottash Institute pp 413 - 438.

Anonymous (1973) "Maize production in the Northern states of Nigeria". Extension Bulletin II. Agricultural Extension and Research Liasion Services, IAR, Zaria, Nigeria, 24pp.

Anonymous (1992). F.A.O. 1992 Food and Nutrition series No. 25. MAIZE in human nutrition. Food and Agriculture organization of the United Nations Rome, 1992. pp. 160.

Anonymous (1995).Bi- monthly bulletin of the crops research Institute, Ghana No.1 Council for Scientific and Industrial Research.

Anonymous (1998). QPM Newsletter, 1998.International Maize and Wheat Improvement Centre (CIMMYT) Mexico.

Black, C.A. (1968). Soil - Plant Relationships John Wiley and Son. New York P 792.

Baker, E.F.I (1975). "Effects and interactions of Pack age deal" inputs on yield and Labour demand on Maize'. Experimental Agriculture II: 295 - 304.

Barry, D.A.J. and M.H Miller,(1989). Phoshorus nutritional requirements of maize. Seedlings for maximum yield. Agron. J. 81, 95 - 99.

Bolanos, J.(1995) Physiological basis for yield differences in selected maize cultivers from central America. Field Crops Research (195) 42 (2/3) 69-80.

Bolton, A. (1971). Response of maize varieties in Tanzania to different plant population and fertilizer level. Experinmental Agriculture, 7: 193 - 203

Black, C.A (1968). Soil-Plant Relationship. John wiley and son Inc. New York. P. 792.

Bouyucus, G.H (1951) A recalibration of the hydrometer method for making mechanical analysis of soils. Agronomy Journal 43: 434 - 438.

Bray, R.H and Kurtz, L.T. (1945). Determination of total organic and available forms of P in soil soil Science 59: 39 - 45.

Bremmer, J.M. (1965). Total nitrogen. In C.A. Black ed Methods of soil analysis part 2: 1149 - 1178. Chemical and miciobiological properties. American Society of Agronomy, Madison, Wisconsin.

Breth, S.A (1998). The Earth and the Sky Consulting Editor Sasakawa African Association, Arlington, Virginia USA.

Bunting, E.S (1973). Plant density and yield of grain maize in England. Journal of Agricultural Science (Cambridge) 81:455 - 463.

Bunting, E.S and L.A. Willey, (1959). The cultivation of Maize for fodder and ensilage 2. The effect of changes in plant density. J. Agric. Sc 52: 313 - 319.

Chinwuba, P.M (1976) Effect of plant population on development and yield of Maize in Western Nigeria African Soils. 12:101-106.

Chude, O. Victor (1996) Fertilizer in Maize Production Department of Soil Science Ahmadu Bello University, Zaria, Nigeria A paper presented at the National workshop on maize production in Nigeria held at Banquet Hall, State House, Kawo, Kaduna July 22, 1996.

Cortez, A. and C. Wild-Altamirano (1972). Contributions to the lime-treated corn flour technology. In R. Bressani, J.E. Braham and M. Behar, eds. Nutritional improvement of Maize. INCAP Pub. L-4, P 99 - 106. Guatemala, INCAP.

Cox, G.M. and Cochran W.(1967). Experimental Design. 2nd Ed. John Willey and Sons 245pp.

Dave, L. (1976) Improved practices in corn production A guide for peace corps volunteers. United States Department of commerce. National Technicasl information Service P.B. 263 840 pp 7-10.

Dickson, J. (1968). Plant density and nitrogen studies with irrigated hybrid maize in Lockey Valley, Queensland. Queensland Journal of Agricultural and Animal science 25: 119 - 210.

Doughlass, J.A. Cottier, K., Kain, W.K., Oconnor M.B. and Dougthorn, T. (1972) Advance in Maize production. Proceedings of Ruskura farmers conference 1972 121 - 128pp.

Dowswell, C.R., R.L Pahiwal, and cantrell, R. P (1996) Maize in the third world. West view press, inc., A Division of Harper collins publishers, Inc. pp 268.

Drowney, L.A (1971) "Relationship between plant density and yield of maize. Journal of Australian Institute of Agricultural Science,

Duncan, D.B (1955) . "Multiple range and multiple "F" test Biometrics. 11:1-42.

Duncan, N.G and J.D Hasketh, (1968). Net photosynthesis rates. Relative growth rates and leaf number 22 races of maize at eight temperatures. Crop science 8: 670 - 674.

Edache, A.O. (1996); Maize production and utilization in Nigeria problems and prospects: Paper presented at National Workshop on maize production, held on 22nd July 1996 at State house Kaduna

Eguchi, T., T. Matshaashina; and M. Ashizana (1958). The effect of nutrition on flower formation in vegetabless. Food and Fertilizer Bulletin, Japan 72pp.

Elemo K. A (1990) Croping scheme meeting Report on cereals Research programme. Institute for Agricultural Research Samaru A.B.U., Zaria. 24-28 Feb, 1992.

El- Sharkawy M.A. (1976): Investigation in Libyan Arab Republic 2. Effects of nitrogen level and time of application on growth and yield of maize in Field Crop Abstracts 32(1) 1979 pp20.

KASIM IBRAHIM

Esechie, H.A (1993). Effect of planting density on growth and yield of irrigated maize (Zea mays L.) in Batina coast region Oman. Journal of Agricultural Science 119(2) 165 - 169. in Maize Abstracts 1993 Vol.9 No.6: 3386.

Fakorede, M.A.B.; Alofe, C.O, Kim, S.K (1993). eds MAIZE Improvement, production and utilization in Nigeria. Maize Association of Nigeria PP 272.

F.A.O (1997). FAO Quarterly Bulletin of Statistics Vol. 3/4, 1997

Filev, D. and V Pan'kin, (1976). Effect of plant density and fertilizers on productivity of maize hybrid. Referativnyi Zhurnal, 1977, 170pp. In Field Crop Abstract 31(3) Abstr. 1717, 1978.

Fredeen, A.L., Rao, I.M and Terry, N. (1989) Influence of phosphorus nutrition on growth and Carbon partioning in Soyabean Glycine max (L.) Merr. Planta 181, 399-405.

Gagro, M. (1978) "Effect of nitrogen fertilizer and plant density on stem height of hybrids; soils and fertilizers, 44 (1), Abstr. 571, 1981.

Haggar, R.J. and D.C. Cooper (1972). Effect of plant population and fertilizer nitrogen on maize grown for silage in Nigeria. Experimental Agriculture, 8: 251 - 263

Heathcote, R. G. (1973). The use of fertilizers in the maintainance of soil fertility under intensive cropping in Northern Nigeria. Proc. 10th Coll. Int. Potash Institute. 467-474.

Hoffman, L.A. (1965). Economic Geography. Ronald press co NewYork.

IITA (1975). Selected methods for soil and plant analysis. IITA, Ibadan - Nigeria.

Janic J., R.W. Schery R.W Woods, and V.W. Rutten, (1974) Plant Science An introduction to World crops. W.H. Freeman and co. pp 317.

Jones, M.J.(1973). Time of application of nitrogen fertilizer to maize at Samaru, Nigeria Experimental Agriculture, 9 (2), Pp.113-120.

Jones, M.J.(1973). Planting time studies on maize at samaru, Nigeria 1970-73. Samaru Misc. paper No. 58 IAR/ABU Samaru, Nigeria.

Jugenheiner, R.W. (1976). Corn: Improvement, seed production and uses. John Wiley and sons New York/London Sedney/Toronto 670 pp.

Juo, A.S.R (1979) Soil and plant analysis IITA Technical Bulletin No. 12.

Kim, S.K., Akintunde, A.Y., Fakorede. M.A.B, Markek, J.H, Kling, J., Bosque-perez, N. and Buddenhagen, I.W. 1988. Research on hybrid maize at IITA. NCMRP Annual meetings, IAR & T Ibadan.

Kling, J.G (1991) Quality and nutrition of maize. IITA Research Guide No. 33. International Institute of Tropical Agriculture (IITA), Ibadam, Nigeria. 29p.

Kohnke, H and Mike, S.R (1951). Rates and patterns of seeding corn on high fertility land; Agronomy Journal, 43; 488-493.

Kumar, V.; J.J Owonubi and J.A. Aremu (1982) Optimum planting time for crops during the dry season in the sudan and Northern Guinea Savanna Zones of Nigeria. A report prepared for the Irrigation Research Committee of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria 22nd October, 1982.

Lonhard-Bory; E. and Nemeth; I. (1989). Effect of P Fertilizer on the development of leaf area in Maize in Field crops Abstract 43 (5): 388

Lynch, J., Lauchli, A. and Epstein, E. (1991). Vegetative growth of the common bean in response to phosphorus nutrition. Crop Sci. 31 380-387.

Marschner, H and I Cakmak, (1989). High light intensity enhances chlorosis and necrosis in leaves of zinc, potassium and magnesium deficient bean (Phaseolus vulgaris) plant. J. Plant physiology. 134, 308 - 315.

Mc-philips, J.K. (1989). Maize yield response to N and P in Southern Province of Zambia . Norwegian Journal Agric. 3 (3): 189 -192.

Mikhail, S.M. and Sheleby, Y.Y. (1979). Effect of plant density and nitrogen on maize dry matter production. Research Bulletin Faculty of Agriculture, Am-Shams University, 1979 No. 1024: 7pp. In Field Crops Abstracts, 33(7) Abstr. 5399, 1980.

Miracle, M.P (1972). Increasing efficiency in maize production in maize in Tropical Africa. Longman pp 233.

Mohammed, M.L., Noor, M.A and Alio, A.N. (1978). The influence of the level of nitrogen fertilizer and spacing on maize in Somalia. Studie Ricerehe 2 (2), 1978, 109 - 115. In field crop Abstracts. 33(2): Abstr. 1151, 1980.

Norden, A.J. (1965). Response of corn (Zea mays L.) to population, bed height and genotype on poorly drained Sandy soil. 11. Top growht and root relationships. Agronomy Journal. 58:299 - 302.

Nye, P.H and Greekind D.J. (1960). The soils under shifting cultivation. Common wealth Bur. Soil Tech. Comm. No. 51, Harpenden England.

Obi, I.U. (1991). Maize Its Agronomy, Diseases, Pests and Food values. Optimal computer solutions Ltd pp 163 - 165.

Okoruwa, A.E (1992) Utilization and processing of maize. IITA Research Guide No. 35 International, Institute for Tropical Agriculture (IITA) Ibadan, Nigeria 27 pp.

Ologunde; O.O. (1974). Effect of N and P and population on yield and yield components of maize. M.Sc. Thesis, University of Missouri, Colombia, 164pp.

Ologunde, O.O and Ogunlela, V.B. (1984). Relationship of plant density and nitrogen fertilization to maize performance in the Nigerian Southern Guinea Savanna Samaru Journal Agricultural Research 2: 99 - 109.

Onwueme, I.C and Singha, T.D (1991). Field crop production in Tropical Africa Principles and Practice. Technical centre for Agricultural and Rural coperation. pp 159 - 175.

Pamplona, P.P., K.E. Pahm, N.E. Doque, S.S. Tinapay, E.J. Jagolina, (1988). The influence of fertilizer rate, population density and irrigation on the yield of corn and soybean. In proceedings of yield research (1990) 93 - 103.

Pissarek, H.P. (1973). Zur Entwicklongder Kalium-Mangelsymptome von Sommer-raps. Z. Pflanzenernahr. Bodenk 136, 1 - 19.

Powell, R.D and Webb, J.R. (1972). Effects of high rates of nitrogen, phosphorus and potassium fertilizer on maize (Zea mays L.) grain yields. Agronomy Journal 64: 653 - 656.

Prasad, K., P. Singh (1998). Response of promising rainfed maize varieties to N application in North Western Himalayas region. Indian Journal of Agriculture Sciences (1990) 60177. 475 - 477.

Purseglove J.W (1972). Maize (Zea mays L.). In Tropical Crops. Monocotyledons 1 and 2 Longman, London Pp 300 - 333.

Rathore, D.N; S. Kirpal and B.P Singh (1976). Effect of N and Plant population on yield attributes of maize. Indian Journal of Agricultural Research 10 (2): 79 - 82.

Reith, J. W. (1967). Effect of soil Magnesium and manganese dressing on crop yield and composition. Technical Bulletins. Ministry of Agriculture and Fisheries (FD): 97 - 109.

Reyes, C.P.; G.E. Javier and D. Miracles (1972). Effect of rate of Nitrogen on grain yield and Agronomic characters of four maize cultivars in xiii Infarmer de investigation. 1971 - 1972. Division de Sciences Agro pecarurias Y maritimes, Instituto Technological de Monterrey Mexico 28 - 29 pp In Field Crop Abstracts, 28(2) Abstr. 745, 1975.

Rossiter, R.C. (1978). Phosporus deficiency and flowering in subterranean clover (TV. subterraneum L.). Ann. Bot. (London) (N.S) 42, 302 - 304.

Salem, S.A. and A.E. Aly, (1979). Effects of nitrogen fertilizer levels and varieties on grain yield and some plant characters of maize (Zea mays L.). Alexandria journal of Agricultural Research, 27 (2) 337 - 345. in Field Crop Abstract, 28 (9) Abstr. 5422, 1975.

Sattar, M.A. et al. (1975). Effects of different levels of nitrogen and dates of planting on three types of corn FCA, Vol. 31, 254pp.

Sharma, R.K. (1973). Response of maize to N. Fertilization. Madras Agricultural Journal 60 (6): 399 - 400 in Field crop Abstract 33(2). Abstr. 9881 - 1980.

Shubeck, F.E. and Caldwell, A.C. (1955). Effects of fertilizers and stand on corn and stand on soil moisture Minnesote Agricultural Experinmental Station Technical Bulletin, 214.

Shukla, S.P. and Bhardwaj, R.B. L (1976). Effect of levels and source of nitrogen and phosphorus on growth, yield and nutrient uptake of maize grown under rain fed conditons. Indian Journal of Agronomy, 21: 436 - 440.

Shun S.X., W. D, G.U and J.Y. Dai (1989). The effect of plant density on lodging of maize. Journal of Shemyong Agricultural University 20(4) 413 - 416pp.

Singh, R.B.D., Singh, N and Singh Y. (1979). Effect of N-fertilization on yield nad moisture extraction by rainfed as affected by soil type and Rainfall in punfab, India. Field crop Research, 2: 109 - 115, 1979.

Singh, R.P and K. P.P. Nair, (1978). Plant density studies in maize in India. Journal of Agricultural Science (Cambridge) 86: 617-621.

Snedecor, G.W and W.G Cochran, (1967): Statistical Methods. 6th ed IOWA State University Press U.S.A. 456.

Sobulo, R.A. (1973). Evaluation of analytical method of determining Potassium status of Nigerian Soils. Pro 10th coll. Int. Potash institute pp 199 - 130.

Sun, S. X., Dair, J.Y. and Du, W.L (1989) Effect of N and P on lodging and yield of maize Journal of Agric. Science 22 (3) 28 - 33.

Steele, K.W., Cooper, D.M. and Dyson, C.B (1982) Estimating nitrogen fertilizer requirements in Maize grain production, 2-Estimates based on ear leaf and grain nitrogen concentration. New Zealand Journal of Agricultural Research 25: 207 - 210.

Tag, P., Okolo, A.J. and Z. Schernmitz, K. (1972). The FAO fertilizer programme in Kenya P.35 Proc. 12th Meeting of the E.A. Spec. Comm. on Soil Fert. and Crop Nutrition.

Trough, E. (1930). The determination of readily available phosphorus of soils. Journal of American Society of Agronomy. 22: 879.

Verma, B.S and Singh, A.A. (1976). Effect of nitrogen, moisture regime and plant density on grain yield and quality of hybrid maize. Indian Journal of Agronomy 21(4): 441-445.

Watson, Stanley A. (1988). Corn Marketing, Processing and cultivation in corn and corn improvement, ed . G.F spraque and J.W. Dudley, 885 - 940. 3rd ed. Madison, Wisconsin: American Society of Agronomy.

Wilson, J.H and Allison, J.C.S. (1978). Effect of plant population on ear differentiation and growth on maize. Annals of Applied Biology 90(1): 127 - 132.

Zuber, M. S. and Grogen, C.O (1956). Rates of planting studies with corn: Missowri Agricultural Experinmental Station Research Bulletin, 60.

Appendix 1a: Meteorological data showing sunshine hours mean minimum and maximum temperature and relative humidity at Kadawa during the 1996/97 dry season.

Month	Rain (mm)	Temperature (°C) max	Temperature (°C) min	Relative humidity (%) max	Relative humidity (%) min	Radiation Mj/M^2	Wind speed (km/hr)
February	0.0"	28.4	14.5	16	11	21.6	1.2
March	0.0"	35.4	19.8	14	8	23.0	1.1
April	8.1"	37.5	23.9	14	8	26.4	2.9
May	66.4"	37.3	24.6	24	8	24.2	2.8
June	146.5"	32.5	21.7	43	9	22.1	2.6

Source: Mean Monthly Data ICRISAT, Bagauda, Kano, NIGERIA, 1997

Appendix 1b

Rainfall, maximum and minimum temperature and Relative humidity at ten day interval during the period of experiment at Samaru, 1997.

	Days	Rainfall (mm)	Temperature (°C) Min.	Max	Relative humidity(%)
June	1-10	71.0	20.9	30.3	73.9
	11-20	48.1	19.7	29.8	82.0
	21-30	36.1	20.8	30.2	82.9
July	1-10	44.6	20.1	28.9	82.1
	11-20	96.3	19.7	28.0	86.4
	21-31	52.6	19.8	29.5	85.0
Aug.	1-10	64.4	20.1	28.5	81.8
	11-20	168.9	19.6	27.6	86.9
	21-31	56.9	19.9	29.2	72.9
Sept.	1-10	96.1	19.8	29.0	81.9
	11-20	72.1	19.3	30.4	80.3
	21-30	14.4	20.3	30.5	80.2
Oct.	1-10	17.2	20.0	31.2	84.4
	11-20	44.6	20.2	31.2	78.0
	21-31	4.6	20.0	31.7	76.8
Total Rainfall		1184mm			

Source: Meteorological station, Institute for Agricultural Research, Samaru, Zaria.

Appendix II: Physical and chemical properties of the soils in which experiments were carried out at Kadawa and Samaru respectively.

Soil characteristic	Kadawa (dry season 1996/97) soil depth (cm) 0 - 15	15 - 30	Samaru Wet season 1997 soil depth (cm) 0 - 15	15 - 30
pH in water (1.25)	7.8	7.6	6.2	6.8
pH in $CaCl_2$ (1.25)	6.2	6.2	4.8	5.0
Organic Carbon (%)	0.78	0.55	0.48	0.56
Total nitrogen (%)	0.08	0.08	0.05	0.06
Available phosphorus (ppm/g)	7.39	3.04	5.89	0.89
Exchangeable bases (Meq/100g)				
Ca	4.39	1.40	0.76	0.80
Mg	0.16	0.17	0.06	0.06
K	0.19	0.08	0.05	0.04
Na	0.42	0.26	0.07	0.07
CEc	2.96	1.64	2.20	1.72
Particle size distribution				
Sand (%)	80	75	59	56
Silt (%)	11	11	29	28
Clay (%)	9.0	14.0	12	16
Textural class	Sandyloam	Sandyloam	Sandyloam	Sandyloam

Appendix III: The amino acid composition in normal and quality protein maize (GH110-28 and Obatanpa) using amino acid analyser.

Amino-Acid composition of maize (g/100g protein)			
	Normal maize	Quality protein maize	
		GH110-28	Obatanpa
Arginine	0.35	0.56	0.56
Cystine	0.19	0.26	0.26
Histidine	0.22	0.35	0.35
Iso-leucine	0.23	0.30	0.30
Leucine	0.77	0.88	0.88
Lysine	0.23	0.36	0.36
Methoionine	0.17	0.15	0.15
Phenylalanine	0.31	0.39	0.39
Threonine	0.24	0.34	0.34
Alanine	0.42	0.57	0.57
Tryptophan	0.06	0.10	0.10
Valine	0.33	0.48	0.48

Source NAFDAC - Kaduna Office - 1999

BIOGRAPHY

NAME: HASSAN, Adamu Hamidu.

DATE OF BIRTH: September, 15th 1962.

PLACE OF BIRTH: Pancu - Bauda.

L.G.A AND STATE: Lere, Kaduna

HOME ADDRESS: Opposite Government College Saminaka.

MARIRAL STATUS: Married.

PREVIOUS ACADEMIC QUALIFICATIONS

Institution attended	From	To	Cert/Degree Awarded
L.E.A. Pri.Sch Bassallah Yarkasuwa	1970	1975	First Sch. Leaving Cert.
Govt. Sec. Sch. Kafanchan	1975	1980	W.A.S.C. O' Level.
Katsina College of Arts, Science and Tech. Zaria	1980	1982	I.J.M.B A' Level.
Ahmadu Bello University, Zaria	1982	1986	B.Sc (Agric).

POST HELD SINCE AWARD OF FIRST DEGREE

ORGANIZATION	FROM	TO	POSITION
Directorate of Food Roads and Rural Infrastructure Pankshin L.G.A Platuea State	1986	1987	AGRIC OFFICER (NYSC)
National Directorate of Employment/Kaduna state ADP Saminaka	1987	1988	EXTENSION AGENT.
Govt. Girls Sec. Sch. Saminaka	1989	1993	AGRIC. SC. TEACHER
Kaduna State ADP Lere Zone, Saminaka	1993	1994	SUBJECT MATTER SPECIALIST (LIVESTOCK)
Sasakawa Global 2000/Kaduna State ADP Lere, Zone	1994	to date	ZONAL COORDINATOR

Year of Admission to Post graduate Studies 1995/96.

Admission Number M.Sc/Agric/12053/1995/96.