GROWTH AND YIELD OF MAIZE (Zea mays L.) IN RELATION TO LEAF ORIENTATION

By

YOLA, LUKA MOHAMMED

NCE; B.Sc (ED) HONS

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Department of Biological Sciences

Faculty of Science,

Ahmadu Bello University

Zaria, NIGERIA.

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DECLARATION

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

All sources of information are specifically acknowledged by means of references.

Signed: Mohammed.
YOLA, LUKA MOHAMMED

Date: 19/10/90.

CERTIFICATION

This thesis "GROWTH AND YIELD OF MAIZE (*Zea mays* L.) IN RELATION TO LEAF ORIENTATION" By YOLA, LUKA MOHAMMED, meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to scientific knowledge.

_____ Date_____

Dr. S. Mu'Azu
Dept. of Biological Sciences
Chairman
Supervisory Committee.

_____ Date_____

Dr.(Mrs) C.O. Ajakaiye
Dept. of Biological Sciences
Member
Supervisory Committee

_____ Date_____

Dr. C.G. Vajime
Head
Dept. of Biological Sciences

_____ Date 17/4/96

Prof. D. I. Saror
Dean
Postgraduate School

DEDICATION

This thesis is dedicated to:

Almighty God for making me to be me.

My grandparents:

Mrs. Mariya Mohammed Kirim

and

Mal. Mohammed Kirim

and

The advancement of Science and Science Education.

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ABSTRACT

Some biological aspects of growth and yield in maize (Zea mays L.) were studied. Leaves were found to first emerge from the embryo side of the kernel and are always oriented at right angles to the plane of the kernels' flat surface.

Vernation is such that leaf blades are rolled either to the right or to the left. It has been found that the direction of rolling of the first foliage leaf is random and seedlings are equally disposed to roll left or right. However, once the manner of rolling is established for the first leaf, subsequent leaves roll in opposite directions.

The growth and yield of the maize was assessed in relation to leaf orientation. In one of the leaf orientations, the leaf plane is along the path of the sun. In the second orientation, the leaf plane is perpendicular to the path of the sun. Although the differences in terms of growth and yield between the two leaf orientations are not statistically significant, leaves oriented with their planes perpendicular to the path of the sun seemed to perform slightly better than those oriented with their planes along the path of the sun.

It is recommended that a more detailed study be carried out so as to identify the most desirable plant-leaf orientation which can be used as a means of increasing maize yield.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BRIEF DESCRIPTION OF THE BOTANY AND IMPORTANCE OF MAIZE

Maize, a grain crop, belongs to the family gramineae and the tribe maydeae distinguished from the other related tribes by the seperation of the male and female flowers on the same plant (Bland, 1971). The tribe maydeae includes a number of genera and the most important ones include Zea Euchlaena and Tripascum found in America and Coix; polytoca; Sclerachne; Chionache; and Trilobachne found in Asia.

The genus Zea is monotypic and attempts have been made to classify Zea mays into subspecies and varieties on the basis of the grain type and texture. Jugenheimer (1958) has the following classification: Dent maize (Zea mays indentata); Flint maize (Zea mays indurata); Sweet maize (Zea mays saccharata); Floury maize (Zea mays amylacen); Popcorn maize (Zea mays averta); Podcorn maize (Zea mays tunicata); and Waxy maize (Zea mays ceretina).

Maize is an annual plant with thick stalk and terminates in a staminal spike called the tassel whereas the ear is produced laterally in leaf axils (Aldrich 1969).

The male inflorescence (tassel) terminates the main culm. It is formed by many ranked central spike and several two lateral branches arranged in a loose panicle on the framework. The flowers are organised into a paired spikelet, one being pedicu-late while the other is sessile. Each spikelet has two florets which contains three anthers and each tassel produces about 2-5 million pollen grains (Aldrich et.al.1975).

The female pistillate inflorescence is borned on one or more lateral branches and the spikelets are attached directly to the cob (F.A.O. 1980). The spikelets are borne in pairs and both are sessile and each has two flowers but only one is fertile. The styles are receptive along the whole length and fertilization of the ovule is complete within 12-18 hours of pollination (Ciba 1979).

Most commercial varieties of maize produce one to two ears although some are known to produce

up to ten ears for example the Argentinian variety.

Maize is generally used for three main purposes:-

1. Used as staple human food.
2. Used as livestock feed.
3. Used as raw materials for many industrial products.

1.2 THE STRUCTURE OF THE MAIZE PLANT

The maize is a stout annual grass with a single stem growing from one to four meters in height. It has a fibrous root system. The stem is solid with clearly defined nodes and internodes. The internodes are usually short and fairly thick at the base and it tapers at the terminal end to form the male inflorescence. Buds in the axils of the leaves at the lowest nodes may grow out to produce tillers while those in the higher leaves borne in an indented eye groove grow out to produce the ears. The leaves are borne alternately on either side of the stem at the nodes so that all the leaves of the mature plant lie on the same plane. The leaf blade is linear and lanceolate. The maize plant is monoecious with the male and

female inflorescences borne in seperate inflorescences on the same plant. The male inflorescence is called the tassel which is a terminal panicle. The female inflorescence is called the ear and is a modified spike produced from a short lateral branch in the axil of one of the largest foliage leaves. The fruit known as the kernel or grain is a caryopsis, which is mature and ripe about 50 days after fertilization. The kernels are borne in an even number of rows.

1.3 SEED GERMINATION AND LEAF ORIENTATION

Under favourable conditions, the radicle emerges 2-3 days after planting and the plumule, enclosed in the coleoptile breaks through the seed-coat 1-2 days later, followed by the other seminal roots, which are usually three in number.

Leaf orientation in a seedling usually becomes apparent after a day of its emergence. Yadav and Gupta (1987) reported that both root and leaf characters are predetermined in the embryo. They found that the first leaf always emerges from the embryo side and the second leaf from the kernel flat side. Therefore leaf orientation can be manipulated through kernel placement. If kernels are sown with

proximal end down and flat side along the drill row, leaves expanded in the inter-row space i.e. perpendicular to row direction and when the kernels are sown with the proximal end down and flat side across the drill row, their leaves are oriented along the drill row.

1.4 GROWTH AND FACTORS AFFECTING GROWTH OF MAIZE

Growth is a complex phenomenon associated with numerous physiological processes. Sinnot (1960) defined growth as a permanent and irreversible increase in size of an organism which is usually accompanied by increase in weight.

Plants show great variaties in their growth points and in their ability to grow. Generally, however, Redrick (1978) noted that plant growth is faster when young, it then reaches a climax and it falls gradually then cease when maturity sets in.

There are several factors which control the growth of maize. These include:

1. MINERAL NUTRIENTS

Maize like any other crop requires specific

rate and ratio of the essential elements viz: Nitrogen, Potassium, Phosphorus, Calcium, Magnesium, Silicon, Iron, Copper, Zinc, Chlorine, Carbon, Oxygen, Hydrogen etc for the synthesis of body material. Maize like any other green plant can manufacture most of their body substances. These simple inorganic material in the non-photosynthetic plants and animals have to be provided by the green plants.

Deficiency in any of these nutrient requirements in maize will result in growth ceasation and under some conditions death may even result.

2. SUITABLE TEMPERATURE

This is another very important factor which controls the growth of maize. All biological processes increases as temperature rise from the minimum value at which no growth is recorded to certain point beyond which growth is retarded. This is due to enzymatically controlled reaction of metabolism. The range of temperature requirement of maize is between 75° - 86°F (24° - 30°C) (Delorit 1974).

3. WATER/RAINFALL

The average or range of rainfall necessary for optimum maize growth is between 65-75cm of rainfall annually. The availability of water influences the growth of maize because it is one of the raw materials for photosynthesis and its availability is related to the quantity of food manufactured in the plant which determines the growth of cell and formation of protoplasm. Through this activity, it influences the growth rate of the plant and size attained. It also determines the morphology of the plant e.g. plant grown on damp soil have greater root hairs. Jugenheimer (1976) reported that for high yield, 50% of the rainfall should come during the growing period.

4. HYDROGEN ION CONCENTRATION (pH)

pH value of 6.0 to 7.0 is the optimum value for maize growth. Very low and high value inhibit the growth and functioning of the roots, hence the rest of the plant is affected. The pH affect enzyme activity and the nutrient availability in the soil.

5. LIGHT

Light is essential for growth because it

provides the energy by which new tissues are synthesized. Vines and Rees (1964) reported that light has two effects on maize and plants in general: Firstly, it causes etiolation when the supply is weak or absent and secondly, the plants are unable to synthesize enough, consequently resulting in retarded plant growth.

1.5 MEASUREMENT OF PLANT GROWTH

Growth can be estimated by measuring some parameters of the plant such as plant height, length of leaves, internode length etc. Measurement of plant height can be made at suitable intervals of time. However, the method is unsatisfactory because it fails to take into account the thickness, degree of branching or spreading of the plant as well as other parts of the plant in the soil.

For this study, the dry weight measurement (i.e weight of residue left after all free water has been removed by heating to 100°C) which is a more satisfactory method of measuring growth was used. Although the dry weight method may be misleading as it may include the weight of salts absorbed by the plant from the soil which does not bear any relationship

with the amount of plant growth, Fogg (1964) maintains that the method has small errors and therefore is the best method so far available.

To determine the dry weight of plants in a row, single plants should be taken at intervals so as to give a good growth curve. Several plants at a time, chosen at random should be taken so as to minimize the effects of variations and representative average values are obtained so as to plot the graph.

1.6 BACKGROUND TO THE RESEARCH STUDY

The requirement of successful crop production are several: a healthy plant, good soil capable of providing support to the plant, adequate plant nutrients, enough but not too much water either falling as rainfall or irrigation, light, adequate amount of carbon-dioxide and oxygen and reasonable control of pests and diseases.

For this study, attempt will be made at assessing the growth rate and yield of maize through leaf orientation studies. This is because radiation (light) is fundamental to crop production because of its role in photosynthesis. The energy of sunlight is used in

photosynthesis to reduce the atmospheric carbon-dioxide to organic carbon substances which make the body of the plant, its agricultural yield and in fact 90 per cent of the total dry matter produced in any crop.

Fogg (1964) noted that the amount of light which is received by a plant depends very much on the detail of leaf form and arrangement. The orientation of the leaf is particularly important. A leaf facing the light source i.e. at right angles to the sun rays (light rays) intercepts the maximum amount while the one with the leaf edge-on i.e. parallel to the rays receives the minimum.

Bainbridge et.al.(1965) reports that most farm crops reach light saturation at visible intensities as small as 0.3-0.4 Cal cm^{-2} min^{-1} with the exception of maize. Maize is a C_4 plant and it possesses the C_4 photosynthetic system. It has an extremely high photosynthetic capacity and Gifford (1970) observed the highest rates at 277 mu cm^{-2} S^{-1} and light saturation occuring at photosynthetically active radiation (PAR) flux densities approximating to full sunlight. This confers on maize the tremendous advantage of growing under conditions which may be unsuitable to

other crops. It's choice and appropriateness for the purpose of this investigation is unquestionable.

Maize also has several other beneficial property which makes it superior over other cereals thereby making it more suitable for use in assessing growth and yield in relation to leaf orientation. Some of these are:

1. It has upright leaves which intercepts a sizeable proportion of rain water and carry it downwards along the leaf sheath to the ground (Yadav, 1983). The water may be used to replenish the soil moisture deficit in the root zone. This therefore confers an advantage on the crop enabling it to resist drought and to be cultivated in arid and semi-arid environments.

2. Maize plant is large and has a large leaf surface, large stem, large root system and an extensive vascular system (Jungenheimer, 1976),

3. Maize being a C_4 plant is relatively

insensitive to day-length and/or temperature with the result that two or more crops can be grown a year.

1.7 RATIONALE FOR THE STUDY

There is a world food shortage and one of the basic problem of agriculture is how to increase the yield of crops. The development of hybrid maize is one of the greatest achievements in crop improvement during the present century. It has been responsible for great increases in the yield of maize.

Some studies on canopy manipulation by mechanical means after seedling emergence and its effects on crop growth and yield have been made by Peters and Wooley (1959) and Prine (1973, 1977). Yadav (1975) also noted that a uniform and definite plant canopy pattern is required for the efficient utilization of light. The identification of the suitable leaf orientation which has the greatest influence on photosynthesis (which influences the rate of plant growth and subsequently yield) can be seen as an important step in providing a more efficient basis for planning better crop management practice.

Secondly, it is known that light intensity during growth can affect subsequent rates of photosynthesis in grasses and cereals (Hesketh 1968; Downes 1971 and Woledge 1971). Gabrielson (1960) found the relative efficiency of photosynthesis in green leaves in weak white light of direct sunlight with the sun at 60° above the horizon to be between 1.02 - 1.14. This corresponds to the quality of the mid-day sunshine. Photosynthesis can be deduced from observations on the growth of plants by the dry weight method since it is the chief means whereby plants increase in substances. Allen (1977) observed that plant growth depends on photosynthesis and the amount of photosynthesis which takes place is dependent on the intensity and duration of light.

Kamanda (1984) reported that almost all students in Sierra Leone Schools when asked to define, describe and explain photosynthesis only answered by giving the process of photosynthesis and concluded with an equation representing the process but omitted the very important concept of energy. He found out that majority of students only learn the definition of scientific terms. Although the students learnt the concept of energy in physics and chemistry classes, they have failed to transfer the concept to learning

about photosynthesis in Biology. The results of this study will provide useful information on how to put some of the theoretical information learnt on photosynthesis into practical use when students are given the opportunity to carry out such simple activities in the school garden.

1.8 THE EDUCATIONAL IMPLICATIONS OF THE STUDY TO THE TEACHING OF BIOLOGY

Perhaps one of the most important concepts that the beginning student of Biology/Integrated Science or even Primary Science should grasp is the fundamental role that plants play in supporting all other forms of life. This is probably the reason why standard science textbooks used in schools include the topic photosyntehsis. However, as Kamanda (1984) pitifully noted, a classroom treatment of the topic is basically a definition followed by experiments and exercises to show the raw materials, the conditions necessary and importance of photosynthesis.

Similarly, Pilts (1961); Lowery and Leonard (1978); Mu'Azu (1980) and Ogunniyi (1982) all reported on the sad way science in our schools is being taught. They noted that science teachers and their students depend very much on their textbooks and they tend to

learn the textbooks "parrot-fashioned" and in total isolation from local empirical data and ideas.

One common error observed in Biology teaching in schools is that teachers do not include enough practical work in their teaching scheme (Ndu 1980; and Aramide 1982). Practical work is a matter of maximum importance in the learning of Biology as it provides opportunity for students to learn various skills and also stimulate interest in the subject. Students should therefore not be made to learn by heart that which has been explained to them by the teacher only. This is why the current approach to the teaching of science emphasizes the use of the environment (Eshiet 1982).

Since photosynthesis and growth are closely connected and the rate of photosynthesis carried out by a plant depends on the area of leaf, it is possible to investigate the differences in the rates of photosynthesis in the field. With the use of very cheap clay pots to cultivate maize in the school garden, it is more feasible to assess photosynthetic yield in the field in terms of dry weight increase.

The need to understand structure as a basis for the understanding of function is not to be denied, but the former without the latter has no much value. Therefore, the teacher has to explore a better way of laying a solid foundation to his students. He may find this study project and its results a useful device to be used in teaching and demonstrating the concept of energy required in the photosynthetic activi', of plants.

1.9 OBJECTIVES OF THE STUDY

The thrust of this research is a simple integrated study of the Biology of the maize (*Zea mays* L) plant from germination to flowering and yield in particular the pattern in which the leaves are rolled and arranged on the stem and the comparative growth rates and yield in relation to leaf orientation.

CHAPTER TWO

2.0 REVIEW OF RELATED LITERATURE.

2.1 MORPHOLOGICAL STUDY OF LEAF ROLLING IN MAIZE.

A young developing leaf originates from the periclinal divisions of a group of cells on the flank of the apex. As a result of these divisions in a localized area, a small protuberance known as the leaf buttress is formed and it gives rise to the future leaf primordium. The siting of the leaf primordia at the shoot apex is a regulated process and it determines the leaf arrangement on the mature shoot (Wareing 1974).

Bonnett (1947) described and illustrated the major phases in the development of the maize plant terminating with the mature seed. A study on vegetative morphology was reported by Sass (1955) but little information is available on the manner the young leaf of the maize plant rolls out to unfold itself on the main axis for the crucial activity of light interception for the purpose of photosynthesis.

Conventionally planted kernels of maize produce

leaves at many different angles to the row with the result that plant leaves overlap. Peters and Wolley (1959) reported that maize plant can be made to produce its leaves to grow into the spaces between the rows through orientation kernel planting. The leaves are produced at about the same angle thereby reducing the chances of mutual shading effects from neighbouring plants thus ensuring maximum interception of sunlight that falls on the leaf surfaces. This results in increase in yield.

Bonnett (1953) reports that morphological studies in maize can help problems of crop production and breeding. Loomis (1969); Russel (1972) and Egharevba (1978) all reported that foliage angle is associated with efficient utilization of solar energy with erect leaves favouring the deep penetration. Similarly, Russel (1967); Berdahl (1972); Prine (1969, 1973 and 1977); and Yadav (1987) have all shown that the amount of production in maize is directly related to the fraction of light intercepted when the canopy is scant. The leaf area during the growth period should therefore be sufficient to intercept as much of the incoming radiation as possible.

Kriedeman et. al. (1964) reported that the two important factors that influence photosynthetic rates

of leaves within the plant canopy are the disposition of the leaves in relation to incident radiation and the optical properties of the leaves themselves. Also important is the question of leaf arrangement and the distribution of the leaves in the canopy.

A detailed investigation into the leaf rolling in maize is therefore important so as to manipulate the angles with which the emerging leaves make on the main axis for better interception of light energy.

2.2 SOLAR RADIATION AND CROP GROWTH RATE (DRY MATTER PRODUCTION)

Solar radiation is very important in crop production because of its role in photosynthesis. The wavelengths of light which are effective in photosynthesis are generally found to lie in the range of 400-700 Mu (Emerson and Arnold, 1932). This wavelength happens to correspond roughly with that visible to the human eye in natural sunlight. Loomis and Williams (1963) estimated the amount of dry matter produced by a crop growing in natural sunlight from where it obtained its photosynthetic energy (see table 1). Such a theoretical calculation have also been reported by several other workers (Dale, 1963; Muramoto, et.al. 1964; Shibles and Weber, 1965 and Berdahl, et.al. 1971) and that with a 500 Cal cm^{-2} day^{-1}, it would be possible to produce 71 grams of dry matter per square meter per day.

TABLE 1: CALCULATION OF POTENTIAL DAILY PRODUCTIVITY FROM A CROP RECEIVING 500 Cal / cm^2 / DAY OF INCOMING RADIATION (AFTER LOOMIS AND WILLIAMS. 1963)

Total solar radiation per day	500 Cal/cm^2
Photosynthetic radiation (400-700Mu)	222 Cal/cm^2
Total light quanta (8.64u Einstein/Cal)	4320 u E/cm^3

TABLE 1 (CONTD)

Inactive absorption and other losses	792 Einstein/cm^2
Total quanta usefully absorbed	3528 "
Amount of Carbondioxide reduced (O=10)	353 u moles/cm^2
Respiration loss (35%)	116 u moles/cm^2
Net production carbohydrate	237 u moles/cm^2
Net daily dry matter possible	71g/m^2

Actual dry matter production reported by several investigators (Pendleton et. al. 1968; Allen, 1977 and Prine, 1977) have all shown that such theoretical yields are far from being achieved and that crops are somewhat inefficient users of light energy in photosynthesis. Among the reasons given for the low rate of conversion of solar energy by plants to dry matter are:

(a) the low amount of global radiation and

(b) the amount of cover.

The amount of radiation reaching the earth's surface is further diminished by haze and cloud cover and indeed the amount of radiation available to plants is closely related to the degree of cloud cover (Loomis and Williams, 1963).

Monteith (1969) also reports that when the sky is cloudy or overcast, the radiation present is characterised by high intensity flux ushering in a high rate of photosynthesis.

Based on the theoretical calculation of dry matter production of 71g/m^2/day (Loomis and Williams, 1963), net dry matter production will come to about 1600kg per hectare per day. This rate of dry matter production is far from being attained by crop plants as already noted by earlier workers. It is the aim of this study to investigate other ways of making the crop plants attain this theoretical upper limit through leaf orientation studies.

2.3 LEAF ORIENTATION AND PLANT DRY WEIGHT

Since solar energy is fundamental in crop production because of its role in photosynthesis, differences in its distribution, arrangement and orientation will determine the productive efficiency of the different leaves in a plant. Egharevba (1981) reported that millet with a horizontal leaf orientation results in the lower leaves being shaded. Thus only the upper leaves receive full sunlight with a lesser amount penetrating to the lower leaves.

Egharevba et.al.(1976) have studied the contribution of assimilates from leaves to the developing grains in maize. Fischer, et.al.(1976) studied the contribution of assimilates from leaves to the developing grains in sorghum (Sorghum bicolor L.) Similarly, Berdahl et.al.(1972) studied the contribution of assimilates from leaves to the developing grains in Barley (Hordeum vulgare L.).

In all these crops studied, most of the dry matter going into the grain came from assimilate produced after ear and head emergence and a great proportion of the assimilate came from the leaves nearest the sinks. In maize, Allison and Watson (1966) reported that the two leaves below and above the ear

contributed over 50% of the total dry matter in the ear. Hoyt and Bradfield (1962) showed that lower leaves of maize contributed less to grain production than did the upper ones and they concluded that the lower contribution by the lower leaves was due to reduction in radiant density from shading by the above leaf canopy.

2.4 SOLAR RADIATION AND CROP YIELD IN RELATION TO LEAF ORIENTATION

Several studies of the maize crop (Williams et al.1964; Pendleton et al. 1966; Aase, et al. 1968; Egharevba, 1978) have either directly or indirectly suggested the importance of adequate solar radiation inputs for optimum yields. Probably by far, the most important aspect of radiation as related to crop production is the density of the foliage canopy receiving the light. Studies of Aase (1968) and Pendleton et al. (1968) have all shown that the amount of production is directly related to the fraction of light intercepted when the canopy is scant.

Monteith (1969) also noted that the distribution of radiation within a plant community is the most important single element of microclimate which influences the pattern of growth and development in field crops. Shibles (1965) reported that as plants grow, light penetration to the middle and lower leaves is affected by intraplant competition and as a result of this, the middle and lower leaves often do not realize their full photosynthetic potential.

Wilson (1965) showed that the angle at which the foliage is inclined can be measured and that its

configuration is a major determinant of net productivity. Verhagen et.al.(1963) and Watson and Witts (1959), have all suggested a vertical-to-horizontal leaf orientation as being the most efficient in terms of efficient distribution of light within the plant canopy. With such an orientation, a fraction of the incoming radiation is absorbed at the upper strata and because of the abundant gaps in the structure, a good percentage of the light is still transmitted to the lower horizontal leaves.

Russell (1972) on the other hand reported that a vertical leaf orientation might be one way of increasing light penetration into the maize canopy. If leaves of maize were more erect, greater penetration of sunlight into the canopy should result thus increasing the total leaf area receiving the light intensity. This will aid in attaining a more uniform distribution of photosynthetically active quanta over all leaves.

Anderson (1966) on the contrary, however, noted that upright leaves may or may not result in a more uniform distribution of quanta depending upon factors such as the angle of the sun above the horizon and cloud cover. On the other hand, Loomis and Williams (1969) noted that foliage angle is associated with

efficient utilization of solar energy, erect leaves favouring the deep penetration of light with a minimum of mutual shading.

Pendleton et. al. (1968) obtained 40% grain yield increase for liguless Hy x C103 as compared with liguled Hy x C103. They described the liguless plants as having leaves oriented approximately 10° from the vertical whereas leaves on liguled plants appeared horizontally oriented.

Inspite of the several reported works on the interception and efficient utilization of solar radiation for net productivity in maize, little information is available on the study of net productivity in maize in relation to the most desirable leaf orientation. It might therefore be useful if the leaf orientation of the maize will be studied with a view to assessing and determining the most desirable orientation which might eventually result in obtaining a remarkable yield over those reported by previous workers.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 GEOGRAPHICAL DESCRIPTION OF ZARIA AND THE PROJECT SITE

Zaria (Latitude 11° 11' N, Longitude 7° 42' E) located on a plateau at an altitude of 686 meters above sea level in the centre of Northern Nigeria lies within a region which has a tropical savanna climate with distinct wet and dry season. The sky is mostly clear as from April through October which permits longer hours of sunshine with a daily average of ten hours. The dry season is practically rainless and the wet season occuring in the high sun-period. The first rain of the year falls as thunderstorm showers in March or April; August being the wettest month and the rains stopping in October.

The research study was conducted on a small parcel of land in the Botanical Garden of the Department of Biological Sciences of the Ahmadu Bello University, Zaria, Nigeria.

The study was started in April and it ended up

in October, 1989. The research period therefore coincides with the period when the sky is clear thus permitting longer hours of sunshine and with the beginning of the rains up to the end of the rainy season.

3.2 STUDIES ON KERNEL PLACEMENT AND LEAF ORIENTATION IN MAIZE

Flat kernels of maize CV Western Yellow were chosen for the experiment under laboratory conditions. The kernels were seeded in 80 small plastic cups with good drainage filled with good garden soil. Four methods of seed placement were investigated. The handle of the cups were used to determine the direction and method of kernel placement.

In the first method of seed placement, the proximal end of the kernel was down, and the embryo side of the kernel in front facing the direction of the cup handle.

In the second method of seed placement, the proximal end of the kernel was up, instead the distal end was down, and the embryo side of the kernel in front facing the direction of the cup handle.

In the third method of seed placement, the proximal end of the kernel was down and the embryo side of the kernel backing the direction of the cup handle.

In the fourth method of seed placement, the proximal end of the kernel was up, instead the distal

end was down, and the embryo side of the kernel backing the direction of the cup handle.

Seedling emergence and progressive leaf orientation were recorded. The leaf orientation (directions) were observed in relation to the method of seed placement.

3.3 SEEDLING MORPHOLOGICAL STUDIES OF LEAF ROLLING IN MAIZE

Flat kernels of maize CV Western Yellow were chosen for the experiment under field and laboratory conditions.

Under field conditions, the kernels were seeded in metal boxes of about 120cm long filled with good garden soil. The methods of seed placement described by Yadav and Gupta (1987) was followed. The seedling emergence and progressive leaf rolling were studied and recorded up to the seventh leaf.

Under laboratory conditions, two investigations were conducted. In the first, 500 kernels were sown in large photographic trays on moist paper and the manner of leaf rolling observed. In the second, 20 kernels were sown in a petri dish on a moist filter paper. Thin sections of the coleoptile were taken immediately the coleoptile starts to emerge on a daily basis and observed under the microscope so as to trace the manner in which the leaves roll out even at the embryonic stage. Examination of the coleoptile sections stopped when the first leaf appeared and rolled out.

A total of 2218 seedlings were studied in all in an attempt to investigate the manner of leaf rolling.

3.4 LAND PREPARATION

An open parcel of land was selected for the cultivation of the crop. The plot was surveyed and the major cardinal points (North, South, East and West) determined locally using the midday shadow. With the establishment of the direction of the sun-rise and sun-set, the amount of shadow cast on the study plot at between 6:30-8:30 a.m. and 4:30-6:30 p.m. was investigated. The crops cultivated were therefore grown within areas of the study plot that had very minimal amount of shading.

The land was prepared in two ways:

1. A total of 250 red earthen pots of about 35cm in diameter and 45cm deep were arranged in the well demarcated area of the plot that was free from shade. The 250 pots were arranged in such a way that they were aligned to run in an East-West direction. The pots were arranged in 18 rows with an average of about 10 pots per row depending on the extent of shadow cast. The pots were filled with good garden soil ready for planting.

2. In the second method, 18 straight ridges running in an East-West direction were constructed in the unshaded demarcated area. The ridges were then ready for planting.

3.5 CULTIVATION AND ORIENTATION OF THE MAIZE PLANT

The maize was cultivated twice. In the first experiment, the maize was cultivated in the 250 earthen pots. Seeds of CVs TZSR were sown on the 17th of April 1989. One seed was sown per pot. The pots were serially numbered and properly labelled. They were arranged in two alternate rows (see plate 1) running in an East to West direction so as to ensure that when the plants germinate, they would continuously receive enough sunshine. The plants were continuously irrigated throughout the growing period.



PLATE 1: Alternating arrangement of the maize plants on the field showing the two leaf orientations.

After the germination of the plants, at the 5-leaf stage, the plants in the pots were oriented mechanically by turning the pots in two ways.

(i) The plants were oriented so that their leaf planes are along the path of the sun's rays i.e the leaves of the plants are directed East and West (see plate 2). For the rest of the discussion, this leaf treatment will be referred to as treatment A.



LEAF ORIENTATION A

PLATE 2: Plants with their leaf planes along the path of the sun rays.

(ii) The plants in the second treatment were oriented so that their leaf planes are perpendicular to the path of the sun i.e. the leaves of the plants are directed North and South (see Plate 3). This treatment will be referred to in the discussion as treatment B.



PLATE 3: LEAF ORIENTATION B.

Plants with their leaf planes perpendicular to the path of the sun-rays.

The plants in the first treatment constitute plants in Row A and will be referred to as treatment A while the second treatment constitute Row B and is referred to as treatment B.

These plants were arranged in alternate rows so as to prevent mutual shading from the leaves thereby cutting down on the intensity or amount of sunshine to be received by each plant.

The pots were arranged at a distance of 90cm inbetween each pot and 90cm inbetween each row. The proper orientation of the plants was ensured daily by mechanically aligning them into the desired orientation as they may be made to turn either due to response for light, wind direction or any other external force.

Using handfork, every pot was weeded as often as weeds appear, taking care not to damage the plant. The weeding was necessary to prevent competition between the plants and weeds for nutrients. Compound fertilizer (N:P.K/15:15:15) was applied three times during the growth period at the rate of an empty small size match box full of fertilizer to a plant. The fertilizer was applied by sowing the fertilizer at a

radius of 5cm away from the stem.

For the second experiment, Western Yellow maize variety was cultivated on the ridges prepared, described earlier under land preparation. The method of seeding established by Yadav and Gupta (1987) was used in sowing the seeds on the ridges. After germination, at the 5-leaf stage, plants that failed to show the desired orientation were carefully uprooted with a handfork and the leaf orientation properly aligned with the rest of the plant through the means of transplanting.

The aim of cultivating the crops on ridges is to assess the performance of the crop in relation to the leaf orientation as well as make a comparison of performance between the plants cultivated in pots and those cultivated on the ridges.

3.6 DETERMINATION OF PLANT DRY WEIGHT AND GROWTH RATE.

The method of determination of plant dry weight and the calculation of growth rate described by Fogg (1964) was used for this study.

The determination of the plant dry weight started four weeks after planting when the plants were well established. Sixteen plants from each plant treatment were randomly sampled, at weekly intervals up to the seventh week. The maize plants, both in the pot and on the ridges are numbered serially. The plant numbers are neatly copied on pieces of paper. The numbers are then put into an envelope. They are thoroughly shaken and the pieces of paper with the numbers are randomly picked until sixteen such numbers are picked. The numbers randomly picked from the envelope then indicates the plant numbers on the field to be harvested, for the determination of the plant dry weight.

The plants when harvested are washed thoroughly in running tap water so as to remove any plant debris and soil. The roots are carefully cut-off at a uniform level and discarded. The roots have not been included in the determination of the plants' dry

weight because many of the roots remain clogged to the soil while some are easily cut off and missing. Therefore, for this study, only the shoot was used for the determination of the dry weight. The shoots (stem and leaves) are carefully chopped into pieces ensuring that very small amount is even lost. The chopped shoot are packed into previously weighed enveloped and oven-dried at 110°C until a constant dry weight is attained. At this time, it is considered that the final weight as a result of finding the difference between the weight of the envelope from the weight of the envelope along with its contents is the final plant dry weight.

The dry weight obtained from each of the treatments at the weekly interval was used to plot a graph so as to determine the growth rates of the plants in the two leaf orientations in the two experiments.

The determination of the plants' dry weight stopped at the seventh week of growth and the remaining plants (62) were allowed to mature to harvest.

3.7 DETERMINATION OF THE INFLUENCE OF LEAF ORIENTATION ON PLANT FLOWERING

The influence of the leaf orientation on flowering in the two experiments was investigated. The cumulative record of flower (tassels and silks) emergence was taken during the period of investigation. For the purpose of this study, a plant was considered to have flowered only when either the tip of the tassels or silks were visible and have actually emerged out of the leaf sheath.

3.8 DETERMINATION OF YIELD

All the remaining 62 plants in each treatment in both the two experiments were harvested and analysed for grain yield. The cobs from each treatment was analysed and kept seperately.

The cobs from each plant was carefully labelled and numbered according to the treatment. They were then dried under natural condition making sure that the moisture contents of the cobs and seeds was as low as 15 per cent (the level of moisture content in the maize grains as they are often stored).

The yield was determined by counting the total number of cobs, the number of seeds per cob and then weighing each cob and seeds and determining the hundred seed weight from each cob. The data obtained was then computerised to find the difference in performance between the leaf orientations investigated in the two experiments using a t-test.

CHAPTER FOUR

4.0 PRESENTATION OF RESULTS

4.1 KERNEL PLACEMENT AND LEAF ORIENTATION STUDY

The leaf orientation in the young seedling became apparent immediately after the emergence of the leaf especially at the 5-leaf stage. It was found that the leaves developed from the embryo side of the kernel from where the first leaf emerged. The leaf plane of the first leaf emerging from the embryo side of the kernels orients perpendicular to the plane surface of the kernel. The leaf plane of the second leaf similarly is oriented perpendicularly to the kernel flat side.

In all the methods of kernel placement investigated, two types of leaf orientation were found. In the first two methods of kernel placement, the leaf orientation in plate 2 was observed while in the third and fourth methods the leaf orientations in Plate 3 was observed.

It was also observed that whether the proximal end of the kernel was placed either up or down into the soil, the leaf emerged from the upper part of the

embryo side while the roots from the lower side of the embryo.

4.2 SEEDLING MORPHOLOGICAL STUDY AND LEAF ROLLING

For the 2218 seedlings studied for the manner in which the young leaf rolls out on the main axis to form the leaf orientation, the results showed that for the first leaves alone, 1115 plants had their leaves rolling to the right and 1103 of the remaining had theirs rolling to the left (table 2). It was found to display a definite pattern when the rolling was traced up to the 7th leaf stage. The manner in which the first leaf rolled out determines the direction in which the subsequent emerging second leaf will roll out to. If the first leaf rolls out clockwise (to the right) the second leaf emerging will roll out anticlockwise (to the left). The third leaf rolls out in opposite direction and the second and the fourth in opposite direction to the third. The definite and regular repeated pattern of leaf rolling was observed up to the 7th leaf stage.

Similarly, results of the anatomical investigation of the leaf rolling at the embryonic stage and during coleoptile emergence showed that the pattern is the same as in table 2 (Plates 4 and 5).

TABLE 2: LEAF ROLLING IN MAIZE IMMEDIATELY AFTER EMERGENCE OF PLUMULE (COLEOPTILE)

LEAF NO.		1ST LEAF		2ND LEAF		3RD LEAF		4TH LEAF		5TH LEAF		6TH LEAF		7TH LEAF	
MANNER OF ROLLING		LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
PLANT NO:	1	o	-	-	o	o	-	-	o	o	-	-	o	o	-
	2	-	o	o	-	-	o	o	-	-	o	o	-	-	o
	3	-	o	o	-	-	o	o	-	-	o	o	-	-	o
	4	-	o	o	-	-	o	o	-	-	o	o	-	-	o
	5	o	-	-	o	o	-	-	o	o	-	-	o	o	-
	6	-	o	o	-	-	o	o	-	-	o	o	-	-	o
	7	o	-	-	o	o	-	-	o	o	-	-	o	o	-
	8	-	o	o	-	-	o	o	-	-	o	o	-	-	o
	9	o	-	-	o	o	-	-	o	o	-	-	o	o	-

TABLE 2 CONTD

LEAF NO.		1ST LEAF		2ND LEAF		3RD LEAF		4TH LEAF		5TH LEAF		6TH LEAF		7TH LEAF	
MANNER OF ROLLING		LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
PLANT NO:	10	o	-	-	o	o	-	-	o	o	-	-	o	o	-
	11	o	-	-	o	o	-	-	o	o	-	-	o	o	-
	12	o	-	-	o	o	-	-	o	o	-	-	o	o	-
	13	o	-	-	o	o	-	-	o	o	-	-	o	o	-
No. 1-2218 GRAND TOTAL.		1103	1115	1115	1103	1103	1115	1115	1103	1103	1115	1115	11103	1103	1115

Results of the leaf rolling statistically analysed based on a significant value of P=0.05, the rolling ratio either to the left or right was found t be 1:1 (X^2 = 0.065; df = 1; P = 0.7-0.8). Statistical there is no significant difference between the leaf rolling.

PLATE 4.



YOUNG DEVELOPING LEAF ROLLING TO EMERGE TOWARDS THE RIGHT IN THE COLEOPTILE EVEN BEFORE IT BREAKS TO OPEN AND ROLL OUT (SEE ARROW).

PLATE 5:



4.3 PLANT DRY WEIGHT AND GROWTH RATE

For the plant dry weight, it was found that in the first experiment, plants in treatment A appeared to produce more dry weight (at the fourth, sixth and seventh weeks except for the fifth) than those in treatment B which produced less except for the fifth week where it performed slightly better than those in treatment A (table 3).

TABLE 3: PLANT DRY WEIGHT OF BATCHES OF 16 PLANTS IN GRAMS IN THE FIRST EXPERIMENT

PLANT AGE AT HARVEST (WEEKS)	PLANT DRY WEIGHT IN GRAMS	
	LEAF ORIENTATION A	LEAF ORIENTATION B
4	63.7	55.6
5	162.4	167.7
6	467.9	393.6
7	983.5	969.1

In the second experiment, unlike in the first experiment, plants in treatment B appeared to produce more dry weight than those in treatment A (table 4). However, it was interestingly observed that while in the fifth week, plants in treatment B of the first

experiment produced more dry weight than those in treatment A, treatment A of the second experiment produced more than those of treatment B in the first experiment.

TABLE 4: PLANT DRY WEIGHT OF BATCHES OF 16 PLANTS IN GRAMS IN THE SECOND EXPERIMENT

PLANT AGE AT HARVEST (WEEKS)	PLANT DRY WEIGHT IN GRAMS	
	LEAF ORIENTATION A	LEAF ORIENTATION B
4	226.1	235.6
5	353.5	347.3
6	817.1	848.8
7	911.89	1165.35

The plant dry weights obtained in the first and second experiments for the two leaf treatments were plotted on a graph so as to determine the plants' growth rates. The growth rates for the leaf treatments in the first experiment is shown in figure 1 while that of the leaf treatments in the second experiment is shown in figure 2.

The graphs of the growth rates showed that plants in treatment A appeared to grow slightly better than those in treatment B in the first experiment.

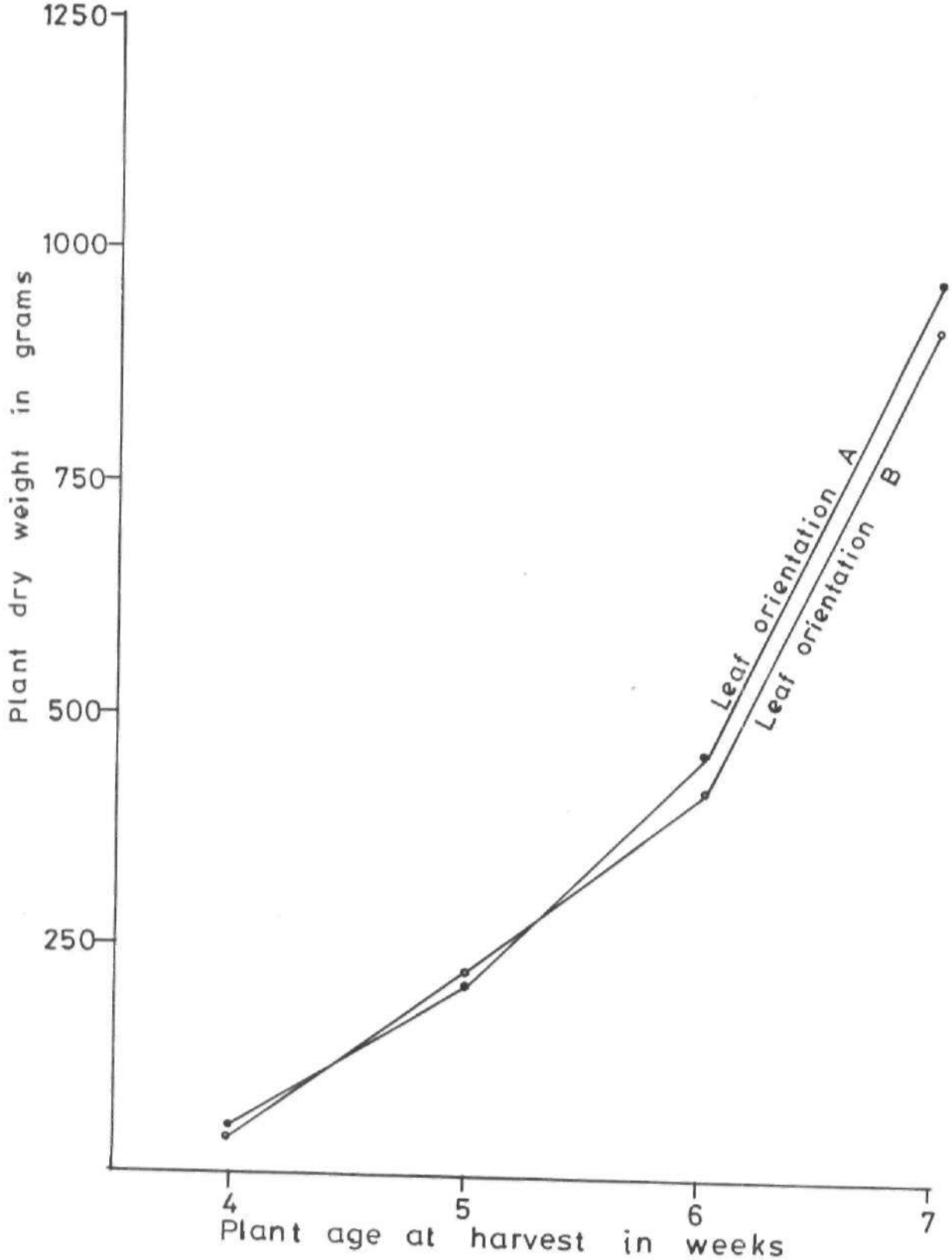

Fig. 1: Growth rates of plants with the two leaf orientations in the first experiment

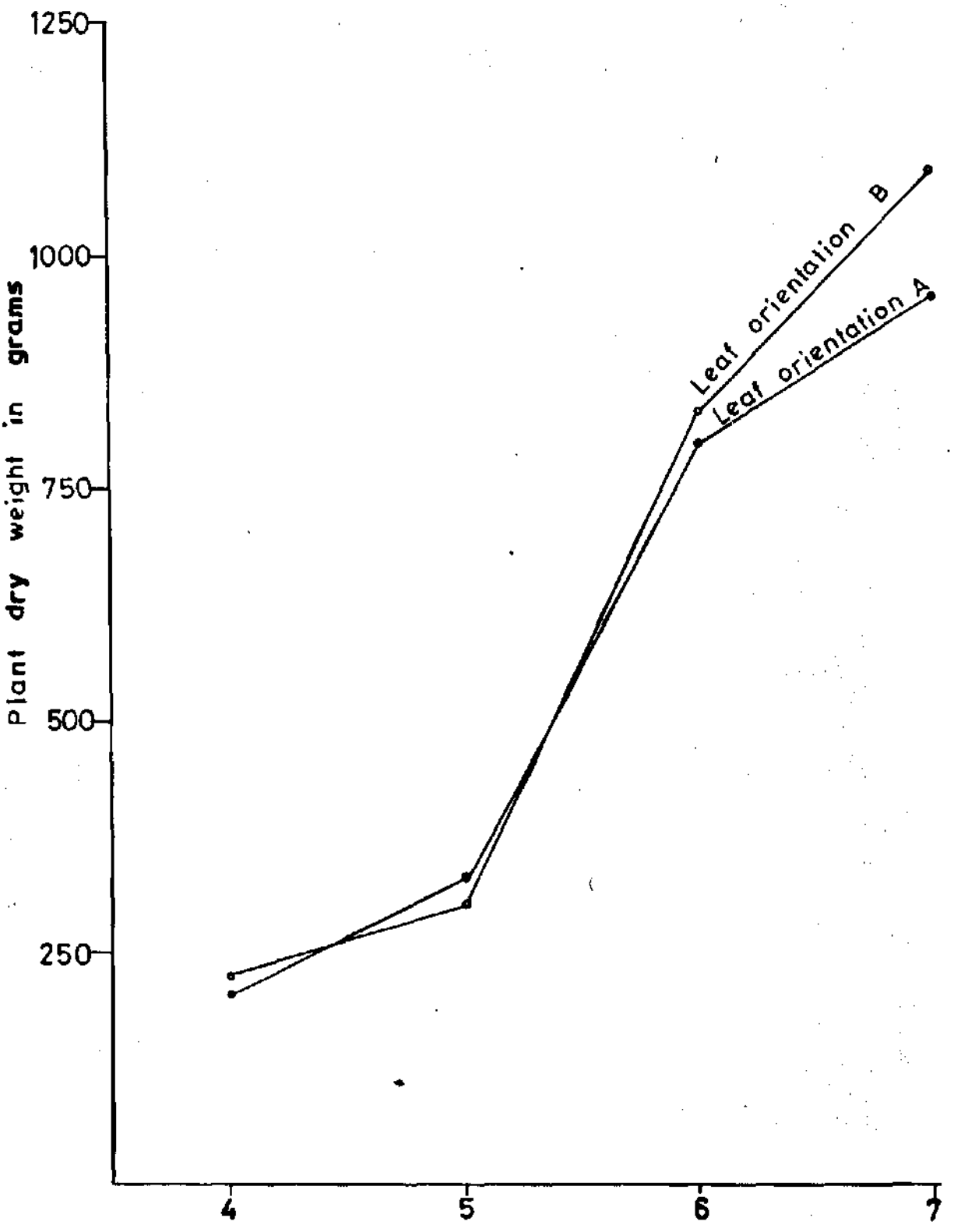

Fig. 2: Growth rates of plants with the two leaf orientations in the second experiment

However, in the second experiments, plants in treatment B appeared to grow better than those in treatment A.

4.4 CUMULATIVE RESULTS OF FLOWERING (TASSELLING AND SILKING) OF MAIZE IN RELATION TO LEAF ORIENTATION.

From the 62 plants that were allowed to mature in each treatment in both the first and second experiments, the result revealed that they all start to flower at about the same time irrespective of the leaf orientations (tables 5 and 6). There was only a day's difference between the initial tassel initiation in the first experiment of treatment A from that of experiment two.

In the first experiment where the plants were cultivated in pots, all plants in the two leaf orientations completed tasselling by the 72 day of age. However, at 58 days, 19 (30.6%) of the plants in treatment A tasselled while only 14 (22.6%) tasselled in treatment B at the same age. The plants in treatment B almost caught up with those in treatment A at the 66th day when 51 (82.3%) plants tasselled as against 53 (85.5%) in treatment A which earlier seemed to have tassel initiation advantage over those in treatment B.

TABLE 5: CUMULATIVE RESULTS OF FLOWERING (TASSELLING AND SILKING) IN RELATION TO LEAF ORIENTATION IN THE FIRST EXPERIMENT

PLANT AGE AT FLOWERING	LEAF ORIENTATION							
	LEAF ORIENTATION A				LEAF ORIENTATION B			
	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING
56	2	3.2	-	-	-	-	-	-
58	19	30.6	-	-	14	22.6	-	-
59	23	37.1	-	-	17	27.4	-	-
60	28	45.2	-	-	22	35.5	-	-
61	37	59.7	1	1.6	30	48.4	-	-
62	39	62.9	1	1.6	35	56.5	1	1.6
63	39	62.9	4	6.5	36	58.1	3	4.8
64	44	71.0	5	8.1	40	64.5	4	6.5
65	49	79.0	9	14.5	48	77.4	10	16.1

TABLE 5: CONTD

PLANT AGE AT FLOWERING	LEAF ORIENTATION							
	LEAF ORIENTATION A				LEAF ORIENTATION B			
	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING
66	53	85.5	13	21.0	51	82.3	14	22.6
67	53	85.5	13	21.0	51	82.3	15	24.2
69	57	91.9	15	24.2	52	83.9	17	27.4
70	60	96.8	35	56.5	60	96.8	33	53.2
71	61	98.4	45	72.6	61	98.4	44	71.0
72	62	100.0	50	80.6	62	100.0	47	75.8
73	62		53	85.5	62		54	87.1
74	62		56	90.3	62		56	90.3
75	62		57	91.9	62		58	93.5
76	62		61	98.4	62		61	98.4
77	62		62	100.0	62		62	100.0
TOTAL PLANTS	62	-	62	-	62	-	62	-

TABLE 6: CUMULATIVE RESULTS OF FLOWERING (TASSELLING AND SILKING) IN RELATION TO LEAF ORIENTATION IN THE SECOND EXPERIMENT

PLANT AGE AT FLOWERING	LEAF ORIENTATION							
	LEAF ORIENTATION A				LEAF ORIENTATION B			
	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING
58	3	4.8	-	-	-	-	-	-
59	23	37.1	-	-	2	3.2	-	-
60	27	43.5	-	-	26	41.9	-	-
61	29	46.8	1	1.6	31	50.0	-	-
62	29	46.8	3	4.8	35	56.5	-	-
63	35	56.5	4	6.5	35	56.5	1	1.6
64	35	56.5	7	11.3	48	77.4	3	4.8
65	40	64.5	7	11.3	50	80.5	5	8.1

TABLE 6 CONTD

PLANT AGE AT FLOWERING	LEAF ORIENTATION							
	LEAF ORIENTATION A				LEAF ORIENTATION B			
	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING
66	40	64.5	11	17.7	53	85.5	6	9.7
67	43	69.4	16	25.8	53	85.5	8	12.9
68	43	69.4	16	25.8	57	91.9	12	19.4
69	45	72.6	18	29.0	57	91.9	12	19.4
70	49	79.0	22	35.5	59	95.2	15	24.2
71	52	83.9	27	43.5	59	95.2	20	32.3
72	55	88.7	45	72.6	60	96.8	42	67.7
73	59	95.2	48	77.4	61	98.4	47	75.8
74	60	96.8	52	83.9	61	98.4	53	85.5

TABLE 6 CONTD

PLANT AGE AT FLOWERING	LEAF ORIENTATION							
	LEAF ORIENTATION A				LEAF ORIENTATION B			
	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING	NO. OF PLANTS TASSELLING	% TASSELLING	NO. OF PLANTS SILKING	% SILKING
75	62	100.0	54	87.1	62	100.0	55	88.7
76	62		56	90.3	62		56	90.3
77	62		58	93.5	62		58	93.5
78	62		60	96.8	62		60	96.8
79	62		62	100.0	62		62	100.0
TOTAL PLANTS	62	-	62	-	62	-	62	-

When the plants were 70 days old, they all at this time attained equal tasselling 60 (96.8%) in each of the treatments.

The silks only start to appear 4 days later after the emergence of the first tassel. There was no difference in the silking of the maize plant in the two leaf treatments. While silks of plants in treatment A started appearing when the plants were 61 days old, 1 (1.6%); plants in treatment B also started silking at 62 days of age, 1 (1.6%). The silking appeared to be the same for both treatments because at 76 days old, they all had the same number of silks.

For the results of the flowering in the plants cultivated on ridges in the second experiment, although a different maize variety was used, the results displayed the same trend with what was obtained in the first experiment. Tassel emergence initially seemed to be faster in plants constituting treatment B but then those plants in treatment A caught up at the 73rd day of age when 95.2% of the plants tasselled. The tasselling seemed to be faster for treatments A in the first experiment while in the second experiment, tassel emergence seemed to be initiated faster in treatment B than in A.

The reverse situation was noticed for silk emergence. While tassel emergence seemed faster in plants in treatment B, silk emergence seemed faster in plants in treatment A. One would have expected that since plants in treatment B seemed to tassel faster, they should equally silk faster. But this has not been observed. It was noticed that while 25.8% (16 plants) had their silks at 67 days of age in treatment A, only 8 plants (12.9%) had their silks at that same age for those plants in treatment B. However, at 76 days old, the same number of plants 56 (90.3%) had their silks in both leaf treatments.

4.5 YIELD ANALYSIS

From the 62 plants harvested in each of the two treatments in the two experiments, the data obtained in the first experiment is as shown in tables 7 and 8.

TABLE 7: TOTAL YIELD OF MAIZE IN THE FIRST EXPERIMENT.

	TOTAL NO OF COBS	TOTAL COB WEIGHT(g)	TOTAL NO OF SEEDS	TOTAL SEED WEIGHT (g)
LEAF ORIENTATION A	107	8100.1g	24333	6035.1g
LEAF ORIENTATION B	109	9019.0g	27169	6829.9g

TABLE 8: YIELD PARAMETER ANALYSIS

	COB WEIGHT (g)	NO. OF SEEDS PER COB	SEED WEIGHT (g)	100 SEED WT. (g)
LEAF ORIENTATION A				
MEAN	75.7	227	56.4	25.1
STANDARD DEVIATION	43.6	137.5	35.4	4.8
LEAF ORIENTATION B				
MEAN	82.7	249	62.7	24.7
STANDARD DEVIATION	50.9	161.0	42.6	5.4

Comparing the means of the cob weights in the two leaf orientations, $t = -1.0907$ and $P > 0.05$, there was no significant difference between the treatments.

Comparing the means of the number of seeds per cob in the two leaf orientations, $t = -1.0715$ and $P > 0.05$, there was no significant difference between the treatments.

Comparing the means of the seed weight in the two leaf orientations, $t = -1.1723$ and $P > 0.05$, there was no significant difference between the treatments.

Comparing the means of the hundred seed weight in the two leaf orientations, $t = 0.6430$ and $P > 0.05$

there was no significant difference between the treatments.

For the second experiment, the data obtained is shown in tables 9 and 10.

TABLE 9: TOTAL YIELD OF MAIZE IN THE SECOND EXPERIMENT

	TOTAL NO. OF COBS	TOTAL COB WT (GRAMS)	TOTAL NO. OF SEEDS	TOTAL SEED WT (GRAMS)
LEAF ORIENTATION A	150	15028.1	47318	10929.5
LEAF ORIENTATION B	138	15552.3	48389	11136.3

TABLE 10: YIELD PARAMETER ANALYSIS

	COB WT. IN (g)	NO.OF SEED PER COB	SEED WT. IN (g)	100 SEED WT (g)
LEAF ORIENTATION A				
MEAN	100.2	315	72.8	22.4
STANDARD DEVIATION	60.6	170.5	48.0	10.3
LEAF ORIENTATION B				
MEAN	112.7	350	80.7	22.0
STANDARD DEVIATION	60.3	162.1	46.0	6.5

Comparing the means of the cob weight in the two leaf treatments, $t = -1.7527$ and $P \leq 0.05$, there was a significant difference between the treatments.

Comparing the means of the number of seeds per cob in the two leaf orientations, $t = -1.7914$ and $P \leq 0.05$, there was a significant difference between the treatments.

Comparing the means of the seed weight in the two leaf orientations, $t = -1.4103$ and $P > 0.05$, there was no significant difference between the treatments.

Comparing the means of the hundred seed weight in the two leaf orientations, $t = 0.4159$ and $P > 0.05$, there was no significant difference between the leaf treatments.

CHAPTER FIVE

5.0 DISCUSSION OF THE RESULTS, CONCLUSION AND RECOMMENDATIONS

5.1 KERNEL PLACEMENT AND LEAF ORIENTATION

The maize kernel has the embryo quite prominently in one of the kernel flat sides. From the results of the investigation, it was observed that the leaf emerges from the embryo tip from where it grew across the kernel flat plane. This result supports the findings reported by Yadav and Gupta (1987). It is therefore possible that by sowing the maize kernels in a regular manner, the shoot canopy above the ground can be manoeuvred.

The results of the maize yield in tables 7,8, 9 and 10 indicate the yields obtained in the two different leaf orientations of the two experiments. Although there were such variations such as varietal differences, agronomic differences in the cultivation, etc, the results seemed to suggests that plants with the leaf orientation in B performed better. Therefore, through the method of kernel placement, it is possible to manipulate the orientations of the leaves so as to realise some increase in the growth rates

(figure 2) as well as the yield of the maize plant.

5.2 MORPHOLOGICAL STUDIES OF LEAF ROLLING

The results of the morphological studies of the leaf rolling (table 2) as well as the anatomic studies (Plates 4 and 5) all showed that the leaves rolled out in a definite and regular pattern which is even precisely determined at the embryonic stage. Wareing (1974) reported that during the initial development of the leaves, siting of leaf primordia in the shoot apex is precisely determined. The results reported here seemed to all suggest that leaf rolling is a precisely determined and well regulated process.

When the total plant population studied for the leaf rolling was statistically analysed, no significant difference was observed between the two ways the leaves normally rolled out. The 1:1 ratio observed in the rolling of the leaves therefore seemed to suggest that the leaf rolling is controlled by a single pair of alleles whose actions on the control of the rolling can be paralleled to the inheritance of sex chromosomes: in which case the male is heterozygous with one X-chromosome and one Y-chromosome. The female is homozygous with two X-chromosomes. Sex is therefore determined by the proportion of X-chromosomes. In the

leaf, the manner of leaf rolling might seem to depend on pure chance so that there are equal chances of the first (cotyledon) leaf rolling left or right but that, once established, the rolling of subsequent leaves is in opposite directions. It is recommended that further studies be carried out in this area so as to identify the factors controlling the leaf rolling.

5.3 PLANT DRY WEIGHT AND GROWTH RATES

The results of plant dry weight and growth rate in the first experiment (table 3 and figure 1) all seemed to suggests that the plants in treatment A performed better than those in treatment B both in terms of the production of dry weight and growth rates. The results of the flowering (table 5) also supports the fact that plants in treatment A seemed to grow faster since they were the first to tassel. For example, when the plants were 61 days old, 59.7% of the plants in treatment A have already flowered while only 48.4% flowered in treatment B.

Loomis and Williams (1969) reported that foliage angle is associated with efficient utilization of solar energy. Wilson (1965) also reported that the angle of orientation of the leaf is a major

determination of net productivity. The production of more plant dry weight and the faster growth rate of plants in treatments A supports these works. It also supports the findings of Watson and Witts (1959) and Verhagen et. al. (1963) who reported a vertical-to-horizontal leaf orientation as being the most efficient in terms of the distribution of light within the plant canopy.

For the results of the amount of plant dry weight and growth rates for the plant treatments in the second experiment, it was however, observed that plant treatment B performed better than those in treatment A. These results does not seem to agree with the findings of the earlier workers who reported on the importance of leaf orientation to efficient utilization of solar energy in which they went further to suggests that a vertical-to-horizontal orientation was better.

A possible explanation that may be advanced for the differences in performance of the two leaf orientations in the two experiments might be caused either by varietal differences. The plants cultivated in the second experiment are of a different variety from those cultivated in the first experiment. The

second possible explanation for the differences in the performance of the plants in the two leaf orientations in the two experiments might be due purely to the agronomic practices employed in the cultivation of the crops. While plants in the first experiment were cultivated in pots that tended to restrict the growth and depth of penetration of the plants' roots, the plants in the second experiment were cultivated on ridges thus allowing the roots to grow to attain maximum size. It can be seen from the results that while plants A in the first experiment at four weeks produced only 63.7g of plant dry weight, the same plant treatment in the second experiment produced 226.1g of plant dry weight at this same age. Similarly, when the dry weight of plants in treatment B at four weeks in the first experiment was 55.6g, it was 235.6g for the same plant treatment in the second experiment at the same plant age. These large differences might therefore best be accounted for by the varietal as well as the agronomic differences.

5.4 LEAF ORIENTATION AND FLOWERING

The cumulative results of the flower emergence (tables 5 and 6) in relation to the leaf orientations in the two experiments showed that plants in treatment A in the first and second experiments

tasselled earlier than those in treatment B. For example, in the first experiment, on the 67th day, 85.5% of the plants in treatment A tasselled while only 82.3% tasselled in treatment B. Similarly, in the second experiment on the 59th day 37.1% of the plants in treatments A tasselled while only 3.2% of the plants in treatment B tasselled.

It was observed that the emergence of the silks is always delayed in all the two experiments. The results supports the findings of Purseglove (1975) who reported that the maize plant is protandrous with the pollen being shed before the silks are receptive.

The tassels which produce enourmous amount of pollen continues to shed the pollen from 2-14 days. The maximum pollen shedding is about the third day and the pollen remains viable for about 24 hours (Purseglove 1975). The tassels in treatments A in both the two experiments were produced much earlier than those in treatments B. Because the silks emerge later than the tassels, it is probable that the relatively low yield obtained from plant treatment A (tables 7, 8, 9 and 10) in the first and second experiment might be due to inadequate pollination because most of the silks emerged after most of the pollen must

have been shed. This might have resulted in the low number of kernels obtained.

The relatively high yield obtained from the plants in treatments B in both the first and second experiment might be due to an overlap of the pollen shedding and silk emergence which results in adequate pollination thereby resulting in more seed number.

5.5 YIELD ANALYSIS

The results of the maize yield obtained in the first experiment (tables 7 and 8) when statistically analysed was found not to be significantly different from each of the leaf treatments. However, there seemed to be a slight edge in terms of better performance of the plants in treatment B in all respects to the number of cobs produced, the total cob weight, the number of seeds produced and the seed weight. This suggests that the plants with their leaf planes perpendicular to the sun's rays intercepts and utilizes the solar energy better than those plants in treatment A whose leaf planes are along the path of the sun's rays.

Similarly, in the second experiment, the two leaf orientations were found to be significantly

different in terms of their cob weights and the number of seeds per cob but not significantly different in the seed weights and the hundred seed weight. It was found that the plants in treatment B performed better than those in treatment A because their cobs weighed more than those in treatment A even with the fact that the plants in treatment A produced more cobs than those in treatment B. Also, the plants in treatment B had cobs that have more number of seeds than those of treatment A. The few number of seeds per cob in treatment A might not be unconnected with the reasons advanced while discussing the effect of leaf orientation on the emergence of the flower. The fewer numbers of seeds might be due to inadequacy of pollination thereby resulting in the failure of the kernels to develop in the cobs.

Although two seed varieties were used in the two different experiments, when the performance of the results in the experiment are compared in terms of leaf orientation, it was found that in both experiments, the leaf orientation B in which leaf planes are perpendicular to the path of the sun's rays intercepted and utilized the solar energy better for the production of both plant dry weight as well as grains. However, when they are compared in terms of their gross yield,

the plants in the second experiment were found to perform better generally in all the two leaf orientations over those in the first experiment. These differences in performances and the increase in gross yield of the second experiment over the first might be explained on the basis of the differences caused by the use of the different seed varieties. The second reason for the difference in performance between plants in the first and the second experiment might be caused by the agronomic practices involved in the cultivation of the plants. While the plants in the first experiment were cultivated in pots, plants in the second experiment were cultivated on ridges. The plants in the pots performed poorly probably because the pots restricted the growth of the roots because it was observed that the roots of the plants were clogged-up in the pots. The roots are very vital for mineral absorption and anchorage. Although fertilizer was applied to the plants in the pots during growth, these vital functions were interfered with. On the other hand, the better performance of the plants in the second experiment in which the plants were cultivated on ridges might be attributed to the fact that the roots' growth is not restricted. It grows extensively in the soil, collects and absorbs more nutrients and even provides better plant anchorage.

5.6 CONCLUSION

The study found that the orientation of the leaf in maize can be manoeuvred through kernel placement in a regular manner. However, the manner of leaf rolling was found to be in a ratio of 1:1 with the leaves rolling either to the left or right in such a definite and alternate manner. The leaf rolling is probably based purely on chance.

The leaf orientation when assessed in terms of growth rates and yield, it was found that the leaf orientation in which the leaf planes are perpendicular to the path of the sun's rays appeared to be a more promising and desirable orientation which maize growers can employ as one of the means of increasing yield other than through breeding programmes. The performance of the maize plants with their leaf planes along the path of the sun's rays performed relatively low. Maize growers may therefore begin to think of the possibility of utilising the results of this study by manoeuvreing the orientation of the maize leaves by sowing the maize kernels in a regular manner so as to obtain the desirable plant-leaf orientation.

5.7 RECOMMENDATIONS

The study conducted used only small plant population to assess the growth and yield of the crop. The results obtained for the yield in the first experiment was statistically found not to be significantly different, although it was significantly different in the second experiment. It is therefore recommended that the work be repeated by cultivating the plants on a large scale so as to obtain larger data so as to provide for more statistical analysis and reliability.

Secondly, for this work, two varieties of seeds and two methods of agronomic practices were employed. These variations might have been responsible for the results obtained. It is recommended that further research be conducted but this time using only one variety of seed and one agronomic method.

Thirdly, this study is recommended to the science teacher who can use it to introduce his students to the principles of scientific thinking and enquiry. Scientific mind and concepts can be

developed in students right from the time the maize seed is sown as they begin to study the Biology of the maize plant up to the time it is harvested and analysed for yield. For example, the problem of understanding the concept of energy in photosynthesis reported by Kamanda (1984) can best be solidly taught to students through the conduct of such a simple integrated experiment. At the end of the experiment when they analysed the results obtained, they will be able to say one of the reasons for the observed differences has to do with the amount of energy available to the plant.

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APPENDIX A_1

PRIMARY DATA ON YIELD OF MAIZE WITH LEAF ORIENTATION

(A) OBTAINED IN THE FIRST EXPERIMENT.

S/NO.	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
1.	52.65	63	18.00	28.57
2	153.00	518	129.20	24.94
3	76.80	193	51.50	26.68
4	115.00	461	84.25	23.34
5	128.60	403	103.95	25.79
6	146.70	546	123.05	22.54
7	102.20	306	84.50	27.61
8	171.20	556	139.00	25.00
9	143.70	387	109.00	28.17
10	102.00	272	65.80	24.19
11	94.70	214	74.80	34.95
12	122.00	249	87.60	35.18
13	112.70	298	62.50	20.97
14	158.80	490	120.40	24.57
15	148.70	589	126.10	21.41
16	132.70	268	96.80	36.12
17	106.70	352	83.40	23.69
18	87.15	300	85.05	28.35

S/NO.	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
19	163.30	432	130.70	30.25
20	42.50	116	30.30	26.12
21	121.40	376	87.70	23.32
22	69.70	320	57.30	17.91
23	135.40	321	105.30	32.80
24	61.70	274	52.60	19.20
25	44.20	138	28.40	20.58
26	67.60	289	59.20	20.48
27	41.90	193	37.05	19.20
28	51.00	168	39.65	23.60
29	62.40	73	22.95	31.44
30	74.20	296	64.70	21.86
31	86.50	307	67.70	22.05
32	89.50	294	68.60	23.33
33	88.40	226	57.20	25.31
34	53.40	122	36.40	29.84
35	85.40	342	68.15	19.93
36	67.85	236	50.50	21.40
37	25.70	192	22.80	11.88
38	81.90	200	63.60	31.80
39	53.30	103	30.30	29.42
40	101.30	242	69.30	28.64

.:/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
41	98.90	286	84.25	29.46
42	60.40	135	38.20	28.30
43	96.60	300	76.65	25.55
44	159.90	388	130.65	33.67
45	40.10	160	32.50	20.31
46	51.50	178	35.10	19.72
47	95.40	338	74.42	22.02
48	64.90	313	52.00	16.61
49	50.80	117	39.60	33.85
50	95.60	325	83.52	25.70
51	98.20	216	65.00	30.09
52	63.00	202	49.30	24.41
53	66.30	160	41.20	25.75
54	124.40	331	95.80	28.94
55	109.90	362	93.50	25.83
56	82.10	111	24.85	22.39
57	89.70	240	69.52	28.97
58	115.90	211	61.50	29.15
59	47.00	129	32.25	25.00
60	35.80	134	28.75	21.46
61	115.80	484	100.50	20.76
62	96.10	256	56.60	22.11

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
63	58.35	162	36.40	22.47
64	84.90	285	60.30	21.16
65	81.70	331	81.00	24.47
66	33.90	138	26.20	18.99
67	40.10	216	63.83	29.55
68	70.70	171	50.65	29.62
69	175.85	409	138.80	33.94
70	125.70	400	88.20	22.05
71	79.70	222	52.90	23.83
72	128.05	342	88.60	25.91
73	93.80	283	73.50	25.97
74	108.90	107	31.50	29.44
75	33.70	41	10.60	25.85
76	72.00	375	72.55	19.35
77	84.60	272	68.42	25.15
78	81.80	338	66.90	19.79
79	118.20	412	94.55	22.95
80	140.40	330	83.30	25.24
81	78.80	228	47.45	20.81
82	72.20	199	52.70	26.48
83	24.90	51	14.40	28.24
84	56.00	214	43.55	20.35
85	13.05	13	2.85	21.92

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
86	98.00	222	58.00	26.13
87	41.00	148	31.60	21.35
88	9.25	1	0.32	32.00
89	13.35	12	4.25	35.42
90	35.50	31	11.00	35.48
91	26.00	43	14.55	33.84
92	17.20	38	10.40	27.37
93	12.90	71	11.30	15.92
94	7.60	3	0.70	23.33
95	10.40	5	1.35	27.00
96	23.65	68	17.20	25.29
97	32.65	51	12.50	24.51
98	128.05	323	94.22	29.17
99	23.58	84	21.60	25.71
100	17.15	64	14.50	22.66
101	25.70	127	19.55	15.39
102	32.65	61	13.10	21.48
103	14.50	42	10.90	25.95
104	16.90	87	15.70	18.05
105	8.50	9	2.30	25.56
106	31.55	285	60.30	21.16
107	7.60	18	4.00	22.22

APPENDIX B_1

PRIMARY DATA ON YIELD OF MAIZE WITH LEAF ORIENTATION (B) OBTAINED IN THE FIRST EXPERIMENT.

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
1	163.65	505	130.22	32.15
2	148.25	472	118.70	25.15
3	125.60	345	94.92	27.51
4	130.20	317	91.70	28.93
5	99.50	419	92.90	22.17
6	88.35	268	69.10	25.78
7	139.10	354	102.70	29.01
8	139.30	458	113.85	24.86
9	148.70	504	121.05	24.02
10	178.55	582	140.80	24.19
11	156.70	473	125.28	26.49
12	92.15	228	68.70	30.13
13	181.25	566	146.20	25.83
14	149.80	468	120.00	25.64
15	179.40	561	144.90	25.83
16	52.80	167	36.80	22.04
17	186.70	519	146.70	28.27
18	107.92	352	83.98	23.86
19	130.40	376	103.80	27.61
20	198.80	529	172.20	32.55

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
21	132.60	495	104.15	21.04
22	33.50	39	13.85	35.51
23	67.15	174	49.63	28.52
24	21.00	24	4.10	17.08
25	98.80	419	86.40	20.62
26	185.15	619	140.55	22.71
27	130.60	326	96.30	29.54
28	14.41	76	10.20	29.06
29	83.41	277	65.30	23.57
30	80.80	203	59.00	29.06
31	123.60	342	93.31	27.28
32	149.40	398	120.40	30.25
33	64.40	96	33.60	35.00
34	132.75	397	111.71	28.14
35	119.05	409	92.60	22.64
36	179.50	441	136.20	30.88
37	87.30	262	65.05	24.83
38	82.00	196	53.65	27.37
39	98.80	311	71.30	22.93
40	80.30	212	62.10	29.29
41	72.60	145	38.80	26.76
42	124.40	411	97.65	23.76

T/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
43	45.40	112	30.30	27.05
44	70.80	299	57.25	19.15
45	75.40	320	52.90	16.53
46	47.30	198	40.45	20.43
47	44.45	150	24.00	16.00
48	38.80	144	31.60	21.94
49	31.70	50	6.00	12.00
50	31.20	83	21.25	25.60
51	164.20	413	113.21	27.41
52	143.60	391	118.40	30.28
53	65.50	164	48.10	29.33
54	46.80	106	26.05	24.58
55	46.15	104	20.70	19.90
56	98.35	219	65.00	29.68
57	133.75	362	112.05	30.95
58	48.45	227	39.20	17.27
59	22.90	41	10.50	25.61
60	84.10	309	68.70	22.23
61	82.70	267	70.05	26.24
62	86.00	179	62.90	35.14
63	99.50	352	88.45	25.13
64	56.22	128	46.10	36.02
65	39.00	105	27.10	25.80

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
66	98.80	223	72.50	32.51
67	38.50	110	23.00	20.90
68	23.30	142	18.10	12.75
69	115.65	362	91.95	25.40
70	123.29	250	86.10	34.44
71	99.75	536	106.85	19.93
72	48.60	181	36.40	20.11
73	33.80	102	24.20	23.73
74	77.50	188	56.80	30.21
75	22.72	34	9.55	28.08
76	106.70	374	87.65	23.44
77	69.20	277	56.40	20.36
78	119.55	399	94.90	23.78
79	97.20	247	72.13	29.20
80	98.50	398	76.31	19.17
81	66.50	235	49.80	21.19
82	98.45	415	80.15	19.31
83	99.30	329	99.05	30.11
84	91.98	330	73.28	22.21
85	42.68	129	24.80	19.22
86	5.80	1	0.30	30.00
87	7.30	18	3.40	18.89
88	66.10	223	33.65	15.09

C/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
89	99.00	334	85.15	25.49
90	55.70	285	59.00	20.70
91	112.70	262	77.10	29.43
92	58.32	162	42.30	26.11
93	37.50	118	28.10	23.81
94	20.45	47	12.52	26.64
95	43.98	66	21.00	31.82
96	36.15	135	27.90	20.67
97	13.20	13	1.40	10.77
98	43.10	88	26.20	29.77
99	6.55	22	7.35	33.41
100	17.85	90	11.10	12.33
101	11.75	43	8.40	19.53
102	6.55	8	1.51	18.88
103	18.95	36	8.30	23.06
104	7.00	20	3.80	19.00
105	6.05	17	2.80	16.47
106	10.38	5	1.05	21.00
107	3.05	6	1.15	19.17
108	144.43	348	73.06	20.99
109	55.70	203	43.60	21.48

APPENDIX A_2

PRINT DATA ON YIELD OF MAIZE WITH LEAF ORIENTATION ( ) OBTAINED IN THE SECOND EXPERIMENT.

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
1	315.05	710	227.78	32.08
2	248.45	506	188.61	37.27
3	123.70	475	93.90	19.77
4	171.70	532	133.50	25.09
5	152.30	509	112.35	22.07
6	108.98	431	74.30	17.24
7	161.45	497	124.60	25.07
8	90.90	296	65.70	22.20
9	145.80	486	114.80	23.62
10	116.20	469	90.30	19.25
11	75.35	279	58.60	21.00
12	180.00	405	130.60	32.25
13	161.40	633	120.00	18.96
14	172.00	492	110.70	22.50
15	87.45	293	59.50	20.31
16	47.18	234	32.00	13.68
17	144.05	560	109.83	19.61
18	176.30	424	136.60	32.22
19	35.20	203	27.20	13.40
20	171.90	417	127.40	30.55

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
21	86.75	389	49.70	12.78
22	78.30	390	139.80	35.85
23	57.20	204	32.45	15.91
24	49.90	220	30.40	13.82
25	51.10	278	37.00	13.31
26	122.00	283	84.00	29.68
27	175.30	380	130.20	34.26
28	192.10	578	140.60	24.33
29	56.70	276	44.65	16.18
30	160.20	420	121.05	28.82
31	172.80	431	133.65	31.00
32	188.00	811	139.80	17.24
33	163.20	573	125.10	21.83
34	125.80	411	98.40	23.94
35	142.50	433	107.72	24.88
36	98.90	355	71.80	20.23
37	254.30	626	193.70	30.94
38	128.20	360	89.85	24.96
39	179.60	552	122.70	22.23
40	109.28	376	78.70	20.93
41	81.56	265	53.70	20.26
42	69.50	414	54.55	13.18
43	184.63	435	137.60	31.63

RECEIVED

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
44	102.50	572	78.55	13.73
45	228.90	625	179.50	28.72
46	68.70	390	47.50	12.18
47	61.35	345	42.80	12.41
48	112.25	463	87.80	18.96
49	129.65	360	90.10	25.03
50	125.90	322	97.50	30.28
51	60.70	225	38.72	17.21
52	70.45	464	50.70	10.93
53	179.00	398	126.78	31.85
54	165.30	602	125.40	20.83
55	190.05	438	121.70	27.79
56	126.85	433	101.51	23.44
57	91.30	158	51.63	32.68
58	180.80	553	145.00	26.22
59	150.80	463	114.30	24.69
60	228.00	593	164.90	27.81
61	94.15	302	69.10	22.88
62	64.40	214	51.62	24.12
63	245.90	464	163.85	35.31
64	102.81	426	75.40	17.70
65	117.40	349	84.10	24.10
66	91.60	323	68.35	21.16

T/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
67	69.15	295	41.12	13.94
68	69.60	233	49.40	21.20
69	43.10	220	33.15	15.07
70	63.00	125	30.15	24.12
71	142.15	567	102.25	18.03
72	95.30	358	73.70	20.59
73	101.20	323	71.90	22.26
74	160.85	480	120.90	25.19
75	190.90	548	144.70	26.41
76	150.45	516	116.30	22.54
77	90.91	287	63.05	21.97
78	70.45	235	47.40	20.17
79	34.10	138	24.20	17.54
80	101.40	414	66.00	15.94
81	102.60	318	76.10	23.93
82	95.08	473	65.70	13.89
83	142.95	530	105.30	19.87
84	50.50	118	26.70	22.63
85	64.20	238	44.45	18.68
86	82.50	158	35.50	22.47
87	62.90	97	23.11	23.82
88	62.58	203	40.00	19.70
89	25.70	115	16.10	14.00
90	51.95	210	30.70	14.62

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
91	17.95	112	13.40	11.96
92	23.30	41	5.10	12.44
93	10.45	23	2.10	9.13
94	45.15	60	15.90	26.50
95	20.25	43	6.30	14.65
96	22.00	66	10.10	15.30
97	18.80	55	10.90	19.82
98	16.40	69	6.75	9.78
99	17.80	41	5.60	13.66
100	12.50	45	2.80	6.22
101	54.30	138	28.70	20.80
102	103.90	279	76.10	27.28
103	151.90	395	121.80	30.84
104	48.80	267	38.25	14.33
105	116.60	237	78.25	33.02
106	107.90	346	76.70	22.17
107	159.40	449	128.55	28.63
108	152.30	369	123.65	33.51
109	101.25	363	76.65	21.12
110	136.80	383	108.10	28.22
111	144.30	396	118.30	29.87
112	130.20	432	103.70	24.00

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
113	105.20	377	77.80	20.64
114	123.15	352	101.15	28.74
115	128.90	387	98.10	25.35
116	146.35	471	114.15	24.24
117	108.00	340	87.70	25.79
118	57.15	160	41.70	26.06
119	172.80	439	140.00	31.89
120	85.10	357	68.60	19.22
121	60.80	212	43.30	20.42
122	119.50	320	85.10	26.59
123	159.20	418	126.50	30.26
124	116.05	357	90.50	25.35
125	101.30	317	81.25	25.63
126	68.80	230	52.30	22.74
127	82.20	179	56.20	31.40
128	61.60	159	34.60	21.76
129	112.55	349	92.70	26.56
130	81.82	292	58.00	19.86
131	57.70	203	42.40	20.87
132	36.80	157	24.25	15.45
133	33.70	98	20.00	20.41
134	45.75	147	22.90	15.58

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
135	42.75	220	33.60	15.27
136	30.70	77	16.50	21.43
137	35.40	99	17.50	17.68
138	43.55	101	37.35	36.98
139	42.80	162	33.15	20.46
140	27.80	106	21.70	20.47
141	21.50	98	11.90	12.14
142	16.20	22	3.90	17.73
143	9.65	11	2.50	22.73
144	19.90	98	12.90	13.16
145	13.15	84	8.05	9.58
146	22.60	61	11.10	19.00
147	21.00	126	16.10	12.78
148	19.65	12	2.10	17.50
149	45.15	60	15.90	26.50
150	25.70	115	16.10	14.00

APPENDIX B_2

PRIMARY DATA ON YIELD OF MAIZE WITH LEAF ORIENTATION (B) OBTAINED IN THE SECOND EXPERIMENT.

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
1	192.70	479	135.82	28.35
2	219.00	562	158.45	28.19
3	245.40	558	182.40	32.69
4	137.00	366	100.10	27.35
5	144.05	532	110.40	20.71
6	161.98	314	107.30	33.64
7	207.30	713	149.15	20.92
8	153.40	465	91.15	19.60
9	149.28	690	110.00	15.94
10	98.60	434	70.40	16.22
11	193.30	500	147.45	29.49
12	184.00	438	130.82	29.88
13	95.30	383	51.82	13.53
14	70.30	282	50.80	18.01
15	210.55	545	169.10	31.03
16	191.80	440	129.70	29.48
17	165.30	334	125.60	37.60
18	146.20	538	106.05	19.71
19	146.00	410	104.90	25.59

/HC	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
20	314.30	675	232.25	34.41
21	111.85	334	70.95	21.24
22	151.00	427	118.80	27.82
23	111.90	319	72.00	22.57
24	87.90	301	60.20	20.00
25	69.85	249	43.48	17.46
26	93.00	413	64.80	15.69
27	135.00	506	112.50	22.23
28	144.20	474	107.35	22.65
29	174.31	411	115.80	28.18
30	114.60	344	81.80	23.78
31	218.69	658	165.51	25.15
32	118.55	348	95.35	27.40
33	205.70	606	162.50	26.82
34	87.70	355	55.40	15.61
35	119.80	326	85.60	26.26
36	146.68	334	108.20	32.40
37	151.30	537	100.55	18.72
38	272.18	547	187.40	34.26
39	143.90	302	102.80	34.04
40	178.40	463	123.70	26.72
41	72.15	262	43.70	16.68
42	73.20	213	40.50	19.01

T/NO	CCB WT. IN GRAMS	NO. OF SEEDS PER CCB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
43	190.38	564	136.10	24.13
44	185.12	401	125.60	31.32
45	183.50	623	139.23	22.35
46	142.65	342	86.50	25.29
47	188.20	463	136.80	29.55
48	97.80	388	68.60	17.68
49	96.30	464	67.60	14.57
50	137.65	471	87.62	18.60
51	131.52	553	94.62	17.11
52	66.15	225	49.40	21.96
53	95.60	312	70.20	22.50
54	158.72	351	119.25	33.97
55	175.40	667	129.52	19.42
56	115.40	279	86.10	30.86
57	220.20	610	146.60	24.03
58	213.32	415	157.51	37.95
59	114.20	461	80.60	17.48
60	109.55	495	76.20	15.39
61	194.70	527	149.90	28.44
62	55.20	196	29.12	14.86
63	105.40	333	78.80	23.66

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
64	132.70	513	97.00	18.91
65	169.90	336	124.25	36.98
66	83.80	399	58.05	14.55
67	144.80	354	105.10	29.69
68	97.00	438	65.00	14.84
69	101.90	250	61.30	24.52
70	75.50	476	55.40	11.64
71	30.00	156	30.00	19.23
72	104.60	388	74.72	19.26
73	109.00	413	81.10	19.64
74	56.90	248	39.40	15.89
75	65.15	288	41.05	14.25
76	79.60	316	53.25	16.85
77	78.95	432	56.00	12.96
78	128.60	402	93.82	23.34
79	31.25	129	20.70	16.05
80	50.50	120	22.00	18.33
81	113.71	265	72.60	27.40
82	106.40	536	66.90	12.48
83	133.25	507	100.10	19.74
84	83.30	342	59.90	17.51
85	154.80	406	104.55	25.75

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
86	92.60	336	69.00	20.54
87	133.70	259	90.40	34.90
88	79.15	295	47.70	16.17
89	46.10	217	30.40	14.01
90	40.30	213	24.20	11.36
91	9.90	13	2.95	22.69
92	46.80	90	17.40	19.33
93	29.10	162	22.20	13.70
94	27.90	98	21.05	21.48
95	29.90	141	21.70	15.39
96	6.58	13	1.50	11.54
97	10.90	4	0.80	20.00
98	10.90	92	8.40	9.13
99	11.50	42	4.05	9.64
100	10.40	32	3.20	10.00
101	178.65	459	129.00	28.10
102	129.50	469	102.85	21.93
103	136.50	472	107.78	22.83
104	99.50	400	89.80	22.45
105	111.10	312	89.30	28.62
106	89.85	313	69.60	24.59

P/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
107	158.30	457	123.20	26.96
108	104.10	348	77.10	22.16
109	105.05	347	74.20	21.38
110	124.00	341	99.05	29.05
111	53.20	253	41.75	16.50
112	81.00	373	68.60	18.39
113	135.82	463	112.20	24.23
114	161.80	458	130.95	28.59
115	172.00	425	137.70	32.40
116	81.00	265	57.75	21.79
117	92.85	260	73.20	28.15
118	98.60	281	73.05	26.00
119	53.95	231	38.70	16.75
120	79.30	343	56.80	16.56
121	127.55	417	99.00	23.74
122	167.10	560	117.40	20.96
123	120.70	464	91.30	19.68
124	29.15	112	19.45	17.37
125	62.85	202	52.00	25.74
126	120.40	367	92.35	25.16
127	121.70	388	100.10	25.80
128	110.70	389	87.15	22.40

S/NO	COB WT. IN GRAMS	NO. OF SEEDS PER COB	SEED WT. IN GRAMS	HUNDRED SEED WEIGHT (g)
129	51.40	188	33.30	17.71
130	26.60	127	20.90	16.46
131	68.70	247	34.80	14.09
132	78.30	162	38.65	23.86
133	31.85	64	13.15	20.55
134	15.05	106	18.15	17.12
135	31.70	31	5.90	19.03
136	12.20	32	4.55	14.22
137	14.95	11	1.80	16.36
138	12.00	28	4.25	15.18