CHAPTER ONE

INTRODUCTION

Introduction

Maize or Corn (*Zeamays*.L) is a monoecious plant that belongs to the family Poaceae.Maize is not only a major cereal in the present–day world but it was also one of the basic crops in America before the arrival of Christopher Columbus at the end of the fifteenth century (Rouanet, 1987). The origin of maize remains uncertain, although its generally agreed that its evolution into modern forms took place in Mexico, and it was introduced to Africa by the Portuguese in the sixteenth century and has become Africa's most important staple food crop (FAO,2005).Maize is the most important cereal crop in the world after wheat and rice and has great yield potential and attained the leading position among cereals based on production as well as productivity (Keskin., 2005).Advances in maize genomics, breeding and production have significant role on the lives of a large proportion of the world's population (Xu and Crouch, 2008).Maize is a multipurpose crop, provides food for human, feed for animals and poultry, and fodder for livestock.It is a rich source of raw materials for the industry. Also, maize is an important source of calories and protein in human diet in many countries of the world and is the main staple food in Africa particularly in eastern Africa (krivanek*et al.,* 2007). Nutritionally, maize is deficient in two essential amino acids, lysine and tryptophan, therefore, there are concerns about the supply of the two essential amino acids in the regions where it constitutes the daily food. Maize is cultivated throughout the world and greater amounts of maize are produced each year than any other grain (IGC, 2013).The United States of America produces 40% of the world harvest.The top ten maize producers in 2013(production in tons) are United States of America (353,699,441), China (217,730,000), Brazil (80,516,571), Argentina (32,119,211), Ukraine (30,949,550), India (23,290,000), Mexico (22,663,953),Indonesia (18,511,853), France (15,053,100) andSouth Africa (12,365,000), Sudan is 117 in the world ranking (FAOSTAT, 2014).In 2009, over 159 million hectares of maize were planted worldwide, with an average yield of over 5 tons per hectare and yield can be significantly higher in certain regions of the world (FAO, 2009). There is conflicting evidence to support the hypothesis that maize yield potential has increased over the past few decades, it is suggested that changes in yield potential are associated with leaf angle, lodging resistance, tolerance of height plant density, diseases/pests tolerance, and other agronomic traits rather than increase of yield potential per individual plant (IGC,2013).

In the Sudan, it is produced in the Northern region (Northern and River Nile states) of the country having long cool and hot seasons (which is considered a suitable area for maize production). The NorthernState is characterized by good fertile soils and suitable climate. In addition to the ground water resource in the Nubian sand stone. Also the area is free from diseases and pests compared to other parts of the Sudan (North State, Ministry of Agriculture, 1995).In the traditional farming of Sudan, the low productivity of maize was attributed to the low yielding ability of the local open- pollinated cultivars that are normally grown and the greater sensitivity of the crop to water stress (Mukhtar, 2006). Recently, there has been an increasing interest in developing maize production in Sudan. However, work in maize improvement in Sudan is limited and only few cultivars have been released and the work in maize cultural practices is scanty. Maize is nitro positive and needs ample quantity of nitrogen to attain high yield. Nitrogen deficiency is a key factor for limiting maize yields (Alvarez and Grigera, 2005). It is, therefore, imperative to use an optimum amount of nitrogen through a suitable and efficient source.

The objectives of the research were:

1- To determine the optimum dose of nitrogen fertilizer.
2- To study the effect of sowing methods on growth and yield of maize.
3- To study the performance of different varieties of maize under Northern State conditions.
4- To determine maize quality under prevailing conditions.
5- To determine the efficiency of the crop for nitrogen use and productivity.

CHAPTER TWO

LITERATURE REVIEW

Background:

2.1 Maize in the Sudan:

Maize (*Zea mays* L).is recently adopted in the Sudan and may have been introduced during the Turkish colonial period in the nineteenth century (Mukhtar, 2006). Cereal grains are the most important component of Sudanese diet. Understanding of cereals production characteristics, in the Sudan, is vital for maintenance of efficient and sustainable agricultural and food production (Abdel Rahman, 2002). The popular name of maize intheSudan "Aishelreef" is consistent with the above notion and as well it was also named in the Northern State of the Sudan by "Makada".

In the Sudan, maize is considered a minor crop and it is normally grown in Sinnar and Blue Nile states, Southern States or in small irrigated areas in the Northern States with average production of about 0.697 ton/ha (FAO,2005). The average yield per unit area of the Sudan is very low compared to that of other similar countries.

Maize (*Zea mays* L) is the third most important cereals (Lerner and Dona, 2005).

2.2 Utilization of Maize:

Maize, the American- Indian word for corn, means literally" that sustains life". It provides nutrients for humans and animals and serves as important raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners and more recently, fuel. The green plant made into silage, has been used with great success in the dairy and beef industries. The straw is good forage for ruminant animals in developing countries. The erect stalks, which in some varieties are strong have been used as long lasting fences and walls. In many other regions, it is consumed as a vegetable although it's a grain crop. The grains are rich in vitamins A, C and E, carbohydrates, essential minerals, and protein. Maize is processed and prepared in various forms depending on the country. Ground maize is prepared into porridge in Eastern and Southern Africa. In all parts of Africa, green (fresh) maize is boiled or roasted on its cob and served as a snack. A heavy reliance on maize in the diet, however, can lead to malnutrition and vitamin deficiency disease such as night blindness and kwashiorkor (IITA, 1992).

2.3 Adaptation:

Maize is grown at latitudes varying from the equator to slightly North and South of latitude 50, at altitudes over 300 meter above sea level under heavy rain- fed and semi- arid conditions, and cold and very hot climates.Maize is a warm–season, annual crop and does best on fertile well drained, loamy soils. It can be grown successfully in soils with pH ranging from 5.5 to 8.0. Maize can be grown in most parts of the world but it is best suited to regions where the average temperature, for three or four consecutive months is between 21-32 ˚C. Planting is generally delayed until the soil temperature is 13˚C or higher. The optimum temperature for plant growth during the flowering and grain ripening is about 30˚C. Little growth occurs if temperature is below 18˚C, and prolonged exposure to temperature below 7˚C may be lethal (Ndahi, 1984). Maize is generally classified as a short – day plant. It grows in locations where precipitation ranges from 450- 600mm and minimum rain fall is about 200 mm and a maximum of 900mm.

2.4Botanical Feature:

Botanically, maize or corn is a member of the Maydeae tribe which belongs to the grass family (*Gramineae*) and is a tall annual plant with an extensive adventitious root system. It is across pollinatedmonoecious plant. The silk develops in the ears, or cobs, often one on each stalk, each cob has 300-1000 kernels in number of rows. Grain makes up about 42 percent of the dry weight of the plant, the kernels are often white or yellow in color but also black, red and a mixture of colors are found. The maize kernel is known botanically as caryopsis (krivanek*et al.,* 2007).

2.5 Nitrogen fertilization:

Nitrogen is an essential nutrient which constitutes about 3-4% in dry matter, and often becomes a limiting factor for plant growth and development (Eekert, 2007), because it plays an important role in plant metabolism. The use of nitrogen by plants involves several steps, including uptake, translocation and assimilation and when the plant is aging, recycling and remobilization (Masclaux*et al*, 2010).

Nitrogen plays an essential role in the growth and development of the plant. Lack of nitrogen results in stunted growth, pale yellow color, small grain size and reduced yield. It is an essential component of amino acids and proteins. The growth of plant primarily depends on nitrogen availability in soil solution and its utilization by the plants. Dry matter production and its conversion to economic yield is a cumulative effect of various physiological processes occurring during the life cycle of a plant (Khan *et al*., 1994).

Nitrogenous fertilizers were widely used by farmers and have contributed to remarkable increase in crop production during the past 50 years (Doberman, 2005), especially staple foods such as maize which is highly responsive to nitrogen and requires large quantity of nitrogen (Moose *et al.*, 2007). Five million tons of nitrogen fertilizers are used annually to fields of maize production in the industrialized world, and use isincreasing in developing nations. In 2011, the world demand for nitrogen fertilizer was 105.348 million tons and predicted to grow by 1.7% annually from 2011-2015 (FAO, 2011).Generally, maize yield increases with high fertilizer dose as maize grain yields are highly responsive to supplemental nitrogen (Moose and Below, 2008). Because of this reason the amount of nitrogen used is increasing every year. Average nitrogen consumption is 10 million metric tons annually worldwide (FAO,2004).

Maize fertilizerrecommendation is generally based on previous yields, expected yield based on the environmental conditions and by testing the available soil- nitrate, to avoid over fertilization in some areas and under fertilization in some areas (Mamo*et al*, 2003). Mahamod*etal*. (2001), studied the effect of the different levels of nitrogen on yield and yield components of maize and revealed that nitrogen had significant effect on plant height, number of grains/cob, 1000 grain weight and harvest index. Similarly, Gokmen*et al.*, (2001) showed that, plant height,cob length, number of grain per cob and 1000 grain weight increased significantly with increasing nitrogen rate. Also, EL–sheikh (1998) reported that application of 160 kg nitrogen /ha significantly increased grain yield of maize.Badr and Authman (2006) indicated that increasing levels of nitrogenous fertilizer led to increased grain yield and its components.Bakhet*et al*,(2006) found that increasing nitrogen fertilizer rate from zero up to 250 kg nitrogen/ha, increased significantly, the studied maize growth, yield and yield components. Maximum number of leaves/plant, number of cobs/plant, number of grains/cobs, plant height, grain and biological yield were recorded in ridge planting when compared with other treatments.Arif*et al*(2010) found that number of cobs/m2, number of grains / cobs, 1000 grain weight, grain yield, biological yield and harvest index were higher at the highest level of nitrogen. On the other hand,Yilmaz and Karaaltun (2005) found non- significant difference in number of seeds per cob due to the increase in nitrogen rate.

Similarly , maximum number of rows /cob, number of grain /row, number of grains/cob, cob length, cob weight, weight of grains/cob, thousand grain weight and grain yield were recorded with application of 240 kg/ha when compared with other nitrogen rates (Delibaltova*et al*., 2010).

Likewise, Hammad*et al*., (2011) reported that nitrogen application, significantly, affected maize growth, yield and related traits, where maximum number of grain per cob, thousand grain weight, grain yield, harvest index and nitrogen use efficiency were recorded in the plots receiving 250 kg nitrogen /ha. Moreover application beyond this nitrogen (i.e. 300 kg/ ha) enhanced biological yield and seed protein contents. Hokmalipour and Darband (2011) pointed out that grain yield and plant height were affected by nitrogen fertilizers in corn cultivars. Korduna cultivar had greatest plant height at all levels of nitrogen fertilizer but maximum yield was obtained at180 kg nitrogen/ ha. Also Wasaya (2011) reported that increasing nitrogen application rate had positive impact on growth, yield components, yield and grain quality. Increased leaf area index, grain weight per cob, thousand grain weight and grain yield were recorded at 200 kg/ha nitrogen compared with 100 and 150 kg/ha nitrogen. In addition nitrogen application showed positive association with protein content. Nitrogen rates affected number of cobs per meter square, thousand grain weight, grain yield, total dry matter and harvest index with significant differences among nitrogen rates(Khalig*et al*., 2009). Dawadi and Sah (2012) indicated that increasing nitrogen levels from 120 kg/ ha to 200 kg / ha enhancedplant height and grain yield but decreased the harvest index. Likewise, Hoshang (2012) observed that there was significant difference among nitrogen levels regarding cob length while there was no significant difference in harvest index.

Khan *et al*., (2012) showed that increase in nitrogen levels increased final seed yield due to increased seed number per cob. Nitrogen also significantlyincreased maize plant height, where the greatest plant height was recorded under 120 and 150 kg/ha nitrogen. (Nemati and Sharifi. 2012)concluded that for increasing of both qualitative and quantitative yield and some agronomic characteristics such as plant height, cob length and diameter, a rate of 25 kg/ha nitrogen level should be applied. Also, Sharifai*et al*., (2012) indicated that the effect of nitrogen on such yield components as cob diameter, cob length and thousand grain weight were significant and the response was in the range of 80 to 120 kg N/ha. Likewise, Moraditochaee*et al*., (2012) showed that the effect of nitrogen fertilizer on grain yield, straw yield, harvest index, plant height, number of cob per plant, thousand grain weight and cob length was significant.

2.6Sowing Methods:

The data obtained by Sharma (1980) revealed that sowing maize crop on ridge and flat resulted in the same yield.Mahal*et al*., (2000) investigated the effect of three levels of flood water, two methods of sowing (flat and ridge) and two levels of nitrogen (120 and 150 kg/ha) and concluded that sowing on ridges reduced the adverse effect of flooding and gave more yield than sowing on flat. Sheikh *et al*., (1994) obtained maximum thousand grain weight, plant height, and grain yield with ridge sowing. ((Sandhu and Hundal, 1991) stated that method of sowing has great effect on maize yield. Farmers generally use the old broadcast method of sowing with so many disadvantages i.e. uneven distribution of seed and depth and seeds lying scattered being picked up by birds. Improved planting method may lead to increased production of maize which will helping attainingself sufficiency in food and feed. Gupta *et al*., (1979) reported that sowing maize and sorghum on ridges yielded 14 to 106 percent and 6 to 59 percent, respectively compared to planting on flat beds. Ridging also improve seedling emergences as well as plant fresh weight. Maximum 1000 grain weight, plant height and grain yield was obtained with ridge sowing (Majid*et al*., 1986, Sandhu and Hundal, 1991, Sheikh *et al*., 1994).

2.7 Maize cultivars:

Varietals differences in maize with respect to yield and growth characteristics have been reported by Ayub*et al*., (1998). On the other hand ,Altin and Hunter (19984) reported non-significant differences among the maize cultivars for hole plant dry matter yield and nutritional quality of forage. Ayub*et al*., (2001) observed significant differences for growth parameters, forage yield and crude protein. However, crude fiber and ether extractable fat content were not influenced significantly. Bertoia*et al*., (2006) indicated significant variation among hybrids for stover yield and hole plant yield. On average commercial hybrids had cob yield greater but lower stover yield than land races and population hybrids. Kalifa*et al*.,(1981) studied the effect of nitrogen on an open-pollinated variety of maize. He found that nitrogen increased the number of days to 50% flowering. In a performance study, the introduced variety 8742 recorded the highest relative growth rate, leaf area index and dry weight as compared to Mugtama45 and Tlatizapan8743 (Mohammed 1997). Graybill (1991) concluded that the selection of cultivars for yield may be important management because it influences the nutritive value .

Rasheed*et al.*, (2003) reported that maize cultivars showed significant difference in some growth parameters namely plant height, days to 50% tasselling, leaf area index and number of leaves per plant. Also, Hussin*et al.*, (2010) reported significant differences in plant height, leaf area, number of cobs/plant, number of seeds/cob and harvest index among maize cultivars.

2.8 Quality:

Optimum supply of plant nutrients is imperative for better growth and development of a crop. However, yield and quality parameters are greatly affected by inadequate availability of plant nutrients.Witt*et al.*, (2008)commented that low yield of maize is due to many constraints but nitrogen fertilizer application is one of the major factors. Nitrogen plays a vital role in vegetative and reproductive phase of crop growth. Higher nitrogen levels are reported to increase plant height, stem diameter, leaf area, leaf area index, dry matter accumulation, net assimilation ratio and yield per hectare (Cheema*et al.*,2010).

Reddy and Bhanumurty (2010) reported that applying 240 kg N/ha gave significantly higher green fodder yield, dry matter yield and crude protein content. Similar finding were obtained by Almodares*et al.*,(2009) who reported that fodder maize biomass and crude protein content increased with increase in nitrogen level. Similarly, Amanullah*et al.*, (2009) concluded that growing maize cultivars at higher nitrogen rate can increase leaf area and plant height which consequently maximize yield. In similar study, Nadeem*et al.*, (2009) reported that the growth characteristics of maize cultivars such as plant height, number of leaves per plant, stem diameter, leaf area index and crude protein were significantly influenced by increasing nitrogen levels. Similarly, Ayub*et al.*, (2003) reported that higher nitrogen application significantly increased plant height, leaf area, number of leaves per plant, stem diameter, crude protein and crude fiber.

2.9 Nitrogen Use Efficiency (NUE) and Agronomic Efficiency (AE):

Nitrogen use efficiency can further be divided into two processes, nitrogen uptake efficiency and nitrogen utilization efficiency. Nitrogen uptake efficiency (NUPE) is the ability of plant to remove nitrogen from the soil, and nitrogen utilization efficiency (NUTE) is the ability of plant to use nitrogen to produce grain yield (Hirel*et al.*, 2007).Also, Samborski*et al.*, (2008) defined nitrogen uptake efficiency as a quotient of plant nitrogen uptake and total crop nitrogen supply (fertilizer plus soil mineral nitrogen). According to Baligar*et al.*, (2001) nitrogen uptake efficiency is attributed to morphological, physiological and biochemical processes in plant and their interaction with climate, soil, fertilizer, biological and management practices. For cereal crops, the ratio of plant nitrogen content to the supplied nitrogen does not exceed 50% whatever the level of nitrogen level applied (Malagoli*et al.* 2005), which suggests that there is possibility and need for improvement of cereal crop species with regard to nitrogen use efficiency (Hirel*et al.*, 2007). In maize, 45-65% of the grain nitrogen is provided from pre-existing nitrogen in the Stover before silking and 35 – 55% is from post–silking nitrogen uptake (Gallais and Coque, 2005). Generally NUE parameters are high under low nitrogen levels and decrease with increasing nitrogen level. Decreased NUE at high nitrogen is attributed to higher losses because the plant is unable to absorb all of nitrogen applied (Giambalvo*et al.*,(2009).

In cereal crops like maize, agronomic efficiency (AE) is most simply expressed as the ratio of grain yield to nitrogen fertilizer supplied.

CHAPTER THREE

MATERIALS AND METHODS

3.1The Experimental site and the climate

The experimental work of this study was conducted during the winter seasons of 2013/2014 and 2014/2015 at the Farm of the Faculty of Agricultural Sciences, University of Dongola, Northern State, Sudan, located at latitude 19 11'N, and longitude 30 29' E and altitude 227m above sea level (ASL).

The objective of the experiment was to study the effect of nitrogenand sowing methods on growth, yield and yieldefficiencyof three maize (*Zea mays* L.) cultivars namely Hudeiba-1, Hudeiba2 and Dongola cultivars. The study was conducted on high terraces soil in the Northern State.

The state lies within the desert region of the Sudan with extremely high temperature and radiation in summer, low temperature in winter (Appendix 1). Rainfall is scarce and the wind prevails from the north. The soil is divided into two main groups, namely soils of the recent flood plain and soil of the high terraces (Karouri, 1978). The soil of this experimental site (high terraces) is alkaline (PH 7.39)with high content of $Caco_3$ (8.43%). According to U.S.A soil taxonomy (1994) it was classified as sandy loam, with 72% sand, 11% silt and 17% clay.

3.2 Land preparation, sowing and the layout of the experiment:

The experimental area was tilled adequately to prepare a suitable seedbed. The implements used included achisel plough (cross plow) to break and loosen the soil and a leveler (Scraper) to level it for easy movement and uniform distribution of irrigation water. The seeds of maize cultivars Hudeiba-1and Hudeiba-2 were obtained from Hudeiba Agricultural Research Station (H.A.R.S) while the local maize cultivar(Dongola cultivar) was obtained from DongolaAgriculturalResearch Station (D.A.R.S). The cultivars Hudeib-1 and Hudeiba-2 were recommended and released in 1999.

The field was then divided into four blocks (replications) each contained 24 equal plots of 3m x4m size (4 ridges each three meters in case of ridge method). Planting was done on the second week of February in both seasons. Three seeds per hole were sown on ridges and in flats in rows 70 cm apart and 30 cm between plants at a seed rate of 37.5 Kg/ha (or 45 gm/plot).The seeds that failed to emerge were re-sown and the plants were later thinned to one plant per hole to give standard plant population.

3.3 Experimental Design and Treatments:

The experimental design used was Randomized Complete Block Design (RCBD) in split- split plot arrangement with four replications. The main plots contained three open-pollinated maize cultivars:

1- Hudeiba-1 (V1)

2-Hudeiba-2 (V3)

3- Dongola cultivar (V2)

Sub- plots were designed to two types of sowing methods:

1- On ridges(S1)

2- In flats (S2)

The sub-sub plots contained four levels of Nitrogen fertilizer:

1- 0 Kg N/ha (NO)
2- 43 Kg N/ha (N1)
3- 86 Kg N/ha (N2)
4- 129 Kg N/ha (N3)

3.4 Cultural practices:

Weeds control was done by hand weeding two weeks after sowing and then as needed throughout the growing season. Irrigation was applied at intervals of seven to ten days according to temperature range and soil need.

The insecticides Ekarosine (1.8% actives ingredient) and super klomite (48% active ingredient) were used in both seasons to protect the crop from stem borers and termites, respectively.

3.5 Data collection:

For data collection, ten randomly selected plants from the middle two ridges (or rows) were used to study the following characters.

3.5.1 Vegetative growth characters

3.5.1.1 Plant height(cm):

The mean plant height was determined after 60 and 90 days from sowing. The height of the ten randomly selected plants wasmeasuredfrom the soil surface to the last leaf.

3.5.1.2 Stem diameter (cm):

The mean stem diameter was determined after 60 and 90 days from sowing, for the ten randomly selected plant from the middle of the plant by using verner clapper.

3.5.1.3 Days to 50% tasselling

The mean days to 50% tasselling were counted from the date of sowing to time when 50% plants in each plot produced tassels.

3.5.1.4 Number of leaves/ plant:

The ten randomly selected plants were used to determine the mean number of leaves/ plant.

3.5.1.5 Leaf area index (LAI):

Leaf area index (LAI) was calculated from the same ten randomly selected plants. The area of individual green leaves (LA) was determined by measuring their Length (L) and maximum width (W) and multiplyingtheir products by 0.75 factor (Bueno and Alkins, 1981), and therefore leaf area index was calculated as follows:

$LA = L \times W \times 0.75$.

LAI= LA × number of leaves/ plant × number of plants /m^2 ground area/(m2)

3.5.1.6 Days to maturity:

The mean days to maturity were counted from the date of sowing to time when plants had completed their maturity.

3.5.2 Yield and yield components.

3.5.2.1 Number of cobs/ plant:

The mean number of cobs per plant was counted from the randomly selected sample of ten plants per plot.

3.5.2.2 Number of cobs /m^2:

The mean number of cobs per meter square was counted from an area of meter square per plot.

3.5.2.3 Cob length(cm):

The mean cob length was determined from the randomly selected sample of ten cobs per plot, measured in centimeters (cm).

3.5.2.4 Number of rows/ cob:

The mean number of rows per cob was counted from randomly selected sample of ten cobs of the ten plants of the sample

3.5.2.5 Number of seeds/ row:

The mean number of seeds per row was counted from randomly selected sample of ten cobs of the ten plants of the sample.

3.5.2.6 Number of seeds/cob:

The mean number of seeds per cob was counted from randomly selected sample of ten cobs of the ten plants of the sample.

3.5.2.7 Thousand seeds weight(gm):

Seeds weight in grams (gm) was obtained after threshing 1000- grains taken randomly from each plot and then weighed.

3.5.2.8 Grain yield (t/ha):

Cobs were harvested from one meter square of each plot, air dried , threshold in bulk, and then weighed . The total grain yield was calculated according to the following formula (Baada, 1995)

$$\text{Total grain yield}(t/ha) = \frac{\text{Grain weight}(kg)/m2}{100}$$

3.5.2.9 Harvest index (HI) (%):

After threshing total plant weight from each plot and calculated grain yield per hectare,harvest index was calculated by using the following formula :

$$\text{Harvest index (Hi)} = \frac{(\text{seed yield}/\mathbf{m2})}{(\text{total plant weight}/\mathbf{m2})} \times 100$$

3.5.2.10 Roots weight(gm):

The average roots weight was determined from randomly selected sample of ten harvested plants from each plot, and then weighed in grams.

3.5.3 The efficiency

3.5.3.1 Nitrogen use efficiency(NUE) (kg dry matter/kg N)

Nitrogen use efficiency calculated as follows :

$$\text{NUE} = \frac{Grain\ yield\ (Kg/ha)}{Actual\ amount\ of\ Nitrogen\ added}$$

3.5.3.2 Agronomic efficiency(AE) (kg grain/kgN):

Agronomic efficiency calculated as follows:

AE = (Y-Y0) F

Where:

Y= crop yield with applied nitrogen

Y0 = crop yield with control (untreated)

F = amount of fertilizer

3.5.4 Proximate analysis:

Seed crude protein and crude fiber contents were determined following the standard methods of the Association of Official American Analytical Chemists (AOAC, 1990). The organic nitrogen content was determined using the micro-Kjeldahal method, and an estimate of the crude protein content was estimated by multiplying the organic nitrogen content by a factor of 6.25% (Sosulski and Imafidon, 1990). Two different samples were analyzed in triplicate.

3.5.5 Statistical analysis:

The data collected were subjected to analysis of variance (ANOVA) appropriate for split-split plot arrangement in a randomized complete block design (Gomez and Gomez, 1984).Duncan's Multiple Rang test (DMRT) was applied for the separation of treatment means.All statistical analysis were performed using MSTAT-C computer program.Associations between the different characters were measured by the correlation coefficient (using two tailed SPSS analysis), that gives an indication of the degree of these relations.

CHAPTER FOUR

RESULTS

4.1Vegetative Growth

4.`1.1 Plant height

4.1.1.1 plant height at 60 days (cm):

The analysis of variance showed nosignificant differences in plant height after 60 days among the various levels of fertilizer and between the two sowing methods in both seasons (Table 1). The levels of fertilizer gaveoverallmean of plant height of 122.59 and 134.87cm respectively, in the first and second seasons, while sowing methods gave overall mean of plant height of 122.60 and 134.87 cm respectively, in the first and second seasons (Tables 2 and 3).

The analysis of variance showed highly significant differences(P=0.01) between cultivars in the first season and significant differences (P=0.05) in the second season in plant height after 60 days (Table 1). In the first season Dongola cultivar gave 26% significantly greater plant height than Hudeiba-2. On the other hand, there was nosignificant difference between the cultivars Hudeib-1 and Dongola in both seasons. (Tables1, 4).

There were non-significant differences in plant height after 60 days between treatments interactions in both seasons (Tables 5, 6, 7 and 8).

4.1.1.2 Plant height at 90 days (cm):

The statistical analysis revealed significant differences (P=0.05) between fertilizer levels in plant height after 90days from sowing in the first season (table 1), where the application of 43 kg/ha gave 5% significantly increased plant height after 90 days over control but there was no significant difference in plant height between the application of 43 and 86 kg/ha and between the application of 129 kg/ha and control. The overall mean of plant height after 90 days was 137.65 and 159.29 cm respectively, in the first and second seasons (Table 2).

The analysis of variance showed nosignificant differences in plant height after 90 days from sowing between the two sowing methods in both seasons (Table 1). Sowing methods gave an overall mean of plant height after 90 days of 137.65 and 159.32cmin the first and the second seasons, respectively (Table 3).

The analysis of variance indicated highly significant differences (P=0.01) in plant height after 90 days among maize cultivars in the first season (Table 1), where the cultivar Hudeiba-1 gave 10% significantly greater plant heightthanDongola cultivar, but Hudeiba-2 had lower plant height compared toDongola cultivar. Maize cultivars gave an overall mean of plant height after 90 days of 137.65 and159.22 cm in the first and the second seasons, respectively (Table 4).

Differences between treatments interactions in plant height after 90 dayswere non-significant in both seasons except for nitrogen levels x sowing methodsxcultivars interaction in the second season. The treatment V1S2N1 increased plant height over all combinations (Tables 5, 6, 7 and 8).

4.1.2 Stem diameter

4.1.2.1 Stem diameter at 60 days (cm):

Statistical analysis indicated non-significant differences between nitrogen levels in stem diameter after 60 days from sowing in both seasons (table 1). Overall mean of stem diameter due to fertilizer levels was 7.29 to 7.26 cm in the first and second seasons, respectively (Table 2).

Also, there were nosignificant differences in stem diameter after 60 days between the two sowing methods in both seasons (Table 1). Sowing after 60 days gave overall mean of stem diameter of 7.19 to 7.01cm in the first and second seasons, respectively (Table 3).However ,there were significant differences (P=0.05) in stem diameter after 60 days from sowing among maize cultivars in the first season (Table 1), where the cultivar Hudeiba-1 gave 11% greater stem diameter after 60 days thanDongola while there was non-significant difference in stem diameter after 60 days between the two cultivars. Maize cultivars gave overall mean of stem diameter of 7.29 and 7.00 cm in the first and second seasons, respectively (Table 4).

Treatments interactions showed non-significant differences in stem diameter after 60 days except for nitrogen levels x cultivars interaction in the first season as shown in tables 5, 6. 7 and 8.

4.1.2.2 Stem diameter at 90 days (cm):

The analysis of variance indicated significant differences (P=0.05) in stem diameter after 90 days from sowing between nitrogen levels in the first season(Table 1). Application of 43 kg/ha gave greater stem diameter after 90 days over control but there was non- significant difference in the character between 43, 86 and 129 kg N/ha. Fertilizer levels gave overallmean of stem diameter after 90 days of 7.76 and 7.00 cm in the first and second seasons, respectively (Table 2).

Also, there washighly significant difference (P=0.01) in stem diameter after 90 days between the two sowing methods in the first season and significant difference (P=0.05) in the second season (Table 1). Sowing on flats gave greaterstem diameter after 90 days than sowing on ridges in the first and second season, respectively (Table 3).

In addition, stem diameter after 90 days exhibited significant differences (P=0.05) among maize cultivars in the first season (Table 1), where the cultivar Hudeiba-1 gave greaterstem diameter Dongola cultivar but there was no significant difference in this character between Hudeiba-2 and Dongola. Maize cultivars gave overall mean of stem diameter after 90 days of 7.76 and 7.02 cm in the first and second seasons, respectively (Table 4).

There were nosignificant differences in stem diameter after 90 days from sowing between treatments interactions in both seasons except for nitrogen levels x cultivars in the first season (Tables 5, 6, 7 and 8).

4.1.3 Days to 50% tasselling:

The analysis of variance showed significant differences (P=0.05) in days to 50% tassellingbetweennitrogen levels in the first season (Table 1). The application of 43 kg/ha decreased days to 50% tassellingover control, but there was nosignificant difference in this character between the application of 43 and 86 kg N/ha and between 129 kg/ha and control (Table 2). There were highly significant differences (P=0.01) between the two sowing methods in days to 50% tassellingin the second season as shown in table (1), where sowing on flats increased days to 50% tasselling over sowing on ridges. Sowing methods gave an overall mean of days to 50% tasselling of 60.99 and 68.66 days in the first and second seasons, respectively(Table 3).

There werehighly significant differences (P=0.01) among maize cultivars in days to 50% tasselling in both seasons (Table 1).In the first season Hudeiba-1 and Hudeiba-2 had more days to 50% tassellingthanDongola. In the second season Hudeiba1 had more days to 50% tasselling than Dongola(Table 4).

There were significant differences (P=0.05) between the nitrogen levels x sowing methodsinteraction in days to 50% flowering in the first season and between nitrogen levelsx cultivars interactions in the first season (Tables 5 and 6).

4.1.4 No of leaves per plant

The analysis of variance indicated significant differences (P=0.05) in number of leaves per plant between nitrogen levels in the first season (Table 1), where the application of 86 kg/ha gave greater number of leaves per plant over control but there was nosignificant difference in this character between the application of 86 and 129 kg/ha and between 43 kg/ha and control (Table 2). However, there werenosignificant differences between the two sowing methods in number of leaves per plant in both season (Table 1). The overall mean of number of leaves per plant was 11.50 and 12.34 in the first and second seasons, respectively (Table 3).

Differences among maize cultivars in number of leaves per plant were highly significant (P=0.01) in the first season (table 1), whereHudeiba-1 and Hudeiba-2 had greater number of leaves per plant thanDongola cultivar (Table 4).

There was no significant between treatments interactionsin number of leaves per plant in both seasons as shown in tables 5, 6, 7 and 8.

4.1.5 Leaf area index:

Theanalysis of variance indicated highly significant difference (P=0.01) in leaf area index among the different levels of fertilizer in the first season(Table 1). The application of 129 kg/ha gave 14% significantly higher leaf area index than the control but, there was nosignificantdifferencebetween the application of 86 and 129 kg/ha and between 43 kg/ha and control (Table 2). There was no significant effect of nitrogen on leaf area index in the second season (Table 1).

Similarly,there were highly significant differences (P=0.01) between the two sowing methods in leaf area index in the first season (Table 1), where sowing onflats gave significantly higher leafarea index than sowing on ridges. Sowing methods gave overall mean of leaf area indexof 4.33 and 5.89 in the first and second seasons, respectively (Table 3).

Differences between maize cultivars in leaf area index were highly significant (P=0.01) in the first season and significant (P=0.05) in the second season (Table 1). In the first season the Hudeiba-1 had 29% greater leaf area index thanDongola cultivar, whereas Hudeiba-2 had 20%. In the second season Hudeib-1 and Hudeiba-2 had 25% greater leaf area index over Dongola (Table 4).

The differences between treatments interactions on leaf area index were significant (P=0.05) except for nitrogen levels x sowing methods interaction. The treatment V1S2N1 increased leaf area index over all combinations (Tables 5, 6, 7 and 8).

5.1.6 Days to maturity:

The analysis of variance indicated that days to maturity were not affected by nitrogen levelsin both seasons (Table 1). The overall mean of days to maturity was 99.45 and 99.66 days in the first and second seasons, respectively (Table 2).

However, there were highly significant differences (P=0.01) in days to maturity between the two sowing methods in both seasons (Table 1). Sowing the crop onflatsdelayed maturity in comparison to ridge sowing in both season (Table 3).

Similarly, there were highly significant differences (P=0.01) in days to maturity among maize cultivars in both seasons (Table 1). Both Hudeiba-1 and Hudeiba-2 matured later than Dongola in both seasons (Table 4). Cultivars interaction with nitrogen and sowing methods on days to maturity was significant in both seasons (Tables 6 and 7).

Table (1)Effects of nitrogen and sowing methods on vegetative and reproductive parameters of three maize cultivars during the winter seasons of 2013/2104 and 2014/2015

Source of variation	C		S		C×S		N		C×N		S×N		C×S×N	
character	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Plant height at 60 days	**33.74******	**9.15***	**0.36 n.s**	**0.38 n.s**	**0.84 n.s**	**1.00 n.s**	**1.43 n.s**	**1.59 n.s**	**1.01 n.s**	**1.21 n.s**	**0.38 n.s**	**1.08 n.s**	**0.74 n.s**	**0.24 n.s**
Plant height at 90 days	**18.15******	**0.36 n.s**	**0.02 n.s**	**0.34 n.s**	**0.03 n.s**	**1.65 n.s**	**3.43***	**2.11 n.s**	**1.09 n.s**	**1.35 n.s**	**1.38 n.s**	**1.13 n.s**	**1.28 n.s**	**2.41***
Stem diameter at 60 days	**9.49***	**2.01 n.s**	**4.44 n.s**	**0.18 n.s**	**0.06 n.s**	**0.79 n.s**	**0.95 n.s**	**0.79 n.s**	**2.49***	**1.41 n.s**	**0.74 n.s**	**0.28 n.s**	**1.45 n.s**	**0.91 n.s**
Stem diameter at 90 days	**5.57***	**1.21 n.s**	**14.62******	**7.34***	**0.23 n.s**	**0.41 n.s**	**3.42***	**0.33 n.s**	**2.08***	**0.49 n.s**	**0.64 n.s**	**1.05 n.s**	**1.89 n.s**	**0.20 n.s**
Days to 50% tasselling	**190.98******	**29.62******	**0.18 n.s**	**11.29******	**0.11 n.s**	**0.68 n.s**	**2.52***	**0.81 n.s**	**2.97***	**1.27 n.s**	**4.05***	**3.71 n.s**	**0.13 n.s**	**3.33 n.s**
No of leaves /plant	**32.07******	**4.17 n.s**	**0.12 ns**	**0.02 n.s**	**0.66 n.s**	**1.09 n.s**	**4.33***	**1.70 n.s**	**0.86 n.s**	**1.58 n.s**	**0.60 n.s**	**2.03 n.s**	**0.50 n.s**	**0.89 n.s**
Leaf area index	**100.46******	**10.43***	**99.52******	**3.45 n.s**	**6.15***	**5.70***	**6.74******	**2.40 n.s**	**4.76******	**0.98 n.s**	**1.39 n.s**	**1.06 n.s**	**6.71******	**1.51 n.s**
Days to maturity	**96.14******	**104.89******	**15.63******	**16.16******	**4.55***	**4.86***	**1.03 n.s**	**1.09 n.s**	**2.86***	**2.10***	**1.25 n.s**	**1.63 n.s**	**1.54 n.s**	**1.98 n.s**

Key: **C**= Cultivars. **S**= Sowing methods. **N**= Nitrogen levels

******= significant at 1% level (Highly significant) .*****= significant at 5% level (significant). **n.s**= not significant

Table (2) **Effect of nitrogen levels on vegetative and reproductive parameters of three maiz the winter seasons of 2013/2014 and 2014/2015**

Treatment	Plant height /cm				Stem diameter /cm				Days to 50% tasselling		No of leaves/plant	
	1st season		2nd season		1st season		2nd season		1st season	2nd season	1st season	2nd season
	60d	90d	60d	90d	60d	90d	60d	90d				
N0	**118.18 a**	**134.30 b**	**128.64a**	**153.70 a**	**7.11a**	**7.38b**	**6.79a**	**7.02a**	**61.33a**	**68.75a**	**10.92c**	**11.92a**
N1	**128.07 a**	**141.54 a**	**141.58a**	**159.61 a**	**7.42a**	**7.86a**	**7.20a**	**7.16a**	**60.04b**	**68.25a**	**11.25bc**	**12.20a**
N2	**123.06 a**	**141.25 a**	**134.40a**	**160.69 a**	**7.40a**	**7.99a**	**6.93a**	**6.92a**	**61.17ab**	**67.75a**	**12.04a**	**12.65a**
N3	**121.06 a**	**133.50 b**	**134.85a**	**163.17 a**	**7.24a**	**7.82a**	**7.11a**	**6.90a**	**61.42a**	**69.00a**	**11.79ab**	**12.58a**
Overall mean	**122.59**	**137.65**	**134.87**	**159.29**	**7.29**	**7.76**	**7.26**	**7.00**	**60.99**	**68.44**	**11.50**	**12.34**
SE±	**3.48**	**3.34**	**4.19**	**2.74**	**0.15**	**0.14**	**0.19**	**0.17**	**0.40**	**0.62**	**0.24**	**0.26**
LSD	**9.87**	**6.65**	**11.88**	**7.76**	**0.41**	**0.40**	**0.55**	**0.47**	**1.14**	**1.74**	**0.69**	**0.73**
C.V %	**13.92**	**8.35**	**15.23**	**8.42**	**9.88**	**8.99**	**13.60**	**11.74**	**3.24**	**4.41**	**10.44**	**10.29**

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple

<u>Table (3)</u>Effect of sowing methods on vegetative and reproductive parameters of three mai during the winter seasons of 2013/2014 and 2014/2015

Treatment	Plant height /cm				Stem diameter /cm				Days to 50% tasselling		No leaves/
	1st season		2nd season		1st season		2nd season		1st season	2nd season	1st season
	60d	90d	60d	90d	60d	90d	60d	90d			
S1	**124.97a**	**137.73a**	**133.04a**	**160.08a**	**6.97a**	**7.21b**	**6.96a**	**6.77b**	**60.79a**	**67.38b**	**11.46a**
S2	**120.22a**	**137.56a**	**136.70a**	**158.55a**	**7.41a**	**8.32a**	**7.06a**	**7.22a**	**61.19a**	**69.50a**	**11.54a**
Overall mean	**122.60**	**137.65**	**134.87**	**159.32**	**7.19**	**7.77**	**7.01**	**7.00**	**60.99**	**68.44**	**11.50**
SE±	**3.48**	**3.34**	**4.21**	**1.84**	**0.15**	**0.14**	**0.16**	**0.12**	**0.40**	**0.45**	**0.24**
LSD	**20.63**	**16.03**	**15.55**	**6.81**	**0.79**	**0.76**	**0.60**	**0.43**	**2.43**	**1.65**	**0.63**
C.V %	**13.92**	**8.35**	**15.23**	**8.42**	**9.88**	**8.99**	**13.60**	**11.74**	**3.24**	**4.41**	**10.44**

Means within column followed by the same letter (s)were not significant different according to Duncan's Mult

<u>Table (4)</u> Performance of cultivars on vegetative and reproductive parameters of three maize (
the winter seasons of 2013/2014 and 2014/2015

Treatment	Plant height /cm				Stem diameter /cm				Days to 50% tasselling		lea
	1st season		2nd season		1st season		2nd season		1st season	2nd season	1 sea
	60d	90d	60d	90d	60d	90d	60d	90d			
V1	**133.76a**	**152.22a**	**142.84a**	**162.52a**	**7.99a**	**8.29a**	**7.35a**	**7.13a**	**63.28b**	**69.06b**	**12.4**
V2	**134.18a**	**137.59b**	**134.24a**	**158.44a**	**7.15b**	**7.43b**	**6.81a**	**6.85a**	**54.38c**	**65.69c**	**10.4**
V3	**99.84b**	**123.13c**	**127.53b**	**156.98a**	**6.73b**	**7.56b**	**6.86a**	**7.09a**	**65.31a**	**70.56a**	**11.6**
Overall Mean	**122.59**	**137.65**	**134.87**	**159.22**	**7.29**	**7.76**	**7.00**	**7.02**	**60.99**	**68.44**	**11.5**
SE±	**3.91**	**3.41**	**2.54**	**4.75**	**0.21**	**0.20**	**0.21**	**0.25**	**0.42**	**0.46**	**0.1**
LSD	**11.74**	**11.82**	**10.13**	**18.99**	**0.72**	**0.68**	**0.83**	**0.99**	**1.46**	**1.83**	**0.6**
C.V %	**13.92**	**8.35**	**15.23**	**8.42**	**9.88**	**8.99**	**13.60**	**11.74**	**3.24**	**4.41**	**10.4**

Means within column followed by the same letter (s)were not significant different according to Duncan's Mult

<u>Table (5)</u> Effect of interaction between nitrogen levels and sowing methods on vegetative growth along with their significance ranking in seasons (2013 &2014 and 2014/2015)

Treatment	Plant height /cm				Stem diameter /cm				Days to 50% tasselling		No of leaves/plan	
	1st season		2nd season		1st season		2nd season		1st season	2nd season	1st season	2 sea
	60d	90d	60d	90d	60d	90d	60d	90d				
S1×N0	**120.53a**	**136.42a**	**129.19**	**167.09a**	**6.76a**	**6.85a**	**6.76a**	**6.70a**	**60.33bcd**	**67.42a**	**10.92a**	**11.5**
S1×N1	**132.28a**	**139.33a**	**135.72a**	**157.87a**	**7.07a**	**7.44a**	**7.07a**	**6.78a**	**59.83d**	**66.92a**	**11.42a**	**12.6**
S1×N2	**122.51a**	**138.92a**	**137.50a**	**163.24a**	**6.96a**	**7.30a**	**7.03a**	**6.93a**	**62.08ab**	**66.67a**	**12.00a**	**12.6**
S1×N3	**124.57a**	**136.25a**	**129.74a**	**152.10a**	**7.11a**	**7.23a**	**6.97a**	**6.76a**	**60.92abcd**	**68.50a**	**11.50a**	**12.6**
S2×N0	**115.83a**	**132.17a**	**128.09a**	**159.24a**	**7.47a**	**7.91a**	**6.83a**	**7.33a**	**62.33a**	**70.08a**	**10.92a**	**12.3**
S2×N1	**123.88a**	**143.75a**	**147.44a**	**161.36a**	**7.77a**	**8.27a**	**7.32a**	**7.53a**	**60.25cd**	**69.58a**	**11.08a**	**11.7**
S2×N2	**123.62a**	**143.58a**	**131.30a**	**158.13a**	**7.83a**	**8.68a**	**6.83a**	**6.91a**	**60.25cd**	**68.83a**	**12.08a**	**12.6**
S2×N3	**117.55a**	**130.75a**	**139.69a**	**155.48a**	**7.38a**	**8.42a**	**7.25a**	**7.13a**	**61.92abc**	**69.50a**	**12.08a**	**12.5**
Overall mean	**122.60**	**137.65**	**134.83**	**159.31**	**7.29**	**7.76**	**7.01**	**7.01**	**60.99**	**68.44**	**11.50**	**12.**
SE±	**4.93**	**3.32**	**5.93**	**3.87**	**0.21**	**0.20**	**0.28**	**0.24**	**0.57**	**0.87**	**0.35**	**0.3**
LSD	**13.96**	**9.40**	**8.38**	**10.97**	**0.58**	**0.57**	**0.77**	**0.67**	**1.61**	**2.46**	**0.98**	**1.0**
C.V %	**13.92**	**8.35**	**15.23**	**8.24**	**9.88**	**8.99**	**13.60**	**11.74**	**3.24**	**4.41**	**10.44**	**10.**

Means within column followed by the same letter (s)were not significant different according to Duncan's Mult

<u>Table (6)</u>Effect of interaction between nitrogen levels and cultivars on vegetative growth parame with their significance ranking in seasons (2013 &2014 and 2014/2015)

Treatment	Plant height /cm				Stem diameter /cm				Days to 50% tasselling		No of leaves/plant	
	1st season		2nd season		1st season		2nd season		1st season	2nd season	1st season	2nd season
	60d	90d	60d	90d	60d	90d	60d	90d				
V1× N0	**131.55a**	**143.75a**	**141.54a**	**168.69a**	**7.95abc**	**7.99abc**	**7.53a**	**7.20a**	**62.50c**	**69.38a**	**11.63a**	**11.78a**
V1× N1	**135.84a**	**157.00a**	**144.50a**	**156.24a**	**7.60abcd**	**8.02ab**	**7.17a**	**7.21a**	**62.75c**	**68.75a**	**12.63a**	**12.88a**
V1× N2	**134.88a**	**160.00a**	**134.61a**	**168.29a**	**8.13ab**	**8.63a**	**7.28a**	**7.06a**	**63.88bc**	**68.00a**	**13.25a**	**12.95a**
V1× N3	**132.79a**	**148.00a**	**150.70a**	**156.85a**	**8.29a**	**8.61a**	**7.42a**	**7.05a**	**64.00bc**	**70.12a**	**12.38a**	**11.84a**
V2× N0	**136.40a**	**139.63a**	**131.95a**	**156.80a**	**7.16cde**	**7.40bcd**	**6.57a**	**6.55a**	**54.38d**	**64.50a**	**10.25a**	**11.63a**
V2× N1	**135.37a**	**142.50a**	**139.83a**	**163.05a**	**7.22cde**	**7.80bc**	**6.97a**	**6.77a**	**54.63d**	**65.38a**	**9.75a**	**11.04a**
V2× N2	**133.05a**	**137.63a**	**134.71a**	**162.03a**	**7.20cde**	**7.39bcd**	**7.06a**	**6.96a**	**54.38d**	**65.63a**	**10.75a**	**11.96a**
V2× N3	**131.93a**	**130.63a**	**130.46a**	**151.90a**	**7.02de**	**7.14cd**	**6.66a**	**6.81a**	**54.13d**	**67.25a**	**10.88a**	**12.28a**
V3× N0	**86.00a**	**119.50a**	**112.44a**	**164.01a**	**6.22f**	**6.84d**	**6.27a**	**7.30a**	**67.13a**	**72.38a**	**10.88a**	**12.37a**
V3× N1	**113.03a**	**125.13a**	**140.41a**	**159.55a**	**7.44bcd**	**7.75bc**	**7.45a**	**7.49a**	**62.75c**	**70.63a**	**11.38a**	**12.67a**
V3× N2	**101.28a**	**126.00a**	**133.88a**	**151.75a**	**6.86def**	**7.94abc**	**6.45a**	**6.74a**	**65.25ab**	**69.63a**	**12.13a**	**13.04a**
V3× N3	**98.46a**	**121.88a**	**123.39a**	**152.61a**	**6.42ef**	**7.72bc**	**7.25a**	**6.84a**	**66.13a**	**69.63a**	**12.13a**	**13.63a**
Overall mean	122.55	137.64	134.87	159.31	7.29	7.70	7.00	7.00	60.99	68.44	11.50	12.34
SE±	6.03	4.06	7.26	4.74	0.25	0.25	0.34	0.29	0.70	1.07	0.42	0.45
LSD	17.10	11.51	20.58	13.44	0.72	0.70	0.95	0.41	1.98	3.02	4.30	1.27
C.V %	13.92	8.35	15.23	8.42	9.88	8.99	13.60	11.74	3.24	4.41	10.44	10.29

Means within column followed by the same letter (s)were not significant different according to Duncan's Mult

Table (7)Effect of interaction between cultivars and sowing methods on vegetative growth paran with their significance ranking in seasons (2013 &2014 and 2014/2015)

Treatment	Plant height /cm				Stem diameter /cm				Days to 50% tasselling		No of leaves/plant	
	1st season		2nd season		1st season		2nd season		1st season	2nd season	1st season	2nd seas n
	60d	90d	60d	90d	60d	90d	60d	90d				
V1×S1	134.46a	153.38	140.91a	162.23	7.66	7.88	7.12a	6.78a	63.38a	68.50a	12.44a	12.1
V1×S2	133.7a	151.06a	144.76a	162.80a	8.32a	8.71a	7.57a	7.48a	63.19a	69.63a	12.50a	12.6
V2×S1	136.95a	137.25a	137.59a	156.97a	6.90a	8.92a	6.89a	6.58a	53.94a	64.25a	10.19a	11.6
V2×S2	131.42a	137.94a	130.88a	159.92a	7.40a	8.04a	6.74a	6.97a	54.81a	67.13a	10.63a	11.7
V3×S1	103.51a	122.56a	120.61a	161.03a	6.35a	6.92a	6.86a	6.96a	65.06a	69.38a	11.75a	13.2
V3×S2	96.17a	123.69a	134.45a	152.94a	7.12a	8.20a	6.85a	7.22a	65.56a	71.75a	11.50a	12.5
Overall mean	122.70	137.65	134.87	159.32	7.29	8.11	7.01	7.00	60.99	68.44	11.50	12.3
SE±	9.68	7.52	7.29	3.20	0.37	0.36	0.28	0.20	1.41	0.77	0.30	0.4
LSD	30.95	24.05	23.33	10.22	1.19	1.14	0.90	0.65	3.64	2.47	0.95	1.2
C.V %	13.92	8.35	15.23	8.42	9.88	8.99	13.60	11.74	3.24	4.41	10.44	10.2

Means within column followed by the same letter (s)were not significant different according to Duncan's Mult

Table (8): Effect of interaction between nitrogen levels, cultivars and sowing methods on vegetative growth parameters of Maize in seasons (2013 & 2014)

Treatment	Plant height after 60days(cm)		Plant height after90 days(cm)		Stem diameter after60 days(cm)		Stem diameter after 90 days(cm)		Days to 50% tasselling	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
V1×S1×N0	134.27a	144.0a	145.50a	166.23abcd	7.69a	7.38a	7.82a	6.65a	61.75a	67.75a
V1×S1×N1	135.23a	135.5a	153.25a	146.25de	7.22a	6.73a	7.53a	6.62a	63.00a	68.0a
V1×S1×N2	136.79a	142.2a	164.60a	175.13ab	7.87a	7.20a	8.00a	7.10a	65.00a	67.5a
V1×S1×N3	131.55a	141.93a	150.25a	149.33cde	7.89a	7.18a	8.15a	6.74a	63.75a	70.75a
V1×S2×N0	128.83a	139.08a	142.0a	159.15abcde	8.22a	7.68a	8.50a	7.74a	63.25a	71.0a
V1×S2×N1	136.46a	153.5a	160.75a	178.23a	7.98a	7.62a	8.51a	7.80a	62.50a	69.50a
V1×S2×N2	132.97a	127.0a	155.75a	161.45abcde	8.39a	7.35a	9.26a	7.02a	62.75a	68.50a
V1×S2×N3	134.04a	159.48a	145.75a	164.38abcde	8.70a	7.65a	9.06a	7.35a	64.25a	69.50a
V2×S1×N0	140.87a	137.75a	144.50a	155.08bcde	7.13a	6.78a	8.83a	6.21a	53.00a	63.50a
V2×S1×N1	138.64a	140.58a	141.00a	165.70abcde	6.83a	7.18a	7.37a	6.44a	54.00a	63.25a
V2×S1×N2	135.05a	139.35a	138.00a	153.83bcde	6.87a	6.84a	6.89a	7.09a	55.00a	64.50a
V2×S1×N3	133.25a	132.7a	139.25a	153.28bcde	6.80a	6.77a	7.87a	6.58a	53.75a	65.75a
V2×S2×N0	131.93a	126.15a	134.75a	158.53abcde	7.20a	6.37a	7.97a	6.90a	55.75a	65.50a
V2×S2×N1	132.10a	139.08a	144.00a	160.4abcde	7.62a	6.75a	8.23a	7.11a	55.25a	67.50a
V2×S2×N2	131.05a	130.08a	141.00a	170.23abc	7.54a	7.28a	7.97a	6.83a	53.75a	66.75a
V2×S2×N3	130.60a	128.23a	132.00a	150.53cde	7.25a	6.55a	8.00a	7.05a	54.50a	68.75a
V3×S1×N0	86.45a	105.83a	119.25a	167.98abcd	7.46a	6.12a	7.91a	7.25a	66.25a	71.0a
V3×S1×N1	122.98a	131.08a	123.75a	161.65abcde	7.16a	7.31a	7.43a	7.28a	62.50a	69.50a
V3×S1×N2	95.90a	130.93a	118.00a	160.78abcde	6.15a	7.04a	7.08a	6.62a	66.25a	68.0a
V3×S1×N3	108.90a	114.6a	129.50a	153.70bcde	6.63a	6.97a	7.27a	6.70a	66.25a	69.00a
V3×S2×N0	86.95a	119.05a	119.75a	160.05abcde	6.99a	6.43a	7.77a	7.34a	68.00a	73.75a
V3×S2×N1	103.08a	149.75a	126.50a	157.45abcde	7.72a	7.58a	8.08a	7.69a	63.00a	71.375a
V3×S2×N2	106.85a	136.83a	134.00a	142.73e	7.57a	5.86a	8.80a	6.87a	64.25a	71.25a
V3×S2×N3	88.02a	132.18a	114.50a	151.53cde	6.21a	7.54a	8.18a	6.99a	67.00a	70.25a
SE±	008.53	005.75	010.27	006.71	0.36	0.35	0.35	0.41	00.99	01.51
LSD	008.53	010.27	005.75	006.71	0.36	0.48	0.98	1.16	02.80	04.27
CV%	024.19	029.11	016.29	019.02	1.02	1.35	8.99	11.74	03.24	04.41

Table (8) continue...

Treatments	No of leaves/plant		Leaf area index		Days to maturity	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
V1×S1×N0	11.75a	10.74a	3.41gh	4.95a	99.00a	100.25a
V1×S1×N1	12.50a	12.67a	4.14efg	5.79a	100.47a	100.50a
V1×S1×N2	13.00a	13.00a	4.82bcde	5.30a	100.33a	100.50a
V1×S1×N3	12.50a	12.09a	5.32bcd	5.80a	91.67a	92.00a
V1×S2×N0	11.50a	12.83a	4.71cde	7.24a	101.45a	102.75a
V1×S2×N1	12.75a	13.08a	6.46a	6.24a	104.04a	104.00a
V1×S2×N2	13.50a	12.91a	5.58b	6.77a	102.56a	103.75a
V1×S2×N3	12.25a	11.58a	5.34bcd	6.47a	103.40a	103.50a
V2×S1×N0	10a	11.51a	3.48gh	5.82a	90.12a	91.75a
V2×S1×N1	9.75a	11.68a	3.18h	4.26a	92.34a	91.00a
V2×S1×N2	10.75a	11.74a	3.03h	5.86a	92.12a	92.50a
V2×S1×N3	10.25a	11.82a	3.66fgh	5.33a	91.87a	92.75a
V2×S2×N0	10.50a	11.76a	3.55gh	4.57a	93.33a	93.50a
V2×S2×N1	9.75a	10.41a	3.35gh	4.60a	98.43a	97.50a
V2×S2×N2	10.75a	12.18a	4.08efg	4.78a	94.76a	95.00a
V2×S2×N3	11.50a	12.74a	4.07efg	4.85a	98.00a	96.25a
V3×S1×N0	11.00a	12.25a	3.52gh	5.91a	102.90a	103.75a
V3×S1×N1	12.00a	13.67a	3.79fgh	5.02a	103.00a	103.50a
V3×S1×N2	12.25a	13.25a	4.53def	5.97a	103.67a	104.75a
V3×S1×N3	11.75a	13.92a	4.07efg	8.07a	103.90a	104.50a
V3×S2×N0	10.75a	12.50a	5.54bc	6.69a	104.40a	105.00a
V3×S2×N1	10.75a	11.68a	4.11efg	6.35a	103.42a	103.75a
V3×S2×N2	12.00a	12.82a	4.52def	7.69a	102.92a	103.25a
V3×S2×N3	12.50a	13.34a	5.56bc	6.93a	102.38a	103.75a
SE±	00.60	00.63	00.26	0.59	001.92	001.54
LSD	00.60	00.63	00.26	0.59	001.92	001.54
CV%	01.70	01.79	00.75	1.66	005.24	004.35

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

4.2 Yield and Yield Components

4.2.1 Number ofseeds per row:

The analysis of variance showed that number of seeds per row was notsignificantlyaffectedby the fertilizer levels in both seasons (Table 9). Theoverallmean number of seeds per row was 21.60 and 26.11 in the first and second seasons, respectively (Table 10).

On the other hands, differences between the two sowing methods in seeds number per rowweresignificant(P=0.05)in the second season(Table 9), where sowing on flats significantly increased 4% in number of seeds per row than sowing on ridges. Sowing methods recorded an overall mean number of seeds per row of 21.61 and 26.11 in the first and second seasons, respectively (Table 11).

There were highly significant differences (P=0.01) among maize cultivars in number of seeds per row in both seasons(Table 9). In the first season Hudeiba-2 and Hudeiba-1 83% and 47% significantly greater number of seeds per row thanDongola cultivar, respectively. In the second season Hudeiba-2 and Hudeiba-1 had higher number of seeds per row thanDongolacultivar by 15% and 13%, respectively (Table 12).

Treatments interactions did not affect number of seeds per row in both seasons (Tables13, 14, 15 and 16).

4.2.2 Number of Rows Per Cob:

Statistical analysis indicated that there were no significant differences in number of rows per cob due to both nitrogen levels and sowing methods (Table 9).

On the other hand , there were highlysignificant differences (P=0.01) among maize cultivars in number of rows per cob in the first season (Table 9), where Hudeiba-1and Hudeiba-2 increased number of rows per cob by 17% over Dongola. However, there was no significant differences in this character between Hudeib-1 and Hudeiba-2. The three maize cultivars gave an overall mean in number of rows per cob of 14.63 and 13.28 in the first and second seasons respectively (Table 12).

There were nosignificant differences between treatments interactions in number of rows per cob in both seasons (Tables 13, 14, 15 and 16).

4.2.3 Number of Seeds Per Cob:

The analysis of variance indicatedthat number of seeds per cob was not significantly affected by nitrogen levels in both seasons (Table 9).overallmeannumber of seeds per cob for all nitrogen levels was 315.80 and 346.64 in the first and second seasons, respectively (Table 10).

However,the analysis of variance indicatedsignificant differences (p=0.05) between the two sowing methods in number of seeds per cob in both seasons. Sowing on flats gave significantlyincreased in number of seeds per cob over ridges in both seasons (Table 11).

Also , there were highly significant differences (P=0.01) among maize cultivars in number of seeds per cob in both seasons (Table 9). In the first season the cultivar Hudeiba-1 gave significantly greater 78% number of seeds per cobthanDongola cultivar, whereas Hudeiba-2 had 121% higher seed number/cob thanDongola cultivar. In the second season Hudeiba-1 gave 11% significantly higher number of seeds per cob than Dongola cultivar , whereas Hudeiba-2 gave 18% higher number of seeds per cob than Dongola.There was no significant differences in number of seeds per cob between Hudeib-1 and Hudeiba-2 (Table 12).

Treatments interactions showed insignificant effect on number of seeds per cobin both seasons (Tables 13, 14, 15 and 16).

4.2.4 Number of cobs per plant:

There were no significant effect on number of cobs per plant due to both fertilizer levels and sowing methods (Table 9).

However, there were highly significant differences (P=0.01) among maize cultivars in number of cobs per plant in both seasons (table 9). Dongola cultivar gave 89% and 117% greater number of cobs per plant than Hudeiba-1 and Hudeiba-2 in the first season and second season, respectively. On the other hand, there was no significant differences between Hudeiba-1 and Hudeiba-2 in number of cobs per plant in both seasons (Table 12).

Treatments interactions had no significant effect in this character in both seasons (Tables 13, 14. 15 and 16).

4.2.5 Number of cobs per meter square

There were no significant differences in number of cobs per meter square due to both nitrogen levels and sowing methods (Table 9).

However, there were highly significant differences (P=0.01) among maize cultivars in number of cobs per meter square in both seasons (Table 9). Dongola cultivar gave 89% and 117% greater number of cobs per plant than Hudeiba-1 and Hudeiba-2 in the first season and second season respectively. On the other hand, there was no significant differences between Hudeiba-1 and Hudeiba-2 in number of cobs per meter square in both seasons (Table 12).

Treatments interactions had no significant effect on number of cobs per meter square in both seasons (Tables 13, 14. 15 and 16).

4.2.6 Cob length (cm):

There were significant differences (P=0.05) in the cob length between nitrogen levels in the second season (Table 9), where129 kg N/ha gave greater cob length thancontrolbutdifferences between other nitrogen levels were statistically non-significant.

On the other hand, there were significant differences (P=0.05) between the two sowing methods in cob length in both seasons (Table 9). In the first season sowing on flats gave 8% significant increase in cob length than ridges, while the increase in the second season was 5% (Table11).

The analysis of variance indicated a highly significant difference (P=0.01) among maize cultivars in cob length in the first season andsignificant difference (p=0.05) in the second season (Table 9). In the first season Hudeiba-2 gave 67% significantly greater cob length than Dongola, whereas Hudeiba-1 increased cob length than Dongola by 23%. In the second season Hudeiba-2 had 7% significantly greater cob length than Dongola cultivar. There was nosignificant difference in cob length between Hudeib-1 and Dongola(Table 12).

There was no significant effect of treatments interactions on cob lengthin both seasons (Tables 13. 14. 15 and 16).

4.2.7 Thousand seed weight(gm):

The analysis of variance revealed significant differences (P=0.05) in thousand seeds weight due to nitrogen levels in both seasons (Table 9). The application of 86 and 43 kg/ha gave 6% and 5% increase in thousand seed weight over control in the first and second seasonrespectively,butdifferences between the fertilizer levels statistically not significant (Table 10). There were significant differences (P=0.05)in thousand seed weight between the two sowing methods in the first season (Table 9), whereflatsowing gave an increase of 14% in thousand seed weight in comparison to ridges.

There were nosignificant differences in thousand seed weight among the three cultivars of maize in both seasons (Table 9).

The statistical analysis indicated significant differences (P=0.05) in thousand seed weight between treatments interactions of nitrogen levels xcultivars,cultivars x sowing methods and nitrogen levels x cultivars x sowing methods in the second season. The treatment V3S1N1 recorded the highest increment of thousand seed weight (11% increase) over all other interactions (Tables 13, 14, 15 and 16).

4.2.8 Roots weight(gm):

The analysis of variance indicated significant differences (P=0.05) between nitrogen levels in roots weigh in both seasons(Table 9). In the first season the application of 129 kg/ha gave 63% significantly greater roots weight over control. In the second season the application of 43 kg/ha gave 19% increased in roots weight over control. There was no significant differences in root weight between the nitrogen levels in both seasons (Table 10).

Insignificant differences in roots weight were revealed in the statistical analysis due to both sowing methods and maize cultivars (Table 9). Moreover, there were no significant differences between treatments interactions in roots weight in both seasons.

4.2.9 Grain yield (tons/ha):

The statistical analysis revealed highly significant differences (P=0.01) in grain yield due to nitrogen levels in both seasons (Table 9). In the first season the application of 129 kg/ha gave 70% significantly greater grain yield over the control but differences between 43, 86 and 129 kg N/ha were statistically not significant. In the second season the application of 43 kg N/ha gave 57% significantly greater grain yield over the control, whereas there were no significant difference in grain yield between the application of 86 and 129 kg/ha (Table 10). There were no significant differences between the two sowing methods in grain yield in both seasons (Table 9).

The analysis of variance, however, indicated that maize cultivars showed highly significant differences (P=0.01) in grain yield in both seasons (Table 9). In the first season Hudeiba-1 produced 118% more grain yield thanDongola, whereas Hudeiba-2 produced 95% higher grain yield than Dongola. In the second season Hudeiba-2 produced 66% more grain yield over Dongola, whereas Hudeiba-1 gave 38% higher yield over Dongola. On the other hand, there was no significant difference between Hudeiba-1and Hudeiba-2 in grain yield (Table 12).

Treatments interactions of sowing methods, nitrogen levels and cultivars showed significant effect (p=0.05) on grain yield for nitrogen levels x sowing methods and cultivars x sowing methodsinteractions in both seasons (Table 13 and 15).

4.2.10 Harvest index (%):

The statistical analysis showed that there were highly significant differences (P=0.01) in harvest index between nitrogen levels in the first seasons and significant differences (P=0.05) in the second season (Table

9). In the first season the application of 43, 86 and 129 kg/ha decreased harvest index over control by 24%, 8% and 5%, respectively. In the second season the application of 43 kg/ha decreased harvest index by 46% over control. On the other hand, there no significant differences between nitrogen levels in harvest index (Table 10).

There were highly significant differences (P=0.01) in harvest index between the two sowing methods in the first season (Table 9), where sowing on flats decreased harvest indexthansowing on ridges.

Similarly, there were highly significant differences (P=0.01) in harvest index among maize cultivars in the first season and significant differences (P=0.05) in the second season (Table 9). In the first season Hudeiba-1 had 52% lower harvest index than Dongola, whereas Hudeiba-2 had 31% lower harvest index than Dongola. In the second season Hudeiba-1 had 16% lower harvest index than Dongola. On the other hand, there was no significant difference in harvest index between Hudeiba-2 and Dongola in this season(Table 12).

Interactions of cultivars and swing methods and interactions between the three factors showed highly significant effect (P=0.01) on harvest index.. The treatmentV2S2N3 increased harvest index by 6% over all interactions (Tables 15 and 16).

<u>Table (9)</u>:Effects of nitrogen levels and sowing methods on yield and yield components of three maize (*Zeamays*.L) cultivars during the winter seasons of 2013/2014 and 2014/2015

Source of variation	C		S		C×S		N		C×N		S×N		C×S×N	
Character	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
No of seeds/row	42.75**	14.71**	0.69 n.s	7.28*	1.08 n.s	1.77 n.s	1.00 n.s	1.16 n.s	1.13 n.s	1.25 n.s	0.61 n.s	1.07 n.s	0.76 n.s	0.59 n.s
No of rows /cob	18.08**	3.83 ns	0.22 n.s	1.73 ns	1.83 n.s	2.90 ns	2.43 n.s	0.32 ns	1.94n.s	1.07 n.s	1.15 n.s	0.75 ns	2.41 n.s	0.80 ns
No of seeds/cob	44.71**	14.75**	8.99*	5.36*	2.94 n.s	1.66n.s	0.40 n.s	0.66 n.s	0.95n.s	1.46 n.s	0.94 n.s	1.12 n.s	0.39 n.s	0.53 n.s
No of cobs/plant	29.68**	75.51**	0.95 n.s	0.95 n.s	0.95 n.s	0.95 n.s	0.26n.s	0.04n.s	0.26 n.s	0.04 n.s	0.60 n.s	0.66 n.s	0.60 n.s	0.66 n.s
No of cobs/m2	29.68**	75.51**	0.95 n.s	0.95 n.s	0.95 n.s	0.95 n.s	0.26 n.s	0.04 n.s	0.26 n.s	0.04 n.s	0.60 n.s	0.66 n.s	0.60 n.s	0.66 n.s
Cob length/ cm	43.04**	5.78*	8.52*	4.74*	2.93 n.s	1.53 n.s	0.93 n.s	3.40*	0.82 n.s	1.62 n.s	1.16 n.s	0.15 n.s	1.17 n.s	2.24n.s
Thousand seeds weight	2.86 n.s	3.44 n.s	4.20*	1.75n.s	0.81 n.s	4.78*	3.48*	3.79*	1.21 n.s	4.57*	0.85n.s	0.13 n.s	0.17 n.s	2.45*
Roots weight	2.53 n.s	1.17 n.s	0.56 n.s	1.02 n.s	1.36n.s	0.85 n.s	3.30*	4.11*	0.93 n.s	1.87 n.s	1.11n.s	1.09 n.s	0.75 n.s	1.28 n.s
Grain yield	31.11**	39.94**	2.87 n.s	3.00 n.s	4.65*	5.00*	14.23**	18.27**	1.12 n.s	1.26 n.s	3.02*	3.20*	1.09 n.s	1.41 n.s
Harvest index	35.17**	12.44*	14.73**	0.33 n.s	12.30**	0.01 n.s	10.14**	3.67*	2.13 n.s	0.82 n.s	1.99 n.s	0.52 n.s	4.77**	0.62 n.s

<u>Table (10</u>Effects of nitrogen levels on yield and yield components of three maize (*Zeamays* seasons of 2013/2014 and 2014/2015

Treatment	No of seeds/row		No of rows /cob		No of seeds/cob		No of cobs/plant		No of cobs/m2		cob length/cm		Thousand seeds weight/gm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
N0	20.59a	25.52a	15.02a	13.11a	309.26a	334.57a	1.25a	1.38a	12.50a	13.75a	16.89a	14.91b	238.20b	274.67b
N1	21.45a	26.52a	14.31a	13.34a	306.95a	353.78a	1.30a	1.39a	13.00a	13.88a	17.52a	15.48ab	250.00a	288.58a
N2	22.71a	26.66a	14.22a	13.29a	322.94a	354.31a	1.32a	1.40a	13.17a	13.96a	17.40a	15.50ab	252.08a	278.33a
N3	21.66a	25.72a	14.96a	13.37a	324.03a	343.88a	1.33a	1.40	13.25a	14.02a	16.62a	16.32a	249.31a	285.33a
Over all mean	21.60	26.11	14.63	13.28	315.80	346.64	1.30	1.39	12.98	13.90	17.11	15.55	247.40	281.73
SE±	0.87	0.53	0.27	0.21	17.65	9.61	0.07	0.06	0.66	0.60	0.44	0.32	5.07	3.31
LSD	2.46	1.25	0.77	0.49	20.00	22.75	0.18	0.17	1.86	1.77	1.25	0.89	11.04	13.74
C.V %	13.45	9.91	9.15	7.60	18.34	13.54	24.82	21.00	24.82	21.00	12.65	9.93	13.66	18.78

Means within column followed by the same letter (s)were not significant different according to Duncan's

<u>Table (11)</u>Effects sowing methods on yield and yield components of three maize (*Zeamays*.L) cul seasons of 2013/2014 and 2014/2015

Treat ment	No of seeds/row		No of rows /cob		No of seeds/cob		No of cobs/plant		No of cobs/m2		cob length/ cm		Thousand seeds weight/gm	
	1st season	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1t season**	**2nd season**	**1st season**	**2nd season**
S1	**21.14a**	**25.62b**	**14.55a**	**13.19a**	**307.59b**	**337.93b**	**1.27a**	**1.38a**	**12.67a**	**13.75a**	**16.48b**	**15.14b**	**228.82b**	**280.52a**
S2	**22.07a**	**26.59a**	**14.70a**	**13.37a**	**324.43a**	**355.51a**	**1.33a**	**1.41a**	**13.92a**	**14.06a**	**17.74a**	**15.96a**	**265.97a**	**282.94a**
me ans	**21.61**	**26.11**	**14.63**	**13.28**	**316.01**	**346.72**	**1.30**	**1.40**	**13.30**	**13.91**	**17.11**	**15.55**	**247.40**	**281.73**
SE ±	**0.87**	**0.25**	**0.27**	**0.09**	**17.65**	**4.84**	**0.07**	**0.02**	**0.66**	**0.23**	**0.44**	**0.27**	**2.64**	**13.31**
LS D	**2.93**	**0.93**	**0.83**	**0.35**	**45.17**	**17.50**	**0.16**	**0.17**	**1.67**	**1.74**	**1.12**	**0.98**	**14.40**	**73.42**
C. V %	**13.45**	**9.91**	**9.15**	**7.60**	**18.34**	**13.54**	**24.82**	**21.00**	**24.82**	**21.00**	**24.82**	**9.93**	**13.66**	**18.78**

Means within column followed by the same letter (s)were not significant different according to Duncan's

<u>Table (12)</u> Performance of cultivars in yield parameters of maize(*Zeamays*.L) along with their significa /2014)and (21014/2015)

Treatment	No of seeds/row		No of rows /cob		No of seeds/cob		No of cobs/plant		No of cobs/m2		cob length/ cm		Thousand seeds weight /gm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1t season	2nd season	1st season	2nd season
V1	22.30b	26.95a	15.45a	13.02a	344.54b	350.89a	1.00b	1.00b	10.00b	10.00b	16.21b	15.24b	256.25a	286.47a
V2	15.01c	23.95b	12.90b	13.02a	193.63c	311.83b	1.89a	2.17a	18.94a	21.72a	13.17c	15.15b	220.31a	265.91a
V3	27.49a	27.41a	15.54a	13.79a	427.19a	377.98a	1.00b	1.00b	10.00b	10.00b	21.94a	16.27a	265.63a	292.81a
Over all Mean	21.60	26.10	14.63	13.28	321.79	346.90	1.30	1.39	12.98	13.91	17.11	15.55	247.31	281.73
SE±	0.96	0.49	0.35	0.23	18.96	8.65	0.09	0.08	0.95	0.78	0.68	0.26	5.41	12.89
LSD	3.31	1.69	1.21	0.91	65.62	29.93	0.32	0.21	3.27	2.06	2.34	0.89	48.67	51.50
C.V %	13.45	9.91	9.15	7.60	18.34	13.54	24.82	21.00	24.82	21.00	12.65	9.93	13.66	18.78

Means within column followed by the same letter (s)were not significant different according to Duncan's Mult

Table (13) Effect of interaction between nitrogen levels and sowing methods on yield parameters of M significance ranking in seasons (2013 /2014)and (21014/2015)

Treatment	No of seeds/row		No of rows /cob		No of seeds/cob		No of cobs/plant		No of cobs/m2		cob length/cm		Thousand seeds weight/gm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1t season	2nd season	1st season	2nd seaso
S1×N0	21.00a	24.83a	15.26a	13.15a	320.46a	329.98a	1.38a	1.33a	11.83a	13.33a	16.95a	14.49a	262.50a	271.68
S1×N1	20.48a	26.81a	13.86a	13.31a	283.85a	357.84a	1.27a	1.44a	12.67a	14.42a	16.80a	15.15a	262.50a	290.83
S1×N2	22.44a	26.11a	14.08a	13.29a	315.96a	345.99a	1.25a	1.48a	12.50a	14.75a	16.37a	15.13a	266.67a	281.25
S1×N3	20.63a	24.74a	15.02a	13.02a	309.86a	324.36a	1.37a	1.40a	13.67a	13.50a	15.79a	15.81a	265.97a	278.33
S2×N0	20.18a	26.20a	14.79a	13.07a	298.46a	345.56a	1.32a	1.42a	13.17a	14.17a	16.83a	15.34a	275.70a	277.67
S2×N1	22.41a	26.23a	14.75a	13.38a	330.55a	349.23a	1.33a	1.33a	13.33a	13.33a	18.24a	15.80a	287.50a	286.33
S2×N2	22.98a	27.22a	14.36a	13.30a	329.99a	362.28a	1.38a	1.42a	13.83a	14.17a	18.43a	15.87a	285.42a	275.42
S2×N3	22.70a	26.70a	14.91a	13.71a	338.46a	365.47a	1.28a	1.46a	12.83a	14.58a	17.44a	16.83a	283.34a	292.33
Overall mean	21.60	26.11	14.63	13.28	315.95	347.59	1.32	1.41	13.10	14.03	17.11	15.55	273.70	282.8
SE±	1.23	0.75	0.39	0.29	24.95	13.59	0.09	0.05	0.93	0.48	0.62	0.45	7.16	18.83
LSD	3.47	1.77	1.09	0.69	70.75	32.17	0.26	0.25	2.63	2.51	1.77	1.05	18.77	53.38
CV %	13.45	9.91	9.15	7.60	18.34	13.54	24.82	21.00	24.82	21.00	12.65	9.93	13.66	18.75

Means within column followed by the same letter (s)were not significant different according to Duncan's

<u>Table (14)</u>Effect of interaction between nitrogen levels and cultivars on yield parameters of Maiz significance ranking in seasons (2013 /2014)and (21014/2015)

Treatment	No of seeds/row		No of rows /cob		No of seeds/cob		No of cobs/plant		No of cobs/m2		cob length/cm		Thousand seeds weight /gm	
	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{t} season	2^{nd} season	1^{st} season	2^{nd} season
V1× N0	19.69a	24.92a	15.83a	12.55a	311.69a	317.49a	1.00a	1.00a	10.00a	10.00a	16.22a	14.00a	287.50a	271.50 abc
V1× N1	23.48a	27.38a	14.90a	13.39a	349.85a	366.98a	1.00a	1.00a	10.00a	10.00a	15.95a	15.52a	287.50a	301.25a
V1× N2	24.17a	28.35a	15.44a	13.30a	373.18a	376.86a	1.00a	1.00a	10.00a	10.00a	17.36a	15.38a	275.00a	285.63 abc
V1× N3	21.88a	27.15a	15.62a	12.85a	341.77a	351.04a	1.00a	1.00a	10.00a	10.00a	15.33a	16.07a	262.50a	287.50 abc
V2× N0	14.27a	23.97a	13.51a	12.77a	192.79a	305.95a	1.75a	2.13a	17.50a	21.25a	12.37a	14.28a	240.63a	255.63c
V2× N1	12.89a	23.96a	12.33a	12.86a	158.93a	308.56a	1.90a	2.16a	19.00a	21.63a	13.63a	14.45a	250.00a	264.50 bc
V2× N2	16.41a	24.83a	12.77a	13.23a	209.56a	327.76a	1.95a	2.19a	19.50a	21.88a	13.03a	15.72a	271.88a	262.50c
V2× N3	16.49a	23.05a	12.99a	13.22a	213.56a	305.60a	1.98a	2.21a	19.75a	22.13a	13.39a	16.15a	278.13a	281.00 abc
V3× N0	20.97a	27.66a	15.73a	14.02a	329.86a	389.87a	1.00a	1.00a	10.00a	10.00a	21.82a	16.46a	279.17a	296.00 ab
V3× N1	27.97a	28.22a	15.69a	13.78a	438.84a	385.06a	1.00a	1.00a	10.00a	10.00a	22.99a	16.46a	287.50a	300.00a
V3× N2	27.55a	26.80a	14.44a	13.35a	397.82a	357.79a	1.00a	1.00a	10.00a	10.00a	21.81a	15.41a	281.25a	286.88 abc
V3× N3	26.63a	26.97a	16.28a	14.02a	433.54a	378.09a	1.00a	1.00a	10.00a	10.00a	21.14a	16.75a	283.34a	187.50 abc
Means	21.03	26.11	14.63	13.28	311.12	347.59	1.30	1.39	12.98	13.91	17.09	15.55	273.74	273.32
SE±	1.50	0.92	0.47	0.36	30.56	16.64	0.11	0.11	1.14	1.03	0.77	0.55	8.77	23.06
LSD	4.26	2.17	1.34	0.84	86.65	39.40	0.32	0.30	3.22	3.08	2.16	1.29	27.37	65.38
C.V %	13.45	9.91	9.15	7.60	18.34	13.54	24.82	21.00	24.82	21.00	12.65	9.93	13.66	18.78

Means within column followed by the same letter (s)were not significant different according to Duncan's Mult

<u>Table (15)</u>Effect of interaction between cultivars and sowing methods on yield parameters of Maize(*Zea*
significance ranking in seasons (2013 /2014)and (21014/2015)

Treatment	No of seeds/row		No of rows /cob		No of seeds/cob		No of cobs/plant		No of cobs/m2		cob length/cm		Thousand seeds weight /gm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1t season	2nd season	1st season	2nd seaso
V1×S1	21.60a	26.25a	15.00a	12.78a	324.00a	337.76a	1.00a	1.00a	10.00a	10.00a	15.96a	14.68a	271.88a	179.06
V1×S2	23.00a	27.66a	15.89a	13.26a	365.47a	368.43a	1.00a	1.00a	10.00a	10.00a	16.46a	15.80a	284.38a	193.88
V2×S1	15.65a	23.95a	13.20a	12.87a	206.58a	308.61a	1.80a	2.10a	18.00a	21.03a	12.91a	14.64a	248.44a	160.31
V2×S2	14.38a	23.96a	12.59a	13.17a	181.04a	315.33a	1.99a	2.22a	19.88a	22.19a	13.44a	15.66a	271.88a	171.50
V3×S1	26.15a	26.68a	15.45a	13.63a	404.02a	372.25a	1.00a	1.00a	10.00a	10.00a	20.57a	16.11a	272.92a	202.19
V3×S2	28.83a	28.14a	15.62a	13.66a	450.32a	383.15a	1.00a	1.00a	10.00a	10.00a	23.30a	16.42a	292.92a	183.44
Overall mean	21.60	26.11	14.63	13.23	321.90	347.59	1.30	1.39	12.98	13.87	17.11	15.55	273.74	181.73
SE±	1.38	0.44	0.39	0.16	21.18	8.38	0.08	0.04	0.78	0.39	0.53	0.46	4.57	34.43
LSD	4.39	1.40	1.25	0.52	67.75	26.79	0.26	0.27	3.54	2.61	1.68	1.47	41.67	110.1
C.V %	13.45	9.91	9.15	7.60	18.34	13.54	24.82	21.00	24.82	21.00	12.65	9.93	13.66	18.78

Means within column followed by the same letter (s)were not significant different according to Duncan's Mult

Table (16): Effect of interaction between nitrogen levels, sowing methods and cultivars on yield parameters of Maize in seasons (2013 & 2014)

Treatment	No of seeds/row		No of rows /cob		No of seeds/cob		No of cobs/plant		No of cobs/m2	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
V1×S1×N0	19.10a	24.51a	15.48a	12.36a	295.67a	309.12a	1.00a	1.00a	10.00a	10.00a
V1×S1×N1	22.03a	27.73a	13.98a	12.80a	307.98a	355.35a	1.00a	1.00a	10.00a	10.00a
V1×S1×N2	23.74a	26.58a	15.39a	13.28a	365.56a	352.89a	1.00a	1.00a	10.00a	10.00a
V1×S1×N3	21.55a	26.18a	15.16a	12.68a	326.70a	333.70a	1.00a	1.00a	10.00a	10.00a
V1×S2×N0	20.28a	25.33a	16.18a	12.73a	328.13a	325.87a	1.00a	1.00a	10.00a	10.00a
V1×S2×N1	24.93a	27.03a	15.83a	13.98a	394.64a	378.62a	1.00a	1.00a	10.00a	10.00a
V1×S2×N2	24.60a	30.13a	15.50a	13.32a	381.30a	400.83a	1.00a	1.00a	10.00a	10.00a
V1×S2×N3	22.20a	28.13a	16.08a	13.03a	356.98a	368.38a	1.00a	1.00a	10.00a	10.00a
V2×S1×N0	14.50a	23.63a	13.50a	12.90a	195.75a	305.0a	1.55a	2.00a	15.50a	20.00a
V2×S1×N1	13.50a	24.33a	12.83a	13.03a	173.21a	317.32a	1.80a	2.33a	18.00a	23.25a
V2×S1×N2	18.14a	25.75a	13.43a	13.15a	243.62a	337.08a	1.75a	2.13a	17.50a	21.25a
V2×S1×N3	16.63a	22.08a	13.06a	12.40a	217.19a	275.03a	2.10a	2.05a	21.00a	20.50a
V2×S2×N0	14.04a	24.31a	13.53a	12.63a	189.96a	306.89a	1.95a	2.25a	19.50a	22.50a
V2×S2×N1	12.43a	23.60a	11.83a	12.70a	147.05a	299.80a	2.00a	2.00a	20.00a	20.00a
V2×S2×N2	14.69a	23.91a	12.11a	13.31a	177.90a	318.44a	2.15a	2.25a	21.50a	22.50a
V2×S2×N3	16.35a	24.02a	12.91a	14.04a	211.08a	336.17a	1.85a	2.38a	18.50a	23.75a
V3×S1×N0	29.40a	26.36a	16.80a	14.20a	493.92a	375.80a	1.00a	1.00a	10.00a	10.00a
V3×S1×N1	26.06a	28.39a	14.77a	14.10a	384.91abcd	400.86a	1.00a	1.00a	10.00a	10.00a
V3×S1×N2	25.44a	25.99a	14.42a	13.43a	366.84abcd	348.01a	1.00a	1.00a	10.00a	10.00a
V3×S1×N3	23.70a	25.98a	16.83a	13.98a	398.87abc	364.35a	1.00a	1.00a	10.00a	10.00a
V3×S2×N0	26.22a	28.96a	14.67a	13.85a	384.65abcd	403.93a	1.00a	1.00a	10.00a	10.00a
V3×S2×N1	29.89a	28.05a	16.61a	13.45a	496.47a	369.26a	1.00a	1.00a	10.00a	10.00a
V3×S2×N2	29.67a	27.61a	15.46a	13.28a	458.70ab	367.57a	1.00a	1.00a	10.00a	10.00a
V3×S2×N3	29.56a	27.96a	15.73a	14.07a	464.98ab	391.84a	1.00a	1.00a	10.00a	10.00a
SE±	02.13	01.29	00.67	00.50	043.22	023.54	0.16	0.15	01.61	01.46
LSD	06.02	03.67	06.02	01.43	122.54	055.72	0.45	0.34	04.56	03.35
C.V %	13.45	09.91	09.15	07.60	018.34	013.54	24.82	21.00	24.82	21.00

Table (16) continue...

Treatment	Cob length/ cm		Thousand seeds weight /gm		Roots weight		Yield (tons/ha)		Harvest index %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
V1×S1×N0	17.72a	13.00a	257.50a	261.25jk	32.67	38.90a	3.84a	4.46da	26.56ij	23.50a
V1×S1×N1	15.15a	14.98a	267.50a	300.00abcde	42.33	45.35a	4.32a	5.81a	28.40fghij	22.62a
V1×S1×N2	16.73a	14.73a	250.00a	285.00efgh	75.00	47.60a	4.26a	5.90a	23.30fghij	22.93a
V1×S1×N3	14.26a	16.01a	262.50a	270.00hij	47.67	36.38a	4.76a	6.04a	26.90hij	23.52a
V1×S2×N0	14.72a	15.00a	257.50a	281.75fghi	63.33	38.10a	3.26a	4.72a	18.34ij	17.16a
V1×S2×N1	16.75a	16.05a	287.50a	302.50abcd	106.83	38.45a	4.62a	7.36a	24.00hij	25.76a
V1×S2×N2	17.99a	16.03a	280.00a	286.25defghi	89.33	42.93a	4.40da	6.21a	26.454eghij	27.68a
V1×S2×N3	16.40a	16.13a	262.50a	305.00abc	138.00	41.75a	4.04a	8.04a	28.12ghij	24.66a
V2×S1×N0	12.83a	13.83a	225.00a	246.25k	69.15	36.35a	2.36a	2.95a	28.89defgh	13.26a
V2×S1×N1	13.13a	13.59a	225.00a	262.50j	127.50	36.45a	2.04a	3.70a	30.13abcd	27.26a
V2×S1×N2	12.89a	15.55a	275.00a	258.76jk	101.68	37.28a	2.29a	5.05a	24.67bcd	21.76a
V2×S1×N3	12.76a	15.59a	268.50a	273.75ghij	100.85	35.53a	2.66a	4.06a	31.00defg	26.38a
V2×S2×N0	12.44a	14.73a	256.00a	265.00j	65.00	40.98a	1.31a	1.78a	14.00ij	14.68a
V2×S2×N1	14.13a	15.32a	275.00a	266.50ij	96.65	47.63a	2.63a	5.57a	32.00ab	27.58a
V2×S2×N2	13.17a	15.88a	268.50a	266.25defg	82.50	35.35a	2.57a	3.54a	27.10efghi	26.71a
V2×S2×N3	14.03a	16.71a	287.50a	288.25ab	96.65	41.98a	2.71a	3.67a	33.80a	25.59a
V3×S1×N0	20.31a	16.62a	265.00a	210.00abcde	15.50	49.98a	2.93a	5.01a	25.15fghij	16.29a
V3×S1×N1	22.13a	16.88a	275.00a	307.50a	25.50	40.60a	4.90a	7.73a	24.00abc	45.45a
V3×S1×N2	19.50a	15.10a	275.00a	300.00abcde	15.50	39.73a	4.79a	6.25a	22.89cdef	30.72a
V3×S1×N3	20.36a	15.83a	266.50a	291.25bcdef	15.50	44.18a	4.93a	5.89a	29.46bcde	20.47a
V3×S2×N0	23.33a	16.29a	283.00a	286.25defgh	17.00	38.98a	3.72a	4.90a	28.12ij	22.24a
V3×S2×N1	23.84a	16.04a	300.00a	290.00cdefg	11.50	37.68a	4.96a	7.30a	15.30ij	26.36a
V3×S2×N2	24.13a	15.71a	287.50a	273.75ghij	22.00	47.88a	4.77a	5.97a	13.60j	23.40a
V3×S2×N3	21.91a	17.66a	300.00a	283.75efgh	29.50	48.45a	4.88a	7.42a	25.46hij	30.35a
SE±	1.08	0.77	32.61	12.41	16.80	4.06	0.26	0.57	0.08	8.31
LSD	3.06	2.18	92.46	14.43	47.62	9.16	3.73	1.61	0.20	23.56
C.V %	12.65s	9.93	18.78	13.66	54.22s	69.96	26.97	21.16	39.46	45.78

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

4.3 Quality

4.3.1 Crude protein content (%):

The analysis of variance (Table 17) indicated that nitrogen levels had highly significant effect(P=0.01) on seed crude protein content in the second season, where the application of 43, 86 and 129 kg/ha increased crude protein over control by 3%, 5% and 7%, respectively.

However, there were no significant differences in crude protein due to sowing methods and maize cultivars in both seasons (Table 17). Interactions of cultivars and sowing methods showed significant effect (P=0.05) on crude protein in the first season.The treatment V3S2N2 increased crude protein by 3% over all combinations as presented in tables (21, 22, 23 and 24).

4.3.2 Crude fiber content (%):

The analysis of variance revealed highly significant effects (P=0.01) of the fertilizer levels in the second season (Table 17), where the application of 43 kg/ha increased crude fiber over control by 9%but there was no significant differences between the application of 86 and 129 kg/ha in crude fiber.

Similarly, there weresignificant difference (P=0.05) in crude fiber between the two sowing methods in the second season (Table 17), where flat sowing gave higher crude fiber content than ridges.

Also,highlysignificant differences (P=0.01) in statistical analysis in crude fiber among maize cultivars were detected in the second season (Table 17), where Hudeiba-1had 13% lower crude fiber than Dongolabut there was no significant difference in crude fiber between Hudeiba-2andDongola.

There were significant differences (P=0.05) between all treatments interactions in crude fiber (Table17). The treatment V2S2N1 increased crude fiber by 12% over all combinations as shown in tables (21, 22, 23 and 24).

<u>Table (17)</u>Effects of nitrogen and sowing methods on quality and efficiency of three maize (*Zea mays* .L) cultivars during the winter seasons of 2013/2014 and 2014/2015

Source of variation	C		S		C×S		N		C×N		S×N		C×S×N	
Character	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
Crude protein content	**0.49 n.s**	**1.18 n.s**	**0.59 n.s**	**1.17 n.s**	**1.03 n.s**	**1.70 n.s**	**1.78 n.s**	**42.78****	**5.90***	**0.63 n.s**	**2.40***	**0.15 n.s**	**3.11***	**0.55 n.s**
Crude fiber content	**0.15n.s**	**21.26****	**1.90 n.s**	**6.02***	**0.31 n.s**	**4.04***	**0.67 n.s**	**46.53****	**3.14***	**1.63 n.s**	**3.80***	**3.20***	**4.14***	**0.53 n.s**
Nitrogen use efficiency	**20.12****	**24.37****	**0.79 n.s**	**4.85***	**1.09 n.s**	**2.01 n.s**	**29.76****	**31.16****	**5.00***	**5.94***	**3.29***	**3.32***	**1.04 n.s**	**2.00 n.s**
Agronomic efficiency	**9.12***	**0.07 n.s**	**1.90 n.s**	**5.62***	**0.27 n.s**	**0.33 n.s**	**31.47****	**35.65****	**0.72 n.s**	**0.91 n.s**	**3.16***	**3.25***	**1.38 n.s**	**2.49 n.s**

<u>Table (18</u>))Effects of nitrogen levels on some quality of three maize (*Zea mays* .L) cultivars during the winter seasons of 2013/2014 and 2014/2015

Treatment	Crude Protein (%)		Crude Fiber (%)	
	1st Season	**2nd season**	**1st Season**	**2nd season**
N0	**10.33a**	**10.88d**	**4.10 a**	**3.60c**
N1	**10.35 a**	**11.20c**	**4.14 a**	**3.94b**
N2	**10.23 a**	**11.47b**	**4.12 a**	**4.05a**
N3	**10.31 a**	**11.61a**	**4.08 a**	**4.14a**
Overall mean	**10.31**	**11.29**	**4.11**	**4.48**
LSD	**00.12**	**00.14**	**0.17**	**0.09**
SE±	**00.04**	**00.04**	**0.06**	**0.03**
C.V%	**01.93**	**02.15**	**3.57**	**4.32**

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level

Table (19)Effects of sowing methods on some quality of three maize (*Zea mays* .L) cultivars during the winter seasons of 2013/2014 and 2014/2015

Treatment	Crude Protein (%)		Crude Fiber (%)	
	1st Season	2nd season	1st Season	2nd season
S1	10.11a	11.18a	3.84 a	3.88b
S2	10.50 a	11.40a	3.88 a	3.99a
Overall mean	10.31	11.29	3.86	3.94
LSD	02.32	01.33	2.11	0.20
SE±	00.36	00.21	0.35	0.03
C.V%	01.93	02.15	3.57	4.32

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

Table (20)Performance of cultivars in some quality characters of Maize(Zeamays.L) along with their significance ranking in winter seasons of 2013/2014 and 2014/2015

Treatment	Crude Protein (%)		Crude Fiber (%)	
	1st Season	2nd season	1st Season	2nd season
V1	10.33 a	10.73a	3.99 a	3.56b
V2	10.19 a	11.42a	3.77 a	4.10a
V3	10.38 a	11.70a	4.07 a	4.13a
Overall mean	10.30	11.28	3.94	3.93
LSD	00.48	03.18	2.49	0.24
SE±	00.14	00.46	0.72	0.06
C.V%	01.93	02.15	3.57	4.32

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

Table (21) **Effect of interaction between nitrogen levels and sowing methods on some quality characters of Maize(Zeamays.L) along with their significance ranking inwinter seasons of 2013/2014 and 2014/2015**

Treatment	Crude Protein (%)		Crude Fiber (%)	
	1st Season	2nd season	1st Season	2nd season
S1×N0	10.10c	10.74a	3.86b	3.53d
S1×N1	10.11 c	11.10a	3.65 b	3.91c
S1×N2	10.12 c	11.37a	3.84 b	4.00bc
S1×N3	10.09 c	11.49a	3.81 b	4.07ab
S2×N0	10.57a	11.01a	4.35a	3.67d
S2×N1	10.59a	11.29a	4.43 a	3.98bc
S2×N2	10.33b	11.57a	4.40 a	4.11ab
S2×N3	10.52c	11.73a	4.35 a	4.20a
Overall mean	10.30	11.29	4.09	3.93
LSD	00.16	00.98	0.24	0.14
SE±	00.06	00.07	0.08	0.05
C.V%	01.93	02.15	3.57	4.32

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

Table (22) **Effect of interaction between nitrogen levels and cultivars on some quality characters of Maize(Zeamays.L) along with their significance ranking in winter seasons of 2013/2014 and 2014/2015**

Treatment	Crude Protein (%)		Crude Fiber (%)	
	1st Season	2nd season	1st Season	2nd season
V1× N0	10.38ab	10.29a	3.98d	3.19a
V1× N1	10.36ab	10.74a	3.99cd	3.67a
V1× N2	10.31abc	10.93a	4.01cd	3.68a
V1× N3	10.27abc	10.98a	3.99cd	3.70a
V2× N0	10.17bc	11.04a	4.33a	3.73a
V2× N1	10.29abc	11.26a	4.30ab	4.06a
V2× N2	10.09c	11.63a	4.28ab	4.25ba
V2× N3	10.23abc	11.78a	4.16bc	4.38a
V3× N0	10.45a	11.31a	4.00cd	4.88a
V3× N1	10.40ab	11.59a	4.12cd	4.09a
V3× N2	10.28abc	11.85a	4.06cd	4.23a
V3× N3	10.42a	12.07a	4.10cd	4.33a
Overall mean	10.30	11.29	4.11	4.02
LSD	00.20	01.44	0.29	0.98
SE±	00.07	00.05	0.10	0.06
C.V%	01.93	02.15	3.57	4.32

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

<u>Table (23)</u> Effect of interaction between cultivars and sowing methods on some quality characters of Maize(Zeamays.L) along with their significance ranking inwinter seasons of 2013/2014 and 2014/2015

Treatment	Crude Protein (%)		Crude Fiber (%)	
	1st Season	2nd season	1st Season	2nd season
V1×S1	10.19a	10.72a	3.86 a	3.54c
V1×S2	10.47 a	10.74a	4.13 a	3.58c
V2×S1	9.91 a	11.05a	3.95 a	4.00b
V2×S2	10.48 a	11.80a	4.59 a	4.20a
V3×S1	10.22 a	11.76a	3.71 a	4.08ab
V3×S2	10.55 a	11.65a	4.43 a	4.18ab
Overall mean	10.30	11.29	4.11	3.93
LSD	02.01	02.32	1.83	0.18
SE±	00.63	00.36	0.57	0.05
C.V%	01.93	02.15	3.57	4.32

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

Table (24) **Effect of interaction between nitrogen levels, sowing methods and cultivars on some quality characters of Maize(Zeamays.L) along with their significance ranking in winter seasons of 2013/2014 and 2014/2015**

Treatment	Crude Protein (%)		Crude Fiber (%)	
	1st Season	2nd season	1st Season	2nd season
V1×S1×N0	10.20defg	10.29a	3.95efg	3.16a
V1× S1×N1	10.19efg	10.72a	3.80fghi	3.68a
V1× S1×N2	10.22defg	10.94a	3.82fghi	3.69a
V1× S1×N3	10.14fgh	10.95a	3.87efgh	3.63a
V1×S2×N0	10.57abc	10.30a	4.01def	3.22a
V1×S2×N1	10.53abcd	10.76a	4.19cd	3.67a
V1×S2×N2	10.40abcdef	10.92a	4.21cd	3.67a
V1×S2×N3	10.41h	11.00a	4.11de	3.77a
V2×S1×N0	9.85gh	10.54a	4.01def	3.67a
V2×S1×N1	9.96gh	10.92a	4.00def	3.98a
V2×S1×N2	9.96h	11.29a	3.95def	4.12a
V2×S1×N3	9.86abcde	11.46a	3.78fghi	4.26a
V2×S2×N0	10.50a	11.53a	4.60ab	3.80a
V2×S2×N1	10.61defg	11.60a	4.65a	4.14a
V2×S2×N2	10.23abc	11.97a	4.57ab	4.37a
V2×S2×N3	10.58bcdefg	12.10a	4.53ab	4.49a
V3×S1×N0	10.26efg	11.41a	3.61i	4.29a
V3×S1×N1	10.18efg	11.67a	3.74ghi	3.76a
V3×S1×N2	10.19efg	11.88a	3.70hi	4.06a
V3×S1×N3	10.25cdefg	12.07a	3.78fghi	4.19a
V3×S2×N0	10.37abcdef	11.21a	4.39efgh	4.33a
V3×S2×N1	10.62a	11.51a	4.51ab	3.99a
V3×S2×N2	10.63a	11.81a	4.41bc	4.12a
V3×S2×N3	10.59ab	12.07a	4.41bc	4.27a
Overall mean	10.39	11.29	4.11	3.93
SE±	00.28	00.21	0.42	0.09
LSD	00.10	01.23	0.18	0.25
C.V %	01.93	02.15	3.57	4.32

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

4.4 The efficiency

4.4.1 Nitrogen use efficiency (NUE) (kg/ha):

The analysis of variance indicated highly significant differences (P=0.01) in nitrogen use efficiency (NUE) due to nitrogen levels in both seasons (Table 17). In the first season 43 kg/ha had 51% and 66% higher nitrogen use efficiency over 86 and 129 kg/ha, respectively . In the second season 43 kg/ha had 56% and 69% significantly higher nitrogen use efficiency over 86 and 129 kg/ha, respectively (Table 25) and figure (1).

On the other hand, there were significant differences (P=0.05) in nitrogen use efficiency between the two sowing methods in the second season only (Table 17), where flat sowing gave10% significantly greater nitrogen use efficiency than ridges.

There were highly significant differences (P=0.01) in nitrogen use efficiency among maize cultivars in both season (Table 17). In the first season Hudeiba-1 gave 54% significantly higher nitrogen use efficiency thanDongola, whereas Hudeiba-2 had 49% higher nitrogen use efficiency than Dongola. In the second season Hudeiba-1 gave 32% significantly higher nitrogen use efficiency thanDongola, whereas Hudeiba-2 had 37% higher nitrogen use efficiency than Dongola (Table 27) and figure (3).

Treatments interactions between nitrogen levels and sowing methods and nitrogen and cultivars showed significant effect (P=0.05)on nitrogen use efficiency (Tables 28 and 29).

4.4.2 Agronomic efficiency (AE):

The statistical analysis revealed highly significant differences (P=0.01) in agronomic efficiency between nitrogen levels in both season (Table 17). The application of 43 kg/ha increased agronomic efficiency by 52% and 65% in comparison to 86 kg/ha in the first and second seasons, respectively. Also, the application of 43 kg/ha increased agronomic efficiency in comparison to 129 kg/ha by 65% and 72% in the first and second seasons, respectively (Table 25).

There were significant differences (P=0.05) in agronomic efficiency between the two sowing methods in the second season (Table 17), where flat sowing gave 32% significantly greater agronomic efficiency than ridges (Table 26) and figure (2).

There weresignificant differences (P=0.05) in agronomic efficiency among maize cultivars in the first season (Table 17), where Hudeib-1gave 82% significantly higheragronomic efficiency thanDongola, while Hudeiba-2 had 77% efficiency than Dongola

There were nosignificant effects of interactions on agronomic efficiency (Table 17) except interaction of nitrogen with sowing methods in both seasons (Tables 28, 29, 30 and 31).

Table (25) **Effect of nitrogen levels on efficiency of three maize (*Zeamays*.L) cultivars during the winter seasons of 2013/2014 and 2014/2015**

Treatment	Agronomic efficiency (kg grain/kg N-fertilizer)		Nitrogen use efficiency (kg/ha)	
	1st Season	**2nd season**	**1st Season**	**2nd season**
N0	-	-	-	-
N1	**46.74a**	**55.62a**	**114.88a**	**145.20a**
N2	**22.33b**	**19.23b**	**56.40b**	**63.81b**
N3	**15.97b**	**15.56b**	**38.68c**	**45.35c**
Overall mean	**28.35**	**30.14**	**69.99**	**84.79**
LSD	**09.08**	**10.64**	**05.22**	**08.46**
SE±	**02.27**	**03.70**	**02.14**	**02.98**
C.V%	**46.10**	**60.29**	**31.23**	**26.53**

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

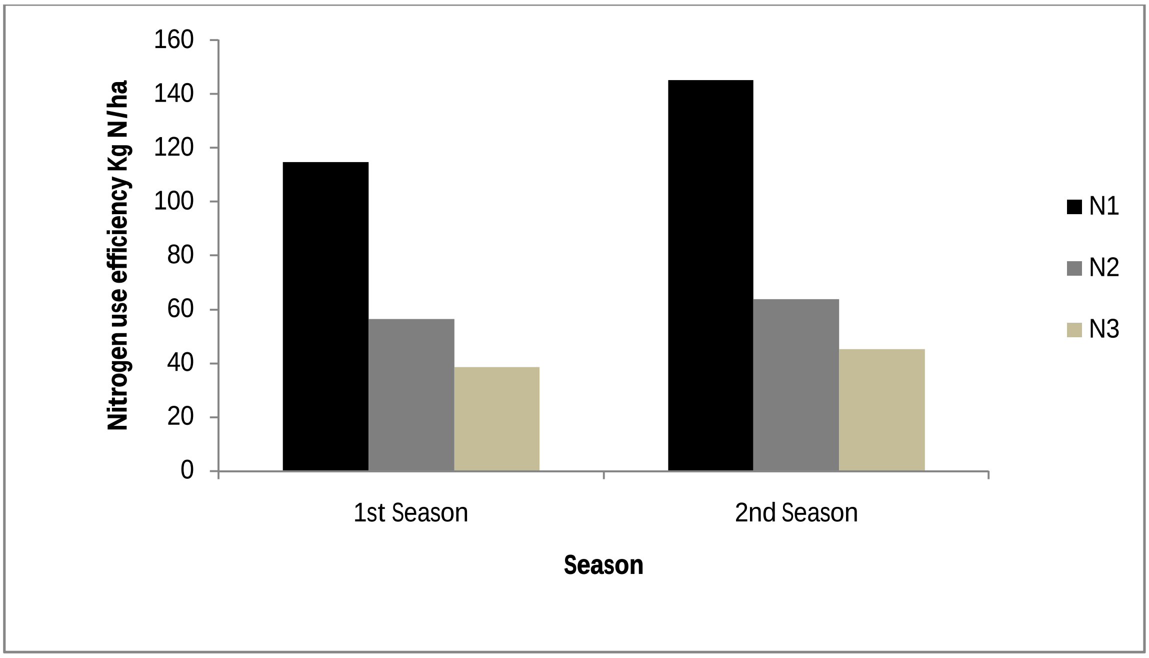

Fig.(4-1) Effect of nitrogen levels on nitrogen use efficiency of maize during 2013/2014 and 2014/2015

<u>Table (26)</u> Effect of sowing methods on efficiency of three maize (*Zeamays*.L) cultivars during the winter seasons of 2013/2014 and 2014/2015

Treatment	Agronomic efficiency (kg grain/kg N-fertilizer)		Nitrogen use efficiency (kg/ha)	
	1st Season	**2nd season**	**1st Season**	**2nd season**
S1	**23.48a**	**24.43b**	**57.56a**	**60.40b**
S2	**22.91a**	**35.85a**	**56.98a**	**66.78a**
Overall mean	**23.20**	**30.14**	**57.27**	**63.59**
LSD	**03.67**	**05.33**	**02.11**	**07.55**
SE±	**02.96**	**03.41**	**00.68**	**2.05**
C.V%	**46.10**	**60.29**	**31.23**	**26.53**

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

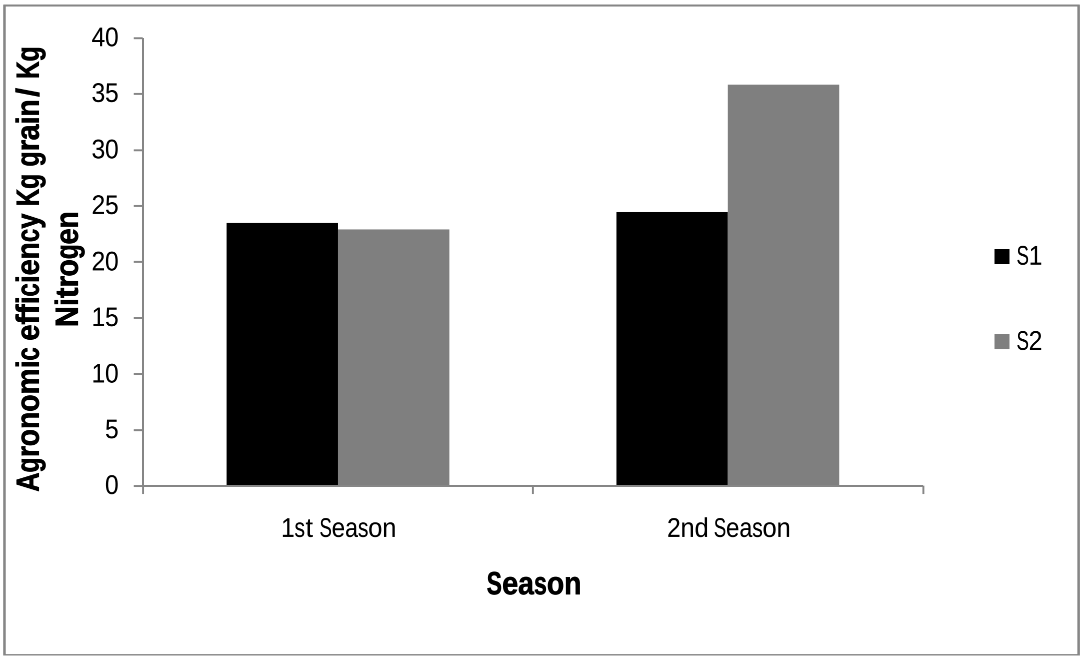

Fig.(4-2) Effect of sowing methods on agronomic efficiency of maize during 2013/2014 and 2014/2015

<u>Table (27)</u>Performance of cultivars on efficiency of Maize along with their significance ranking inthe winter seasons of 2013/2014 and 2014/2015

Treatment	Agronomic efficiency (kg grain/kg N-fertilizer)		Nitrogen use efficiency (kg/ha)	
	1st Season	**2nd season**	**1st Season**	**2nd season**
V1	**29.19a**	**28.99a**	**63.26a**	**69.50a**
V2	**5.11b**	**31.42a**	**28.95b**	**46.92b**
V3	**22.44a**	**30.03a**	**56.51a**	**74.36a**
Overall mean	**18.91**	**30.15**	**49.57**	**63.59**
LSD	**27.12**	**15.72**	**06.70**	**10.26**
SE±	**08.86**	**04.54**	**03.64**	**02.97**
C.V%	**46.10**	**60.29**	**31.23**	**26.53**

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

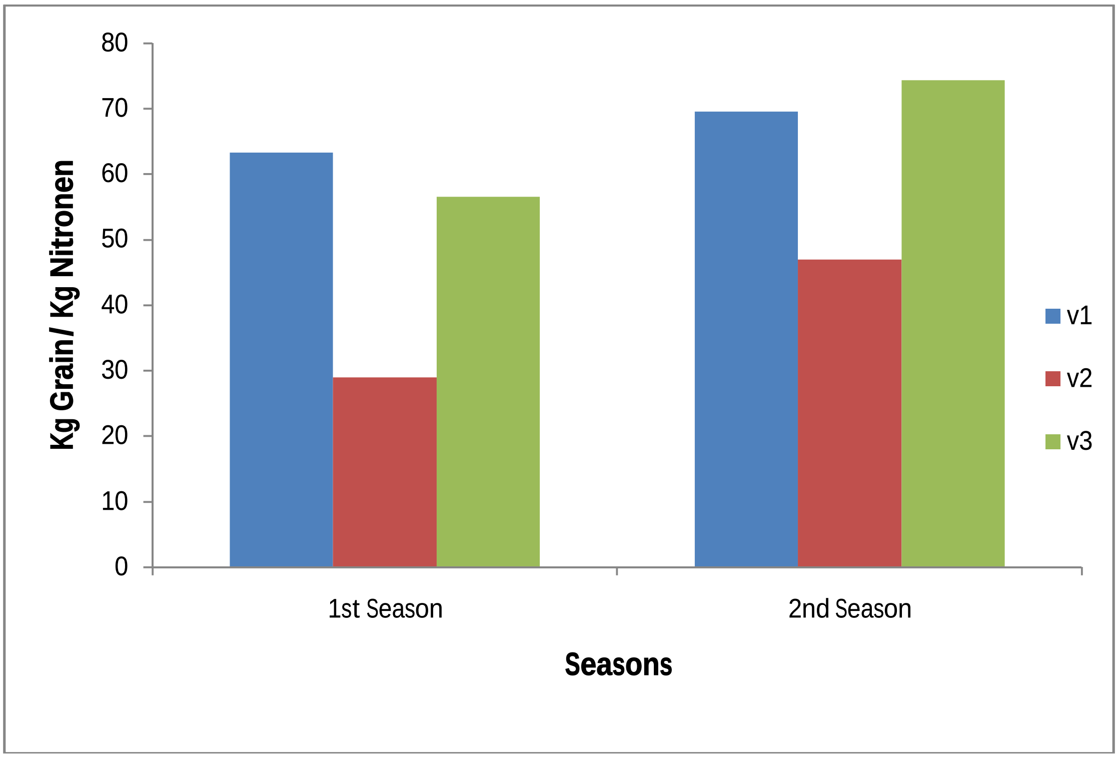

fig.(4-3) Effect of cultivars on nitrogen use efficiency of maize during 2013/2014 and 2014/2015

<u>Table (28)</u> Effect of interaction between nitrogen levels and sowing methods on efficiency of Maize along with their significance ranking inthe winter seasons of 2013/2014 and 2014/2015

Treatment	Agronomic efficiency (kg grain/kg N-fertilizer)		Nitrogen use efficiency (kg/ha)	
	1st Season	2nd season	1st Season	2nd season
S1×N0	-	-	-	-
S1×N1	40.00a	42.66b	112.09a	133.62b
S1×N2	19.53b	19.46c	55.58cd	66.68c
S1×N3	7.91c	11.16c	31.94e	41.31e
S2×N0	-	-	-	-
S2×N1	7.21c	68.58a	94.66b	156.78a
S2×N2	13.37c	19.01c	57.10c	60.94cd
S2×N3	8.60c	19.96c	37.74de	49.39de
Overall mean	16.10	30.14	64.85	84.79
LSD	18.30	15.04	10.25	11.96
SE±	06.35	05.24	05.13	04.22
C.V%	46.10	60.29	31.23	26.53

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

<u>Table (29)</u> Effect of interaction between nitrogen levelsand cultivars on efficiency of Maize along with their significance ranking inthe winter seasons of 2013/2014 and 2014/2015

Treatment	Agronomic efficiency (kg grain/kg N-fertilizer)		Nitrogen use efficiency (kg/ha)	
	1st Season	2nd season	1st Season	2nd season
V1× N0	-	-	-	-
V1× N1	23.72a	47.96a	127.21a	153.02b
V1× N2	12.79a	18.43a	64.53c	70.38d
V1× N3	7.37a	20.59a	41.86d	54.58de
V2× N0	-	-	-	-
V2× N1	0.23a	59.30a	56.51de	107.81c
V2× N2	0.12a	23.30a	28.25f	49.97e
V2× N3	2.02a	11.59a	20.78f	29.89f
V3× N0	-	-	-	-
V3× N1	25.58a	59.60a	114.65b	174.77a
V3× N2	11.05a	15.97a	55.58e	71.09d
V3× N3	8.29a	14.51a	37.98d	51.57e
Overall mean	10.13	30.14	60.82	84.79
LSD	24.12	18.42	18.29	16.91
SE±	08.23	06.42	07.36	05.96
C.V%	46.10	60.29	31.23	26.53

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

<u>Table (30)</u> Effect of interaction between cultivars and sowing methods on efficiency of Maize along with their significance ranking the winter seasons of 2013/2014 and 2014/2015

Treatment	Agronomic efficiency (kg grain/kg N-fertilizer)		Nitrogen use efficiency (kg/ha)	
	1st Season	2nd season	1st Season	2nd season
V1×S1	18.72a	23.09a	52.79a	62.60a
V1×S2	16.28a	34.89a	50.35a	76.39a
V2×S1	5.81a	21.12a	28.26a	44.05a
V2×S2	4.42a	41.67a	29.65a	49.78a
V3×S1	11.16a	29.05a	45.23a	74.55a
V3×S2	10.47a	30.99a	44.53a	74.16a
Overall mean	11.14	30.14	41.80	63.58
LSD	21.90	18.88	09.24	10.05
SE±	06.02	05.90	03.78	3.54
C.V%	46.10	60.29	31.23	26.53

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%

<u>Table (31)</u> Effect of interaction between nitrogen levels, sowing methods and cultivars on efficiency of Maize along with their significance ranking the winter seasons of 2013/2014 and 2014/2015

Treatment	Agronomic efficiency (kg grain/kg N-fertilizer)		Nitrogen use efficiency (kg/ha)	
	1st Season	2nd season	1st Season	2nd season
V1×S1×N0	-	-	-	-
V1× S1×N1	11.16a	34.24a	100.47a	135.00a
V1× S1×N2	4.88a	19.59a	49.43a	68.58a
V1× S1×N3	7.13a	15.46a	36.90a	46.83a
V1×S2×N0	-	-	-	-
V1×S2×N1	31.63a	61.67a	107.44a	171.05a
V1×S2×N2	13.26a	17.27a	51.16a	72.18a
V1×S2×N3	6.05a	25.72a	31.32a	62.33a
V2×S1×N0	-	-	-	-
V2×S1×N1	7.44a	30.41a	47.44a	86.04a
V2×S1×N2	0.81a	24.42a	26.63a	58.74a
V2×S1×N3	2.33a	8.55a	20.62a	31.42a
V2×S2×N0	-	-	-	-
V2×S2×N1	30.70a	88.19a	61.16a	129.58a
V2×S2×N2	14.65a	22.18a	29.88a	41.19a
V2×S2×N3	10.85a	14.63a	21.00a	28.36a
V3×S1×N0	-	-	-	-
V3×S1×N1	45.81a	63.32a	113.95a	179.83a
V3×S1×N2	21.63a	14.36a	55.70a	72.72a
V3×S1×N3	15.50a	9.48a	38.22a	45.67a
V3×S2×N0	-	-	-	-
V3×S2×N1	28.84a	55.87ba	115.35a	169.71a
V3×S2×N2	12.21a	17.59a	55.47a	69.46a
V3×S2×N3	8.99a	19.54a	37.83a	57.48a
Overall mean	15.22	30.14	55.53	84.79
SE±	10.07	09.08	8.56	8.44
LSD	28.17	26.06	21.16	23.91
C.V %	46.10	60.29	31.23	26.53

Means within column followed by the same letter (s)were not significant different according to Duncan's Multiple range test at 5%level.

CHAPTER FIVE

DISCUSSION

5.1 Vegetative Growth

Generally, most of the growth attributes studied showed significant response to nitrogen in the first season with exception of plant height after 60 days, stem diameter after 60 days and days to maturity.

The increase in plant height with different nitrogen levels can be attributed to the fact that nitrogen promotes plant growth, increases the number and length of the internodes, which results in progressive increase in plant height. Similar results were reported byGokmen*et al*., (2001), Mahamoud*et al*., (2001), Bakht*et al*., (2006), Dawadi and Sah (2012), Khan *et al*., (2012) andMoraditochaee*et al*.,(2012)who indicated that nitrogen enhanced and significantly increased plant height.

The results of this study indicated significant differences in stem diameter after 90 days between the nitrogenous fertilizer levels, where the application of 43 kg/ha gave the highest increase in stem diameter over control. The increase in stem diameter due to application of nitrogen can be explained by the fact that nitrogen promotes plants growth. Similar results were reported by Bakht*et al*., (2006) and Cheema*et al*.,(2010) who found that nitrogen significantly increased stem diameter.

Days to 50% tasselling were significantly affected by the nitrogenous fertilizer levels in the first season. Nitrogen application accelerated the time to reach 50% tasselling as compared to control. These results are in line withKalifa*et al*., (1981) andRasheed*et al*.,(2003) who indicated that nitrogen significantly increased days to 50% tasselling.

Number of leaves per plant was significantly affected by nitrogen levelsin the first season only, wherethe application of 86 kg/ha increased number of leaves per plant over control. The increase in number of leaves per plant could be ascribed to the fact that nitrogen often increases plant growth and plant height and this resulted in more nodes and internodes and subsequently more production of leaves. Similar results were indicated by many researchersAyub*et al.*, (2003),Bakht*et al.*, (2006) and Nadeem*et al.*, (2009).

Leaf area index was significantly increasedbynitrogen in the first season and the application of 129 kg/ha gave the greatest increase in leaf area index over control . Increase in leaf area index by nitrogen may be due to the fact that nitrogen increased number of leaves, leaf area and eventually total leaf area per plant. This result was similar to that found by Mohammed (1997),Rasheed*et al.*, (2003), Nadeem*et al.*, (2009) Cheema*et al.*, (2010) and Wasaya (2011).

In this study, stem diameter after 90 days and days to maturity exhibited significant differences due to sowing methods in both seasons, while leaf area index showed significant differences in the first season and days to 50% tasselling in the second season.

The results for plant height contrasted with those obtained by Majid*et al.*,(1986) Sandhu and Hundal(1991) and Sheikh *et al.*, (1994)who reported that sowing on ridges was significantly better.

This contradiction between the result of this study and other results can be attributed to the environment.The better growth on flats may be attributed to efficient utilization of resources by crop plants. On the other hand ,decrease of growth on ridges may be attributed to soil texture.

The result of this studyshowed significant differences between the three cultivars of maize in most vegetative growth parameters in both seasons. Significant differences among maize cultivars in growth characteristics have been reported by many researchers Ayub*et al.*,(2001),Bertoia*et al*,.(2006)Nemati and Sharifi (2012)(Sharifi*et al.*,(2012). This variation could be mainly due to genetic variations between the three cultivars.

The interaction between cultivars and sowing methods , nitrogen levels and cultivars had significant effect on days to maturity in both seasons. The interaction between nitrogen levels and cultivars showed significant effects on some vegetative growth parameters in the first season only. The interaction between cultivars and Sowing methods had significant effect in days to maturity and leaf area index in both seasons. The interaction between nitrogen levels, sowing methods and cultivars showed highly significant effects on leaf area index in the first season and significant effects on plant height after 90 days in the second season. These significant effects of interactions indicated that the three cultivars differentially to the environment.Maybe due to assimilation and uptake different between the three cultivars.

5.2 Yield and Yield Components

Maize yield is high with high fertilizer dose as maize grain yield is highly responsive to supplemental nitrogen (Moose and Below, 2008).

In this study, significant differences were detected in thousand seed weight, grain yield and harvest index due to nitrogenous fertilizer in both seasons. In addition significant differences in cob length between the fertilizer levels were detected in the first season. Similar results for thousands seeds weight byArif*et al.*, (2010),Delibaltova*et al.*, (2010) Gokmen*et al.*, (2010) Hammad*et al.*, (2010) Wasaya (2011) and Sharifai*et al.*, (2012)

There were highly significant difference in grain yield between nitrogen levels in both seasons. This result was similar to those reported byDoberman (2005) ,Badr and Authman (2006),Bakht*et al.*, (2006),Moose and Below (2008),Delibaltova*et al.*, (2010),Hammad*et al.*, (2011),Wasaya (2011) and Khan *et al.*, (2012) they found the same results.

The result showed that there were significant differences in harvest index between the fertilizer levels in both seasons. Similarly,Mahmoud*et al.*, (2001),Arif*et al.*, (2010) and Hammad*et al.*, (2011) and revealed that nitrogen had significant effect on harvest index. In contrast, Hoshang (2012) reported that there was no significant effect of nitrogen on harvest index.

The resultof this study revealed insignificant effect of nitrogen on yield and yield components studiedinboth seasons. Similar results were reported by Yilmaz and Karaaltun (2005). However, other works reported different findings Gokmen*et al.*, (2003),Mamo*et al.*, (2003) Arif*et al.*, (2010),Hammad*et al.*, (2010), Hussin*et al.*, (2010) and Khan *et al.*,

(2012) found significant effect of nitrogen on number of seeds per cob. Moreover,Delibaltova*et al*., (2010) found significant effect of nitrogen on number of seeds per row and number of rows per cob.

Also ,Arif*et al*., (2010) ,Hussin*et al*., (2010) andMoraditochaee*et al*., (2012) indicated significant differences in number of cobs per plant and number of cobs per meter square due to the increase in nitrogen levels.

In this study, effect sowing methods on some yield and yield components were significant. The results indicated that sowing method on flats was better in most of yield and yield components compared to ridges. This may be attributed to the efficient utilization of resources by crop plants with flat sowing.

On the other hand, this study indicated insignificant effect of two sowing methods on some yield attributes in both seasons namely number of rows per cob, number of cobs per plant, number of cobs per meter square, roots weight and grain yield. Similar results were reported bySharma (1980) who found that sowing maize crop on ridge or flat resulted in the same yield. However, Mahal*et al*., (2000) found that sowing on ridges resulted in higher yield than flat.

In this study, there were significant differences among the cultivars of maize in most of yield parameters studied in bothseasons.Cultivars differences with respect to yield have been reported byAyub*et al*, (1998),Ayub*et al*.,(2001) and Bertoia*et al*,.(2006). The variation in grain yield among cultivars could be attributed to differences in genetic makeup, environment and interaction between these aspects.

Interaction between the treatments had significant effects on grain yield and yield components.

5.3 Quality

The results of this study revealed highly significant differences in the second season and insignificant differences in the first season for both protein content and fiber content due to nitrogenous fertilizer. The increase in crude protein due to nitrogen can be attributed to the fact that nitrogen often plays a great role in the synthesis of protein. Similar results were obtained byAyub*et al*., (2003),Almodares*et al*., (2009).Nadeem*et al*., (2009) and Reddy and Bhanumurty (2010.

Similarly, nitrogen significantly increased fiber content while the lowest value was obtained from control. A similar result reported by Ayub et al., (2003) who indicated that higher nitrogen application significantly increased crude fiber.

Sowing methods significantly affected crude fiber content but they did not affected crude protein content.

The result of this study showed that therewassignificant differences in crude fiber content among maize cultivars in the second seasononly.Similar result was obtained by Ayub*et al*., (2001) who reported that maize cultivars did not differ significantly in crude fiber content.

On the other hand, there were no significant differences in crude protein content among maize cultivars in both seasons. This could be attributed to low genetic base. Similar result reported by Altin and Hunter (1984). In contrast to this result, Ayub*et al*., (2003) reported significant differences in crude protein between maize cultivars.

The interaction of the treatments showed significant effects on crude protein and crude fiber in the first season.

5.4 The Efficiency

The result of this study indicated a highly significant effect of nitrogenon nitrogen use efficiency (NUE)in both seasons. Nitrogen use efficiency decreased significantly with the increase of nitrogen rate. Probably this could be attributed to inability of plants unable to assimilate all of nitrogen taken up. Similar result was reported by Giambalvo*et al.*, (2009) who indicated that nitrogen use efficiency decreased with the increase of nitrogen rate because the plants were unable to assimilate all of nitrogen taken up.

Similarly, the result of this study revealedhighly significant differences in agronomic efficiency (AE) where agronomic efficiency decreased with higher nitrogen level.Indicates that maize requires low nitrogen fertilization to optimize yield.

The result of this study showed that there were significant differences between sowing methods in nitrogen use efficiency in the second season but there was no significant differences in the first season. Sowing the crop on flat gave greater nitrogen use efficiency than ridges, which may indicate that plants sown on the flat were more efficient in utilization of nitrogen than on ridges.

Similarly, differences between sowing methods in agronomic efficiency were significant in the second season only. Sowing the crop on flats resulted in higher agronomic efficiency than on ridges. Again this could be indicate higher efficiency of plants sown on flat in utilization of resources.

The result of this studyindicatedhighly significant differences in nitrogen use efficiency among maize cultivars in both seasons. The differences in nitrogen use efficiency between the three cultivars of maize may be due to the fact that improved cultivars usually have higher nutrient use efficiency than traditional cultivars.

On the other hand, this study indicated significant differences in agronomic efficiency among maize cultivars in the first season only.

The interaction of nitrogen levels and cultivars had significant effect on nitrogen use efficiency in both seasons, indicating that the cultivar Hudeiba-1 is more efficient in utilization of nitrogen. Also, the interaction of nitrogen levels and sowing methods was significant in nitrogen use efficiency in both seasons, indicating that plants sown on flats were more efficient in utilization of nitrogen.

Also, this study indicated significant effect of the interaction of nitrogen levels and sowing methods on agronomic efficiency in both seasons.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

The study was conducted during the seasons of 2013 / 2014- 2014/2015at the Farm of Agricultural Sciences, University of Dongola, Northern State, Sudan to study the effect of nitrogen and sowing methods on growth, yield and yield efficiency of three maize*(Zeamays*.L) cultivars under irrigation. The following conclusions were reached:

1. The nitrogen significantly increased most of vegetative growth characters in the first season with exception of plant height after 60 days, stem diameter after 60 days and days to maturity.
2. Increase in nitrogen levels gave highly significant increases in grain yield of maize in both seasons.
3. The fertilizer levels revealed significant effects on some of yield components namely thousand seeds weight, roots weight and harvest index in both seasons in addition to cob length in the second season.
4. Nitrogen had highly significant effects on the studied quality characters of maize which include crude protein and crude fiber in the second season.
5. Nitrogen significantly affected nitrogen use efficiency and agronomic efficiency of maize crop so thatnitrogen use efficiencydecreased with the increasing in nitrogen rate and thereby the crop requires low nitrogen fertilization to optimize grain yield.
6. The effect of sowing methods on vegetative growth was significant with regard to stem diameter after 90 days and days to maturity in both

seasons and leaf area index in the first season in addition to days to 50% tasselling in the second season.

7. Differences between sowing methods effect in yield and yield components were significant for number of seeds/cob and cob length in both seasons and thousand seeds weight and harvest index in the first season and number of seeds/row in the second season.
8. Differences between sowing methods led to significant differences in crude fiber in the second season but differences in crude proteinwerenotsignificant.
9. Sowing methods led to significant differences in agronomic efficiency and nitrogen use efficiency of maize in the second season only.
10. Differences among maize cultivars were significant in most of vegetative growth characters in both seasons with exception of plant height after 90 days, stem diameter after 60 and 90 days and number of leaves/plant which showed significant differences in the first season.
11. With exception of thousand seed weight and roots weight which showed insignificant differences in both seasons, differences among maize cultivars in most of yield and yield components were significant in both seasons namely number of seeds/row, number of seeds/cob, number of cobs/plant, number of cobs/meter square, cob length, grain yield and harvest index and number of rows/cob which showed significant differences in the first season.
12. Differences among maize cultivars in maize quality were significant with regard to crude fiber in the second season, but insignificant in crude protein in both seasons.
13. There were highly significant differences in nitrogen use efficiency in both seasons while there were significant differences in agronomic efficiency in the first season between the three cultivars of maize.

The study concludes with the following recommendations:

1- The optimum fertilizer level in high terraces soil is 43 kg N/ha.
2- Sowing the crop on flats is better than on ridges.
3- The cultivar Hudeiba-1 performed better in most characters studied and was more efficient in nitrogen use efficiency and productivity.
4- Improving nitrogen use efficiency can help in optimizing nitrogen use.
5- Since there are major winter crops which can be grown in the area (wheat, faba bean, funnel….etc) that compete with maize,the suggestion of growing the maize crop as a summer crop will help in intensification and diversification of the rotations of the agricultural schemes in the area.
6- More studies are needed on the study of nitrogen use efficiency and agronomic efficiency on high terraces soil.

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APPENDICES

Appendix (1) Climate of Northern State (desert climatic zone)

Sun light duration (hr/year)	3800
Solar radiation (MJ)m2/day)	23.1
Maximum temperature(˚C)	43 (July)
Minimum temperature(˚C)	8 (January)
Temperature (˚C)	35
Rainfall {mm/annum}	Less than100
Evaporation {mm /annum}	2500
Wind speed {km/hr}	15.7

Source: Adam (2002)

Appendix (2): Mean monthly temperature (˚C) at Dongola Meteorological Station during the experimental period 2013 and 2014

year	2013		2014	
Month	Mean temperature ˚C		Mean temperature ˚C	
February	Maximum	Minimum	Maximum	Minimum
	30	10	33	12
March	33	12	31	11
April	40	14	40	12
May	41	18	42	19

Source: Sudan Meteorological Station

Appendix (3) Characteristics of experimental site

Characteristics	Value
Ph (paste)	7.39
E.C (ds/m)	0.55
Caco3 %	8.43
Na (meq/L)	0.09
Ca+Mg (meq/L)	28.7
SAR (meq/L)	0.033
ESP %	0
Clay%	17
Silt%	11
Sand%	72

Source: Mahgoub (2012)