MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF IRRIGATED DURUM WHEAT *(Triticum durum* desf) VARIETIES IN K ADAWA SUDAN SAVANNA

BY

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A thesis submitted to the postgraduate school, Ahmadu Bello University, Zaria, in partial fulfillment of the requirements for the award of degree of Master of Science in Agronomy

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DECLARATION

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

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CERTIFICATION

This thesis entitled "MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF IRRIGATED DURUM WHEAT (*Triticum durum desf*) VARIETIES IN SUDAN SAVANNA" by Ibrahim Mohammed Jari meets the regulation governing the award of degree of Master of Science in Agronomy of Ahmadu Bello University Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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This work is dedicated to my grandfather Ummarun Dallaje (Emir of Katsina) for laying a concrete and solid foundation for the entire Dallazawa dynasty.

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ABSTRACT

Field trials were conducted at Irrigation Research Sub-station Farm of the Institute for Agricultural Research, Ahmadu Bello University, Kadawa (11°, 39'N 80°, 27' E and 500m above sea Level), during the 2002/2003 and 2003/2004 dry seasons to determine the morphological and physiological characteristics of Irrigated durum wheat varieties. The treatments consisted of fourteen Durum wheat varieties (Silver 13, Betriq5, Mexicali75, Minimus, Musk l5, Platal8, Nasser 5, SRN1/6, Anser, Spot, Tody's' Altar 84, SN-Turk and Silver 15). The treatments were laid out in a Randomized Complete Block Design, with three replications. The result had shown both similarities and variation in growth and development among the varieties tested. Minimus was observed to be superior to most of the varieties in terms of plant height, number of tillers, dry matter accumulation. The variety was also observed to record higher values in terms of number of grains per spike and grain yield. However, the grain yield produced by Minimus was observed to be statistically similar with that of other varieties except Tody's and Altar 84 that had the least grain yield. When grain yield was correlated with growth and yield components, positive and significant association was observed on plant height (0.3128), tiller number (0.3713) and number of grains per spike (0.3156), while negative and non significant correlation was observed with dry matter accumulation (-0.008).

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Origin

The wheat (*Triticum spp*) is a cereal that belongs to the family Poaceae and evolved in the Middle East through repeated hybridization of *Triticum species* (*Triticum monococum*, *T. tauchii* and unknown diploid wild grass) with closely related grass genus, *egilops* (Oz, and David, 2001). However, bread wheat (*Triticum aestivum*) is believed to have originated from South Western Asia. Some of the earliest remains of the crop has been found in Syria, Jordan and Turkey (Gibson and Benson, 2002). Though its actual origin is not known, it is believed to have been under cultivation in the Middle East as far back as the 5^{th} century B.C.

1.2 Production Trend

Wheat is the most important and the most extensively grain grown crop in the world. In 2008, total world production of wheat was estimated at 690 millions metric tonnes from 223 millions hectares of land. In Africa wheat production was estimated at 21,128723 millions metric tonnes from 9 million hectares of land while in Nigeria the production figure was 53,000 tonnes from 32,000 hectares of land (FAOSTAT, 2008).

Most of durum wheat is grown in Mediterranean countries, the former Soviet Union, North America and Argentina (Wikipedia, 2007). However, the largest producer of durum wheat is Canada, where it is the third most prominent crop, after red spring wheat. In Nigeria, wheat cultivation, which dates back to the sixteenth century, is done under irrigation during the dry but cool weather condition in the savanna ecological zones between latitudes 10^0 and 14^0 N and in areas of altitudes 240-360m above sea level. The state of Jigawa, Borno, Sokoto, Kano and Katsina are the main producing areas of the country. The highlands of Jos, Mambilla and Obudu are potential lands for the production of wheat.

Although wheat is essentially a temperate crop, whose production is mainly in Europe, America, Asia, North, East and Southern Africa, it is successfully grown in small quantity in West and Central Africa on high altitude and during the dry and cool season under irrigation (Olugbemi, 1973).

1.3. Importance and Uses

Wheat for human consumption is prepared in different forms to suit different classes of people. Bread is the principal food made from wheat. Wheat flour is the major ingredient in biscuit, cookies, macaroni, spaghetti and other confectioneries. In Nigeria, Mustapha (1998) reported that locally, wheat flour is used in making Taliya, Finkaso, Alkaki, Tabiska, Masa, Tuwo, Gurasa, Puff-puff, Chincin and other local dishes. Industrially, wheat starch is used in paper, textile and laundry industries. Wheat is use in making industrial sugar and fermented for alcohol production. Extracted gluten can be used to improve the protein content of baked products. A significant amount of wheat is also used as animal feeds.

1.4 Justification

Nigeria has made a lot of effort towards reducing net import of wheat by encouraging local production, through the establishment of River Basin Authorities to provide large irrigation facilities and the introduction of accelerated wheat programme in the wheat producing areas. However, wheat production in Nigeria is still characterized by low yield, few improved varieties, poor water and fertilizer management, weed and soil problem at farmers' field.

The introduction of varieties with genetics potential adapted to the growing zone will lead to increased output and profit by farmers. This will meet up with rising demand for wheat that resulted from the rapidly expanding population of Nigeria, hence narrowing the gap between production and consumption. Introduction of varieties adapted to the Nigeria wheat growing conditions will go a long way in raising the income of wheat farmers, thus boosting total production.

Among the yield determinants in wheat are genetic potentials of a particular wheat variety which play vital roles in improving the grain yield per hectare. The introduction of new high yielding and adaptable wheat varieties in to the country will therefore improve the economy.

1.5 Objectives

1. To determine the morphological and physiological characteristics of different durum wheat varieties.
2. To find out which of the varieties are suitable for Sudan savanna.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 *Varieties*

Wheat varieties differ physiologically and morphologically. The gene by environment interaction are shown phenotypically through plant height, tiller number per plant, number of plants per unit area, total biomass, leaf area index, crop growth rate, length of spike, days to flowering, physiological maturity, spikelets per spike, 1000-grain weight, grain yield and harvest index (Abubakar, 1999).

Marked phenotypic difference in heights is manifested in cultivars. Height ranges from 30 cm in dwarf varieties to 150 cm in tall varieties. Several genes have been identified to reduce height in wheat plant (Gale and Youssefian, 1985). Cultivars with Rht1 and Rht 2 dwarfing genes are shorter than those without the dwarfing genes (Allan, 1983). Cultivars vary in tillering ability (Sutton *et al.*, 1986; Krenzer and Nipps 1991). Cultivars having winter habit produce more tillers than those with spring habits (Sutton *et al.*, 1986).

Early maturing cultivars such as "Siete cerros" produce fewer tillers than late maturing ones such as "Tusson" (Olugbemi *et al.*, 1981). Kulthrestha and Jain (1978) reported that the semi-dwarf wheat had higher harvest index, kernel weight and tiller number than tall types found in hexaploid wheat. Fischer *et al.* (1981) and McClung *et al.* (1986) also observed that the semi-dwarf wheat had a higher yield capacity, which they attributed to greater carbon dioxide leaf permeability.

Wheat varieties commonly show compensation in yield components. Several workers have highlighted the negative relationship between number of grains and their average weight. The increased grain setting abil ty of modern versus old, semi-dwarf versus tall cultivars was partially compensated by decrease in average grain weight (Slafer *et al.*, 1996). Stapper and Fischer (1990) also observed that grain number was associated with low grain weight and vice versa both within and between genotypes.

An important factor for the choice of varieties in agronomic studies is their response to biotic stresses. The various classes of wheat varieties and their progenies have demonstrated a superior level of tolerance to drought and heat and improved nutrient efficiency and utilization (Abubakar, 1999). These wheat are not only high yielding but invariably have demonstrated superior stability under low input conditions (Rajaram and Van Ginkel, 1996). While they have large number of grains per spike, their grain size is smaller (Kronstad, 1996). Rajaram *et al.* (1992) observed that agronomic component that were consistently different among cultivars were grain yield per ear and grain weight. Bonciarelli (1983) observed that, even varieties with similar grain yield have marked and consistent differences in yield components with the greater variation accruing to the grain number per ear (21-44) and ear number per m^2.

2.2 Growth Character of Different Durum Varieties

Growth in crop plants is a function of both genetic composition and environment. Fischer (1983) reported that depending on conditions, wheat genotypes vary in their flag leaf area ranging from 22 to 54 cm^2. Abubakar (1991) reported a flag leaf area of 25.8

and 27.0cm^2 for "*Siete cerros*" and "Florence Aurore 8193", respectively. Leaf angle varies with genotypes, especially after the vegetative period.

Leaves of same genotypes, usually those with small leaves, resist bending and produce eractophile canopies (Abubakar, 1991).

Tahakashi and Gotoh (1989) reported that the rate of dry weight increase was higher at initial stage of plant growth and reached maximum during the reproductive phase. Sayed and Ghandora (1983) reported significant increase in grain filling rates for durum wheat genotyes. Negedu (1994) reported that dry matter accumulation by "Florence Aurore 8193" was significantly higher than for "Siete cerros". Natrova (1984) observed that dry matter and period of grain growth were significantly influenced by year and cultivar interaction.

Sutton *et al.* (1986) reported a significant difference in tillering capacity of wheat cultivars, with cultivars having winter habit producing more tillers than those having spring habit. Early maturing varieties such a "Siete cerros" and "ww-844" produced fewer tillers than late maturing one's like "Tusson" (Olugbemi *et al.*, 1981). However, Gupta (1975) reported that, the extent of tillering varies greatly with conditions ranging from complete absence to development of several tillers. Austin *et al.* (1980) as well as Perry and D' Antounio (1989) attributed yield increase to improvement in harvest index. Nass (1973) reported varietal difference in harvest index with modern cultivars having significant higher harvest index than non-dwarf ones. Sani and Nada (1984) reported that harvest index will decline when there is an inverse partitioning of dry matter between ear and stem.

In a study of dry matter production of wheat and Triticale varieties in India, Lal *et al.* (1979) found that dry matter accumulation in plant followed almost a sigmoid pattern with respect to time. The leaf and culm dry matter increased with crop age but dropped after reaching a maximum, depending on variety.

In an experiment at Kadawa, it was observed that "Florence Aurore 8193" was significantly taller than "Siete ceros" and additionally produced more straw yield at harvest (Abubakar, 1991; Negedu, 1994). Joppa (1973) found that the Semi-dwarf genotypes had increased tillering capacity than the tall genotype. Waddington *et al.* (1986) reported high biomass production is associated with long duration genotypes. Campbell *et al.* (1981) suggested that condition of growth prior to anthesis influences the yield not only by the number of grains but also by determining the ultimate magnitude of the organs involved in the storages of the grain dry matter. Grain yield of durum wheat (*Triticum turgidum* L. var. *durum*) under meditreanean conditions is frequently limited by both high temperature and drought during grain growth (Garcia del Moral, *et al.*, 2003).

2.3 Plant Height

Plant height is governed by genetic factor as well as by crop nutrition and environmental factors (Hud and Baker, 1989).Tall growing varieties has weak straw and is susceptible to lodging on application of nitrogen (Malavia et al., 1987; Mekenzie and Se, 1989). On the other hand Pali *et al.* (1987) reported that dwarf and semi-dwarf varieties have stiff straw and are respondinge to fertilizer application. Similarly, Philipeak (1987) observed that the high-yield, short-strawed variety "Polukerlik 2" differed from the tall "Akhtyr" in having a more vigorous photosynthetic apparatus and greater increase in photochemical activities of the chloroplast in response to mineral nutrition. However, the shortest genotypes were more sensitive to heat stress during filling stage than tall or semi-dwarf genotypes (Hoogendova and Gale, 1988). Plant height has direct effect on genotype versus environment interaction and influence on yield (Knezevic *et al.*, 2001)

2.4 Yield and Yield Components

2.4.1 Number of spikes/m^2

An important yield component of wheat is the number of spikes per unit area. Marked genetic variability for grain yield and its component has been reported. Adray and Al-Fahady (1987) reported that number of ears (spikes) per unit area was positively correlated with yield. Similarly, Bangarwa *et al.* (1989) in correlation and path-co-efficient analysis of yield and its components in 22 wheat population revealed that grain yield per plant was highly and positively correlated with spikes per plant.

2.4.2 Number of grains per spikes

The number of grain per spike is one of the most important yield attributes of wheat. Slafer *et al.* (1996) reported that grain number per spike is the yield components most affected by selection. High number of grains per m^{-2} in modern varieties was related to the production of higher number of grains per spike relative to the old varieties (Uddi and Marshal, 1989; Kofpen and Mersebugen 1989; Adray and Al-Fahady, 1987). Researchers that have reported positive and significant correlation of grain number with yield include Yu *et al.* (1988), Allan et al. (1989) and Hung *et al.* (1989).The number of kernels per spike had a significant contribution to grain yield, especially under drought conditions (L.F. Garcia del moral *et al.*, 2003).

2.4.3 1000- grain weight

Various researchers have reported their findings on 1000-grain weight of wheat. According to Goziniomoro (1989), Gogas (1989) and Hadji (1989), high 1000-grain weight had contributed to high grain yield of varieties. Figures ranging between 30 and 50g per 1000 grains have been recorded by many workers. Others that have confirmed that 1000 grain was among the yield attribute of wheat were Roya and Rogoga (1988) and Maudilouch (1989) as well as Abubakar (1999). In addition 1000 kernel weight was found to have positive direct effect on the yield. (Koksal, 2009).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The research was conducted at the Irrigation Research Sub-Station Farm of the Institute for Agricultural Research, Ahmadu Bello University, at Kadawa, Kano state during the 2002/2003 and 2003/2004 dry seasons. The sub-station is located at Sudan savanna ecological zone of Nigeria (11^0, 39'N 80^0, 27 'E and 500m above sea level).The soil of the experimental site was found to be sandy loam with low organic carbon and nitrogen content (Appendices 1). However, the dry season start about mid-October to the end of April. The months of November to March are rainless and characterized y low temperatures. The temperature ranged from 12.7^0C and 40.3^0C in 2002 / 2003 and 11.7^0C and 43.2^0C in 2003 / 2004.The relative humidity also ranges between 15-78% in 2002 / 2003 and 12-66% in 2003 / 2004 (11 and 111).

3.2 Physico-chemical Properties of the Soil

Prior to the establishment of the trial in each season, composite soil samples were taken from depths of 0-15 cm and 15-30 cm of the experimental field. The samples were air dried and analyzed for physical and chemical properties (Appendix 1) using standard procedures as recommended by AOAC (1980).

3.3 Treatments and Experimental Design

The treatments consisted of fourteen Durum wheat varieties (Silver 13, Betriq 4, Mexicali 75, Minimus, Musk 15, Silver 15, Plata 18, Nasser 5, SR N1/6, Ansar 8, Spot, Tody's'' Altar 84, and SN Turk) which were laid out in Randomized complete Block Design (RCBD) and replicated three times. The gross plot size was 4m x 3m, while each of the net plots measured 2m x 3m.

3.4 Seed Source

The seeds of the varieties were sourced from Lake Chad Research Institute (LCRI) Maiduguri, Borno State.

3.5 Cultural Practices

3.5.1 Land preparation

In each of the trial season, the experimental site was ploughed, harrowed and leveled to obtain a fine tilth for proper germination of seeds. Later, the land was divided into basins, and channels for proper irrigation and drainage.

3.5.2 Sowing

The seeds were sown manually by hand drilling at the rate of 100 kg per hectare in rows 20 cm apart, on 15 and 20 December, in 2002 and 2003, respectively. The seeds were dressed with Apron plus (10% matexyl, 6% carbon, 34% furathiocarb) at the rate of one sachet per 2kg of seeds before sowing to ensure protection against seedling diseases and pests.

3.5.3 Fertilizer application

Nitrogen, phosphorous and potassium were applied to the plots using the recommended dose 120 kg N, 60kgP_2O_5 (50kg P) and 60kgK_2Okgha^{-1} (26.6kg K). All the phosphorous and potassium and half of nitrogen were applied at planting. The remaining half dose of nitrogen was applied at six weeks after sowing. The first dose of the nutrients was supplied by NPK 15:15:15 whereas the second dose of nitrogen was supplied by Urea (46%N) using broadcast method.

3.5.4 Weeding

Weeding was carried out manually using hoe at three and six weeks after sowing. This ensured long season weed control during the two seasons of the experiment.

3.5.5 Irrigation

Irrigation was applied immediately after sowing and thereafter at a weekly interval until crop reached physiological maturity. Irrigation was stopped at 2 weeks before harvest to hasten maturity and facilitate harvesting operations.

3.5.6 Pest and disease control

No pest or disease incidence was recorded during the conduct of the experiment.

3.5.7 Harvesting and threshing

The crop was harvested at maturity. Maturity was determined when more than 75% of the peduncles of the crop had turned brown. The harvesting was done on the 7th

May 2003 for the first trial and 14th May 2004 for the repeat trial by cutting as close to the ground as possible with a sickle to avoid substantial loss of biomass. Each of the net plots was harvested and packed into heap, dried in the field and threshed plot by plot. The seeds were cleaned, dried and weighed on per plot basis.

3.6 Observation and Data Collection

Five tagged plants, in each plot were used for the purpose of measuring growth parameters at 3, 6, 9 and 12 WAS.

3.6.1 Plant height

Heights of the five tagged plants were measured from the ground level to tip of the canopy leaf at vegetative stage. While at reproductive stage, height was measured from the base of the plant to the peak of the spike.

3.6.2 Flag leaf area

The length and the breath of flag leaf from each of the tagged plant per treatment was measured and multiplied by a factor 0.75 to get the leaf area.

3.6.3 Leaf area index

Leaf area so obtained in 3.6.2 above, was multiplied by the number of leaves per plant and divided by the land area occupied by plant to obtained LAI per treatment.

$$LAI = \frac{Total\ Leaf\ Area}{Land\ area\ occupied\ plant}$$

3.6.4 Dry matter accumulation (gm^2)

Plants from 25cm linear row length were collected from each plot and oven-dried at 75^{0}C to a constant weight. The oven-dried leaves and stems were weighed and the values obtained were expressed in gm^2. The samples were weighed using top loading digital balance.

3.6.5 Relative growth rate (RGR)

Increase in plant material per unit of initial plant material per unit of time was determined as described by Radford (1967) using the formula below:

$$RGR = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1} = gg^{-1}wk^{-1}$$

Where W_1 and W_2 are the dry weights of the plants while t_1 and t_2 are the times.

3.6.6 Net assimilation rate (NAR)

This measures the photosynthetic efficiency of the assimilatory surface. It was also computed using formula suggested by Watson (1958).

$$NAR = \frac{LogA_2 - LogA_1}{t_2 - t_1 \quad A_2 - A_1} \; gg^{-1}wk^{-1}$$

Where W_1 and W_2 are the dry weights of the plants and t_1 and t_2 are the times

3.6.7 Crop growth rate

The rate of dry matter production per unit of time or dry matter increment per unit of area of land per unit time was determined by the formula described by Radford (1967). This is defined as the change in dry weight per unit of land area per unit of time and worked as per the formula.

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \quad gg^{-1}wk^{-1}$$

Where W_2 and W_1 are dry weights of the plants in g/plant at times t_1 and t_2, weeks respectively.

3.6.8 Number of tiller per m^2

Number of tillers was counted at 7 WAS from 25cm linear row of each plot taken at random, and was later expressed as tiller m^{-2}.

3.6.9 Days to 50% anthesis

The number of days to anthesis was determined when 50% of spikes from the time of planting had extruded at least one anther. This was recorded for each plot.

3.6.10 Days to physiological maturity

The number of days to physiological maturity per each of the plot was determined when more than 50% of the peduncles have turned golden yellow at the time of planting.

3.6.11 Number of spikes/m^2

The was determined by counting the number of spikes from two rows of 0.5 meter length for each treatment and number of spikes per m^2 calculated therefrom.

3.6.12 Length of spike (cm)

The length of the spike was measured from the point of attachment of spike to the peduncle. The average length of five samples per treatment was recorded. The lengths were measured using meter rule.

3.6.13 Number of spikelets/spike

Five plants were tagged in each plot and their spikes were picked and the number of spikelet per each was counted. An average value for the number of spikelet/spike treatment was recorded.

3.6.14 Number of grain/spike

The grains from five (5) spikes were obtained and counted after threshing and the average number of grains/spikes in each treatment recorded.

3.6.15 1000- grain weight

This was estimated by taking sample from each plot. One thousand grains were counted and weighed. The weight for each plot thereafter recorded.

3.6.16 Grain yield (Kg/ha)

This was computed from yield of individual net plot which was recorded in kilogramme per plot and later converted to kilogramme per hectare.

3.7 Meteorological Data

Data on temperature, relative humidity and sunshine hours during the period of the experiment were collected from the meteorological unit of Irrigation Research Station Kadawa and is presented in Appendix 2.

3.8 Statistical Analysis

The data collected were subjected to statistical analysis of variance and the means of such treatments were then compared using the Duncan Multiple Range Test (Duncan, 1955). Correlation coefficients were worked out as described by Snedecor and Cochran (1967) to determine the relationship between the growth characters, yield components and grain yield. Path coefficient analysis was used to determine the nature and extent of direct and indirect effect of yield components as described by Dewey and Lu, (1959) and Wright (1960). The percentage contribution of individual yield components and their combined contributions and residual were worked out as per the procedure suggested by Ajala *et al.* (1996).

CHAPTER FOUR

4.0 RESULTS

4.1 Plant Height

Table 4.1 and 4.2 showed the plant height of fourteen varieties of durum wheat. The variation in height among these varieties was significant only at 9 WAS of both seasons. In 2002 / 2003, Ansar was taller only than SN-Turk while 2003/2004, Betriq 5 variety had taller plant than Minimus. Other varieties produced similar plant heights.

4.2 Tiller Number per Plant

Table 4.3 showed the tiller number of fourteen varieties of durum wheat in 2002 /2003, 2004 / 2004 and combined cropping seasons. It was observed that Minimus consistently recorded higher number of tillers per plant in the two seasons and combined than all the other varieties. All other durum varieties produced statistically similar number of tillers per plant in both seasons and the combined.

4.3 Leaf Area Index (LAI)

The variation in leaf area index (LAI) of varieties in 2002 / 2003 is presented in Table 4.4 .At 3 WAS, Ansar produced significantly larger LAI than Nasser 5, SRNI/6, Musk 15, Betriq 5 and Spot. LAI for the later 5 mentioned varieties were statistically at par. At 6 WAS, Spot produced significantly larger LAI than other cultivars, while the least LAI was produced by Altar 84. At 9 WAS Mexicali 75 and Minimus and Silver 13 produced significantly similar and higher values for LAI. While the least LAI produced came from Betriq 5. At 12 WAS, Minimus, Musk 15 and Anser have statistically similar and highest LAI while the least LAI was produced by Betriq 5. In 2003 / 2004 (Table 4.5) trial, Minimus produced statistically higher LAI than all cultivars at 6, 9 and 12 WAS, though at 6 WAS, it was statistically at par with Silver 15, Mexicali 75, Silver 13, Anser, Spot and SN-Turk. At WAS, Anser and Mexicali 75 produced statistically similar but significantly larger LAI than all cultivars.

Table 4.1: Mean plant height (cm) of irrigated durum wheat varieties during 2002/2003 dry season at Kadawa.

Variety	Plant height (cm)			
	3 WAS	6 WAS	9 WAS	12 WAS
Silver 13	15.40	30.77	45.03ab	69.59
Betriq 5	14.00	26.66	43.11ab	53.99
Mexicali 75	15.63	32.16	49.52ab	72.69
Minimus	13.47	30.59	50.33ab	72.95
Musk 15	13.73	30.58	40.77ab	66.28
Silver 15	13.50	31.86	47.02ab	71.09
Plata 18	14.67	28.87	44.69ab	67.56
Nasser 5	13.50	30.10	50.78ab	69.77
SRNI/6	14.23	30.49	48.97ab	69.18
Ansar	14.00	31.62	51.79a	67.57
Spot	14.85	31.80	37.07b	67.27
Tody's'	14.17	30.85	45.17ab	63.47
Altar 84	14.60	31.29	46.83ab	64.43
SN-Turk	14.27	26.22	37.07b	71.15
SE ±	1.304	1.967	4.900	5.966
CV (%)	15.79	11.16	18.11	15.26

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.2 Mean plant height (cm) of irrigated durum wheat varieties during 2003 / 2004 dry season at Kadawa.

Variety	**Plant height (cm)**			
	3 WAS	**6 WAS**	**9 WAS**	**12 WAS**
Silver 13	19.57	33.13	71.55ab	78.77
Betriq 5	19.23	32.94	73.23a	77.31
Mexicali 75	19.07	45.35	66.07ab	78.29
Minimus	18.89	44.37	56.13b	78.69
Musk 15	17.16	37.31	67.74ab	77.22
Silver 15	18.30	37.97	67.27ab	76.29
Plata 18	18.57	37.97	67.27ab	76.29
Nasser 5	18.19	42.70	65.58ab	79.68
SRNI/6	17.49	39.48	69.79ab	74.09
Ansar	17.73	39.60	64.57ab	80.87
Spot	17.57	37.47	65.03ab	76.64
Tody's'	18.13	34.21	60.85ab	74.69
Altar 84	18.78	38.05	62.14ab	75.51
SN-Turk	18.45	44.35	67.97ab	77.43
SE±	0.874	4.536	4.573	2.857
CV (%)	8.23	20.05	11.94	6.39

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significant.

Table 4.3 Mean tiller number per plant of irrigated durum wheat varieties during 2002/2003, 2003/2004 and combined dry season at Kadawa

Treatment	Tiller number per plant		
	2002 / 2003	**2003 / 2004**	**Combined**
Silver 13	4.53b	5.33b	4.933b
Betriq 5	4.13b	5.60b	4.867b
Mexicali 75	4.83b	6.20b	5.517b
Minimus	7.63a	20.40a	14.017a
Musk 15	4.60b	6.73b	5.667b
Silver 15	4.50b	5.93b	5.217b
Plata 18	3.93b	4.97b	4.450b
Nasser 5	5.17b	6.53b	5.850b
SRNI/6	4.93b	6.07b	5.50b
Ansar	5.07b	6.40b	5.733b
Spot	4.00b	5.40b	4.70b
Tody's'	4.67b	6.72b	5.07b
Altar 84	3.73b	5.27b	4.50b
SN-Turk	4.3b	5.67b	4.98b
SE±	0.731	3.335	1.053
CV (%)	26.82	83.48	71.84

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significant.

Table 4.4 Leaf Area Index (LAI) of irrigated durum wheat varieties during 2002/2003 dry season at Kadawa.

Treatment	WAS	Leaf Area Index (L A I)		
	3	6	9	12
Silver 13	0.293a-c	0.450b	0.677ab	0.586a
Betriq 5	0.223c	0.306d	0.422f	0.376g
Mexicali 75	0.321ab	0.382b-d	0.722a	0.513bc
Minimus	0.274ab	0.420bc	0.692a	0.593a
Musk 15	0.244c	0.373b-d	0.493d-f	0.541a-c
Silver 15	0.273a-c	0.391b-d	0.507df	0.477c-f
Plata 18	0.264a-c	0.356cd	0.642a-c	0.462df
Nasser 5	0.233c	0.382b-d	0.541de	0.473c-f
SRNI/6	0.215c	0.365b-d	0.583b-d	0.461df
Ansar	0.329a	0.401bc	0.574cd	0.570ab
Spot	0.213c	0.601a	0.565c-e	0.506b-e
Tody's'	0.253a-c	0.301d	0.493df	0.413fg
Altar 84	0.253a-c	0.183e	0.465ef	0.437e-g
SN-Turk	0.270a-c	0.355cd	0.535de	0.471c-f
SE ±	0.025	0.026	0.031	0.022
CV (%)	16.28	12.35	9.62	7.83

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significant

Table 4.5 Leaf Area Index (LAI) of irrigated durum wheat varieties during 2003/2004 dry season at Kadawa.

Variety	Leaf Area Index (L A I)			
	3 WAS	6 WAS	9 WAS	12 WAS
Silver 13	0.303b	0.526a-d	1.036b	0.725b
Betriq 5	0.236e	0.363f	0.833de	0.534ef
Mexicali 75	0.341a	0.558ab	0.903cd	0.685bc
Minimus	0.306b	0.571a	1.143a	0.814a
Musk 15	0.256de	0.444d-f	0.736f	0.696bc
Silver 15	0.296bc	0.524a-d	0.926c	0.652b-d
Plata 18	0.263de	0.464c-e	0.804ef	0.672bc
Nasser 5	0.241e	0.443d-f	0.761ef	0.562ef
SRNI/6	0.240e	0.473b-e	0.643g	0.565ef
Ansar	0.336a	0.543a-c	0.906c	0.614c-e
Spot	0.240e	0.544a-c	0.623g	0.577ef
Tody's'	0.286b-d	0.425ef	0.831de	0.501f
Altar 84	0.271c-e	0.433d-f	0.583g	0.512f
SN-Turk	0.263de	0.497a-e	0.543f	0.574ef
SE±	0.010	0.027	0.024	0.026
CV (%)	6.42	9.89	4.98	7.43

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

4.4 Number of Days to Physiological Maturity

Table 4.6 showed variability in days to physiological maturity among fourteen durum wheat varieties during 2002 / 2003, 2003 / 2004 dry seasons and the combined. There was no statistical difference among the cultivars with respect to days to physiological maturity in 2002 / 2003 trial. However, in 2003 / 2004, Ansar reached physiological maturity much later than musk 15, Minimus and Altar 84. When the two years data were combined, it was observed that Musk 15, matured earlier than Betriq 5, Silver 15, Ansar and SN-Turk, the last four matured at the same time statistically.

4.5 Dry Matter Accumulation

Table 4.7 showed dry matter accumulation of fourteen durum wheat varieties during 2002 / 2003 dry season. At 3 WAS Minimus accumulated significantly more dry matter only than Betriq 5, Mexicali 75. Musk 15, Plata 18, SRN 1/6. Tody's' and Altar 84. The fourteen varieties did not differ in their dry matter accumulation at 6 WAS. At 9 WAS, of all the varieties Minimus recorded statistically higher dry matter than Betriq 5, Plata 18, Anser, Spot, Today's and SN-Turk. At 12 WAS Minimus consistently maintained its lead on all the varieties earlier mentioned except when compared with Betriq 5 and Anser.

During 2003 / 2004, at 3 WAS Minimus produced significantly higher dry matter than SRN1/6, Altar 84 and SN-Turk (Table 4.8). At 9 WAS Minimus maintained its superiority over most of cultivars tested in terms of dry matter accumulation except Silver 13, Musk 15 and Nasser 5. There was no significant difference among all the cultivars in terms of dry matter production at 12 WAS.

Table 4.6: Number of days to physiological maturity of irrigated durum wheat varieties during 2002/2003, 2003/2004 dry season and combined at Kadawa

	Days to physiological maturity		
Treatment	**2002/2003**	**2003/2004**	**Combined**
Variety			
Silver 13	80.00	86.33a-d	83.17ab
Betriq 5	85.67	92.33ab	89.00a
Mexicali 75	76.67	91.67a-c	84.17ab
Minimus	82.67	81.67b-d	82.17ab
Musk 15	80.00	78.33d	79.1b
Silver 15	83.00	93.00ab	88.0a
Plata 18	78.67	85.00a-d	81.83ab
Nasser 5	84.33	87.67a-d	86.00ab
SRNI/6	78.67	86.00a-d	82.33ab
Ansar	81.67	94.33a	88.00a
Spot	82.33	92.33ab	87.33ab
Tody's"	78.33	86.33a-d	82.33ab
Altar 84	81.00	80.33cd	80.67ab
SN-Turk	84.00	93.00ab	88.50a
SE ±	3.683	3.401	2.502
CV (%)	7.84	6.71	7.26

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Table 4.7: Dry matter accumulation (gm^{-2}) of irrigated durum wheat varieties during 2002/2003 dry season at Kadawa

Variety	Dry matter accumulation g cm^{-2}			
	3 WAS	6 WAS	9 WAS	12 WAS
Silver 13	1.83a-c	21.64	47.43ab	58.23a-d
Betriq 5	1.42bc	14.77	31.57b	58.40a-d
Mexicali 75	1.47bc	19.64	41.17ab	61.61a-d
Minimus	2.28a	20.18	58.03a	84.42a
Musk 15	1.63bc	18.08	44.97ab	73.99ab
Silver 15	1.87a-c	18.60	43.37ab	69.13a-c
Plata 18	1.43bc	17.13	31.77b	48.97b-d
Nasser 5	1.67a-c	18.30	45.43ab	57.53a-d
SRNI/6	1.32bc	18.17	39.70ab	65.65a-d
Ansar	2.00ab	19.24	32.07b	57.00a-d
Spot	1.73a-c	19.77	31.00b	39.14d
Tody's''	1.37bc	15.78	30.80b	42.61cd
Altar 84	1.24c	26.44	37.46ab	50.50b-d
SN-Turk	1.70a-c	18.60	32.17b	47.97b-d
SE ±	0.192	3.628	6.293	8.470
CV (%)	20.26	32.99	27.86	25.16

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significant.

Table 4.8 Dry matter accumulation (gm^{-2}) of irrigated durum wheat varieties during 2003 / 2004 dry seasons at Kadawa.

Variety	Dry matter accumulation gcm^{-2}			
	3 WAS	**6 WAS**	**9 WAS**	**12 WAS**
Silver 13	2.33a-c	18.20	55.17a-c	69.63
Betriq 5	2.03a-c	15.60	46.80bc	74.87
Mexicali 75	1.93a-c	12.43	50.57bc	78.13
Minimus	3.10a	20.17	76.53a	95.20
Musk 15	2.67ab	18.20	57.90a-c	94.20
Silver 15	2.73ab	16.37	51.30bc	91.00
Plata 18	2.00a-c	15.20	50.90bc	71.30
Nasser 5	2.00a-c	18.87	61.00ab	94.70
SRNI/6	1.83b-c	13.10	50.07bc	94.27
Anser	2.23a-c	14.57	49.13bc	71.53
Spot	2.6ab	14.80	39.67bc	58.67
Tody's'	2.20a-c	17.57	35.80c	63.13
Altar 84	1.60bc	17.37	46.37bc	59.97
SN-Turk	1.27c	10.97	43.50bc	72.23
SE ±	0.360	2.849	7.342	12.108
CV (%)	28.57	30.81	24.88	26.94

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significant.s

4.6 Net Assimilation Rate (NAR)

Tables 4.9 and 4.10 showed the net assimilation rate of irrigated durum wheat varieties during 2002/2003 and 2003/2004 dry season. In both seasons at 6 and 12 WAS varieties tested did not record any statistical differences in NAR. However, at 9 WAS of both, it was observer that Minimus had the highest NAR which was at par with that of all except varieties Plata 18, Ansar, Spot, Tody's', and SN-Turk in 2002 / 2003 and the last three mentioned varieties and Alter 84 in 2002/2003 dry seasons that recorded statistically lower NAR.

4.7 Crop Growth Rate (CGR)

The growth rate of durum wheat varieties in 2002 / 2003 and 2003 / 2004 seasons are presented in Table 4.11and 4.12 .The variability in growth rate was only shown at 9 WAS. Minimus had higher growth rate than Ansar, Spot, Altar 84 and SN-Turk in the first season. Minimus had significantly higher CGR than Spot, Tody's' and Altar 84 during the second season.

4.8 Relative Growth Rate ($g^{-1}cm^{-2}$)

Table 4.13 and 4.14 showed relative growth rate (CGR) of irrigated durum wheat varieties during 2002/2003 and 2003/2004 dry seasons at Kadawa. The variation in relative growth rate among the varieties tested was only significant at 6 WAS in 2002/2003 dry seasons. At this sampling period, all the varieties produced statistically similar relative growth rate except Altar 84 that produced higher relative growth rate than Betriq 5, Minimus, Silver 15 and Ansar.

Table 4.9 Mean of Net Assimilation Rate (NAR) of irrigated durum wheat varieties during 2002/2003 dry season at Kadawa

Variety	Net assimilation Rate g/m of leaf area		
	6 WAS	9 WAS	12 WAS
Silver 13	6.52	8.54ab	3.55
Betriq 5	4.34	5.50ab	8.86
Mexicali 75	5.97	7.11ab	6.76
Minimus	5.88	12.56a	8.75
Musk 15	5.52	8.90ab	9.62
Silver	5.52	8.16ab	8.53
Plata 18	5.14	4.81b	5.68
Nasser 5	5.45	6.93ab	3.97
SRNI/6	5.52	7.12ab	8.59
Ansar	5.68	4.22b	8.26
Spot	5.92	3.68b	2.66
Tody's'	4.70	4.93b	3.87
Altar 84	4.99	6.94ab	4.28
SN-Turk	4.55	4.45b	5.21
SE ±	0.804	2.13	2.52
CV (%)	25.45	53.72	68.98

Mean within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range test (DMRT) at 5% level of significance.

Table 4.10 Mean of Net Assimilation Rate (NAR) of irrigated durum wheat varieties during 2003/2004 dry season at Kadawa

	Net assimilation rate g/m^{-2} of leaf area		
Treatment	**6 WAS**	**9 WAS**	**12 WAS**
Variety			
Silver 13	5.424	12..07ab	8.78
Betriq 5	4.42	10.34ab	9.31
Mexicali 75	3.44	12.66ab	9.15
Minimus	5.63	18.74a	6.19
Musk 15	5.09	13.18ab	12.06
Silver	4.47	11.59ab	13.19
Plata 18	4.33	11.84ab	6.76
Nasser 5	5.54	13.99ab	6.76
SRNI/6	3.67	12.27ab	14.69
Ansar	4.07	11.47ab	7.43
Spot	3.99	8.24b	6.28
Tody's'	5.04	6.02b	9.06
Altar 84	5.17	9.61b	4.48
SN-Turk	3.16	10.79b	9.53
SE $\pm$	0.96	2.51	3.46
CV (%)	36.87	37.31	67.76

Mean within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range test (DMRT) at 5% level of significance.

Table 4.11: Crop Growth Rate (g m^{-2} $week^{-1}$) of irrigated durum wheat Varieties during 2002/2003 dry seasons at Kadawa.

	Crop growth rate $gm^{-2}week^{-1}$		
Treatment	**6 WAS**	**9 WAS**	**12 WAS**
Variety			
Silver 13	6.60	8.60ab	3.60
Betriq 5	4.45	5.60ab	8.94
Mexicali 75	6.06	7.18ab	6.82
Minimus	5.97	12.62a	8.80
Musk 15	5.48	8.96ab	9.68
Silver	5.60	8.23ab	8.59
Plata 18	5.23	4.88ab	5.73
Nasser 5	5.54	9.05ab	4.03
SRNI/6	5.62	7.18ab	8.65
Ansar	5.76	4.28b	8.31
Spot	6.01	3.74b	2.72
Tody's'	4.80	5.01ab	3.94
Altar 84	8.40	3.57b	4.35
SN-Turk	5.64	4.52b	5.26
SE ±	1.525	2.374	2.524
CV (%)	35.60	61.49	68.37

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.12 Crop growth rate (gm^{-2} $week^{-1}$) of irrigated durum wheat varieties during 2003/2004 dry seasons at Kadawa.

	Crop growth rate $gm^{-2}week^{-1}$		
Variety	**6 WAS**	**9 WAS**	**12 WAS**
Silver 13	5.49	12.12ab	4.82
Betriq 5	4.52	10.40ab	9.36
Mexicali 75	5.50	12.71ab	9.19
Minimus	5.67	18.79a	6.22
Musk 15	5.18	13.24ab	12.10
Silver 15	4.55	11.65ab	13.23
Plata 18	4.40	11.90ab	6.80
Nasser 5	5.62	14.05ab	11.23
SRNI/6	3.76	12.32ab	14.73
Ansar	4.11	11.52ab	7.47
Spot	4.07	8.29b	6.33
Tody's'	5.12	6.08b	9.11
Altar 84	5.25	9.67b	4.54
SN-Turk	3.23	10.85ab	9.58
SE±	0.967	2.511	3.473
CV (%)	36.34	37.18	67.45

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.13 Relative Growth Rate ($gg^{-1}wk^{-1}$) of irrigated durum wheat varieties during 2002/2003 dry seasons at Kadawa.

Variety	WAS Relative growth rate $gg^{-1}week^{-1}$		
	6 WAS	**9 WAS**	**12 WAS**
Silver 13	0.82ab	0.27	0.07
Betriq 5	0.77b	0.27	0.21
Mexicali 75	0.86ab	0.26	0.12
Minimus	0.72b	0.34	0.14
Musk 15	0.79ab	0.31	0.16
Silver 15	0.78b	0.28	0.15
Plata 18	0.84ab	0.19	0.14
Nasser 5	0.81ab	0.30	0.08
SRNI/6	0.88ab	0.25	0.18
Ansar	0.76b	0.15	0.20
Spot	0.82ab	0.16	0.08
Tody's'	0.82ab	0.22	0.12
Altar 84	0.98a	0.16	0.10
SN-Turk	0.80ab	0.18	0.14
SE ±	0.056	0.073	0.047
CV (%)	12.05	53.08	60.31

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.14 Relative Growth Rate ($gg^{-1}wk^{-1}$) of irrigated durum wheat varieties during 2003/2004 dry seasons at Kacawa.

Variety	Relative growth rate $gg^{-1}wk^{-1}$		
	6 WAS	**9 WAS**	**12 WAS**
Silver 13	0.69	0.37	0.07
Betriq 5	0.68	0.35	0.17
Mexicali 75	0.64	0.48	0.13
Minimus	0.61	0.46	0.07
Musk 15	0.64	0.40	0.15
Silver 15	0.60	0.39	0.19
Plata 18	0.69	0.39	0.11
Nasser 5	0.77	0.39	0.15
SRNI/6	0.65	0.45	0.22
Ansar	0.64	0.41	0.12
Spot	0.59	0.33	0.12
Tody's'	0.69	0.23	0.22
Altar 84	0.77	0.36	0.08
SN-Turk	0.72	0.46	0.17
SE±	0.084	0.073	0.050
CV (%)	21.62	32.50	62.05

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

4.9 Flag Leaf Area (cm^2)

Table 4.15 showed the flag leaf area of irrigated durum wheat varieties during 2002/2003, 2003/2004 dry seasons and the combined. In both season and the combined, Minimus consistently produced statistically higher flag leaf area among all varieties tested during sampling period except in 2003/2004 season in which it was at par with Musk 15 and Silver 15.In 2002/2003 Betriq 5, Plata 18 and Tody's'' had the least flag leaf while in 2003/2004 Mexicali, Nasser 5, Ansar and Spot had the smallest flag leaf area.

4.10 Number of Days to 50% Anthesis

Days to 50% anthesis for each of the fourteen irrigated durum wheat as affected by variety during 2002 / 2003 and 2003 / 2004 dry seasons and the combined is presented in Table 4.16. Number of days to 50% anthesis recorded significant variation among the varieties only in 2002 / 2003 dry season and the combined. All the varieties produced statistically similar number of days to 50% anthesis except Anser which significantly attained anthesis much later than Minimus in 2002 / 2003 and the combined.

4.11 Number of spike/m^2

The number of spikes per m^{-2} of fourteen irrigated durum wheat varieties during 2002 / 2003, 2003 / 2004 dry seasons and the combined at Kadawa is presented in Table 4. 17. There was no significant difference among all the varieties tested on number of spike/m^2 in both seasons and the combined.

Table 4.15: Flag leaf area (cm^2) of irrigated durum wheat varieties during 2002/2003,2003/3004 and combined dry seasons at Kadawa.

Variety	Flag leaf area (cm^2)		
	2002/2003	**2003/2004**	**Combined**
Silver 13	20.17b-d	22.00b-d	21.09b-d
Betriq 5	15.14e	18.72c-e	16.93ef
Mexicali 75	16.19de	17.34e	17.16ef
Minimus	27.00a	28.37a	27.68a
Musk 15	23.37b	25.23ab	24.30b
Silver 15	21.65bc	25.23ab	22.02bc
Plata 18	14.38e	17.78de	16.08f
Nasser 5	20.0b-d	17.24e	18.67d-f
SRNI/6	18.37c-e	18.40c-e	18.39d-f
Ansar	18.25c-e	16.60e	17.42ef
Spot	17.71c-e	16.51e	17.01ef
Tody's'	15.02e	17.64de	16.33f
Altar 84	17.53de	17.57de	17.55ef
SN-Turk	18.10c-e	20.57c-e	19.39c-e
SE±	1.223	1.356	0.912
CV (%)	11.24	11.88	11.58

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.16: Number of days to 50% to anthesis of irrigated durum wheat varieties during 2002/2003, 2003/3004 and combined dry seasons at Kadawa.

	Days to 50% to anthesis		
Variety	**2002/2003**	**2003/2004**	**Combined**
Silver 13	69.00ab	61.67	65.33ab
Betriq 5	61.67a-c	62.00	61.83abc
Mexicali 75	68.00ab	63.67	65.83ab
Minimus	57.00c	60.67	58.83c
Musk 15	70.33ab	62.33	66.33ab
Silver 15	60.00bc	61.67	60.83bc
Plata 18	68.67ab	62.33	65.50ab
Nasser 5	69.33ab	62.33	65.83ab
SRNI/6	68.00ab	64.00	66.00ab
Ansar	71.00a	62.33	66.67a
Spot	67.33ab	64.00	65.67ab
Tody's'	66.67a-c	61.33	64.00a-c
Altar 84	67.67ab	62.33	65.00ab
SN-Turk	66.33a-c	61.67	64.00a-c
SE±	3.095	1.493	1.701
CV (%)	8.05	4.15	6.53

Table 4.17: Number of spike m^{-2} of irrigated durum wheat varieties during 2002/2003, 2003/2004 and combined dry seasons at Kadawa.

	Number of spike m^{-2}		
Variety	**2002/2003**	**2003/2004**	**Combined**
Silver 13	268.33	269.00	268.67
Betriq 5	271.67	273.33	272.50
Mexicali 75	275.00	275.00	275.00
Minimus	276.67	280.00	278.33
Musk 15	283.33	286.33	284.83
Silver 15	270.00	270.67	270.33
Plata 18	268.67	269.33	269.00
Nasser 5	266.00	266.67	266.33
SRNI/6	265.00	266.33	265.67
Ansar	263.00	266.67	264.83
Spot	266.67	267.67	267.17
Tody's'	270.33	270.33	270.33
Altar 84	267.00	267.33	267.17
SN-Turk	266.67	268.00	267.33
SE $\pm$	8.844	11.069	7.072
CV (%)	21.89	26.90	24.57

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

4.12 Number of spikelet spike^{-1}

The number of spikelet spike^{-1} for each of the fourteen varieties of durum varieties is shown in Table 4.18. The effect of variety was significant in 2002 / 2003 and combined. Silver 13, Betriq 5, Minimus, Silver 15 and SRN1/6 produced significantly higher number of spikelet spike^{-1} than Anser in 2002 / 2003 seasons. The combined showed that Silver 13 and Silver 15 produced more spikelets per spike than Ansar.

4.13 Length of Spike (cm)

Table 4.19 show the length of spike of irrigated durum wheat varieties during 2002 / 2003 and 2003 / 2004 dry seasons and the combined. In 2002 / 2003 and 2003 / 2004 and combined Minimus which produced similar length of spike with Tody's'' was consistently superior to all other cultivars. Variety Spot produced the shortest spike.

4.14 Number of Grains Spike^{-1}

Table 4.20 shows number of grains per spike of fourteen irrigated durum wheat varieties during 2002/2003, 2003/2004 dry seasons and the combined. During 2002/ 2003, 2003/2004 and combined amongst fourteen durum wheat varieties tested during the trial, Minimus produced significantly more grains and it was comparable to Mexicali 75 in 2004/2003, Betriq 5, Mexicali 75, Silver 15, Nasser 5, Spot, Tody's'' and SN-Turk in 2003/2004 and only Mexicali 75 when the two years data were combined.

Table 4.18: Number of spikelet spike^{-1} of irrigated durum wheat varieties during 2002/2003, 2003/2004 dry season and combined at Kadawa.

	Number of spikelet spike^{-1}		
Variety	**2002/2003**	**2003/2004**	**Combined**
Silver 13	11.40a	14.08	12.740a
Betriq 5	11.37a	12.03	11.67a-c
Mexicali 75	9.63ab	12.13	11.02a-c
Minimus	11.13a	13.93	12.53ab
Musk 15	9.83ab	12.87	11.35a-c
Silver 15	11.10a	14.80	12.95a
Plata 18	10.30ab	13.53	11.92a-c
Nasser 5	9.33ab	11.73	10.53a-c
SRNI/6	11.45a	13.48	12.46a-c
Ansar	7.91b	12.13	10.02c
Spot	9.25ab	12.00	10.62a-c
Tody's'	10.53ab	14.80	12.67ab
Altar 84	8.70ab	11.70	10.20bc
SN-Turk	9.87ab	13.47	11.67a-c
SE $\pm$	0.896	1.169	0.747
CV (%)	15.32	15.48	15.55

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.19: Length of spike (cm) of irrigated durum wheat varieties during 2002/2003 and 2003/2004 dry seasons and combined at Kadawa.

	Length of spike (cm)		
Variety	**2002/2003**	**2003/2004**	**Combined**
Silver 13	6.78cd	6.78cd	6.78c-e
Betriq 5	7.15b-d	7.15b-d	7.15cd
Mexicali 75	5.77cd	5.77cd	5.77e
Minimus	10.21a	10.21a	10.21a
Musk 15	7.13b-d	7.13b-d	7.13cd
Silver 15	7.56bc	7.50bc	7.53c
Plata 18	6.14cd	6.14cd	6.14de
Nasser 5	6.28cd	6.28cd	6.28c-e
SRNI/6	7.26b-d	7.26b-d	7.26cd
Ansar	6.17cd	6.17cd	6.17de
Spot	5.51d	5.51d	5.51e
Tody's'	8.92ab	8.92ab	8.92b
Altar 84	5.75cd	5.75cd	5.75e
SN-Turk	6.60cd	6.60cd	6.60c-e
SE ±	0.565	0.567	0.399
CV (%)	14.09	14.14	14.12

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.20: Number of grains spike^{-1} of irrigated durum wheat varieties during 2002/2003 and 2003/2004 dry seasons at Kadawa

	Grains spike^{-1}		
Variety	**2002/2003**	**2003/2004**	**Combined**
Silver 13	13.00bc	13.67b	13.34bc
Betriq 5	13.33bc	15.00ab	14.16b
Mexicali 75	14.33ab	18.67ab	16.50ab
Minimus	18.33a	20.67a	19.50a
Musk 15	11.67bc	13.67bc	12.67bc
Silver 15	12.33bc	15.00ab	13.66bc
Plata 18	12.00bc	13.67bc	12.84bc
Nasser 5	13.67bc	16.33a	15.00ab
SRNI/6	11.67bc	14.33bc	13.00bc
Ansar	10.67bc	13.00c	11.84bc
Spot	13.67b	17.00ab	15.34ab
Tody's'	11.33bc	16.67a	14.00bc
Altar 84	9.33c	13.00c	11.65c
SN-Turk	11.67bc	13.33a	13.50bc
SE ±	1.404	1.878	1.641
CV (%)	25.57	26.15	25.86

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

4.15 Weight of Grains Spike^{-1} (g)

Table 4.21 shows number of grains per spike of fourteen durum wheat varieties during 2002 / 2003, 2003 / 2004 dry seasons and the combined. In 2002 / 2003 Minimus produce the heaviest spike which was fallowed by that of Musk 15. In 2003 / 2004, Minimus had statistically similar weight of grains per spike as Musk 15, which in turn were higher than that for the other varieties. In the combined, the same trend was observed as for 2002 / 2003 seasons.

4.16 1000-grain Weight (g)

Table 4.22 shows mean of 1000-grain weight of irrigated durum wheat varieties in 2002 / 2003, 2003 / 2004 dry seasons and the combined. In 2002 / 2003, Minimus produced significantly heavier 1000-grains than Silver 13, Musk 15, Plata 18 and SRN1/6. In 2003 / 2004, Minimus had significantly higher 1000-grain weight than all the varieties except Musk 15, Silver 15 and SN-Turk. When the two years data were combined, the same Minimus was superior to all the varieties with respect to 1000-grain weight except Silver 15, and SN-Turk.

4.17 Grain Yield Kg ha^{-1}

Grain yields of fourteen irrigated durum wheat are presented in Table 4.23. Significant variation in durum wheat yield was observed in 2002 / 2003 and the combined means. In 2002/2003 seasons Minimus (4549kgha^{-1}), Musk 15 (4177 kgha^{-1}), Silver 15 (3709 kgha^{-1}), Plata 18 (33294 kgha^{-1}), SRN 1/6 (3496 kgha^{-1}), Spot (3039 kgha^{-1}) and SN-Turk (3340 kgha^{-1}) produced statistically similar grain yields which were higher than that of Altar 84 (1867 kgha^{-1}). In the combined means, Mexicali 75 (2006 kgha^{-1}) and Altar 84 produced statistically the lowest grain yields compared to the other varieties. However, variety Minimus had higher (4549 kgha^{-1}) grain yield than Mexicali 75 (2006 kgha^{-1}), Tody's`` (2590 kgha^{-1}) Altar 84 (1867 kgha^{-1}).

Table 4.21: Weight of grains spike^{-1} (g) of irrigated durum wheat varieties during 2002/2003, 2003/2004 and combined dry seasons at Kadawa

	Weight of grains spike^{-1}(g)		
Variety	**2002/2003**	**2003/2004**	**Combined**
Silver 13	1.03cd	0.99b-e	1.01cd
Betriq 5	0.89d	0.51g	0.70f
Mexicali 75	0.85d	0.85d-g	0.85d-f
Minimus	1.77a	1.54a	1.65a
Musk 15	1.44b	1.31ab	1.38b
Silver 15	1.25bc	1.17a-d	1.21bc
Plata 18	0.93d	0.85d-g	0.89d-f
Nasser 5	1.06cd	0.93b-f	0.99c-e
SRNI/6	0.95d	0.66e-g	0.81d-f
Ansar	0.79d	0.90c-g	0.85d-f
Spot	0.97cd	0.54fg	0.76ef
Tody's'	0.86d	0.53g	0.69f
Altar 84	0.79d	0.79d-g	0.79d-f
SN-Turk	1.06cd	1.28a-c	1.17bc
SE $\pm$	0.089	0.119	0.075
CV (%)	14.81	22.55	18.62

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.22: *1000-grain weight (g) of irrigated durum wheat varieties during 2002/2003, 2003/2004 and combined dry seasons at Kadawa*

	1000-grain weight (g)		
Variety	**2002/2003**	**2003/2004**	**Combined**
Silver 13	31.40b	49.37b-d	40.38bc
Betriq 5	37.43ab	44.47c-e	40.95bc
Mexicali 75	36.00ab	47.31b-e	41.66bc
Minimus	45.17a	66.24a	55.71a
Musk 15	33.00b	54.90a-c	43.95bc
Silver 15	39.47ab	57.47ab	48.47ab
Plata 18	41.00b	42.68c-e	41.84bc
Nasser 5	35.47ab	39.80ed	37.63c
SRNI/6	32.33b	36.67e	34.50c
Ansar	40.93ab	43.64c-e	42.29bc
Spot	42.13ab	43.66c-e	42.90bc
Tody's'	38.73ab	47.52b-e	43.13bc
Altar 84	44.73ab	39.37ed	42.05bc
SN-Turk	50.03ab	58.11ab	54.07a
SE $\pm$	4.731	3.688	2.994
CV (%)	20.92	13.31	16.85

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 4.23: Grain yield (kg ha^{-1}) of irrigated durum wheat varieties during 2002/2003, 2003/2004 and combined dry seasons at Kadawa

	Grain yield (kg ha^{-1})		
Variety	**2002/2003**	**2003/2004**	**Combined**
Silver 13	3524.7a-c	3615	3569.7a
Betriq 5	3199.7bc	2660	2929.9a
Mexicali 75	3066.7b-d	946	2006.2c
Minimus	4758.0a	4341	4549.7a
Musk 15	4158.1ab	4197	4177.4a
Silver 15	4074.4ab	3345	3709.6a
Plata 18	4025.0ab	2564	3294.3a
Nasser 5	3391.4bc	2887	3139.4a
SRNI/6	3641.4a-c	3352	3496.6a
Ansar	3258.3bc	2655	2956.6a-c
Spot	3583.3a-c	2495	3039.3a
Tody's'	2669.2cd	2512	2590.5bc
Altar 84	1933.1d	1801	1866.9c
SN-Turk	3641.4a	3040	3340.6a
SE ±	388.9	107.6	571.8
CV (%)	19.25	64.59	43.92

Means within a column of a set of treatment followed by unlike letter(s) are significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

4.18 Correlation Matrix between Yield, Yield Components and Growth Parameters

The relationship between grain yield and growth and yield attributes of wheat during 2002 / 2003 and 2003 / 2004 dry season and the combined is presented in Tables 4.24, 4.25 and 4.26. In 2002 / 2003 grain yield was positively and significantly correlated with tiller number per plant (r = 0.3677), length of spikelet per spike (r = 0.3503), number of grain per spike (r = 0.4197) as well as weight of grain wheat per spike (r =0.6434). However, grain yield was observed to be negatively correlated with number of days to 50% anthesis(r = -0.1637). In 2003 / 2004 dry season grain yield was positively and significantly correlated with tiller number per plant (r = 0.2994), number of grain per spike (r = 0.3215) and weight of grain per spike (r = 0.5749). Days to 50% anthesis was observed to be negatively correlated with grain yield(r = - 0.0096).

When the two years data were combined, it was observed that grain yield was positively and significantly correlated with tiller number per plant (r = 0.2718), leaf area index (r = 0.4840), length of spikelet per spike (r = 0.2777), number of grain per spike (r = 0.3489) and weight of grain per spike(r = 0.4192). Day to 50% anthesis (-0.1637) negatively correlated with grain yield.

Table 4.24 Correlation Matrix between Yield and Yield Component and Growth Parameters in 2002/2003.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.0000											
2	0.0877	1.0000										
3	0.1387	0.3329*	1.0000									
4	0.1028	0.4146**	0.1480	1.0000								
5	-0.1049	-0.2103	0.0436	-02641	1.0000							
6	0.0454	0.1568	0.1741	0.2133	-0.1027	1.0000						
7	-0.1107	0.0779	0.0493	0.0205	0.0791	0.1735	1.0000					
8	-0.0112	0.3522**	-0.0051	0.1627	-0.4541 **	0.0287	0.1672	1.0000				
9	-0.0802	0.2969*	0.2800	0.1557	-0.1971	-0.0189	0.1739	0.2905	1.0000			
10	0.1487	0.3643**	0.0998	0.4001 **	-0.1607	0.1484	0.3827 **	0.5199**	0.3922**	1.0000		
11	0.0711	0.1262	-0.0238	0.0508	-0.1435	0.3989*	0.0345	0.0268	0.0994	0.078	1.0000	
12	0.0625	0.3677**	0.2511	0.2501	-0.1637	0.1098	d0.2124	0.3503 *	0.4197**	0.6434**	0.0352	1.0000

DF = n-2

KEY

1. Plant Height 2. Tiller Number 3. Leaf Area Index 4. Dry Matter Accumulation 5. Number of Days to 50% Anthesis 6. Number of Days to Physiological Maturity 7. Number of Spikelet per spike 8. Length spikelet per spike (cm) 9. Number of Grain per spike 10. Weight of Grain per spike 11. 1000 Grain Weight 12. Grain Yield

Table 4.25 Correlation Matrix between Yield and Yield Component and Growth Parameters in 2003/2004.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.0000											
2	-0.0283	1.0000										
3	0.1920	0.4093**	1.0000									
4	0.0787	0.2439	0.2010	1.0000								
5	0.3066*	0.1274	0.2545	-0.1763	1.0000							
6	0.2008	0.0004	0.0782	-0.0829*	0.0266	1.0000						
7	-0.3042*	0.1918	0.1824	-0.1253	-0.1486	0.0291	1.0000					
8	-0.2198	0.0887	0.0515	0.0294	-0.3295*	-0.3430*	0.2366	1.0000				
9	-0.0534	0.2539	0.2764	-0.1219	0.1644	-0.0588	-0.1010	0.3145*	1.0000			
10	0.1413	0.3045*	0.4198*	0.3793*	-0.2076	-0.2375	0.0361	0.2869	0.0418	1.0000		
11	0.0205	0.2302	0.4517**	0.1703	-0.2749	-0.0396	0.1304	0.4654**	0.2059	0.2884	1.0000	
12	0.2288	0.2994*	0.1456	0.1515	-0.0096	0.0959	0.1260	0.2740	0.3215*	0.5749**	0.2131	1.0000

DF = n-2

KEY

1. Plant Height 2. Tiller Number 3. Leaf Area Index 4. Dry Matter Accumulation 5. Number of Days to 50% Anthesis

6. Number of Days to Physiological Maturity 7. Number of Spikelet per spike 8. Length spikelet per spike (cm) 9. Number of Grain per spike 10. Weight of Grain per spike 11. 1000 Grain Weight 12. Grain Yield

Table 4.26 Correlation Matrix between Yield and Yield Component and Growth Parameters in 2002/2003-2003/2004 (combined).

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.0000											
2	0.1376	1.0000										
3	0.4652**	0.4309**	1.0000									
4	0.3128*	0.3713**	0.4346**	1.0000								
5	0.1247	-0.1012	0.033	-0.3538**	1.0000							
6	0.3220*	0.1310	0.3106**	0.3156*	-0.2352*	1.0000						
7	-0.1170	0.1545	0.1224	0.0908	-0.0068	0.1014	1.0000					
8	-0.0647	0.2528*	0.2109	0.0773	-0.3472*	0.1766	0.2029	1.0000				
9	0.2802*	0.3063*	0.4736**	0.1843	-0.2379	0.1059	0.0359	0.2735*	1.0000			
10	0.0226	0.1246	0.0756	0.2494*	-0.0569	-0.1505	0.1801	0.3894*	0.0887	1.0000		
11	0.2620*	0.0540	0.3546**	0.2959*	0.3121*	0.3124*	0.0976	0.2380	0.2475	0.2379*	1.0000	
12	0.0245	0.2718*	0.4840**	0.0080	-0.0275	0.1283	0.0267	0.2777*	0.3489*	0.4192**	0.0252	1.0000

DF = *n*-2

KEY

1. Plant Height 2. Tiller Number 3. Leaf Area Index 4. Dry Matter Accumulation 5. Number of Days to 50% Anthesis 6. Number of Days to Physiological Maturity 7. Number of Spikelet per spike 8. Length spikelet per spike (cm) 9. Number of Grain per spike 10. Weight of Grain per spike 11. 1000 Grain Weight 12. Grain Yield

4.19 Path Coefficient Analysis

Table 4.27 shows the direct and indirect effect of some selected growth and yield attributes on grain yield of durum wheat. It was generally observed that grain weight/spike had the great effect on grain yield of durum wheat in both seasons and the combined. The direct effect of number of grain per spike on grain yield was next to grain weight/spike while spike length and tiller number when the two year data were combined in 2002/2003 and 2003/2004 had the least effect on grain yield.

Tiller number via spike length in 2002/2003, grain weight/spike via LAI, in 2003/2004 and number grain/spike via LAI had the greatest indirect effect on grain yield. While number of grains/spike via LAI in 2002/2003, number of grains/spike via dry matter accumulation and LAI via grain weight/spike were the least indirect effect on grain yield.

Percentage individual contribution and combine contribution of some selected growth and yield parameters to grain yield durum wheat were presented on table 4.28. Grain weight/spike generally made the greatest individual percentage contribution to grain yield of durum wheat in each of the season and the combined. It was followed by number of grain per spike while spike length in 2002/2003 and dry matter accumulation and number of tiller in 2003/2004 made the least individual percentage contribution to grain yield of less than 1%. But when the two year data were combined it was observed that number of tillers again had the least individual percentage (%) contribution of slightly above 1%

The combined percentage (%) contribution of two parameters to grain yield of durum wheat had shown that association of number of tillers and number of grain weight per spike in 2002/2003 and 2003/2004 contribute positively more to the grain yield. But when the two years data were combined it was observed that contribution of leaf area index and number of grain per spike made highest and positive contribution to grain yield. The least combined contribution of two parameters to grain yield were from leaf area index+spike length in 2002/2003 and dry matter accumulation+spike length in 2003/2004 and number of tiller+LAI when the two years data were combined. The percent contribution that could not be explained were 50.4%, 33.4% and 12.2% in 2002/2003, 2003/2004 and the combined, respectively.

Table 4.27 The direct and indirect contribution of different yield components on grain yield in 2002/2003, 2003/2004 **and combine** at Kadawa

Yield attribute	Effect through						
2002/2003	1	2	3	4	5	6	Total (yield)
1. Tiller number	**0.1052a**	0.0426	-0.0246	-0.0044	0.0425	0.2064	0.367
2. Leaf area index	0.0350	**0.1283a**	-0.0087	6.38*E*-05	0.0401	0.0565	0.251
3.Drymatter accumulation	0.0436	0.0189	**-0.0593a**	-0.0020	0.0223	0.2265	0.250
4. Spike length	0.3704	-0.0006	-0.0096	**-0.0125a**	0.0416	0.2944	0.350
5. No. grain spike^{-1}	0.0312	0.0358	-0.0092	-0.0036	**0.1434a**	0.221	0.419
6. grain weight spike^{-1}	0.0384	0.0127	-0.0237	-0.0065	0.0562	**0.5663a**	0.643
2003/2004							
1. Tiller number	**0.4127a**	-0.1717	-0.0098	6.48*E*-05	0.1614	0.2752	0.299
2. Leaf area index	0.0181	**-0.4195a**	-0.0081	3.76*E*-05	0.1757	0.3794	0.145
3.Drymatter accumulation	0.0107	-0.0843	**-0.0402a**	2.15*E*-05	-0.0775	0.3427	0.152
4. Spike length	0.0039	-0.0261	-0.0012	**0.0007a**	0.1045	0.1876	0.274
5. No. grain spike^{-1}	0.0112	-0.1159	-0.0049	0.0012	**0.6358a**	-0.2146	0.322
6. grain weight spike^{-1}	0.0135	-0.1761	-0.0159	0.0005	-0.1510	**0.9036a**	0.575
Combined							
1. Tiller number	**-0.1147a**	0.1008	-0.1474	0.1543	0.1852	0.0935	0.272
2. Leaf area index	-0.0495	**0.2341a**	-0.1725	0.1287	0.2864	0.0567	0.484
3.Drymatter accumulation	-0.0426	0.1017	**-0.3971a**	0.0472	0.1114	0.1873	0.008
4. Spike length	-0.0290	0.0494	-0.0306	**0.6105a**	-0.1438	-0.1786	0.277
5. No. grain spike^{-1}	-0.0352	0.1108	-0.0732	-0.1453	**0.6046a**	-0.1130	0.348
6. grain weight spike^{-1}	-0.0143	0.0176	-0.0990	-0.1453	-0.091	**0.7511a**	0.419

a=direct effect

Table 4.28: Percentage contribution of different growth and yield attributes of Durum wheat vatities to grain yield Kg^{-1} (2002/2003, 2003/2004 and combined) at Kadawa.

Treatment	**Percentage contribution (%)**		
Individual contribution	**2002/2003**	**2003/2004**	**combined**
1. tiller number	1.106	0.1965	1.3176
2. leaf area index	1.643	17.6045	5.4811
3.Dry matter accumulation	0.353	0.1619	15.7675
4. spike length	0.015	5.34E-05	37.2797
5. number of grain/spike	2.055	40.4276	36.5613
6. grain weight/spike	32.072	81.6334	56.4139
Combined contribution			
1. tiller and LAI	0.897	-1.520	-2.3160
2. tiller and DMA	-0.517	-0.086	3.3848
3. tiller and spike length	-0.926	0.005	-3.5436
4. tiller and grain number/spike	0.895	1.427	-4.2519
5. tiller and grain weight/spike	4.339	2.436	-2.1485
6. LAI and DMA	-0.225	0.678	-8.0804
7. LAI and spike length	0.002	-0.003	6.0294
8. LAI and grain number/spike	1.028	-14.747	13.4086
9. LAI and grain weight/spike	1.448	-31.835	2.6587
10. DMA and spike length	0.024	-0.002	-3.7483
11. DMA and number of grains/spike	-0.265	0.624	-8.8509
12. DMA and grain weight/spike	-0.671	-3.054	-4.5095
13. spike length and number of grain/spike	-0.104	0.015	-17.5659
14. spike length and grain weight/spike	-0.736	0.027	-21.8200
15. grain/spike and grain weight/spike	6.368	-27.293	-13.6701
Residual	50.3654	33.2733	12.2014
Total	100.000	100.000	100.000

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of Season

The growth and yield of wheat in the wheat growing areas of Nigeria are very much influenced by prevailing air temperature during the growing season. Wheat yield varied with the growing seasons. During the period of this study, daily air temperatures were relatively more conducive for wheat growing in 2002 / 2003 than that of 2003 / 2004 growing season. This had attributed to higher grain yield in 2002/2003. Similar effect of higher temperatures on wheat growth were earlier reported by Negedu (1984) who found that higher temperatures experienced between anthesis and maturity increased growth rate of ear and therefore decreased that of the stem and this hastened senescence of the ear and therefore decreased final grain yield.

5.2 Growth Response

The varieties of wheat used in this experiment varied in some of the growth parameters measured. This was expected because crop varieties are known to react and adapt to environmental factors (moisture, nutrient, space, light e.t.c) in different ways because of the differences in the genetic make up. Genetic versus environment plays a very important role in the performance of crop varieties (Moghaddam, *et al, 1997)*

The result of this study had shown Minimus to be a tall variety with high tillering ability. This could be as result of a large leaf area size which could have intercepted large amount of solar radiation leading to high dry matter production and accumulation. The high dry matter and crop growth rate recorded by the same variety might have been utilized for the production of more tillers. High tillering in a crop like wheat is a desirable character needed for high yield and is believed to play great role in economizing planting materials (seeds). Similar observation was reported by (El-sharkawy *et al*, 1977) who recorded differences in growth among wheat varieties. Contrarily Betriq 5 was observed to be a small stature with smaller leaves and mature late. The small leaf area of Betriq 5 could imply low assimilatory leaf area, leading to low dry matter production. Although Betriq 5 statistically did not differ from the vegetative robust variety (Minimus) in terms of yield, it attained maturity almost a week after. This indicated that longer exposure to solar radiation coupled with combined large assimilatory leaf area is critical for high yield in wheat (Sikka and Jain 1960). Falaki (1994) and Abubakar (1999) also reported variation in growth among wheat varieties and attributed such to the interaction of genes and environment.

5.3 Yield and Yield Attributes

Minimus recorded the highest grain yield ha^{-1}only than Todys and Altar 84.This could be attributed to heavier seeds produced by the variety when compared with other varieties. Likewise longer spike that contained more grains produced by the same variety could have helped it greatly in attaining higher grain yield. Production of longer spike with more and heavier grains is believed to be among the important yield determinants in wheat (Slafer and *et al.*, 1994) Likewise the higher tillering ability of the variety (Minimus) with larger assimilatory leaf area could have contributed significantly for higher values of yield and yield components. Similar observation was reported by Iranova, (1986) who observed differences in the yield of wheat varieties used. They ascribed these differences to differences in the genetic make-up among the varieties and how the genes react to their different environment.

The low yield attribute values recorded by Alter 84 in terms of numbers of spikelet and grains/spike could be as a result of the smaller leaf area which in turn led to low dry matter accumulation and slow crop growth and low yield. This shows that for high yield in wheat, variety with larger leaf area, high dry matter accumulation and higher growth rate could be used.

5.4 Correlation and Path Analysis

The significant and positive correlation between the grain and length of spikelet per spike, numbers of tillers/plant and grain per spike may be attributed to the fact that these characters are very important in determining yield in wheat. Production of more tillers per plant with longer spikelet will in turn enhance the grain carrying capacity of wheat thereby increasing yield. This is in line with the findings of Kinyera and Ayiecho (1992), He and Rajavan (1993), Falaki (1994) and Abubakar (1999) whose results indicated that an increase in any of these variables increase grain yield. The negative relationship recorded between grain yield and days to 50% anthesis, indicates that early flowering would allow for longer period for grain filling thereby leading to large grain size, which in turn enhanced grain yield.

The path analysis revealed that grain weight/spike character made the greatest contribution to grain yield per hectare of between 32 to 82%. This is expected since it is the summation of yield from each crop in one hectare that constitutes the grain yield per hectare. Path analysis appears to be useful tool for understanding grain yield formation and provides valuable additional information for improving grain yield via selection of its yield components (Garcia del moral, 2003). However, path analysis were very useful in clarifying the effect of yield component and penology on grain yield formation, which were not accurately reflected in simple correlation analysis, thus providing helpful information for durum wheat breeders (Garcia del moral, 2003).

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

Two field trials were conducted at Irrigation Research Sub-station farm of the Institute for Agricultural Research Ahmadu Bello University, Kadawa, (11^0, 39'N, 80^0, 27 'E and 500m above sea level), during the 2002/2003 and 2003/2004 dry seasons to determine the morphological and physiological characteristics of irrigated durum wheat varieties.

The treatments consisted of fourteen Durum wheat varieties (Silver 13, Betriq 5, Mexicali 75, Minimus, Musk 15, Plata 18, Nasser 5, SRN1/6, Anser, Spot, Tody's'' Altar 84, SN-Turk and Silver 15) which were laid out in a Randomized Complete Block Design, with three replications. The result had shown both similarity and variation in growth and development among the varieties tested. Minimus was observed to be superior to most of the varieties in terms of plant height, number of tillers, leaf area index, dry matter accumulation and flag leaf area. However, the same variety had reached maturity much later than some varieties. Silver13 and Minimus had the highest number of spikelets per spike while Anser had the least. Minimus proved superior to most varieties in terms of number of spikes per m^2 and number of grains per spike. Most of the growth and yield attributes except days to 50% anthesis, plant height, leaf area index and numbers of spikelets per spike were positively and significantly correlated with grain yield.

Based on the result obtained in this study, it could be concluded that among the fourteen cultivars tested, Minimus, Ansar 15, Silver 15, Plata 18, SRN 1/6, Spot and SN Turk, showed greater adaptability through the display of good growth and yield under local weather conditions of Kadawa.

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Appendix 1: Physico-chemical characteristics of soil (0-30 cm) taken from the experimental site.

Soil Properties	2002/2003		2003/2004	
	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)
Physical properties				
% Sand	63	59	61	59
% Silt	26	26	30	26
% Clay	11	15	9	15
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Chemical properties				
pH in water	6.2	6.0	5.8	6.2
pH in 0.1m $CaCl_2$	5.4	5.2	4.8	5.4
% Organic Carbon	0.41	0.22	0.43	0.29
Available P (Cmol kg^{-1})	4.91	2.56	9.44	4.83
% Total Nitrogen	0.070	0.035	0.088	0.053
Exchangeable cations (Cmol kg^{-1})				
K	0.08	0.08	0.18	0.25
Mg	0.33	0.33	0.33	0.37
Ca	1.0	1.80	1.0	1.0
Na	0.17	0.17	0.18	0.25
CEC	1.68	2.81	1.80	1.93
Exchangeable acidity H^+ and Al	0.10	0.20	0.81	0.10

Source: Soil Science Department, Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria.

Appendix II: Meteorological data showing mean minimum and maximum temperature, relative humidity and sunshine hours during 2002/2003 dry season at Kadawa.

Month	Days	Air Temperature (°C)			Relative Humidity (%)	Sunshine (Hours)
		Min	Max	Mean		
Dec., '02	1 – 10	13.6	35.0	24.3	26.9	5.0
	11 – 20	14.0	33.3	23.7	23.4	5.7
	21 -31	12.7	32.0	22.4	18.5	6.0
Jan., '03	1-10	15.1	34.3	24.7	20.8	5.0
	11 – 20	13.6	32.6	23.1	24.5	4.5
	21 – 31	NA	NA	-	27.2	4.5
Feb., '03	1 10	14.0	30.9	22.5	15.4	5.0
	11 – 20	15.9	35.6	25.8	15.5	6.1
	21 – 31	16.9	37.3	27.1	NA	6.8
Mar., '03	1 – 10	19.0	35.8	27.4	23.9	5.4
	11 – 20	17.4	33.2	25.3	20.9	6.0
	21 – 31	20.5	37.6	29.1	16.5	6.0
April '03	1 – 10	25.1	40.3	32.7	58.3	NA
	11 -20	23.7	39.3	31.5	53.9	NA
	21 -31	22.9	39.2	31.1	78.1	NA
May '03	1 - 10	26.2	29.0	27.6	74.8	NA

Source: Meteorological unit of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria.

NA = Not available

Appendix III: Meteorological data showing mean minimum and maximum temperature, relative humidity and sunshine hours during 2003/2004dry season at Kadawa.

Dec., '03	1 – 10	14.0	33.5	23.8	18.9	6.8
	11 – 20	13.2	32.6	22.9	18.0	7.0
	21 -31	13.5	33.0	23.3	18.2	6.1
Jan., '04	1-10	11.7	31.6	21.7	19.3	6.1
	11 – 20	14.9	35.7	25.3	17.8	5.8
	21 – 31	13.4	34.3	23.9	24.5	5.0
Feb., '04	1 – 10	14.8	35.1	30.0	14.2	6.2
	11 – 20	17.9	38.2	28.1	26.5	6.8
	21 – 31	20.1	36.3	28.2	18.8	6.7
Mar., '04	1 – 10	18.3	37.1	27.7	12.2	5.4
	11 – 20	18.2	37.4	27.8	6.8	5.6
	21 – 31	27.7	40.8	31.3	NA	6.0
April '04	1 – 10	24.0	43.2	33.6	4.8	NA
	11 -20	25.5	41.6	33.6	25.5	NA
	21 -31	25.1	42.2	33.7	65.7	NA
May '04	1 - 10	20.5	42.8	31.7	43.8	NA

Source: Meteorological unit of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria.

NA = Not available

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