

**PERFORMANCE OF BREAD WHEAT (*Triticum aestivum* L.) AND
DURUM WHEAT (*Triticum durum* Desf.) VARIETIES UNDER
RAINFED CONDITION AT GEMBU ON MAMBILLA PLATEAU,
NIGERIA**

BY

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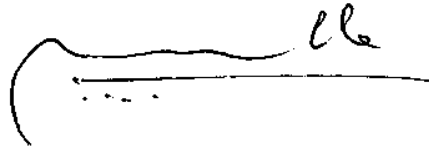
**A DISSERTATION SUBMITTED TO THE POSTGRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN
AGRONOMY**

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

SEPTEMBER, 2000

DECLARATION

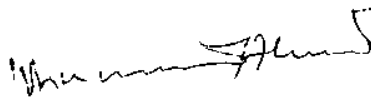
I hereby declare that this dissertation has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.



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CERTIFICATION

This dissertation entitled “PERFORMANCE OF BREAD WHEAT (*Triticum aestivum* L.) AND DURUM WHEAT (*Triticum durum* Desf.) VARIETIES UNDER RAINFED CONDITIONS ON MAMBILLA PLATEAU, NIGERIA” by Michael Chike IKWELLE meets the regulations governing the degree of Philosophy of Ahmadu Bello University Zaria, and it is approved for its contribution to scientific knowledge and literary presentation.



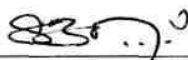
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DEDICATION

This work is dedicated to my wife, Victoria Ngozi Ikwelle.

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I wish to express my profound, sincere and unalloyed gratitude and appreciation to my major supervisor, Professor M. K. Ahmed for his valuable and unquantifiable guidance, suggestions and expertise advice throughout the course of this study. The same sincere and immeasurable appreciation is extended to Dr. U. F. Chiezey who jointly supervised the work and made unimaginable contributions in the execution of this project and final preparation of the dissertation.

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ABSTRACT

Three field experiments were carried out during 1991, 1992 and 1993 rainy seasons at Gembu (6° 55' N, 10° 38' E and 1,500 m above sea level) on Mambilla Plateau, Nigeria to study the performance of bread wheat (*Triticum aestivum* L.) and durum wheat (*Triticum durum* Desf.) under rainfed conditions. The treatments consisted of 121 wheat lines/varieties (88 bread and 33 durum wheats) laid out in a 11 x 11 simple lattice design with two replications. Height in durum wheat ranged between 70.9 and 87.8 cm while in bread wheat, it was between 65.3 and 109.1 cm. Mean tiller number was 22 percent higher in bread wheat compared with durum wheat across the years. Within durum wheat total tillers ranged between 207 and 625 whereas among bread wheat, it was 251 and 751 across the years. Flowering was four days earlier in bread wheat than durum wheat when averaged over the three years. Among durum wheat flowering ranged between 57 and 99 days, while in bread wheat, it was 56 and 84 days. Maturity was four days earlier in bread wheat than in durum wheat. Within durum wheat entries, maturity period differed within the years and averaged over the three years ranged between 92 and 126 days whereas in bread wheat it was 90 and 119 days. Mean number of spikes/m² in durum wheat ranged between 152 and 467 spikes/m² while in bread wheat, it was 146 and 730. Number of seeds/spike in durum wheat ranged between 20 and 33 seeds/spike whereas in bread wheat, it was between 21 and 36. Bread wheat produced significantly more number of seeds/spike than durum wheat. In both wheat species, the weight of 1000 seeds was statistically similar and in durum wheat, it ranged between 25.7 and 32.6 g while in bread wheat it was 21.7 to 36.4 g. The mean grain yield of bread wheat was 46.0 percent higher than durum wheat with the highest grain yield of 2,055 kg/ha recorded by CIRUNBGRES in durum wheat while in bread wheat Veery 'S' CM330297 - PCBWH1931 gave the highest grain yield of 3711 kg/ha. In both durum and bread wheat, grain yield had positive and high significant correlations with number of spikes/m², number of seeds/spike and 1000-seed weight. Number of spikes/m² had the highest direct effect on grain yield in all the seasons in both durum and bread

wheat varieties. In the seed samples, moisture content ranged from 6.7 to 8.0 percent in durum wheat, while in bread wheat, it was 6.4 to 8.6 percent. Protein content in durum wheat was between 14.6 and 18.2 percent whereas in bread wheat, it was between 13.5 and 18.2 percent. In the experimentally milled flour for durum wheat, moisture content was from 8.4 to 9.4 percent, whereas in the bread wheat, it was 7.9 to 10.2 percent. Flour extraction from selected samples of durum wheat was between 56.5 and 70.8 percent, while in bread wheat, it was 56.7 and 73.8 percent. The wet gluten content ranged from 41.5 to 48.0 percent in durum wheat, whereas in bread wheat, it was 35.5 to 51.5 percent. Entries with high wet gluten content in both durum and bread wheat also gave high dry gluten content and in durum wheat the highest was 15.5 percent, while in bread wheat it was 16.8 percent.

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CHAPTER ONE

1.0 INTRODUCTION

Wheat (*Triticum spp*) is known to have occurred in the Middle East as early as 5600 BC and subsequently spread around the Mediterranean and Central Europe. Due to development of new varieties, it was even grown in some of the humid tropical environments like Tanzania (Waterbolke, 1968). There is evidence to show that the crop was grown in very limited area in northern Nigeria in Fadama under irrigation during the dry season since the 12th century (Anon, 1987).

Wheat belongs to the family *Gramineae* and to the sub-family *Povideae* of annual grasses. The two most important species of wheat are the common or bread wheat (*Triticum aestivum* L.) and durum wheat (*Triticum durum* Desf). They differ in their morphological and grain quality hence they are used for different purposes. Durum wheat is hardy and is used for making products like semovita, macaroni, spaghetti and Nigerian sweet alkaki, while bread wheat is used for bread, cakes, biscuits, confectioneries. It can also be used for local preparation such as burabusko, which is Nigerian wheat meal, gurasa, Nigerian wheat bread, and others. and others.

In Nigeria, production was 50,000 tonnes in 1986/87 seasons. When importation of wheat was banned in 1987, production rose to 140,000 tonnes in 1987/88 and 492,826 tonnes in 1988/89 and 550,000 tonnes in 1989/90 seasons (Anon, 1989). However, when the ban on wheat importation was lifted in 1993, production dropped to less than 40,000 tonnes.

Intensive research work on wheat started in Nigeria in 1959. Most of the work concentrated on irrigated wheat and less than a dozen varieties have been evaluated

on rainfed condition. Seventy-three percent of world wheat area is grown under rainfed while 27% is irrigated (CIMMYT, 1989). Rainfed wheat production does not involve construction of huge irrigation infrastructural facilities. The system ensures cheap and sustainable means of production. Ethiopia currently produces over 600,000 hectares of rainfed wheat with an average yield of 2000 kg/ha (Tanar, 1987). There is therefore an urgent need to explore the possibility of growing wheat under rainfed condition in Nigeria to reduce production costs, expand the area under production and subsequently increase the overall productivity and production of wheat in Nigeria.

The objectives of the study therefore were:-

1. To evaluate agronomic performance of a large number of bread and durum wheat varieties and lines under rainfed condition.
2. To assess the grain quality of selected bread and durum wheat.
3. To investigate the baking quality of selected varieties of bread wheat.

CHAPTER TWO

2.0 LITERATURE REVIEW

Research on rainfed wheat in Nigeria is scanty. However, a lot of information on the crop is available from other parts of the world where wheat is grown under rainfed condition.

2.1 Adaptation

Wheat has a wide range of adaptation and is grown from the Arctic circle to the tropical plains of Northern India and the highland of East Africa (Purseglove, 1975). Although wheat cultivation in Nigeria dates back many centuries, there was not much interest in the crop until 1959. Since then, many cultivars and varieties have been introduced and adapted to local conditions (Curtis and Andrews, 1966; Van Blom, 1971; Kowal and Knabe, 1972; Andrews and Palmer, 1972; Van Blom, 1974; Palmer, 1976 and Olugbemi *et al.*, 1979). Orakwue and Palmer (1982) reported that there seemed to be genetic variability for the tolerance to some of the adverse conditions known to prevail in Nigeria for growing wheat under rainfed condition. Earlier trials on rainfed wheat in Mambilla Plateau recorded little success due to limited number of varieties evaluated (Anon, 1983).

2.2 Climatic Condition

Wheat grows well where the ripening season is long, cool and the rainfall moderate (Wabe, 1968, Singh and Nwang, 1976). Under the climatic conditions in Nigeria, natural limitations to rainfed wheat production are most likely to be high temperature and humidity during the short growing season and so the use of adaptable

and resistant cultivars may influence wheat yields considerably during the season (Weigand *et al.*, 1981). Halloria (1977) postulated that regardless of photoperiod and vernalisation responses, varieties differ in yield performance among them. Similarly, Rawson (1987), Wither (1988) and Shukla *et al.* (1988) reported differential response of wheat cultivars to increase in temperature. In the wet season, high humidity is conducive to disease development but cultivars resistant or tolerant to prevailing diseases have been reported (Taygi and Olugbemi, 1980; Menta, 1985; Gilchrist, 1986; Wall, 1987; Punja, 1988; Remakes, 1988 and Tammer, 1989). Other workers who have reported resistance or tolerance of wheat to prevailing disease conditions include Botevan *et al.* (1985), Sharma *et al.* (1988), and Anaso and Gwary (1990). Kumar *et al.* (1990) suggested that the time for sowing wheat should be adjusted to coincide with the optimum temperature for germination (20 – 27°C) growth (19 – 23°C and grain development (18 – 24°C). Temperatures as high as 35°C during ripening were reported to have caused serious damage to wheat (Nuttson, 1957).

2.3 Soil Conditions

Ayer (1953) reported that clayey soils especially in humid regions were not suitable for wheat production due to impeded drainage. Wheat grows well where the soil is well drained but not sandy (Rammumi *et al.*, 1987; Tanta and Aage, 1987 and Sharma and Ray, 1988). Moderately fertile to fertile soils favour a vigorous growth of wheat and optimum pH range for the crop is between 5.5 and 8 (Foy, 1987; Harsharu *et al.*, 1987; Ives and Shaykewich, 1987 and Stein *et al.*, 1984). Varieties exhibit better tolerance to salinity than sodicity (Nigeria, 1983). Maximum yield values have been obtained at soil nitrogen levels of 100 kg/ha (Wicke *et al.*, 1983).

However, fertilizer rates used depend on soil conditions, climatic factors and varietal characteristics (Rammumi *et al.*, 1987, Sharma and Ray, 1988).

2.4 Commercial Wheat Species

Dalrymple (1986) recognized two major commercial species of wheat – common or bread wheat (*Triticum aestivum* L) and Durum wheat (*Triticum durum* Desf.). The common wheats which are high in gluten content and have tough rachis fringed with short hairs at the margins and used for bread, were first extensively grown in Northern Europe (Khelifi and Branland, 1988, Cermey *et al.*, 1989). The durum wheats are hard and are used for pastry products such as macaroni, spaghetti, semovita, nodules and also for biscuits and cakes. They were first extensively grown in the Mediterranean countries, in southern and Eastern Russia, Asia minor and in East Africa (Damania and Somario, 1988 and Katata, 1989). Their rachis are tough and fringed with frontal tout of hairs. Most of the high yielding wheat varieties developed in the International Centre for Maize and Wheat (CIMMYT), abbreviated in Spanish, are bread wheat. However high yielding durum wheat varieties are gaining importance nowadays particularly in the Mediterranean countries and East Africa (Dalrymple, 1986; Choudry *et al.*, 1988; Posche, 1988 and Allan *et al.*, 1989).

2.5 Improved Varieties

Since the early 1960s, more than 400 high yielding semi-dwarf wheat varieties from CIMMYT, the United States Department of Agriculture (USDA) and the Food and Agricultural Organization of the United Nations (FAO), have been released in some 509 countries (CIMMYT, 1987). These materials in general have much better disease and insect resistance than local varieties. Botezan *et al.* (1981) Ivanova

(1986) and Wall (1987) reported that the improved varieties produced more grains than local materials under low fertility conditions. They have the capacity to yield twice or more than traditional varieties under better fertilizer and moisture conditions and mature earlier than traditional varieties (Sabale, 1987; Sharma and Ray, 1988 and Tanner, 1989).

2.6 Plant Height

Plant height is an index of growth. It is governed by genetic factor as well as by crop nutrition and environmental factors (Koga *et al.*, 1986; Hud and Baker, 1989). Tall growing varieties have weak straw and are susceptible to lodging on application of optimum levels of nitrogen (Malavia *et al.*, 1987; Mckenzie and Se, 1989). On the other hand, Pali *et al.* (1987) and Miur (1989) reported that dwarf and semi-dwarf varieties are stiff strawed and have high response to fertilizer application. Similarly, Philipeaks (1985) observed that the high-yielding, short-strawed variety Polukerlik 2 differed from the tall Akhtyr in having a more vigorous photosynthetic apparatus and greater increase in photochemical activity of the chloroplast in response to mineral nutrition. However, the shortest genotypes were more sensitive than tall or semi-dwarf genotypes to heat stress during grain filling stage (Hoogendoova and Gale, 1988; K uroyenagi and Paulgen 1988).

2.7 Maturity

In environments with short growing season and double cropping systems, number of days to maturity is an important growth attribute of varieties. Entries with early maturing traits have escaped high temperature levels during grain filling periods and recorded higher grains than late maturing ones (Bovarenko, 1985, Angrawal

et al., 1988, Sarkar *et al.*, 1989 and Allen (1989)), Sharma *et al.* (1989) in cultivar option trials for rice-wheat cropping systems, reported that rice cultivar Jaya followed by wheat UP30, a medium maturing cultivar, gave the highest total yield of 8.68 t/ha and fitted well into the double cropping system of the project than long duration wheat cultivars. Similar results of pest and diseases control measures using early maturing varieties gave yields of more than 6.5 t/ha as reported by Dalruple (1986) Kaha *et al.* (1987), Carmin and Paster (1988) and Adarg and Al-Fahady (1989).

2.8 Spikes/m²: 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. Adarg and Al-Fahady (1987) reported that number of ears (spikes) per unit area was positively correlated with yield. Similarly, Bangarwa *et al.* (1987) in correlation and path-coefficient analysis of yield and its components in 22 wheat populations, revealed that grain yield per plant was highly and positively correlated with spikes per plant. Other workers have also reported positive correlation of number of spikes per plant with grain yield (Watson *et al.*, 1963; Fisher and Kohell, 1966; Evans and Dunstone, 1970; Fisher, 1975 and Abubakar 1999).

2.9 Number of Grains per Spike: Number of grains per spike is about the most important yield attribute of wheat. Slafer and Andrade (1989) reported that grain number per square metre and grain number per spike were the yield components most affected by selection. High number of grains per square metre in the modern varieties were related to the production of higher number of grains per spike relative to the old varieties (Uddi *et al.*, 1989; Kofpen and Mersebugen, 1986; Bergarwa *et al.*, 1987 and Adarg and Al-Fahady, 1987). Researchers that have reported positive and significant

correlation of grain number with yield included Yu *et al.* (1988), Allan (1989), Hung *et al.* (1989) and La (1989).

2.10 One Thousand Grain Weight: Various researchers have reported their findings on 1000-grain weight of wheat. According to Gaziniomoro (1989) Gogas (1989) and Hadjichristodoulou (1989), high 1000-grain weight had contributed to high grain yield of varieties. Figures ranging between 30 and 50 g per 1000 grains have been recorded by the above workers. Others that have confirmed this yield attribute of wheat were Roya and Raugosa (1989) and Maudilouch (1989), as well as Abubakar (1999).

2.11 Grain Yield: A lot of workers have reported differences in grain yield of varieties. Of the 15 varieties tested during 1982 – 84 seasons, the highest yielders were Trayaunasadow, Super and Charodeika which yielded 6 t/ha grain. Bimizolatta (1988), Iranova (1986), Samagio (1986) reported yield ranging from 5.1 to 5.8 t/ha. High yields of 7.0 t/ha has also been recorded by researchers (Fiazjanni *et al.*, 1988 and Mariam *et al.*, 1989). In Nigeria, grain yields under rainfed conditions was reported to have increased from 571 to 2795 kg/ha due to differences in varieties (Palmer, 1988; Ikwelle 1990).

2.12 Grain Protein Content

The grain protein content and the quality of protein are very important attributes in the grain quality of wheat varieties. Craspar and Zama (1986) reported high crude protein content and gluten in materials they worked with. The mean crude protein content of 15 cultivars tested in field trials ranged from 13.2 to 15.6 per cent. Similarly, Aluko

et al. (1990) reported that the crude protein contents of wheats grown in Nigeria were normal and ranged between 13.1 and 16.9 percent. They were of good bread making qualities. Information on crude protein and quality of protein has been confirmed by Criopsanes (1983), Anjum *et al.* (1986), Indrain *et al.* (1987) and Abd-el-Hamed *et al.* (1988)

2.13 Baking Quality

Quality is basically controlled genetically but it can be influenced by environmental factors such as climate, soil and management practices. Baking is most importantly affected by the protein content of wheat the rheological properties such as specific loaf volume, appearance of loaf, water absorption capacity, crumb colour and texture, mixing tolerance, dough development and strength of wheat were all reported to be influenced by the gluten content of the wheat flour (Johnson *et al.*; 1985 and Kentieze *et al.*, 1988)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

Three field experiments were conducted during 1991, 1992 and 1993 rainy seasons at Gembu ($6^{\circ} 55' N$, $10^{\circ} 38' E$ and 1500 m above sea level) at Mambilla Plateau, Nigeria. The soil was sandy loam, acidic in nature with low organic carbon, low available P and very low in total N content. It has low exchangeable cation exchange capacity and exchangeable calcium. (Appendix 1)

Meteorological data for the three seasons are given in Appendix II. The total rainfall was similar to the long term mean and among the three seasons, temperature and humidity were more favourable during 1991 seasons although these climatic factors have not deviated much from long term mean.

3.2 Treatment and Experimental Design

One hundred and twenty-one lines/varieties (Appendix III) consisting of 88 bread wheat and 33 durum wheat were evaluated in field experiments using 11 x 11 simple lattice design with two replications. The gross plot consisted of 7.5 m² while the net plot was 5 m². Due to large number of treatments, number of observations were limited to the most essential parameters. The fudicial limit was used to identify the top 2.5 percent of the varieties, which were highlighted.

3.3 Cultural practices

3.3.1 Land preparation: The land was ploughed once and harrowed twice to obtain a fine tilth for a good seedbed. Plots and replicates were demarcated by hand and measured 5 m x 1.5.

3.3.2 Fertilizer application: A uniform dose to supply 13 kg P and 25 kg K were applied through single superphosphate (SSP 7.9% P) and muriate of potash (49.8% K) per hectare, respectively and incorporated in the final harrowing. Nitrogen was applied through urea (46% N) at the rate of 120 kg N/ha in two equal splits at sowing and four weeks after sowing.

3.3.3 Sowing: The seeds were sown on 20th August in 1991, 21st August in 1992 and 1993 seasons, respectively at the rate of 100 kg/ha.

3.3.4 Weeding: First weeding was done three weeks after sowing followed by two other weeding as and when necessary but before the peak tillering.

3.3.5 Harvesting: The crop was harvested on 29 December in 1991 and 31st December in 1992 and 1993 seasons, respectively. Harvesting was done at full ripe stage when the crop turned yellow by using sickles. Threshing was done manually by flailing with sticks. Seeds were cleaned, dried and weighed.

3.4 Determination of Soil Nutrient Status:

Composite soil samples were taken to a depth of 30 cm before ploughing and analyzed for both physical and chemical properties. The soil texture was analyzed by the hydrometer method (Bouyocos, 1951) and the textural class determined by using the soils texture triangle (USDA, 1960).

3.4.1 Soil nitrogen: Total soil nitrogen was determined by macrokjeldhal procedure (Bremner, 1965; IITA, 1975).

3.4.2 Available phosphorus: Available phosphorus was measured by shaking 2 g of soil with 40 ml of 0.002 N sulphuric acid (Trough, 1930). The extracted phosphate was determined by the molybdate blue colour method (Bray and Kurts, 1945) and modified by Murphy and Riley (1962).

3.4.3 Exchangeable cations: Exchangeable cations were determined by the acetic acid method (Reith, 1967). Magnesium, Calcium and Potassium were determined by the absorption spectrophotometry using Perkins Model 403 spectrophotometer.

3.5 Observations:

3.5.1 Plant height: Height was measured at harvest using metre ruler from ground level to the tip of spikes excluding awns if any by sampling ten plants per plot.

3.5.2: Number of total tillers/m²: The number of total tillers was counted from one metre linear row of each plot taken at random from which the total number of tillers/m² was calculated.

3.5.3 Time to 50% flowering: This was recorded in days from the day of sowing to 50% bloom stage when half of the plants in each plots have shed their pollen (anthesis).

3.5.4 Time to maturity: Number of days from sowing to physiological maturity when the rachilla turned brown.

3.5.5 Number of spikes/m²: This was determined by counting the number of spikes in one metre linear row of each plot taken at random and expressed as number of spikes/m².

3.5.6 Number of seeds/spike: Seeds from 10 spikes were threshed and counted separately and the mean recorded was expressed as number of seeds per spike.

3.5.7 1000-seed weight: This was estimated by counting three samples of 200 seeds each from each plot and weighing them. Weight of a thousand seeds was calculated therefrom.

3.5.8 Grain yield: This was computed from the yield of individual net plot in grams and converted to grain yield/ha by multiplying with a factor of 2000.

3.5.9 Proximate Analyses: The methods adopted for the proximate analysis were those of the American Association of Cereal Chemists (AACC, 1983).

3.5.10 Wet and dry Gluten: These were determined as described by Kent (1983).

3.11 Data Analyses: The data collected were subjected to statistical analysis of variance as described by Snedecor and Cochran (1967) and the significance among treatment means evaluated using Duncan's Multiple Range Test (DMRT) (Duncan, 1965). Simple correlation analysis was done between yield components and grain yield to assess the magnitude and type of relationship between yield components and yield and within the components themselves (Little and Hills, 1978). The direct and indirect contributions of the characters to grain yield were computed using the procedure suggested by Singh and Choudhary (1979).

CHAPTER FOUR

4.0 RESULTS

4.1 Plant Height

The height of durum wheat is shown in Table 1 for the three seasons. The analyses of data revealed that differences within the mean of varieties in the years were highly significant. In 1991, three durum varieties (entries 46, 23 and 44) were found to be in the top 2.5 percent height whereas in 1992 and 1993 four varieties were included in the tallest group of 2.5 percent. These include entries 42, 29, 26 and 38 in 1992 and 42, 26, 47 and 29 in 1993 seasons. When 1992 and 1993 seasons were compared, entry 42 was found to be the tallest in both seasons, whereas entries 42, 26 and 29 were found to be in the tallest group in both seasons. The general mean height for the three years for durum wheat was 79.6 cm.

The height of bread wheat is also shown in Table 1 for the three seasons. The analyses of data revealed that the differences within the means in the years were highly significant. In 1991, six bread wheat varieties (entries 97, 69, 102, 92, 82 and 70) were found to be in the tallest top 2.5 percent group. In 1992 and 1993 seasons, six entries were also found to be among the tallest varieties group. These include entries 101, 102, 97, 69, 80 and 82 in 1992 and entries 101, 102, 97, 80, 112 and 69 in 1993. In 1992 and 1993, entries 101 and 97 maintained their top ranks. The general mean for the bread wheat was 87.1 cm. In the durum wheat, the mean height of entries were 83.4, 77.3 and 78.2 cm during 1991, 1992 and 1993, respectively whereas in bread it was 95.9, 83.0 and 82.5 cm in 1991, 1992 and 1993, respectively. When the means for the two were compared on three-year basis, durum, wheat was found to be shorter than bread wheat.

Table 1. Plant height (cm) of wheat lines/varieties grown under rainfed conditions at Gembu during 1991 – 1993 seasons

Entry No.	1991	1992	1993	Mean
Durum wheat lines/varieties				
26	87.3b-h	86.3abc	89.4ab	87.8
42	75.9ghi	94.5a	82.5a	87.6
29	82.6c-l	87.5ab	88.5a-d	86.2
23	94.9ab	81.2a-d	82.5b-f	86.2
38	80.2c-l	85.5abc	84.5a-e	83.4
31	89.1a-f	81.2a-d	79.3d-l	83.2
47	79.7d-l	80.5a-d	89.3abc	83.2
28	84.3b-l	79.5a-b	82.3b-g	82.0
27	87.4b-g	78.5a-d	79.0d-l	81.6
43	90.2a-d	75.5bcd	77.1e-j	81.6
46	100.4a	71.8bcd	72.5g-k	81.6
54	81.0c-l	82.0a-d	81.5b-h	81.5
24	87.1b-h	79.5a-d	76.3e-f	81.0
36	83.1b-l	78.3a-d	81.3b-h	80.9
45	85.3b-l	77.7a-d	77.5e-j	80.2
44	92.1abc	74.0bcd	78.3f-k	80.1
49	74.8l	81.3a-d	82.5b-f	79.5
48	77.1f-l	81.4a-d	81.0b-l	79.4
39	84.1b-l	76.5bcd	77.7e-j	78.3
30	87.0b-h	74.5bcd	73.5f-k	78.1
22	87.5b-g	72.2bcd	74.2f-k	77.4
50	82.4c-l	76.5bcd	73.5f-k	77.3
51	78.6d-l	75.5bcd	76.7e-j	77.1
33	89.3a-e	75.3bcd	75.1e-k	76.8
32	80.8c-l	75.1bcd	77.5g-k	76.8
34	75.3hi	77.5a-d	74.9e-k	74.9
52	77.2f-l	72.5bcd	72.5g-k	73.3
37	76.0ghi	75.5bcd	71.2ijk	73.2
37	80.7c-l	68.0d	68.5jk	71.2

Table 1 (contd.)

Entry No	1991	1992	1993	Mean
25	85.7b-l	65.5d	72.0h-k	73.2
40	77.e-l	69.5cd	77.0e-l	73.0
53	78.5d-l	73.5bcd	79.5c-l	71.2
41	81.7c-l	65.5d	65.5k	70.9
Mean	83.4	77.3	78.2	79.6

Significance

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*

*

Bread wheat lines/varieties

101	112.4ab	104.4a	100.5a	109.1
97	123.6a	102.5ab	97.1abc	107.7
102	120.0abc	102.6ab	98.5ab	107.0
69	123.6a	99.5abc	90.5a-d	104.5
80	102.4e-o	98.5a-d	96.5a-d	99.1
92	116.1a-d	91.3a-l	88.1c-l	98.5
82	113.3a-e	93.2a-f	88.5c-h	98.3
112	104.1d-n	97.4a-e	93.1a-e	98.28
89	112.6a-g	92.7a-g	88.5c-h	97.9
72	110.1a-f	92.2a-h	89.5b-g	97.9
77	113.1a-g	92.1a-h	86.6e-l	96.9
93	111.1a-g	90.6a-l	86.4e-k	96.0
70	113.1a-g	86.4b-m	88.4c-h	95.0
95	110.3b-l	87.3a-m	88.5c-h	95.1
100	111.1b-h	86.0b-n	86.5e-k	95.0
68	108.4c-k	86.5b-n	85.53-l	93
113	106.5d-m	86.5b-m	86.5e-k	93.2
79	100.9f-p	89.5a-l	88.1c-l	92.8
83	101.7e-o	87.5a-m	87.0	92.1
103	109.2c-j	84.7c-n	82.3f-p	92.1
114	94.3m-w	87.4a-m	87.5c-l	89.7
94	94.2m-m	90.2a-k	83.2e-o	89.2

Table 1 (contd.)

Entry No.	1991	1992	1993	Mean
111	94.7m-w	84.3c-n	83.2e-o	89.2
88	93.1n-w	87.5a-m	82.5f-p	88.0
91	100.3g-q	80.5e-o	80.4g-t	87.9
67	102.e-o	79.4f-o	83.5e-n	87.3
81	99.0h-r	80.0e-o	78.5I-v	87.1
64	94.2n-w	83.5c-n	83.5e-n	87.1
58	101.3e-p	81.2d-n	78.2I-v	86.0
66	98.2I-s	84.1c-n	78.2I-v	87.0
5	96.3k-v	80.3e-n	82.5f-p	86.4
57	101.0e-p	77.5f-o	79.8g-v	86.1
59	86.4s-d	87.5a-m	83.3-e-o	85.7
16	92.1n-x	80.5e-o	84.5e-m	85.7
110	93.6n-w	79.3f-o	84.5e-m	85.7
16	92.1n-n-x	80.5e-o	84.5e-m	85.7
99	107.8c-l	78.5f-o	70.5uvw	85.6
71	97.3j-u	79.5f-o	79h-v	85.3
85	93.5n-w	75.4g-o	76.5-w	84.9
86	94.6m-v	82.5c-n	81.1f-s	84.7
98	91.9n-x	82.5c-n	83.5e-n	84.6
7	99.0h-f	77.7f-o	79.4h-v	84.6
56	86.6s-d	84.5c-n	73.7o-w	84.6
62	91.1o-3	78.4f-o	75.5m-w	84.6
116	95.7l-v	81.2d-n	81.7f-r	84.2
115	94.4m-w	79.9e-o	75.4m-w	84.2
60	95.81I-v	70.5mno	76.3l-w	83.2
9	94.1n-w	78.1f-o	81.7f-r	82.8
74	84.3v-e	77.5f-o	83.0f-o	82.7
109	89.40p-b	76.4f-o	78.8h-v	82.1
119	100.5g-p	70.5mno	80.1g-u	82.1
75	92.1n-x	78.1f-o	74.5n-w	82.2

Table 1 (contd.)

Entry No.	1991	1992	1993	Mean
104	88.1q-b	77.5f-o	85.5e-l	81.9
73	94.4m-w	76.4f-o	74.5n-w	81.8
14	78.7a-f	82.0c-n	85.5e-l	82.1
21	78.77j-t	71.5mno	74.5n-w	81.5
73	94.4m-w	76.4f-o	85.5e-l	81.8
8	86.5s-d	73.1j-o	75.3m-w	81.0
1	79.23-f	79.4f-o	74.5e-n	80.0
87	85.8t-d	77.5f-o	78.5l-v	80.6
106	92.7n-w	76.7f-o	72.7p-w	80.7
6	87.7r-c	77.0f-o	76.3l-w	80.3
118	89.8p-a	74.5l-o	76.3l-w	80.2
86	84.5v-e	78.5f-o	77.3j-w	80.1
117	91.3o-y	76.8f-o	71.5s-w	79.9
12	79.1z-f	79.2f-o	81.4f-r	79.9
2	78.4a-f	74.3l-o	81.2f-s	79.6
76	92.2n-w	77.3f-o	70.5uvw	79.3
55	83.1w-e	78.3f-o	76.5l-w	79.0
17	90.4o-a	78.5f-o	73.0p-w	78.8
63	77.5b-f	77.5f-o	79.5h-v	78.4
120	85.2u-d	70.0mno	71.5s-w	78.4
107	79.6y-f	80.2e-o	76.1l-w	78.7
18	91.20-y	74.8h-o	71.2t-w	77.1
4	69.6fg	79.5f-o	81.f-r	77.2
105	85.4t-d	80.3e-o	71.3t-w	75.7
108	75.1d-g	74.8h-o	81.4f-r	75.4
10	65.8g	80.3e-o	71.3t-w	75.2
121	88.1q-b	68.5no	72.5q-w	74.3
61	79.7y-f	71.5mno	80.2g u	75.7
90	91.40-y	70.5mno	69.0v-w	74.7
65	73.1ag	74.5l-o	73.5o.w	75.7

Table 1 (contd.)

Entry No.	1991	1992	1993	Mean
11	79.4y-f	71.6m-o	70.5r-w	74.4
19	80.1x-f	71.0mno	70.5uvw	75.9
3	68.2fg	72.11-o	76.51-w	72.3
20	75.2d-g	67.5o	69.5vw	70.7
15	64.8g	63.5o	67.5w	65.3
Mean	95.9	83.0	82.5	87.1
Significance	**	*	*	
SE ($\pm$)	3.81	4.27	3.10	

Means followed by the same letter(s) within the same column are statistically the same at 5 percent level (Duncan's Multiple Range Test).

* and ** = Significant at 5 and 1 percent levels, respectively.

4.2 Total Tillers

The total number of tillers/m² of durum wheat is shown in Table 2 for the three seasons. The analyses of data showed that the differences within the means of varieties in the years were highly significant. In durum wheat in 1991, seven varieties were found in the top 2.5 percent and three entries with highest number of tillers include 28, 26 and 37. All these fell within the same group of significance. In 1992 five varieties were in the top 2.5 percent with three entries 26, 37 and 25 giving the highest number of tillers/m² which are highlighted. In 1993, only one variety was found in the top 2.5 percent class using fiducial limit and that was entry 26. Its significant group included entries 25 and 37. It could be observed that entry 26 was found in the top 2.5 percent in all the three seasons while entry 37 was in this class in 1991 and 1992 seasons. The mean tillers/m² was 420, 359 and 380 for 1991, 1992 and 1993 seasons, respectively and the general mean was 386. In the bread wheat, total tillers/m² is also shown in Table 2 for the three seasons. The analysis of data revealed that the differences within the means for total tillers were highly significant. In 1991 four varieties were found in the top 2.5 percent with entries 80, 5, 8 and 93 recording the highest total tillers/m². In 1992, four varieties fell into this top 2.5 percent class and the highest tillers/m² were produced by entries 107, 5, 8 and 93. In 1993, again four varieties were found in the top 2.5 percent group with entries 16, 17, 13, and 79 recording the highest producers of tillers. The mean tillers/m² for bread wheat was 524, 438 and 465 during 1991, 1992 and 1993, respectively and the general mean was 470 tillers/m². Bread wheat produced significantly higher tillers than durum wheat.

Table 2. Total number of tillers per m² of wheat varieties grown under rainfed conditions at Gembu during 1991 – 1993 seasons

Entry No.	1991	1992	1993	Mean
Durum wheat lines/varieties				
26	680ab	608a	589a	625
25	625ab	517abc	444a-d	528
37	651ab	531ab	401a-d	528
31	585ab	490a-d	418a-d	498
29	530a-e	506a-d	445abd	494
23	585ab	480a-d	442abd	491
27	585abc	486a-d	465abc	488
35	533a-e	435a-f	497a	488
39	429c-h	372a-g	523a	428
24	488a-f	393a-f	402a-d	428
30	487b-g	427a-f	385a-d	423
33	440c-h	320b-l	501a	383
28	798a	383a-f	378a-d	520
42	429c-h	500a-d	535a	488
34	285f-j	311b-l	487ab	361
22	285f-j	323b-l	345a-d	350
43	485abc	373a-f	220bcd	353
32	400c-h	364a-g	270a-d	345
54	401c-h	324b-l	341a-d	355
45	385c-h	346a-h	270a-d	334
36	402c-h	322b-l	442a-d	389
44	397c-h	433a-f	170d	327
51	343e-h	309b-l	327a-d	326
41	281f-j	281b-l	393a-b	318
38	280f-j	252d-l	438a-d	323
50	218f-j	251d-l	337a-d	289
52	241hij	217e-l	284a-d	247

Table 2(contd.)

Entry No.	1991	1992	1993	Mean
53	343e-h	203f-l	394a-d	237
40	234hij	267c-l	186cd	279
49	265hij	265c-l	336a-d	278
47	231hij	260c-l	347a-d	279
46	220hij	192hj	275a-d	176
48	241hij	188ghi	240cd	208
Mean	420	359	380	386
Significance:	**	**	*	

Bread wheat lines/varieties

16	703a-f	597a-j	962a	754.0
5	842a	743ab	553b-k	713
1	462h-p	444d-g	400g-u	445
11	785abc	648a-e	596b-h	688
3	748abc	648a-e	582b-l	683
80	892a	648a-e	582b-l	808
13	533e-n	483a-g	932a	649
76	601c-j	541b-n	801ab	648
17	442h-g	523b-o	939a	635
8	841a	736abc	597b-h	725
12	685a-g	580a-l	598b-h	621
7	785abc	685a-e	379g-v	616
14	601c-j	500b-p	714a-e	605
2	729a-e	618a-h	420	589
93	820a	722a-d	712a-e	751
56	625c-l	567b-l	535b-m	576
62	485g-o	433e-r	795abc	571
10	757a-d	653a-f	300j-v	570
78	601c-j	541b-n	801a-b	552
74	601c-j	541b-n	598b-n	580
75	703a-f	633a-g	700a-e	679

Table 2 (contd.)

Entry No	1991	1992	1993	1994
82	785abc	540b-n	705a-e	677
15	576c-k	475d-g	544a-e	532
58	625c-l	559b-n	400g-u	528
18	651a-h	533b-o	376g-v	520
79	650a-h	653a-f	880a	727
107	442h-q	821a	381g-v	548
77	576c-k	582a-k	744a-d	634
9	653a-h	561b-m	302j-v	505
6	537e-k	484c-q	949a	657
92	576c-k	478c-q	422f-t	492
102	530e-n	478c-q	420f-t	477
97	524e-n	438e-f	465d-r	470
100	500f-n	462d-q	464d-r	470
112	524e-n	430e-f	473d-r	470
57	485g-o	428e-r	473d-r	462
70	513f-n	461d-q	400g-u	458
20	633a-h	511b-o	743a-d	629
21	507f-n	412f-t	439e-t	453
83	506f-n	410f-t	557b-j	491
19	601c-j	505b-o	225o-v	444
61	460h-p	383g-v	557b-j	467
120	576c-k	493b-o	398g-u	420
117	504f-n	430e-f	343h-v	426
88	463h-p	417f-t	390g-v	423
106	530e-n	477d-g	389g-v	421
101	401j-s	361h-u	991d-o	418
60	462h-p	470d-g	738a-d	557
103	563d-d	418f-t	259m-v	413
55	513f-n	461d-q	240m-v	411
84	358l-t	322l-w	554b-k	411

Table 2 (contd.)

Entry No.	1991	1992	1993	Mean
116	507f-n	382g-v	378g-v	422
96	442h-g	398f-u	341h-v	394
4	442h-q	346j-w	381g-v	390
113	512f-n	377g-u	341h-v	400
73	485g-o	361h-u	376g-v	400
90	421I-r	379g-v	343h-v	381
118	441h-q	363h-u	353h-v	372
87	486g-o	417f-t	490d-o	464
121	484g-o	561b-m	350h-v	465
94	480g-o	417f-s	554b-k	484
68	421I-r	329k-w	352h-v	367
81	480g-o	461d-g	582b-I	508
110	475g-o	356l-v	273l-v	370
89	474g-o	343j-w	301j-v	373
95	505f-n	379g-u	580b-I	488
86	377k-t	330k-w	293j-v	333
91	474g-o	460d-g	332h-v	422
105	377k-t	345j-w	247n-v	323
65	470g-o	343j-w	571b-I	461
64	358l-t	322l-w	274l-v	318
72	356l-t	344j-k	447c.-s	382
111	421I-r	298n-w	299j-v	339
85	470g-o	379g-u	168u-v	339
59	360t-t	378g-u	422f-t	387
114	361t-t	322l-w	229o-v	304
99	377k-t	322l-w	23lo-v	310
67	471g-o	379g-u	704a-e	518
71	815ab	298n-w	349h-v	487
69	375k-t	323l-w	367g-v	355

Table 2 (Contd.)

Entry No.	1991	1992	1993	Mean
109	470g-o	247p-w	332h-v	350
115	576c-k	240p-w	267l-v	361
63	375k-t	217r-w	234s-v	275
66	503f-n	246p-w	880a	543
98	509f-n	245p-w	393g-v	382
104	358l-t	240p-w	179s-v	259
108	350l-t	238p-w	196r-v	261
119	342l-t	235p-w	195r-v	251
Mean	524	438	465	470
Significance:	**	**	**	
SE ($\pm$)	69.91	68.21	93.27	-

Means followed by the same letter(s) within the same column are statistically the same at 5 percent level (Duncan's Multiple Range Test)

* and** = Significant at 5 and 1 percent levels, respectively.

4.3 Days to 50 percent Flowering

Days to 50 percent flowering of durum wheat is shown in Table 3. The analyses of data showed that the difference within the mean for 50 percent flowering of varieties were highly significant for the three seasons. In 1991, in durum wheat only one variety fell into the top 2.5 percent group and that was entry 44. In 1992 eight varieties were found in the top 2.5 percent group and the first three were highlighted. The highest number of days to flowering was recorded by entries 43, 44 and 50. In addition, entries 54, 51, 45, 47 and 41 were included in this top group. Also in 1993, eight entries belonged to the top 2.5 percent class with entries 44, 43, 50 and 54 highlighted and recording highest days to flowering. In 1991, 1992 and 1993, mean days to flowering was 69, 71 and 75, respectively.

In bread wheat, days to 50 percent flowering is also shown in Table 3. Analyses of data revealed that the differences within the mean varieties were highly significant in all the three seasons. In 1991, as much as 15 varieties fell into the top 2.5 percent group. Entries with highest days to 50 percent flowering include 55, 109, 84, 2 and 94. Others that belonged to this top class include entries 80, 1 and 100. In 1992, 16 entries were found in the top 2.5 percent. The first three in this category were again entries 55, 109 and 84. Included in this top group were entries 86, 15, 100, 74, 2, 64 and 80. In 1993, 15 varieties belonged to the top 2.5 percent group with entries 55, 86 and 109 topping the list. Others that belonged to this 2.5 percent elite group included entries 77, 80, 64, 84 and 115. Mean flowering days was 64, 67 and 70 for 1991, 1992 and 1993, respectively, while the general mean was 67 days. When the two species were considered bread wheat attained 50 percent flowering earlier than durum.

Table 3. Days to 50 percent flowering of wheat varieties grown under rainfed conditions at Gembu 1991 – 1993 seasons.

Entry No	1991	1992	1993	Mean
Durum wheat lines/varieties				
44	98a	91a	99a	96
43	92ab	93a	95a	93
50	82abc	84b	88b	85
54	81a-d	82bc	88b	84
51	80a-d	80cd	84bc	81
47	75b-f	77de	84bc	79
34	75b-f	75ef	82cd	77
40	75b-f	75ef	82cd	77
45	75b-f	77de	78de	77
41	75b-f	77de	76efg	76
37	74b-g	75ef	77ef	75
42	71c-g	72fg	77ef	73
48	68c-g	70gh	78de	72
40	69c-g	71g	75efg	72
49	68c-g	70gh	78de	72
52	69c-g	69ghi	75efg	71
53	69c-g	69ghi	74e-h	71
46	68c-g	71g	74e-h	71
39	67c-g	67hij	77ef	70
35	67c-g	72fg	72g-I	70
36	66c-g	71g	73f-j	70
38	65c-g	67hij	69ijk	67
22	63d-g	65jk	70h-k	66
26	63d-g	63kl	69ijk	65
24	60efg	63kl	72g-j	65
23	61efg	66ij	64l	64
29	61efg	60	68jkl	63

Table 3 (contd.)

Entry No.	1991	1992	1993	Mean
27	57g	63kl	68jkl	63
28	62efg	62lm	64l	63
32	59fg	60m	68jkl	62
31	60efg	63kl	64l	62
33	60efg	6l	66kl	62
25	58fg	60m	60m	60
Mean	69	71	75	72
Significance:	**	**	**	
Bread wheat lines/varieties				
55	83a	84a	86a	81
109	78ab	82ab	85a	82
84	78ab	82ab	82abc	81
86	75b-e	82ab	86a	81
115	75a-e	82ab	82a-d	80
80	77abc	77cd	83abc	79
77	75a-e	76cd	84ab	78
64	74a-f	77cd	83abc	78
2	78ab	77cd	78d-g	78
100	76a-d	81ab	74g-k	77
74	75a-e	79bc	78d-g	77
1	76a-d	74de	77e-h	76
82	74e-f	76cd	78d-g	75
4	74a-g	72efg	76e-l	75
63	72a-g	72efg	80b-e	74
65	72a-g	74def	79c-f	74
9	69a-h	74def	75f-j	72
113	69a-h	75d-e	73h-	72
112	67a-h	72efg	72l-m	72
94	78ab	62nop	76e-l	72
91	67a-h	72efg	77e-h	71

Table 3 (contd.)

Entry No.	1991	1992	1993	Mean
8	70a-h	71fgh	75f-j	71
88	70a-h	71fgh	72l-m	71
70	68a-h	69g-j	72l-m	71
83	68a-h	72efg	75f-j	71
104	64b-h	71fgh	72l-m	70
81	68a-h	71fgh	75f-j	70
75	65a-h	71fgh	71j-n	70
12	69a-h	68h-k	75f-j	7
98	68a-h	71fgh	73h-l	70
97	66a-h	67l-l	70k-o	69
69	68a-h	71fgh	68m-g	69
14	67a-h	68h-k	69l-p	68
13	65a-h	66j-m	72l-m	68
85	61b-h	69g-j	72l-m	67
101	63b-h	65k-n	74g-k	67
67	66a-h	66klm	69l-p	67
59	64b-h	67k-l	70k-o	67
66	66a-h	66k-m	69l-p	67
108	63b-h	65k-m	74g-k	67
111	61b-h	69g-j	72l-m	67
93	62b-h	69g-j	68m-g	66
20	68a-h	70ghi	61tuv	66
3	61b-h	65k-n	70k-o	66
110	64b-h	66j-m	73h-l	66
5	66a-h	64l-o	67n-r	66
68	66a-h	64l-o	66o-s	65
103	63b-h	63mno	69l-p	65
6	62b-h	62nop	69l-p	65
11	60b-h	63mno	70k-o	64
96	61b-h	66j-m	68m-g	64

Table 3 (contd.)

Entry No.	1991	1992	1993	Mean
114	58d-h	62nop	67n-r	64
71	60b-h	63mno	67n-r	63
58	61b-h	63mno	65p-t	63
102	61b-h	65k-n	65p-t	63
78	60b-h	65k-n	63r-v	63
73	59c-h	62nop	63r.v	62
87	58d-h	60pg	65p-t	62
72	60b-h	61opg	65p-t	62
56	58d-h	60pg	68m-g	62
57	59c-h	63mno	68m-g	62
7	59c-h	63mno	64g-u	62
62	58d-h	61opq	67n-r	62
21	59c-h	60pg	66o-s	62
60	59c-h	61opg	65p-t	62
116	58d-h	60pg	69l-p	62
118	59c-h	63mno	65p-t	62
107	55gh	66j-m	64g-u	62
117	57c-h	61opq	67n-r	62
92	58d-h	64l-o	62s-v	61
89	56fgh	61opq	66o-s	61
76	55gh	60pq	67n-r	61
16	58d-h	59q	67n-r	61
19	60b-h	61opq	62s-v	61
121	54gh	60opq	68m-g	81
105	56fgh	63mno	64g-u	61
120	55gh	61opq	68m-q	61
90	58d-h	61opq	62s-v	60
79	57c-h	60pg	63r-v	60
17	57c-h	61opq	61tuv	60

Table 3 (contd.)

Entry No.	1991	1992	1993	Mean
106	59c-h	63mno	59v	60
95	57e-h	63mno	59v	60
99	55gh	63mno	61tuv	60
61	58d-h	59q	60uv	59
18	55gh	61opq	60uv	59
10	55gh	60pg	61tuv	59
119	55gh	60pg	61tuv	59
15	53h	56r	60uv	56
Mean	64	67	70	67
Significance:	**	**	**	
SE ($\pm$)	0.96	2.45	1.83	-

Means followed by the same letter(s) within the same column are statistically the same at 5 percent level (Duncan's Multiple Range Test).

* and ** = Significant at 5 and 1 percent levels, respectively.

4.4 Days to Maturity

Mean number of days to maturity of durum wheat in all the three seasons is shown in Table 4. The analysis of data revealed that the differences within the means of varieties were highly significant in all the three seasons. In 1991, 12 entries were included in the top 2.5 percent group with entries 44, 43 and 50 and 51 giving the highest number of days to maturity. Some other entries found in this top maturity class include entries 51, 54, 34, 41 and 47. In 1992, three entries were found in the top 2.5 percent group and these include entries 44, 43 and 50 again. Entries 44 and 43 were significantly at par and longer than entry 50 in maturity. In 1993, 12 entries were found in top 2.5 percent group. Entries 44, 50 and 34 had statistically similar duration for maturity and longer than all other entries. Entries 53, 42, 45, 49 and 43 had similar duration and their duration was significantly lower than other entries stated above.

In bread wheat, the mean number of days to maturity is also shown in Table 4. The analyses of data revealed that the differences within the means of varieties were highly significant in all the three seasons. In 1991, 31 bread wheat entries were included in the top 2.5 percent group. Entries 55 and 115 took the longest period to mature compared with all the other entries in this group. They were followed by entries 100, 94, 77, 84, 109, 80, 86 and 82 which were significantly at par. Three other entries, 91, 97 and 70 took significantly lower number of days to mature than the other entries stated above. In 1992, eight entries belonged to the top 2.5 percent group. Entry 115 took comparatively longer period of 123 days to mature but was significantly at par with 55 and 100. Entries 55, 100, 77 and 80 constituted the same group of maturity, but 55 and 100 took longer period to mature when compared with

Table 4. Days to maturity of wheat lines/varieties grown under rainfed condition at Gembu during 1991 – 1993 seasons

Entry No	1991	1992	1993	Mean
Durum wheat lines/varieties				
44	127a	128a	122a	126
43	122b	125a	108f-h	118
50	117c	120b	118ab	118
51	115c	115cd	115bc	115
54	111d	117bc	113cd	114
34	110d	111def	118ab	113
41	110d	113cde	111cde	111
47	110d	111def	111cde	111
37	109de	110d	111def	111
49	107ef	112de	108fgh	109
40	110d	107fgh	109d-g	109
45	105fgh	11def	108fgh	108
42	106fg	11def	106f-I	108
53	104ghi	107fgh	106f-I	106
36	104ghi	107fgh	105ghi	105
48	103hi	107fgh	104hi	105
46	103hi	105hi	104hi	104
35	102I	105hi	105ghi	104
38	98lk	110jk	99jk	102
22	98jk	99jki	102ij	100
52	99j	100lk	99jk	99
26	98jk	101ijk	98ijk	99
32	94mno	103hi	99jk	99
23	96klm	101ijk	98ijk	98
39	97ijk	98kl	99jk	98
33	95lmn	98kl	96klm	96
31	95lmn	98kl	94mn	96
30	94mno	93mn	94lmn	94
25	93mno	94mn	92mn	93

Table 4 (contd.)

Entry No.	1991	1992	1993	Mean
29	91pq	96 ¹ m	91n	93
27	92opq	96lm	90n	93
28	92opq	92n	94 ¹ mn	93
24	90q	94mn	93mn	92
Mean	103	106	104	104
Significance:	**	**	*	
Bread wheat lines/varieties				
115	116a	123a	118a	119
55	118a	119ab	118a	118
100	113b	119ab	118a	115
94	113b	115bcd	117ab	115
77	113b	115abc	115abc	114
80	112b	116bc	115abc	114
84	113b	113c-f	117ab	114
86	112b	115bcd	115abc	114
109	113b-f	11c-f	114a-d	113
64	109cd	112c-g	113b-e	111
82	111bc	111d-h	111c-f	111
74	109cd	111d-h	109d-h	110
2	108de	112c-g	108e-I	109
65	107def	106I-m	114a-d	109
81	108de	110e-I	108e-I	109
63	107def	111d-h	108e-I	109
4	109c-t	107h-l	110c-g	109
1	106fg	111d-h	108e-I	108
112	104ghi	115bcd	106g-k	106
88	107def	109f-j	109d-h	108
83	105fgh	111d-h	108e-I	108
66	106def	109f-j	107f-j	108
99	102jik	113c-f	106g-k	107

Table 4 (contd.)

Entry No.	1991	1992	1993	Mean
98	105fgh	111d-h	105h-l	107
12	104ghi	111d-h	106g-k	107
113	106efg	108g-k	104l-m	106
69	103hij	107h-l	105h-l	105
70	103hij	105k-m	107f-j	105
91	102ijk	108g-k	105h-l	105
3	101h-l	107h-l	103j-n	104
97	103hij	102m-q	102k-o	102
9	99lmn	105k-n	101l-p	102
14	102ijk	104l-o	99n-r	102
104	99lmn	108g-k	98o-s	102
67	101jkl	100o-s	103j-n	101
13	100klm	101n-r	103jn	101
8	100klm	102m-q	100m-q	100
116	100klm	102m-q	98o-s	100
20	98mno	100o-s	102k-o	100
103	100klm	102m-q	98o-s	100
71	95pqr	106l-m	98o-s	99
6	97nop	103m-p	98o-s	99
110	98mno	101n-r	98o-s	99
85	98mno	101n-r	99n-r	99
78	98mno	100o-s	99n-r	99
101	98mno	101n-r	98o-s	99
114	100klm	101n-r	94s-w	99
102	98mno	100o-s	96r-u	98
68	100klm	97r-u	98o-s	98
19	95pqr	100o-s	98o-s	98
79	95pqr	101n-r	97p-t	98
92	96opq	99p-t	98o-s	98
17	93rst	101n-r	97p-t	97

Table 4 (contd.)

Entry No.	1991	1992	1993	Mean
5	94qrs	99p-t	97p-t	97
62	93rst	98q-t	99n-r	97
120	92stu	100o-s	100m-q	97
95	95pqr	99p-t	96r-u	97
75	97nop	98q-t	97p-t	97
93	97nop	99p-t	96r-u	97
89	98mno	97r-u	96r-u	97
90	96opq	101n-r	94s-w	97
87	95pqr	98q-t	97p-t	97
106	96opq	97r-u	96r-u	96
61	93rst	97r-u	99n-r	96
57	94qrs	100o-s	94s-w	96
21	94qrs	98o-s	96	96
16	93rst	97ru	97p-t	96
58	96opq	97r-u	94s-w	96
105	94qrs	100o-s	93t-x	96
72	94pqr	97r-u	96-ru	96
56	93rst	97r-u	96r-u	95
59	93rst	99p-t	94s-w	95
60	94qrs	96s-v	95r-v	95
111	94qrs	98q-t	94s-w	95
118	94qrs	98q-t	93t-x	95
121	91t-u	97r-u	96r-u	95
96	93rst	93vw	96r-u	94
119	92stu	98q-t	91vwx	94
76	91tu	100o-s	92u-x	94
73	93rst	95t-w	94s-w	94
117	92stu	95t-w	93t-x	93
108	92stu	96s-v	92u-x	93
107	92stu	94uvw	92u-x	93

Table 4 (contd.)

Entry No.	1991	1992	1993	Mean
18	90uv	97r-u	91vx	93
11	90uv	95t-w	92u-x	92
7	92stu	92w	92u-x	92
10	90uv	93uw	90wx	91
15	88v	92w	89x	90
Mean	99	102	100	100
Significance	**	**	**	
SE ($\pm$)	0.96	5.29	1.48	-

Means followed by the same letter(s) within the same column are statistically the same at 5 percent level (Duncan's Multiple Range Test).

* and ** = Significant at 5 and 1 percent levels, respectively.

entries 84 and 86 in the top 2.5 percent group of maturity. In 1993, 28 entries were found among the same group of significance and took 114 to 118 days to mature. Entries 97, 91, 70, 69 and 98 constituted shorter group which range from 101 to 105 days in the top 2.5 percent group of maturity. When the three years data were considered, durum wheat took significantly longer period to mature than bread wheat.

4.5 Number of Spikes/m²

Number of spikes/m² of durum wheat is shown in Table 5 for the three seasons. The analyses of data showed that the differences within the means for number of spikes/m² of varieties were highly significant for the three seasons. In 1991, in durum wheat, five entries were found in the top 2.5 percent group. Among the top five, entry 28 was found to have the highest number of spikes/m². This was followed by entries 33, 26, 29 and 42 in that order which belonged to the same significant group. In 1992, only one entry (entry 24) was found in this top group of 2.5 percent and in 1993 again only one entry (entry 51)) fell into this top group of 2.5 percent.

In bread wheat, the number of spikes/m² is also shown in Table 5 for the three seasons. Analyses of data revealed that the differences within the means for number of spikes/m² of varieties were highly significant for the three seasons. In 1991, 12 entries were found in the top 2.5 percent group. In this group, entry 80 recorded the highest number of spikes/m² followed by entry 93 which statistically is in the same group of entry as 80. Entries 82, 79, 75, 97, 76, 77 and 8 all belonged statistically to the same group. In 1992, 26 entries were found in the top 2.5 percent. In this group, entry 93 produced the highest number of spikes/m² followed by entries 79 and 82 are highlighted. The other entries in this category fell into various statistical groups. In

Table 5. Number of spikes/m² wheat lines/varieties grown under rainfed condition at Gembu during 1991 – 1993 seasons

Entry No.	Durum wheat lines/varieties			Mean
	1991	1992	1993	
28	778a	288bcd	334a-d	467
24	366b-g	485a	356a-d	402
26	430bc	314ab	431ab	392
33	464b	269bcd	427ab	387
29	429bc	320b	352a-d	367
25	351-d-I	311bc	416bcd	359
27	367b-g	249bcd	460a	359
35	391-bcd	239bcd	431ab	354
23	324b-h	299bcd	414bcd	346
22	329b-h	322b	316a-d	337
51	321c-h	193bcd	482a	332
36	379b-f	248bcd	330a-d	319
42	409bcd	240bcd	290a-d	313
53	282c-h	158d	356a-d	299
37	343b-h	248bcd	298a-d	298
30	301c-h	252bcd	314a-d	289
39	334b-h	236bcd	298a-d	289
41	265b-I	238bcd	357a-d	287
47	310b-h	219bcd	301a-d	277
38	298c-h	250bcd	272a-d	273
34	283c-h	223bcd	311a-d	272
50	278c-h	234bcd	301a-d	271
54	290c-h	224bcd	284a-d	266
49	259d-I	226bcd	283a-d	256
31	261d-I	245bcd	256a-d	254
44	294c-h	317bc	140d	250
52	305c-h	169cd	241a-d	238

Table 5 (Contd.)

Entry No	1991	1992	1993	Mean
45	224f-I	217b-c	237a-d	226
43	209hi	287bcd	178bcd	225
48	232c-I	184bcd	237a-d	218
46	215ghi	188bcd	237a-d	210
32	126ghi	198bcd	223a-d	210
40	125I	184bcd	146cd	152
Mean	302	290	310	301
Significance:	*	**	**	

Bread wheat lines/varieties**Number of spikes per m²**

80	884a	463c-g	844a	730
93	809a	683a	646a-g	713
79	636bc	634bc	835abc	702
82	775bc	525bc	476e-g	581
75	603cde	507c-m	633a-g	581
97	605cde	333m-y	714ae	551
16	433f-v	590be	594b-h	541
60	453d-t	452d-t	718a-e	547
77	553c-h	395m-y	675a-f	541
8	644c-I	412d-k	544d-l	541
14	502c-m	429d-j	562c-I	500
67	440f-v	376e-p	675a-f	49
66	493c-n	127w	816a-d	497
76	566c-f	456d-h	402f-s	479
83	500c-m	383e-n	488e-n	457
71	811a	254l-w	301l-t	455
74	382c-m	425d-j	547d-j	451
121	473d-q	540a-d	331h-t	448
61	413f-v	382e-n	548d-j	448

Table 10 (contd.)

Entry No.	1991	1992	1993	Mean
13	348m-y	374cq	601b-n	441
56	463d-s	372e-q	485e-n	440
5	461d-s	378e-o	479c-o	439
11	563c-f	400d-l	347h-t	437
92	556c-q	438d-l	307l-t	434
120	505c-l	429d-j	354h-t	429
95	488c-o	227o-w	543d-k	419
70	510c-k	401d-l	343h-t	148
94	452d-t	255l-w	500e-l	402
84	331p-z	347g-t	496c-m	391
65	403g-w	221q-w	542e-k	389
12	373k-w	392d-m	399g-s	388
7	507c-k	311g-v	345h-t	388
17	437f-v	367f-r	356h-t	387
87	482d-q	213s-w	465e-p	387
3	367k-w	230n-w	543d-k	380
81	452d-t	436d-l	216n-t	368
102	462d-s	244m-w	398g-s	368
21	378j-w	312g-v	395g-t	362
91	423f-v	358f-s	295l-t	359
10	290u	314g-v	446e-q	350
115	574cde	223p-w	240l-t	346
118	430f-t	298l-w	305l-t	344
57	396l-w	223p-w	413f-r	344
116	471d-q	276j-w	264l-t	337
58	365k-w	292l-w	350h-t	336
73	471d-q	219q-w	314l-t	335
59	314w	304h-v	386g-t	335
55	438f-v	349g-t	215n-t	334

Table 5 (contd.)

Entry No.	1991	1992	1993	Mean
113	507c-k	213s-w	281j-k	334
106	369k-w	256l-w	375g-t	333
15	423f-v	335g-v	240l-t	333
69	349l-k	314g-v	320l-t	328
112	425f-v	340g-t	204p-t	323
96	401g-w	262k-w	304l-t	322
89	470d-r	218r-w	265l-t	318
107	424f-v	187uvw	338h-t	316
68	384j-w	251l-w	305l-t	313
117	285v-b	257l-w	309l-t	284
103	445f-u	204s-w	201q-t	283
88	343n-s	l-w	254l-t	283
9	334n-z	219q-w	272k-t	275
10	292u-b	258l-w	271k-t	274
105	372k-w	205s-w	216n-t	264
99	373k-w	201t-w	218n-t	264
63	363k-w	202yt-w	206o-t	259
6	365k-w	175vw	222m-t	254
1	252w-b	233n-w	266l-t	250
2	322q-a	250l-w	178q-t	250
18	299t-a	205s-w	238l-t	247
78	335n-z	220t-w	178q-t	244
62	33n-z	142w	213l-t	237
4	198z-b	288l-w	223m-t	237
64	257w-b	198t-w	251l-t	237
104	338n-z	214r-w	151rst	234
108	311s-b	215s-w	167rst	231
119	297t-a	203t-w	124t	208
114	163b	224t-w	192q-t	193

Table 5 (contd.)

Entry No.	1991	1992	1993	Mean
20	176ab	187uvw	165rst	176
19	206x-b	145w	169rst	173
100	192ab	124w	123t	146
Mean	424	302	362	363
Significance:	*	**	**	
SE (+)	59.67	31.77	93.20	-

Means followed by the same letter(s) within the same column are statistically the same at 5 percent level (Duncan's Multiple Range Test).

* and ** = Significant at 5 and 1 percent levels, respectively.

1993, 11 entries belonged to the top 2.5 percent. Topping the list again was entry 80 followed by entries 79, 66, 60, 97, 77, 67, 93 and 75. Analysis of data for the two species further revealed that bread wheat produced significantly higher number of spikes/m² than durum wheat.

4.6 Number of Seeds/Spike

Number of seeds/spike of durum wheat is presented in Table 6 for the three seasons. The analyses of data revealed that the differences within the means for seeds/spike of varieties were highly significant for the three seasons. In 1991, only one entry (entry 25) was found in the top 2.5 percent group. However, other entries that produced high number of seeds/spike included entries 26, 24 and 33 which are also included in the same group of significance. In 1992, three entries belonged to the top 2.5 percent category. These included entries 25, 28 and 37 which were at par with one another and were the same statistically. In 1993, there were again three entries that belonged to the top 2.5 percent group. These included entries 24, 28 and 33 with entry 24 giving the highest number of seeds/spike followed by entry 28.

Table 6. Number of seeds per spike of wheat varieties grown under rainfed conditions at Gembu during 1991 – 1993 seasons.

Entry No.	1991	1992	1993	Mean
Durum wheat lines/varieties				
25	35a	31a	32a-d	33
24	32an	27e-e	36a	32
28	30a-d	31a	34-ab	32
33	32ab	30a-c	33abc	32
23	31abc	29a-b	31a-d	31
26	33ab	30a-c	32a-d	31
29	31-abc	30a-b	32a-d	30
27	31abc	26a-e	29a-g	30
37	29a-e	31a	30a-f	29
22	30a-d	26a-e	30a-f	29
54	28a-t	30a-c	30a-f	28
30	31abc	22de	3-a-f	28
32	25a-g	29a-d	30a-f	27
34	28a-f	23cde	30a-f	27
36	30a-d	26a-e	25d-l	27
38	25a-g	26a-e	31a-e	27
35	26a-g	269-e	28b-h	27
48	21a-d	29a-d	3-a-f	27
31	29a-e	26a-d	24efg	26
41	3-a-d	26a-e	21e	26
51	29a-f	22de	29a-g	26
39	21c-g	26a-e	28b-h	25
45	24b-g	32a	20ij	25
44	27a-g	20e	26c-l	24
53	21a-g	29a-d	24f-f	24
40	23b-g	27a-e	20ij	23
42	18fg	23cde	29a-g	23
52	20d-g	21e	27b-l	23

Table 6 (contd.)

Entry No.	1991	1992	1993	Mean
46	20d-g	23cde	23f-l	22
47	18lg	23cde	26c-l	22
43	17g	23cde	22g-l	21
50	19efg	24b-c	20ij	21
49	17g	26a-e	17l	20
Mean	26	26	28	27
Significance:	**	**	**	
Bread wheat lines/varieties				
80	36ab	37a	35abc	36
71	35abc	29b-j	39a	34
88	38a	29b-j	35abc	34
103	32a-d	29b-j	34a-b	34
69	33a-d	35abc	34a-b	33
77	31a-f	33a-e	32a-e	33
79	32a-e	33a-e	29b-g	33
116	33a-d	32a-f	33a-e	33
97	32a-e	33a-e	29b-g	33
98	33a-d	32a-f	33a-e	33
70	32a-d	31a-g	34a-d	33
93	33a-d	34a-d	30b-g	32
109	33a-d	31a-g	33a-e	32
73	35abc	25abc	36ab	32
113	36ab	26e-l	34a-d	32
84	28a-f	37a	30b-g	32
87	31a-f	31a-g	33a-e	32
102	31a-f	32a-g	32a-e	32
61	33a-d	27d-l	34a-d	32
60	31a-f	31a-g	32a-e	31
75	31a-f	31a-g	32a-e	31
76	31a-f	31a-g	32a-e	31

Table 6 (contd.)

Entry No.	1991	1992	1993	Mean
82	33a-d	33a-e	28c-h	31
96	35abc	25f-l	34a-d	31
16	33a-d	26e-t	34a-d	31
81	31a-f	30a-l	32a-e	31
90	33a-d	27d-l	33a-e	31
92	30a-f	31a-g	32a-e	31
101	33a-d	26e-l	34a-d	31
117	32a-e	27d-l	34-a-d	31
8	31a-f	30a-l	27d-f	31
14	31a-f	31a-l	30b-g	31
20	34abc	28c-k	30b-g	31
59	31a-f	29b-j	32a-e	31
110	29a-g	32a-f	31b-f	31
115	28a-g	28c-k	27d-f	30
11	32a-e	26e-l	31b-f	30
56	27a-g	32-a-f	30b-g	29
83	30a-f	23l-l	35abc	29
85	27a-g	32a-f	29b-g	29
108	29a-g	28c-k	31b-f	29
121	24a-f	33a-e	31b-f	29
7	35abc	25f-l	27d-f	29
74	26b-h	30a-e	31b-g	29
58	27a-g	28c-k	32a-e	29
95	30a-f	26c-l	31b-f	29
114	32a-e	24h-l	31b-t	29
120	26b-h	30a-l	31b-f	29
68	30a-fb-h	23a-l	33a-e	29
106	34abc	21ki	31b-f	29
18	30a-f	25f-l	30b-g	28
21	28a-g	26e-l	31b-g	28

Table 6 (contd.)

Entry No.	1991	1992	1993	Mean
66	30a-f	21ki	34b-g	28
111	26b-h	28c-k	31b-f	28
17	24a-g	26e-l	29b-g	28
89	28a-g	26e-l	30b-g	28
78	25b-l	32a-f	27d-f	28
99	27a-g	27d-l	30b-g	28
118	28a-g	25t-l	31b-f	28
15	27a-g	28c-k	28c-h	28
107	29a-g	25f-l	29fbg	28
19	28a-g	25f-l	29bg	27
86	23d-l	33a-e	26e-l	27
5	25b-l	25f-l	29b-g	26
57	22e-l	27d-l	30b-g	26
94	26b-h	24b-h	29b-g	26
10	24c-l	28c-k	26e-l	26
67	25b-l	27d-l	26e-l	26
100	23d-l	29b-j	26e-l	26
112	25b-l	25f-l	28e-h	26
105	28a-g	20l	30b-g	26
62	29a-g	25f-l	23hi	26
13	24c-l	25f-l	27d-l	25
72	21f-l	32a-f	23hi	25
119	23d-l	26e-l	27d-l	25
9	24c-l	25f-l	26e-l	25
4	24c-l	28c-k	23hi	25
2	26b-h	21ki	27d-l	25
104	27a-g	26e-l	21hi	25
65	22-e-l	25f-l	26e-l	24
91	24c-l	22jkl	27d-l	24
12	24c-l	22jkl	27d-l	24

Table 6 (contd.)

Entry No.	1991	1992	1993	Mean
3	19ghi	27d-l	26e-l	24
64	24c-l	25f-l	23hi	24
1	21f-l	26e-l	24ghi	24
6	21f-l	29b-j	21hi	24
63	16hi	28c-k	23hi	22
55	15l	28c-k	20l	21
Mean	28	28	30	29
Significance:	**	**	**	
SE ±	3.51	2.17	2.36	-

Means followed by the same letter(s) within the same column are statistically the same at 5 percent level (Duncon's Multiple Range Test).

* and ** = Significant at 5 and 1 percent levels, respectively.

In bread wheat, number of seeds/spike is again shown in Table 6 for the three seasons. The analysis of data revealed that the differences within the means for seeds/spike of varieties were highly significant for the three seasons. In 1991, seven entries belonged to the top 2.5 percent group. The highest number of seeds/spike was produced by entry 88 followed closely by entries 80 and 113 and then entries 71, 73, 96 and 7 which were at par with one another within the top 2.5 percent. These entries belonged to the same group statistically. In 1992, nine entries were found in the top 2.5 percent group. The highest seeds/spike was produced by entries 80 and 84 followed closely by entries 69 and 93. Entries 77, 79, 82 and 121 were at par with one another and they belonged statistically to the same group as the other entries mentioned above. In 1993, five entries fell into the top 2.5 percent group. The highest seeds/spike was recorded by entry 71 followed by entry 73 and entries 80, 88 and 83 which were at par with one another. Comparing the two species, bread wheat produced statistically higher number of seeds/spike than durum wheat.

4.7 1000–Seed Weight

The 1000–seed weight of durum wheat is presented in Table 7 for the three seasons. Analyses of data revealed that the differences within the means for 1000 – seed weight of varieties were highly significant for the three seasons. In 1991, in durum wheat, five entries fell into the top 2.5 percent group. The highest 1000 – seed weight was produced by entry 26 followed by entries 49, 27, 24 and 37 in that order. All these entries were statistically in the same group. In 1992, only two entries were found in the top 2.5 percent group. These included entries 23 and 27. The highest 1000 –seed weight was produced by entry 23 followed by entry 27. Also in

Table 7. Weight of 1000–grains (g) of wheat line/varieties grown under rainfed conditions of Gembu during 1991 – 1993 seasons.

Entry No.	1 991	1992	1993	Mean
Durum wheat lines/varieties				
23	30.1abc	32.3a	35.3a-d	32.6
27	31.1abc	31.4ab	35.4abc	32.6
49	31.3ab	28.3a-b	36.8ab	32.1
24	30.3abc	29.1a-d	35.7abc	31.7
26	31.4a	28.4a-d	35.4abc	31.7
28	30.2a-e	26.1bcd	37.9a	31.4
22	30.1a-f	29.1a-d	35.1a-d	31.4
37	30.3abc	29.5abc	34.5a-d	31.4
33	30.1abc	29.3a-d	34.5a-d	31.3
32	29.1a-g	30.1abc	34.1a-d	31.1
53	28.4a-h	30.1abc	33.4bcd	31.1
42	27.5d-I	29.3a-d	34.1a-d	30.6
31	27.5a-e	28.5a-d	34.5a-d	30.3
52	30.2a-e	25.1cde	35.1a-d	30.2
38	27.5a-I	29.1a-d	33.3cde	30.1
25	28.1a-I	27.4a-d	34.4a-d	30.0
54	27.1c-I	29.1a-d	33.5a-d	30.0
29	27.1c-I	28.4a-d	33.6a-d	29.9
50	26.4d-h	28.3a-d	34.1a-d	29.7
34	27.2c-I	27.3a-d	34.1a-d	29.6
45	27.3b-I	29.3a-d	31.7cd	29.5
35	25.5ghi	29.4a-d	32.7bcd	29.4
46	27.0b-I	25.1cde	34.5a-d	29.2
48	25.5ghi	27.1a-d	33.4cd	28.7
51	23.1ghi	25.7c-f	35.4abc	28.7
43	27.0d-I	26.0bcd	32.5bcd	28.5
47	26.0ghi	28.8bed	33.6a-d	28.3
44	26.2e-I	24.7a-d	33.4bcd	28.1

Table 7 (contd.)

Entry No.	1991	1992	1993	Mean
40	24.3I	27.1a-d	31.7cd	27.7
41	24.1I	25.7c-f	33.4bcd	27.7
36	26.1f-I	26.1bcd	30.9d	27.7
39	24.4hi	23.3def	31cd	26.4
30	25.3ghi	20.1fe	31.4cd	25.7
Mean	27.7	27.3	33.9	29.6
Significance:	*	*	**	
Bread wheat lines/varieties				
80	36.0a	36.4ab	36.4abc	36.3
97	31.9b-f	35.3a-d	38.8ab	35.3
82	32.0b-f	37.4a	35.4b-c	34.9
69	34.1abc	27.2f-e	40.3a	33.9
75	30.1c-k	35.4a-d	36.1abc	33.9
93	31.4b-g	36.1abc	34.1c-h	33.9
79	30.1c-k	35.0a-c	36.3abc	33.8
59	30.4b-l	32.4-abf	36.4abc	33.1
76	32.0b-f	32.3a-f	33.5c-h	32.6
57	31.3b-g	30.4b-h	35.6bcd	32.4
81	33.2a-d	29.0f-l	34.7b-g	32.3
21	29.3d-l	31.3a-g	35.4b-c	32.0
14	31.2b-g	28.2f-n	36.4abc	31.9
92	30.2c-j	29.0f-l	36.3abc	31.8
102	29.1c-n	31.3a-g	35.1b-c	31.8
56	31.1c-n	30.3b-h	34.4b-h	31.6
83	30.2c-j	30.1c-l	34.4b-h	31.6
77	30.0c-k	28.5f-m	35.7bc	31.4
70	31.3b-g	28.1f-o	34.2b-g	31.4
60	30.3b-j	29.4d-k	34.3c-h	31.3
74	31.0b-h	29.3d-k	33.6c-h	31.3
15	29.4d-l	29.1c-l	35.3b-c	31.2
66	30.3b-j	28.1f-o	35.1b-c	31.2

Table 7 (contd.)

Entry No.	1991	1992	1993	Mean
68	29.2d-m	29.4-d-k	34.4b-h	31.0
87	29.4d-l	29.0f-l	34/4b-h	30.9
106	29.4d-l	30.3b-h	33.1c-I	30.9
95	31.2b-f	27.1f-g	34.1c-h	30.8
105	31.2b-g	27.1f-g	34/1c=h	30.8
8	28.2f-b	29.3d-k	33.1c-h	30.2
103	31.5b-g	24.7h-v	34.1c-h	30.2
72	26.01I-s	24.1I-w	34.3c-h	30.1
18	26.11-s	29.5d-j	34.3c-h	30.0
20	29.1c-m	29.4f-r	34.3c-h	29.9
84	39.1c-k	24.5h-v	35.b-h	29.9
118	30.4b-I	23.5j-x	35.4b-e	29.8
12	30.9b-h	25.0h-v	33.3c-h	29.7
88	30.5b-I	24.0I-w	34.7b-g	29.7
109	31.2b-g	22.3h-x	35.7bc	29.7
10	28.3f-o	25.3g-u	35.5bcd	29.7
110	30.4b-I	22.2n-x	35.9abc	29.7
5	28.9c-h	26.0f-r	33.9c-h	29.6
6	28.9c-h	26.0f-r	33.9c-h	29.6
62	28.9c-h	26.0f-r	33.9c-h	29.6
78	28.9c-h	26.0f-r	33.9c-h	29.6
103	28.9c-h	26.0f-r	33.9c-h	29.6
63	27.0h-r	28.1f-o	33.5c-h	29.5
101	34.3abc	19.4u-x	34.5b-h	29.4
111	31.5b-g	21.4b-x	35/3bcd	29.4
67	26.1k-s	28.5t-f-m	33.3c-h	29.3
99	30.5b-I	23.11I-x	34.3c-h	29.3
13	30.4b-I	24.3h-w	33.1c-I	29.3
120	29.3d-l	30.1c-I	28.4j-k	29.3
71	32.0b-f	20.4r-x	35.1b-c	29.2

Table 7 (contd).

Entry No.	1991	1992	1993	Mean
2	25.0d-l	25.1h-v	33.0c-I	29.0
73	30.3b-j	23.4l-k	33.4c-h	29.0
85	29.3d-l	23.4j-k	34.3c-h	29.0
107	31.3b-g	22.4m-x	33.3c-h	29.0
11	27.1h-r	26.4f-r	33.3c-h	29.0
116	29.1c-n	22.4m-x	35.3bcd	29.9
58	29.1c-h	24.0l-w	33.3c-h	28.8
121	29.1c-n	28.8f-m	29.9ijk	28.8
4	29.0d-l	23.3k-x	33.3c-h	28.5
104	27.1hr	23.9j-w	34.6b-h	28.5
3	29.0d-l	26.4f-r	30.0h-k	28.5
89	27.1h-r	23.1l-k	34.9b-f	28.4
9	23.5rst	28.1f-o	33.3c-h	28.3
98	29.1c-n	19.4u-x	36.1abc	28.2
96	27.5g-q	23.7j-w	33.3c-h	28.2
100	30.1c-k	21.0r-w	33.3c-h	28.1
17	28.0f-q	23/4j-k	32.4c-j	27.9
94	28.0f-q	19.4u-x	36.3abc	27.9
19	24.1q-t	27.1f-g	32.1c-j	27.8
112	29.1c-n	21.5p-x	32.7c-j	27.8
113	26.0l-s	23.9j-w	33.1c-I	27.7
16	31.1b-h	19.3u-x	32.1c-j	27.5
86	24.0q-t	25.1h-v	33.1c-I	27.4
55	25.0o-t	24.0l-w	33.1c-I	27.4
115	26.7j-s	22.0o-x	33.4b-e	27.4
61	25.1n-s	21.5b-x	35.4b-e	27.3
64	25.0o-t	24.0l-w	32.4c-j	27.1
65	24.1q-t	26.4f-r	30.3g-k	26.9
90	26.3j-s	20.2s-x	34.1ch	26.9
117	25.8l-s	21.1q-x	33.4c-h	26.8

Table 7 (contd).

Entry No.	1991	1992	1993	Mean
7	28.5l-s	19.0vwx	31.2d-j	26.2
114	24.2b-x	21.4p-x	32/7c-j	26.1
1	22.7st	22.0o-x	33.5c-h	25.8
108	29.1e-n	18.2wx	30.0h-k	25.8
91	24.0q-t	19.6t-x	31.0d-j	24.9
Mean	28.9	26.0	33.9	29.6
Significance:	**	**	**	
SE $\pm$	1.25	1.89	1.40	-

Means followed by the same letter(s) within the same column are statistically the same at 5 percent level (Duncan's Multiple Range Test)

* and ** = Significant at 5 and 1 percent levels, respectively.

1993 only two varieties were found in the top 2.5 percent group. These were entries 28 and 49.

In bread wheat, the 1000–seed weight is also shown in Table 7 for the three seasons. Analyses of data revealed that the differences within the means for the 1000–seed weight of varieties were highly significant for the three seasons. In 1991, seven entries fell into the top 2.5 percent group. These included entries 80, 97, 82, 69, 93, 76 and 81. The highest seed weight was recorded by entry 80 followed by entries 69 and 81. In 1992, 14 entries were found in the top 2.5 percent group. The highest 1000–seed weight in this group was recorded by entry 82 followed by entries 80, 93, 75 and 97. The other entries belonged to the same statistical group as the last four entries mentioned above. In 1993, only two entries were found in the top 2.5 percent of the varieties. These included entries 97 and 69 with the highest 1000 seed weight recorded by entry 69. The mean 1000–seed weight recorded by both durum and bread wheat for the three seasons was at par with each other.

4.8 Grain Yield

The grain yield of durum wheat is presented in Table 8 for the three seasons. The analyses of data revealed that the differences within the means for the grain yield of varieties were highly significant for the three seasons. In 1991, in durum wheat, 13 entries belonged to the top 2.5 percent group. The maximum yield of 4,260 kg/ha was produced by entry 37 which was statistically at par with entries 29, 50, 30, 32, 35, 44, 46, 40, 36, 38, and 24. In 1992, seven entries were found in the top 2.5 percent group. The maximum yield of 3,052 kg/ha was recorded by entry 52 followed by entries 24, 29, 22, 23, 27 and 33. In 1993, there were 10 entries in the top 2.5 percent

Table 8. Grain yield (kg/ha) of wheat varieties grown under rainfed conditions at Gembu during 1991 – 1993 seasons.

Entry No.	1991	1992	1993	Mean
Durum wheat lines/varieties				
29	3310ab	1358bc	1500b	2055
24	2056a-g	1610b	2150a	1939
22	1860b-g	1302bcd	2292a	1818
37	4260a	518g-j	562def	1780
30	3036abc	850c-j	1348bc	1745
27	1830b-g	1206b-e	2196a	1744
23	1600b-g	1344bc	2140a	1695
28	1496b-h	896c-l	2198a	1530
32	2756a-d	780c-j	958cd	1497
33	1500b-g	1162b-f	1610b	1424
26	1290b-g	1056b-g	1830ab	1392
44	2436a-g	1024b-g	620def	1360
50	3110abc	508g-j	396ef	1338
35	2570a-e	640e-j	616def	1275
52	280fg	3052a	316ef	1213
25	1080c-g	958c-h	1564b	1201
38	2210a-g	736d-f	508def	1151
46	2320a-g	588f-g	410ef	1106
40	2260a-g	650e-j	392-ef	1101
36	2224a-g	318ij	356ef	966
45	740d-g	796e-j	984cd	840
34	1550b-g	412hij	378ef	780
54	1120b-g	536g-j	516def	724
49	598d-g	532g-j	944cd	691
31	1330b-g	374ij	356ef	687
53	546d-g	516g-j	798de	620
47	360efg	736d-j	616def	571

Table 8 (contd.)

Entry No	1991	1992	1993	Mean
42	620d-g	704d-g	294f	539
41	350efg	530g-j	396ef	425
51	350efg	396h-j	420ef	389
43	206g	512g-j	394ef	371
48	246fg	476g-j	370ef	371
39	330fg	276l	364ef	331
Mean	1571	829	933	1111

Significance: * ** *

Bread wheat lines/varieties

80	4750a	2310a-d	4074ab	3711
79	3600a-e	2520ab	3640bc	3253
93	3916abc	2672a	3036d-g	3208
77	3180a-h	2240a-e	4166a	3195
97	3270a-f	2290a-d	3340cde	2967
75	3260a-g	2296a-d	3034d-g	2862
82	3704a-d	2500ab	2244i-m	2816
76	3180a-h	2230a-e	2146j-q	2519
92	2920a-i	2044b-f	2112l	2359
71	4496ab	1126k-v	1430v-b	2351
66	2036c-i	1440f-k	3556c	2344
70	2426b-i	1780c-j	2772fgh	2326
74	2460b-i	1822c-l	2630g-j	2304
121	2280b-i	2334abc	2280h-n	2298
8	2459b-i	1780c-j	2620g-k	2280
56	2000c-i	1522f-r	3172c-f	2231
61	2290b-i	1604f-o	2728f-l	2207
56	2186c-i	1530f-g	2770fgh	2162
96	2130c-i	1500f-s	2850e-h	2160
120	2332b-i	1888c-h	2240l-m	2153
7	2346b-i	1724d-k	2280h-n	2117

Table 8 (contd.)

Entry No.	1991	1992	1993	Mean
106	2176f-i	15030f-g	2570g-l	2092
94	2186c-i	1528f-g	2516h-m	2077
60	1456d-i	1216l-v	3490cd	2054
110	1510d-i	1168k-v	17400-x	1473
73	2226b-i	458w-d	2670ghi	1451
113	1976c-i	226cd	2130k-g	1444
109	1336f-i	1294h-v	1570s-z	1400
118	1340f-i	1438f-u	1404v-b	1394
20	1510d-i	1160k-v	1508t-a	1393
11	1516d-i	1064l-v	1595s-z	1392
72	1536d-i	1056l-w	1574s-z	1389
90	1530d-i	1070l-v	1556s-z	1385
17	1340f-i	1136k-v	1480t-b	1319
86	1076fi	11305h-v	1565s-z	1315
115	1146f-i	1286h-v	1482t-b	1305
89	1366e-i	1020o-y	1416v-b	1267
58	1210f-i	848t-b	1730p-x	1263
5	1250f-i	1036n-x	1412v-b	1233
91	1416f-i	1004o-y	1532t-z	1224
67	1190f-i	1130k-v	1030abc	1192
105	1190f-i	960p-y	1390v-b	1180
12	1230f-i	940q-y	1340w-b	1170
112	1092f-i	1042m-w	1330x-b	1155
111	1156f-i	918r-z	1316x-b	1130
107	1020ghi	910s-z	1428v-b	1119
99	1056f-i	850t-b	1438u-b	1115
16	2184c-i	1632e-n	2242l-n	2019
21	1976c-i	1484t-p	2566g-l	2009
83	2080c-i	1560f-p	2292h-n	1977
14	2080c-l	1664e-l	2160j-p	1968

Table 8 (contd.)

Entry No.	1991	1992	1993	Mean
102	2010c-i	1410g-u	2396h-n	1939
85	2020c-i	1650e-m	2130k-g	1933
87	1736c-i	1988b-g	2032m-s	1919
65	2036c-i	1428g-u	2290h-n	1918
95	2046c-i	1440f-x	2142j-q	1876
69	1936 ^{c-i}	1236 ^{i-v}	2236 ^{i-o}	1803
81	1790c-i	2042b-f	1558s-z	1797
103	10806c-i	1264i-v	1946n-t	1672
57	1782c-i	1248i-v	1972n-t	1667
10	1686.1c-i	1335.6i-v	1830.5o-x	1617.4
15	1686.2c-I	1334.8i-v	1829.9o-x	1617.2
18	1687.0c-I	1333.4i-v	1829.9o-x	1617.3
59	1586.1c-I	1435.5 i-v	1830.5o-x	1617.4
61	1776.1c-I	1235.8I-v	1830.5o-x	1617.5
68	1687.2c-I	1335.8I-v	1730.5p-x	1617.4
84	1596.8c-I	1438.2I-v	1830.6o-x	1617.6
88	1686.2c-I	1335.6I-v	1830.5o-x	1618.7
100	1796.1c-I	1225.6I-v	1830.5o-x	1618.7
101	1676.2c-I	1345.5I-v	1830.5o-x	1618.4
114	1676.1c-I	1335.6I-v	1830.4o-x	1617.3
55	1030ghi	722v-d	1386v-B	1046
19	936hi	876t-A	1192y-B	1001
13	960hi	846t-B	1016BC	941
98	850I	792v-C	1138zAB	927
104	810i	850v-d	1002BC	797
108	740i	918r-z	448D	702
119	446j	830u-B	510D	602
62	376j	436x-D	558CD	457
3	450j	33-z-D	586CD	455
63	300j	430y-D	404D	378

Table 8 (contd.)

Entry No.	1991	1992	1993	Mean
78	330j	322z-D	420D	357
6	330j	320A-D	352D	324
9	226j	300A-D	406D	311
64	226j	274ABC	344D	295
2	224j	200D	356D	260
1	250j	185D	306D	247
4	220j	196D	202D	206
Mean	1686.1	1335.6	1830.5	1617.4
Significance:	**	**	**	
SE ($\pm$)	141.57	112.31	189.97	-

Means followed by the same letter(s) within the same column are statistically the same at 5 percent level (Duncan's Multiple Range Test).

* and ** = Significant at 5 and 1 percent levels, respectively.

group. The maximum yield of 2,292 kg/ha was produced by entry 22 which was significantly at par with entries 28, 27, 24, 23, 26, 25, 29 while the second group of significance included entries 29, 30, 33, 26 and 25. When the means of those years were considered, it was observed that the grain yield of 1991 was higher compared with the other two years. In terms of percent yield, the 1991 was higher than 1992 by 189 percent and it was also higher than 1993 by 168 percent. On the other hand, in durum wheat in 1991, 14 entries were found in the lower 2.5 percent group. The lowest yield (206 kg/ha) was recorded by entry 43 followed by entries 48, 39, 41 and 51. In 1992, 13 entries were found in the lower, 2.5 percent group. The lowest yield (276 kg/ha) was observed in entry 39 followed by entries 51, 48, 43 and 51 in ascending order of magnitude. In 1993 season, 16 entries fell into the lower 2.5 percent group. The lowest yield (294 kg/ha) was recorded by entry 42 followed by entries 39, 48, 43, 41 and 51 in ascending order.

In bread wheat, the grain yield is presented in Table 8 for three seasons. The analyses of data revealed that the differences within the means for the grain yield of varieties were highly significant for the three seasons. In 1991, 33 entries of bread wheat fell into the top 2.5 percent group. The maximum yield of 4,750 kg/ha was produced by entry 80 followed by entries 71 and 93. Seven entries constituted another group of the top 2.5 percent. This included entries 82, 79, 97, 75, 76, 77 and 97. There were four other significant groups found in this top 2.5 percent class. In 1992, 22 entries were found in the top 2.5 percent group. The maximum yield of 2,672 kg/ha was recorded by entry 93 followed by entries 79 and 82. Six entries that constituted another significant group in the top 2.5 percent included 121, 80, 75, 97,

77 and 76. The rest of the entries were found in other significant groups of the top 2.5 percent. In 1993, the top 2.5 percent group contained 27 entries. The maximum yield was 4166 kg/ha that year and was recorded by entry 77 followed by entries 80 and 79. Other top yielders included entries 66, 97, 60, 56, 93 and 75. On the other hand in 1991, 32 bread wheat entries were found in the lower 2.5 percent group. The lowest yielder (220 kg/ha) was entry 4 followed by entries 2, 9 and 64. In 1992, 30 entries fell into the lower 2.5 percent group. The lowest yielder (185 kg/ha) was entry 1 followed by entries 2, 4 and 64. In 1993 season, 28 entries were found in the lower 2.5 percent group. The lowest yielder (202 kg/ha) was from entry 4 followed by entries 1, 64, 6 and 2. When the means for three years for bread wheat were considered it was observed that the grain yield of 1993 was the highest compared with the other two years. In terms of percentage of 1991 and 1992, 1993 was higher than 1991 by 108 percent and in 1992 it was 137 percent. Generally, bread wheat produced higher yields than durum wheat.

4.9 Correlation Coefficient of Yield Components With Yield and

Within the Components

The correlation coefficients of yield components with yield and within the components of durum wheat for the three seasons is shown in Table 9. In 1991, the correlation coefficients between the yield components: spikes/m², seeds/spike and 1000-seed weight with yield were highly significant ($P \geq 0.01$). The association within the yield components themselves: spikes/m² and seeds/spike, seeds/spike and seed weight as well as spikes/m² and seed weight were significant ($P \geq 0.05$). In 1992, the correlation coefficients between spikes/m² and yield was highly significant ($P \geq 0.01$) while the correlation coefficient between seeds/spike and yield, seed

Table 9. Correlation coefficients of yield components with yield and within the components of wheat varieties tested at Gembu during 1991 to 1993 seasons.

1991				
Durum wheat lines/varieties				
	Spikes/m²	Seeds/spike	Seed wt.	Yield
Spikes/m²	1.000			
Seeds/spike	0.398*	1.00		
Seed weight	0.389*	0.247*	1.00	
Yield	0.502**	0.588**	0.618**	1.00
1992				
	Spikes/m²	Seeds/spike	Seed wt.	Yield
Spikes/m²	1.00			
Seeds/spike	0.150*	1.00		
Seed weight	0.133*	0.548**	1.00	
Yield	0.735**	0.371*	0.355*	1.00
1993				
	Spikes/m²	Seeds/spike	Seed wt.	Yield
Spikes/m²	1.00			
Seeds/spike	0.509**	1.00		
Seed weight	0.359*	0.325*	1.00	
Yield	0.666**	0.564**	0.559**	1.00

* = Significant at 5% level of probability ($P \geq 0.05$)

** = Significant at 1% level probability ($P \geq 0.01$)

weight and yield were significant at ($P \geq 0.05$). Within the yield components themselves the association between spikes/m² and seeds/spike was significant ($P \geq 0.05$), between seeds/spike and seed weight, it was highly significant while between spikes/m² and seed weight it was significant ($P \geq 0.05$). In 1993 the correlation coefficient between the three yield components: spikes/m², seeds/spike and seed weight with yield were highly significant ($P \geq 0.01$). In the association with the yield components themselves, spikes/m² was highly significantly correlated with seeds/spike ($P \geq 0.01$) while seeds/spike was significantly correlated with seed weight ($P \geq 0.05$), as well as spikes/m² and seed weight ($P \geq 0.05$).

For bread wheat, the correlation coefficients of yield components with yield and within the yield components themselves for three seasons is shown in Table 18. In 1991, the correlation coefficients between the yield components and yield were highly significant ($P \geq 0.01$). Within the yield components themselves, the correlation coefficients between spikes/m² and seeds/spike, seeds/spike and seed weight and then spikes/m² and seed weight were significant ($P \geq 0.05$). In 1992, the association between the yield components: spikes/m², seeds/spike and seed weight with yield was highly significant ($P \geq 0.01$). The association between spikes/m² and seeds/spike was significant ($P \geq 0.05$) while between seeds/spike and seed weight, the association was highly significant ($P \geq 0.05$). The correlation between spikes/m² and seed weight was significant ($P \leq 0.05$). In 1993 the correlation coefficients between spikes/m², seeds/spike and seed weight with yield were highly significant, while the association within the yield components themselves, spikes/m² and seeds/spike,

Table 10. Correlation coefficients of yield component with yield and within the components with yield and within the components of bread wheat varieties tested at Gembu during 1991 to 1993 seasons.

		1991		
	Spikes/m²	Seeds/spike	Seed wt.	Yield
Spikes/m²	1.00			
Seeds/spike	0.382*	1.00		
Seed weight	0.436*	0.441*	1.00	
Yield	0.762**	0.595**	0.516**	1.00
		1992		
	Spike/m²	Seeds/spike	Seed wt.	Yield
Spikes/m²	1.00			
Seeds/spike	0.387*	1.00		
Seed weight	0.467**	0.373*	1.00	
Yield	0.663**	0.462**	0.530**	1.00
		1993		
	Spikes/m²	Seeds/spike	Seed wt.	Yield
Spikes/m²	1.00			
Seeds/spike	0.334*	1.00		
Seed weight	0.253*	0.353*	1.00	
Yield	0.896**	0.590**	0.409**	1.00

* = Significant at 5% level of probability ($P \geq 0.05$)

** = Significant at 1% level of probability ($P \geq 0.01$)

seeds/spike and seed weight and also spikes/m² and seed weight was significant ($P \leq 0.05$). In general the association between spikes/m² and yield was highest followed by seeds/spike while the lowest association was recorded between seed weight and grain yield in this study.

4.10 Direct, Indirect and Total Effect of Yield Components On Grain Yield

The direct, indirect and total effect of yield components on grain yield of durum wheat during 1991 to 1993 seasons is shown in Table 11. The path coefficient analyses in 1991 revealed that out of a total correlation of 0.502, number of spikes/m² had direct positive effect of 0.258. The indirect effect through number of seeds/spike and 1000-seed weight were 0.123 and 0.176. When the total correlation between number of seeds/spike and yield was partitioned into direct and indirect effects, the direct effect was significant and amounted to 0.421, while the indirect effects through number of spikes/m² and 1000-seed weight were 0.063 and 0.112. In the 1000-grain weight, the total correlation was 0.619. The direct effect was 0.453 while the indirect effect through number of spikes/m² and seeds/spike was 0.062 and 0.104. In 1992, the path coefficient analysis revealed that out of a total correlation of 0.735, number of spikes/m² contributed a direct positive effect of 0.686. The indirect effects through number of seeds per spike and 1000 –seed weight were 0.027 and 0.022. Number of seeds/spike had a direct positive effect of 0.178, while through number of spikes/m² and 1000-seed weight, it indirectly contributed 0.103 and 0.91. In the 1000 – grain, weight component, the total contribution to yield amounted to 0.354. The direct effect was 0.166 whereas indirect effect through number of spikes/m² and seeds/spike

Table 11. Direct, indirect and total effects of yield components on yield of wheat at Gembu during 1991 to 1993 seasons.

1991				
Durum wheat lines/varieties				
	Spikes/m²	Seeds/spike	Seed Wt.	Total
Parameters				
Spikes/m²	<u>0.258</u>	0.123	0.176	0.557
Seeds/spike	0.063	0.421	0.112	0.596
Seed weight	0.062	0.104	<u>0.453</u>	0.619
1992				
	Spikes/m²	Seeds/spike	Seed wt.	Total
Parameters				
Spikes/m²	<u>0.686</u>	0.027	0.022	0.735
Seeds/spike	0.103	<u>0.178</u>	0.091	0.372
Seed weight	0.091	0.097	<u>0.166</u>	0.354
1993				
	Spikes/m²	Seeds/spike	Seed wt.	Total
Parameters				
Spikes/m²	<u>0.425</u>	0.135	0.118	0.678
Seeds/spike	0.217	<u>0.244</u>	0.107	0.568
Seed weight	0.091	0.097	<u>0.238</u>	0.516

Direct effects are underlined.

were 0.091 and 0.097. In 1993, the path coefficient analyses revealed that the total correlation was 0.678 for number of spikes/m². The direct contribution by this parameter was 0.425, whereas indirectly through number of seeds/spike and 1000-seed weight it contributed 0.135 and 0.118. Seeds/spike had a direct positive effect of 0.244 while indirectly through number of spikes/m² and 1000-seed weight, it contributed 0.217 and 0.107. Total contribution by this component was 0.568. The analyses also revealed that the 1000-seed weight had a direct positive contribution of 0.328 and indirect effect through spikes/m² and seeds/spike of 0.091 and 0.097. The total contribution was 0.516.

The direct, indirect and total effect of yield components on yield of bread wheat during 1991 to 1993 seasons is shown in Table 12. In 1991, the path coefficient analysis revealed that out of a total correlation of 0.760, number of spikes/m² had a direct positive contribution of 0.588. The indirect effect through number of seeds/spike and 1000-seed weight was 0.122 and 0.050. The number of seeds/spike had a direct positive contribution of 0.320 while indirectly through spikes/m² and 1000-seed weight, it contributed 0.245 and 0.052. When the effects from 1000-grain weight were considered, the total correlation was 0.516. The direct effect was 0.119 while the indirect effects through spikes/m² and seeds/spike were 0.256 and 0.141. In 1992, the path coefficient analyses revealed that out of a total correlation of 0.663, number of spikes/m² had a direct contribution of 0.481, while indirectly through seeds/spike and 1000-seed weight, it contributed 0.072 and 0.110. The number of seeds/spike had a positive contribution of 0.186 while indirectly through spikes/m² and 1000-seed weight it was 0.180 and 0.088. The total

Table 12. Direct, indirect and total effects of yield components on yield of bread wheat at Gembu during 1991 to 1993 season.

		1991		
	Spikes/m²	Seeds/spike	Seed wt.	Total
Parameters				
Spikes/m²	<u>0.588</u>	0.122	0.050	0.760
Seeds/spike	0.245	<u>0.320</u>	0.052	0.617
Seed weight	0.256	0.141	<u>0.119</u>	0.516
		1992		
	Spikes/m²	Seeds/spike	Seed wt.	Total
Parameters				
Spikes/m²	<u>0.481</u>	0.072	0.110	0.663
Seeds/spike	0.180	<u>0.186</u>	0.088	0.454
Seed weight	0.225	0.069	<u>0.236</u>	0.530
		1993		
	Spikes/m²	Seeds/spike	Seed wt.	Total
Parameters				
Spikes/m²	<u>0.540</u>	0.107	0.038	0.685
Seeds/spike	0.192	<u>0.358</u>	0.099	0.649
Seed weight	0.136	0.127	<u>0.145</u>	0.408

Direct effects are underlined.

correlation was 0.454. In the 1000-seed weight, the direct effect was 0.236, whereas indirectly through spikes/m² and seeds/spike, 0.225 and 0.069. The total correlation was 0.530. The path coefficient analyses in 1993 revealed that out of a total correlation of 0.685, spikes/m² had a direct positive contribution of 0.540. The indirect contribution through seeds/spike and 1000-seed weight was 0.107 and 0.038. When the total correlation between number of seeds/spike and yield was partitioned into direct and indirect effect, the direct was significant and contributed 0.358, while the indirect effects through spikes/m² and 1000-seed weight was 0.192 and 0.099. In the 1000-seed weight component, total correlation was 0.408. The direct effect was 0.145, while the indirect effect through spikes/m² and seeds/spike was 0.136 and 0.127.

4.11 Percent Contribution of Yield Components to Grain Yield

The percent contribution of yield components to total grain yield of durum wheat is presented in Table 13. Number of spikes per m² was found to contribute the highest towards yield and its contribution ranged from 18.09 in 1993 to 47.10 percent in 1992. The contribution in 1991 was 20.48 percent. The second most important contribution to grain yield was by the number of grains per spike which ranged from 3.15 in 1992 to 17.73 percent in 1991. The 1000-seed weight contributed the least to yield and this ranged from 2.51 in 1991 to 5.84 percent in 1993.

When the combined contribution of any two parameters were examined, it was observed that number of spikes per m² and number of seeds per spike contributed more towards yield in all the three seasons. This ranged from 3.66 to 10.46 percent in 1992 and 1993 seasons, respectively. The next parameter that contributed to grain

Table 13. Contributions (percent) of yield components to yield of durum wheat at Gembu during 1991 to 1993 seasons.

Character	Percent contribution			
	1991	1992	1993	Mean
Individual contribution				
No. of spikes per m ²	20.48	47.10	18.09	28.56
No. of grains per spike	17.73	3.15	10.76	10.55
1000-grain weight	7.51	2.76	5.84	5.37
Combined Contribution				
No. of spikes/m ² and No. of seeds/spike	9.42	3.66	10.46	7.85
	5.57	3.03	10.02	6.21
No. spikes/m ² and 1000-grain weight				
No. of seeds/spike and 1000-grain weight	5.31	3.24	5.15	4.57
Residual	33.98	37.06	39.68	16.91
Total	100.00	100.00	100.00	100.00

yield was the combined effects of number of spikes per m^2 and 1000-seed weight which contributed between 3.03 and 10.02 percent. The number seeds per spike and 1000-grain weight was the least and ranged from 3.24 in 1992 to 5.31 percent in 1991. The residuals in 1991, 1992 and 1993 was 38.98, 37.06 and 39.68 percent, respectively.

In bread wheat the percentage contribution of yield components to total grain yield is presented in Table 14. Number of spikes per m^2 was again found to have contributed highest towards yield and its contribution ranged from 23.14 in 1992 to 34.59 percent in 1991. The second highest contribution to grain yield was given by number of seeds per spike and it ranged from 5.56 in 1992 to 12.81 percent in 1993. In 1991, it was 10.24 percent. The contribution from 1000-seed weight was the least and it ranged from 1.40 to 3.46 percent.

When the combined contribution of any two parameters in bread wheat was examined, it was observed that number of spikes per m^2 and number of seeds per spike contributed most towards grain yield. This ranged from 6.92 in 1992 to 12.91 and 14.38 percent in 1993 and 1991, respectively. Number of spikes per m^2 and 1000-seed weight was the next and ranged from 3.96 in 1993 to 10.59 percent in 1992. Again, the least combined contribution came from number of seeds per spike and 1000-grain weight. It ranged from 3.27 in 1992 to 3.70 percent in 1993. The contribution in 1991 was 3.35 percent. The residuals in 1991, 1992 and 1993 seasons were 29.96, 47.06 and 35.37 percent, respectively.

Table 14. Contributions (Percent) of yield components to yield of bread wheat at Gembu during 1991 to 1993 seasons.

Character	<u>Percent Contribution</u>			
	1991	1992	1993	Mean
Individual contribution				
No. spikes per m ²	34.59	23.14	29.14	28.95
No. seeds per spike	10.24	5.56	12.81	9.54
1000-grain weight	1.40	3.46	2.11	2.32
Combined contribution				
No. spikes/m ² and No. seeds/spike	14.38	6.92	12.91	11.40
No. seeds/spike and 1000-grain weight	6.08	10.59	3.96	6.88
No. spikes/m ² and 1000-grain weight	3.35	3.27	3.70	3.44
Residual	29.96	47.06	35.37	37.46
Total	100.00	100.00	100.00	100.00

4.12 Proximate Composition of Wheat Grain and Flour

The proximate composition of wheat grain samples and experimentally milled fractions for both durum wheat and bread wheat are shown in Tables 15 and 16. In the grain samples (Table 15), the moisture content ranged from 6.75 to 8.0 percent in the durum wheat with the highest recorded by entry 24 followed by entries 27 and 33. In the bread wheat it was from 6.4 to 8.6 percent with the highest recorded by entry 16 followed by entries 120 and 71. Out of the 41 samples tested, 20 fell in the top elite group and out of this number 5 of them were durum wheat while 15 were bread wheat. The protein content in the grain samples ranged from 14.16 to 18.20 percent in the durum wheat with the highest recorded by entry 28 followed by entries 33 and 30. In the bread wheat, the protein content range was from 13.5 to 18.90 percent with entry 97 giving the highest content followed by entries 120 and 7. In these samples, 15 out of the 41 samples fell in the top elite 2.5 percent group and 6 of this group were durum wheat while 9 were bread wheat. The fat, ash and carbohydrate contents in the wheat grains followed a similar trend and recorded high in these samples. The carbohydrate content in the durum wheat ranged from 70.65 to 74.55 percent. The highest content was recorded by entry 33 followed by entries 22 and 24 in that order. In the bread wheat, carbohydrate content ranged from 66.95 to 75.15 percent with the highest recorded by entry 56 and followed by entries 16 and 21 from the 41 samples tested, 10 belonged to the top 2.5 percent elite group out of which three were durum and seven bread wheat.

In the experimentally milled flour (Table 16), the content ranged from 8.4 to 9.4 percent in the durum wheat with 32 recording the highest moisture content followed by entries 28 and 33. In the bread wheat species, moisture content ranged

Table 15. Proximate composition of durum and bread wheat lines/varieties composite samples from Gembu during 1991 – 1993 seasons.

Entry Number	Moisture (%)	Protein (N x 6.25)	Fat (%)	Ash (%)	Carbohydrates (%)
Durum wheat					
29	6.95	16.75	1.92	1.8	73.0
24	8.00	15.3	1.92	1.90	73.20
22	6.81	16.4	1.96	1.73	74.5
37	7.10	14.16	1.92	1.72	71.3
30	7.55	17.3	2.07	1.8	71.8
27	7.70	16.75	1.97	1.8	72.85
23	7.50	15.9	2.05	1.8	71.1
28	6.75	18.20	1.85	2.15	71.8
32	7.30	17.05	2.12	1.59	70.65
33	7.65	17.6	2.23	1.84	74.55
Bread wheat					
75	7.65	13.50	2.07	2.05	72.3
80	6.55	17.6	2.05	1.68	71.1
79	6.60	11.85	1.85	1.88	72.7
93	7.00	15.0	1.89	1.89	74.15
77	6.75	16.95	1.86	1.61	72.9
97	6.45	18.90	2.1	1.68	73.6
82	7.6	16.05	2.27	1.81	72.5
76	7.45	16.45	1.72	1.88	71.7
92	7.95	16.85	1.82	1.67	72.75
71	8.3	16.05	1.82	1.71	71.75
66	8.00	16.35	1.72	1.40	72.75
70	7.6	15.95	2.05	1.65	72.45
74	7.8	16.2	1.82	1.8	72.85
121	6.55	17.0	1.85	1.8	72.4
8	7.50	16.45	1.95	1.72	72.75

Table 15 (Contd.)

Entry Number	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrates (%)
56	7.8	15.6	2.07	1.67	75.15
61	6.81	14.60	2.12	1.35	73.0
59	7.15	16.05	2.0	1.8	72.5
96	7.8	15.65	2.2	1.80	66.95
120	8.5	18.20	2.19	1.67	70.75
7	7.05	18.05	2.16	1.97	71.35
106	7.45	17.35	2.15	1.69	72.95
94	8.00	15.4	2.08	1.7	73.05
60	7.35	16	1.95	2.11	72.7
16	8.6	14.75	2.07	1.88	74.5
21	6.50	15.3	1.86	1.90	74.5
83	6.40	15.95	1.87	1.34	73.85
14	7.85	15.6	2.07	1.8	72.05
102	7.15	17.4	2.11	1.36	74.35
85	6.70	15.2	1.98	1.70	72.75
117	7.70	15.8	1.82	1.76	72.50
Mean	7.37	15.92	1.98	1.75	72.58
SE±	0.01	0.39	0.02	0.03	0.22

from 8.45 to 10.25 percent. The highest moisture content was recorded by entry 93 followed by entries 92 and 71. Out of 41 samples examined, 14 belonged to the top 2.5 percent class of which one of them was durum wheat while 13 were bread wheat. The protein content ranged from 13.05 to 17.25 percent in the durum wheat. The highest protein content was recorded by entry 28 followed by entries 33 and 29. In the bread wheat, the range was from 13.0 to 17.90 percent. The highest protein content was observed in entry 76 and this was followed by entries 77, 121 and 7.

Table 16. Proximate composition of experimentally milled rainfed durum and bread wheat lines/varieties composite wheat flour samples from Gembu during 1991 – 1993 rainy seasons.

Entry Number	Moisture (%)	Protein	Fat (%)	Ash (%)	Carbohydrate (%)
Durum wheat					
29	8.85	16.40	1.5	0.335	73.6
22	8.5	15.85	1.565	0.49	73.6
37	8.7	13.051	1.505	0.395	76.35
30	8.4	15.95	1.785	0.595	73.6
27	9.0	16.05	1.67	0.355	72.95
23	8.65	14.9	1.685	0.675	74.05
28	9.2	17.25	1.35	0.675	71.51
32	9.4	16.1	1.3	0.62	72.6
33	9.15	16.5	1.4	0.63	72.35
Bread wheat					
79	8.65	16.05	1.56	0.665	73.2
93	10.25	13.8	1.6555	0.62	72.7
80	8.55	16.45	1.875	0.355	71.151
77	9.8	16.95	1.54	0.57	74.45
97	8.55	14.75	1.78	0.485	73.35
75	9	13.0	1.505	0.66	75.85
82	9.2	15.3	1.625	0.535	73.3
76	8.6	17.9	1.3	0.525	72.85
92	10.06	15.7	1.65	0.665	71.91
71	10.05	15.75	1.475	0.44	72.4
66	9.8	14.4	1.44	0.68	74.7
70	9.2	15.0	1.325	0.74	73.7
74	8.6	13.45	1.3	0.715	79.95
121	9.3	16.65	1.325	0.44	72.5
8	9.7	14.7	1.3	0.565	74.55
56	9.3	14.5	1.15	0.57	74.3
61	9.45	13.5	1.49	0.62	75.0

Table 13 (Contd.)

Entry Number	Moisture (%)	Protein	Fat (%)	Ash (%)	Carbohydrate (%)
59	8.5	14.2	1.375	0.665	75.4
96	9.45	13.5	1.175	0.62	75.0
14	8.5	14.2	1.2	0.665	75.4
12	9.45	15.1	1.55	0.645	71.41
120	9.6	15.7	1.545	0.625	71.41
7	8.65	16.65	1.39	0.63	72.7
106	8.45	15.0	1.025	0.355	75.2
94	9.6	14.7	1.425	0.6	73.65
60	8.5	15.85	1.025	0.515	75.1
16	9.7	14.2	1.0	0.6	74.5
21	7.91	14.5	1.47	0.64	75.75
83	10.0	14.45	1.505	0.67	73.35
102	8.95	15.95	1.36	0.465	73.3
85	10.05	14.15	1.465	0.565	73.8
117	9.15	15.1	1.415	0.39	73.95
Mean	9.13	15.21	1.43	0.56	73.81
SE±	0.09	0.18	0.03	0.02	0.05

From the fractions determined, 17 belonged to the top 2.5 percent group out of which seven were durum wheat and 10 bread wheat. Also the fat, ash and carbohydrate contents tested were quite high. In the durum wheat, carbohydrate content ranged from 71.26 to 76.35 percent with the highest content recorded by entry 37 followed by entries 23 and 22, 29 and 30 which were at par with one another. In the bread wheat the carbohydrate content ranged from 71.15 to 79.95 percent. The highest content was recorded by entry 74 followed by entries 75 and 59, 14 which were at par with each other. From the fractions, 17 out of the 41 samples tested belonged to the top 2.5 percent out of which two were durum wheat and 15 bread wheat.

4.13 Flour Extraction, Wet and Dry Gluten

Flour extraction from the wheat samples considered is shown in Table 17. It ranged from 56.5 to 70.8 percent in the durum wheat with entry 24 giving the highest flour extraction followed by entries 29 and 23. In the bread wheat sample ranged from 56.7 to 73.8 percent. The highest extraction percentage was recorded by entry 70 followed by entries 21 and 92. Out of the 41 sample tested, 19 belonged to the top 2.5 percent elite group from which three were durum and 16 bread wheat. The wet gluten content of durum ranged from 41.5 to 48.0 percent with the highest content recorded by entries 23 and 28 followed by entries 32 and 3. In the bread wheat, range is from 35.5 to 51.5 percent. The highest value was obtained from entry 92 followed by entries 77, 85 and 102 which were all at par with one another. Out of the samples tested, 18 belonged to the top 2.5 percent group with four coming from durum while 14 were from bread wheat entries. The dry gluten content extraction ranged from 13.0 to 15.5 percent in the durum wheat with entries 22, 23 and 28 recording the highest

Table 17. Flour extraction, wet and dry gluten contents of rainfed wheat experiment grown at Gembu during 1991 – 1993 seasons.

Entry Number	Flour (%)	Wet Gluten (%)	Dry Gluten (%)
Durum wheat			
29	70.7	43.5	14.0
24	70.8	41.5	13.0
22	68.3	45.5	15.5
37	67.5	43.0	14.0
27	61.8	44.5	14.0
23	68.7	48.0	15.5
28	56.5	48.0	15.5
32	63.0	46.0	14.0
33	65.9	45.0	14.4
Bread wheat			
80	64.0	44.5	15.5
79	72.7	45.5	14.9
93	65.7	41.5	12.4
77	70.0	47.5	15.5
97	72.2	46.5	13.8
80	70.6	43.5	14.0
75	65.5	46.5	12.2
82	71.0	45.5	13.5
76	72.9	45.0	14.5
92	73.2	51.5	14.5
71	68.7	47.0	16.3
66	60.7	44.0	14.0
70	73.8	42.0	15.2
74	59.7	36.5	12.0
121	69.2	40.5	15.0
8	71.5	40.0	13.0
56	65.5	50.0	16.0
61	69.6	38.0	13.0

Table 17 (Contd.)

Entry Number	Flour (%)	Wet Gluten (%)	Dry Gluten (%)
59	71.3	40.5	13.7
96	64.9	38.0	12.5
120	68.5	46.0	16.8
7	60.4	46.5	16.6
106	58.5	40.5	14.8
94	68.3	43.5	14.0
60	72.2	44.0	13.5
16	72.9	35.5	12.1
21	73.3	47.0	14.5
83	71.8	46.5	15.3
14	66.7	40.5	12.5
102	56.7	47.5	14.5
85	71.3	47.5	13.0
117	63.4	44.0	12.5
Mean	67.55	44.15	14.1
SE $\pm$	0.75	0.56	0.17

extraction percent which were at par followed by entries 33, 29, 37, 27 and 32 which were at par. In the bread wheat dry gluten extraction percentage ranged from 12.0 to 16.8 with the highest extraction percentage scored by entry 120, closely followed by entries 7 and 71. Out of the 41 samples tested, 10 belonged to the top elite 2.5 percent group with three coming from durum wheat and seven from bread wheat.

CHAPTER FIVE

5.0 DISCUSSION

Adaptation of wheat varieties to rainfed conditions at Gembu in the Mambilla Plateau of Nigeria was successfully demonstrated. Significant differences were observed among all the wheat lines/ varieties evaluated including between bread and durum wheat and within the two wheat species. Performance was better in 1993 due to a more conducive weather conditions that prevailed with very cool temperatures and well distributed rainfall pattern. These findings conformed with those reported by (Fisher, 1993; Aggrawal *et al.*, 1995).

Bread wheat lines/varieties generally yielded higher than durum wheat lines/ varieties. Earlier work by Halilo *et al.*, (1993) reported similar results. This is due to inherent characteristics of bread wheat for higher yielding ability.

Plant height is an important attribute particularly in cereal crops due to its effect on lodging. In this study, bread wheat varieties were generally taller than durum wheat. Crop varieties with shorter stature have been recommended for their suitability to mechanization (Jawmal, 1987).

In this study, bread wheat was observed to have flowered earlier than durum wheat. In relation to early flowering (Jawmal, 1989) reported that early maturing varieties usually have longer grain filling periods compared with late flowering types. Also early flowering varieties tend to be better adapted to their environments (Abdallah, 1987). In the present study also, early flowering varieties have the

advantage of having longer grain filling periods and hence better grains as well as high chances of better adaptation.

Bread wheat matured earlier than durum wheat. Long duration crop was reported to have a sharp decrease in grain yield when the high summer temperature set in early wheat varieties. This could be due to photosynthates produced during the day are used in respiration with high night temperatures. Early maturing varieties in this study, have high degree of adoption and could be well fitted into the double cropping system in the zone.

Number of spikes is a varietal attribute but can be positively influenced by such factors as spacing, cool temperature regimes, availability of moisture and adequate nutrient supply. In the durum and bread wheat, entries with high number of spikes/m² were also among the top yielders. Entry number 80 in the bread wheat which produced the highest number of spikes/m² also gave the highest grain yield indicating a very high positive correlation between number of spikes/m² and grain yield. Its consistently high percent contribution to yield proved that it is the most important yield contributing factor. Similar results were reported by a number of other researchers Hay (1995), Jackson *et al* (1996), Kearsy and Pousi (1996), and Sayre *et al.* (1997).

Number of seeds per spike is the second important yield component after spikes/m². Entries with high number of seeds/spike recorded high grain yield in both durum and bread wheat species. This again reflects a high positive correlation of grain number and grain yield of varieties. This positive correlation between grain

yield and seed number has also been reported by Bindraban *et al.* (1997), CIMMYT (1995), Dawoch and Baller (1990), and De Wit (1992).

Significant differences in grain weight were observed in among varieties in the three test years. It ranks third as a direct yield contributing factor, it is governed mainly by genotype and to some extent by the environmental conditions. Many workers have reported similar differences in 1000-grain weight of wheat varieties (Brewit *et al.*, 1978; Ansori *et al.* 1989; and Bicingir *et al.*, 1997).

Grain yield is a complex attribute that depends on a number of interacting factors. Number of spikes/m², seeds/spike and 1000-grain weight are among the main yield contributing components of wheat. Other biotic and abiotic factors such as pests and diseases, temperature, moisture positively or negatively to affect total grain yield of lines/varieties. It was observed that entries with the highest number of spikes/m² seeds per spike and 1000-grain weight also produced high grain yield showing high positive correlation of these parameters to grain yield. Similar correlation of these yield parameters with grain yield have been reported by other workers (Slafer and Savia, 1994; Slafer *et al.*, 1994; Slafer *et al.*, 1996, and Van Ginko *et al.*, 1997).

When the percent average contributions of yield components to yield of durum and bread wheat lines/varieties were critically examined, it was observed that the three yield components, spikes/m², seeds/spike and seed weight directly contributed 44.48 and 40.81 percent in durum and bread wheat. The three yield components in combination of each other contributed 18.61 and 21.73 in durum and bread wheat, respectively. The average residual in durum and bread wheat were found to be 36.91 and 37.46.

When the direct contribution of individual yield components was examined, spikes/m² contributed 28.56 and 28.95 percent in durum and bread wheat. The direct contribution of seeds/spike in durum and bread wheat were 10.55 and 9.54 and of seed weight were 5.37 and 3.32, respectively. The average combined contributions of spikes/m² and seeds/spike were 7.85 and 11.4 in durum and bread wheat. Similarly, the number of seeds/spike and seed weight contributed 6.21 and 6.88 percent in durum and bread wheat and spikes/m² and seed weight contributed 4.57 and 3.44 in durum and bread wheat, respectively.

In all the three experiments, three durum lines/varieties, entry 22 – Veery ‘S’/BOW, entry 24 – CNAR ‘S’ ANA/CN and entry 29 – CIRUN were included in the 2.5 percent top yielding lines/varieties and another three entries, numbers 23, 27 and 30 (CHEN ‘S’/ALTAR 84, OPATA 85B and S-179) were included in the top 2.5 percent high yielding groups in two out of three seasons, therefore, these six lines/varieties of durum wheat are suggested to be included for zonal trials. Similarly, in bread wheat, fine entries (77, 79, 80, 93 and 97) IBN876, Veery ‘S’ CM 33027-PCBWH, Veery ‘S’ CM 330297-PCBWH1931, JUPBJYIM – CM35PCBWH977 and HECKET ‘S’ CM404554 – PCBWH-977 were found in all the three experiments in the top 2.5 percent high yielding varieties. Also, three other lines/varieties (entry numbers 75, 76 and 82) IBN 146, IBN136 and IBN 044 were included in the top high yielding varieties in two out of the three experiments. Thus, six durum and eight bread wheat varieties are suggested to be included in further regional trials for their testing adaptability under elite wheat varietal trial and lines/varieties which produce

more than 1.5 t/ha should continue in screening trials by including new entries to continue search for high yielding new genotypes.

Moisture content of wheat grains affects the quality greatly. The low moisture contents observed in the entries was due to the dryness of the season after harvest.. Protein content in wheat varies from about 6 to 21 percent depending in part on the genotype as well as environmental factors during growth and development. High protein contents were recorded by entries used in this study. It is due to the basic inherent characteristics as well as the favourable environmental conditions and soil nitrogen content (Finney *et al.*, 1957; Kent, 1983). It has also been reported that for the production of yeast leavened bread, flour with a protein content of at least 11 percent is preferred (Nkama *et al.*, 1991). To produce such a flour, the wheat grain must have a protein content of about 12 percent. In this study, most of the samples evaluated have protein content of 13 percent and above.

In experimental milling operations, the yield of straight grade flour for bread wheat or semolina in the case of durum wheat is the most important factor of milling quality (Kent, 1983). The flour extraction for the various rainfed wheat samples considered in this study range from 56.5 to 73.8 percent indicating a very high percentage flour extraction. Similarly, the wet and dry gluten contents as determined by the hand washing method (AACC, 1983) were quite high ranging from 35.5 to 51.5 percent, for the wet gluten and 12.0 to 16.8 percent for dry gluten. Entries with high wet gluten also recorded high dry gluten content indicating high quality of gluten from the genotypes studied.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

Three years of field experiments were conducted consecutively at Gembu in Mambilla Plateau from 1991 to 1993 wet seasons to evaluate the performance of bread wheat (*Triticum eastivum* L.) and durum wheat (*Triticum durum* Desf) lines/varieties under rainfed conditions. In the trials the mean plant heights of bread wheat was significantly taller than the durum wheat and the bread wheat also produced significantly more tillers compared with durum wheat. Similarly, the bread wheat flowered 5 days earlier and matured 4 days earlier than the durum wheat.

The durum wheat and the bread wheat produced seed weights which were at par 29.6 g. Comparing the grain yield of the bread and durum wheat, the bread wheat out-yielded the durum by 45.5 percent, the highest yielder in the bread wheat (entry 80) produced 3,711 kg/ha while in the durum wheat the highest yielder entry 29 produced 2,055 kg/ha over the three years of the trials.

Correlation analysis revealed a positive and highly significant association of three yield components with the yield. The path co-efficient analysis revealed that direct and indirect effect of yield components on yield was highest through number of spikes/m².

The percentage contribution of yield components to yield indicated that number of spikes/m² consistently gave the highest individual contribution to grain yield in both durum and bread wheat varieties in all the three years.

Quality tests on selected durum and bread wheat varieties revealed that the varieties have good physical characteristics with plump kernel and high seed weights. The heaviest seed weight for bread wheat was found in entry 80 which recorded 36.6 g while in durum wheat entries 27 and 23 recorded the heaviest seed weight with 32.6 g each.

Proximate analysis of the wheat samples revealed bread wheat varieties with high protein content ranging from 13.50 to 18.205 while in the durum species the range was also high ranging from 14.16 to 18.20 percent other properties such as fat, ash and carbohydrate contents registered high values for both the durum and the bread wheat species in both wheat samples and experimentally milled flour.

Flour yield from flour extraction as wet and dry gluten were quite high in both the durum and bread wheat varieties. The highest flour yield of 73.8% was recorded in entry 70 for bread wheat while in the durum entry 24 with 7 flour yield of 70.9 percent gave the highest yield. The highest wet gluten (51.5%) was recorded by entry 92 in bread wheat while entries 23 and 28 in the durum wheat with 48.0 percent each gave the highest wet gluten content. Entries with high wet gluten content also gave high dry gluten content.

In conclusion, therefore, this study revealed that wheat can be successfully grown under rainfed condition in the Mambilla Plateau of Nigeria with thorough evaluation and selection of adaptable varieties where the conducive weather and adequate rainfall that prevail in the Plateau favour the productivity of rainfed wheat with high grain yield, good milling and baking properties.

It is therefore recommended that entries that yielded 1.5 t/ha and above should continue in screening trial (12 durum and 18 bread wheat) as a continuous project and six durum and eight bread wheat lines/varieties to be included into elite regional wheat lines/varietal trial to test their adaptability in the region.

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Appendix 1: Physical and Chemical properties of the soil of the Experimental plots at Gembu during 1991 to 1993 wet season.

Composition	YEARS		
	1991	1992	1993
Physical Characteristics			
Clay (%)	12.0	14.0	17.0
Silt (%)	36.0	31.0	35.0
Sand (%)	52.0	54.0	50.0
Texture Class	Sandy/loam	Sandy/loam	Sandy/loam
Chemical Characteristics			
pH (H ₂ O)	5.6	5.5	5.3
pH (CaCl ₂)	5.0	5.0	4.9
Org. Carbon (%)	0.5	0.5	0.6
Available P (ppm)	2.5	2.5	2.6
Total N (%)	0.04	0.04	0.05
Exchangeable bases (Meg/100 g/Soil)			
Exchangeable Ca (Meg/100 g. Soil)	1.3	1.2	2.3
Exchangeable Mg (Meg/100 g Soil)	0.7	0.7	0.8
Exchangeable K (Meg/100 g Soil)	0.3	0.3	0.3
CEC (Meg/100 g Soil)	5.6	5.4	5.6

Appendix II. Rainfall maximum and minimum temperatures and relative humidity at Gembu during 1991 to 1993.

Months	1991			Relative Humidity (%)	1992			Relative Humidity (%)	1993			Relative Humidity
	Rainfall Amt (mm)	No. of Rain days	Temperature Max Min		Rainfall Amt (mm)	No. of Rain days	Temperature Max Min		Rainfall Amt (mm)	No. of Rain days	Temp (°C) Max Min	
Jan.	Nil	Nil	27 14	33	Nil	Nil	28 14	55	Nil	Nil	27 14	38
Feb.	2.1	1	28 18	38	Nil	Nil	29 15	43	6.9	1	28 16	31
Mar	72.0	6	29 18	38	56.4	7	28 18	67	107.2	15	27 18	62
April	176.9	16	26 17	71	134.2	16	27 18	69	85.6	16	27 18	70
May	215.9	22	25 17	74	242.1	19	26 17	72	147.6	18	26 18	75
June	160.2	19	25 17	78	196.7	18	24 17	76	318.2	22	25 17	83
July	204.9	25	23 16	82	368.3	27	24 16	85	302.7	21	24 17	85
Aug.	202.7	22	25 16	80	224.8	21	23 17	85	332.7	26	24 15	83
Sept.	248.9	22	25 16	76	311.3	21	24 16	82	293.0	25	24 15	78
Oct.	208.0	20	25 16	70	248.5	23	24 16	73	151.0	18	26 15	70
Nov.	0.6	1	26 16	48	46.9	5	26 15	51	22.6	8	27 15	46
Dec.	Nil	Nil	27 14	34	Nil	Nil	28 14	51	Nil	Nil	27 14	34
Totals	1492.2	154	- -	-	1829.0	157	- -	-	1767.5	162	- -	-

**APPENDIX III: ENTRY NUMBERS AND NAMES OF LINES/VARIETIES
USED IN THE TRIALS**

Entry No.	Entry Name
Durum wheat	
22	Veery 'S'/BOW 'S'
23	CHEN 'S'/ALTAR 84
24	CHAR 'S'/ANA/CN
25	OPATA 85671
26	OPATA 861895
27	OPATA 85B
28	CHEN 'S'/ALTAR
29	CIRUNBUGRES
30	S-179
31	S-84791
32	AJARA 'S'
33	BD 120/3/ATA 'S'/MEX 'S'
34	BD 121/3/ATA 'S'/ITA
35	BD 124/3/ATA/SB3
36	S-1874
37	S-177
38	S-187475
39	V-185/PAB4/'S'
40	Veery 'S'
41	Verry 'S'/SB4/8516
42	Veery 'S'/SB845/PCOH
43	APATA 'S'/MEX/14
44	S-185 'S'/PB4
45	S-145/S/125
46	S-187/146/'S'/4
47	Veery 'S'/PWBH/817

Entry No.	Entry No.
48	S-125/SB/1345
49	Verry 'S'/137/815
50	AJARA 'S'/12378
51	Veery 'S'/1378/149
52	Cnt/489/18/s/419
53	Chen 's'/altar991
54	Cir/'s'
Bread wheat	
1	V 7312/PA4
2	SW 57PA4/125
3	V 3145/312
4	SW 347P4
5	V 4567
6	SB 5676
7	TAB/CEP7780
8	IA 563/ALBAN 'S'
9	TAB 4715
10	TAB 56745/PAB4
11	SB 56768617
12	V 84133
13	V 578417
14	SW4/145
15	V 578A43456/PAB
16	SB 461PABSB4
17	V 789781/PAB4
18	V 788931747
19	SB 675185
20	V 78986158

Entry No.	Entry No.
21	PB 81APB/'S'/315/PBH
55	CNT/04/LV5AGA
56	SW 7S56891
57	PBHW/S/3179
58	SW 59/BUC 'S'
59	THB/CEP7780
60	BOW 'S'/PVN'S'
61	THB/CEP/8478/94
62	APB/'S'/418/PBHW
63	PBH/'S'/819314
64	BW 31785/3419
65	B 27812-E-02
66	K 47891/'S'/418
67	BW 189127/S/90
68	H 3789
69	KALH2/BB/FLKS 'S'
70	H 41
71	K 73569
72	CEP 78918/49
73	CEP 78780/BOW 'S'
74	IBN 146
75	IBN 136
76	IBN 876
77	Veery 'S' CMD 135/PCBH
78	Veery 'S' CM33027-PCBWH
79	Veery 'S' CM330297-PCBWH1931
80	Veery 'S' CM330297-PCBWH1931

Entry No.	Entry No.
81	IBN 317
82	IBN 044
83	CEPII?BOWCM70006
84	CEP18/BWCM8076
85	BON-5225
86	BON-57818
87	BON-31789
88	BON-4189
89	IBWYT-4718
90	IBWYT-4813
91	IBWYT-4918
92	CD62911-D-27
93	JUPBJYYIM-CM35PCBWH251
94	437-PF7339/IPAN 'S'
95	V 937568
96	V 7304
97	HECKAT 'S' CM404554-PCBWH-977
98	HECKAT 'S' CM471895
99	B14898
100	B149/3/LD7
101	JUMPBJYIM-CM3189
102	B143/3/LD
103	CEP 71589/127
104	CEP 856/1375
105	LAK4/819
106	LAK4/514
107	V 897/'S'/PBWH
108	V 893/'S'/PCBWH
109	5 Chre 'S'

Entry No.	Entry No.
110	K 89791
111	SW 147(PA17)
112	SW 189(PA21)
113	IBW-YT124
114	BOW 'S'/PVN'S'/41
115	PBHW/S/3718
116	THB/CEP/3124
117	Siete Cerros
118	K 4798/'S'/312
119	H 375/'S'/478/PH
120	SW579(PA14)
121	CEP/315/'S'/85

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Institutions Attended	Period	Certificates/Diploma/Degree
St. Joseph's Central School Oraukwu	1950 – 56	First School Leaving Certificate.
Bishop Shanaham Sec. School, Orlu	1957 – 61	West African School Certificate.
University of Nigeria, Nsukka	1970 – 73	BSc. (Plant/Soil Science).
CIMMYT, Mexico	1980	Diploma (Irrigated Wheat Agronomy)
Ahmadu Bello University, Zaria	1983 – 85	MSc. (Agronomy).
International Agricultural Centre, Wageningen, Netherlands.	1987	Certificate (Farming Systems Res.)

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Organization	Period	Position
National Cereals Research Institute, Moor Plantation, Ibadan	1973 – 77	Research Officer i/c Ngala Sub-station, Ngala, Borno State.
Lake Chad Research Institute, Maiduguri.	1979 – 82	Senior Research Officer i/c Ngala research station.
Lake Chad Research Institute, (LCRI) Maiduguri	1985 – 88	Principal Research Officer and Head of Crops Research Division.
LCRI, Maiduguri	1988 – 90	Asst. Chief Research Officer.

LCRI, Maiduguri	1990 – 92	Chief Research Officer and Co-ordinator FRS network, North-east zone.
LCRI, Maiduguri	1993	Asst. Director i/c Research Division.
LCRI, Maiduguri	1994 – 98	Acting Director, LCRI, Maiduguri.
National Root Crops Research Institute, Umudike	July 1998 - Date	Substantive Director NRCRI, Umudike

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