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THE PERFORMANCE OF BARLEY VARIETIES (*Hordeum vulgare* L.) IN THE SUDAN SAVANNA ZONE OF NIGERIA

By

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A thesis submitted to the postgraduate school
Ahmadu Bello University
in partial fulfilment of the requirements for

the Degree of Master of Science in Agronomy

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DECLARATION

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

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CERTIFICATION

This thesis entitled 'THE PERFORMANCE OF BARLEY VARIETIES (*Hordeum vulgare* L.) IN THE SUDAN SAVANNA ZONE OF NIGERIA' by MICHAEL CHIKE IKWELLE meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

To my wife, Victoria.

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ABSTRACT

A field trial was conducted during the dry season 1983-84 at Kadawa in the Sudan Savanna ecological zone of Nigeria to evaluate the performance of 169 (80, 2-row and 89, 6-row) barley varieties.

The trial was laid out in a 13 x 13 simple lattice design replicated twice. Each variety was hand-sown in four rows, 25cm apart using a seed rate of 100 kg/ha. The gross plot size was 5 x 1m and yield was assessed from the two central rows.

Phosphorus was broadcast uniformly and worked into the seed-bed before harrowing at the rate of 40kg $P20_5$/ha in the form of single superphosphate (8.3% P). Nitrogen at the rate of 60 kg N/ha as urea was applied in two equal splits at planting and four weeks after planting. Plots were irrigated by gravitational method through siphon system and 60mm of water was applied to the plots at seven days interval. Two hand weedings were carried out at two and four weeks after planting.

In 2-row species, plant height ranged from 50-84, 85-93 and 94-l27 cm for short, intermediate and tall plants, while the corresponding height in 6-rOw for the three groups mentioned above were 45-78, 82-92 and 93-118 cm.

Entries were classified into short (80-89 days)

medium (90-99) and long (mare than **100) duration, the** relative per cent in each species was 29, 34, **for** short; 49 each for medium and 22, 17 in long duration varieties, for 2 2 and 6-row barley species, respectively* The 6-row barley produced significantly higher mean number of spikes per square metre (611.5) than 2-row barley with mean spikes per square metre of 593.3.

Highest number of grains in a spike was recorded by **EX-LCRI 3D** and CI 15244 **(35.5** and 27**.7)** in 6- and 2-row barley species, respectively. The 2-row barley produced significantly heavier grains than 6-row with their mean **grain**' weight as 4**3.5** and 34.6g/1000 **grains,** respectively.

In 2-row barley, the highest grain yield (6,611 kg/ha) was recorded by CI 16185 while it was (6,014 kglha) in 6-raw observed in EX-LCRI 22. The grain yield of 2-row standard variety, Ketch, was 4,198 kg/ha.

The mean grain protein content was 8.91 and 8.40% in 2- and 6-row barley species, respectively. The grain crude protein content ranged from 4.62 to 15.54% and **5.04** to 13.86% in 2- and 6-row barleys.

Yield was highly associated with all the yield components as evinced in the coefficients of correlation which were positive and highly significant in both 2- and 6-row barley species.

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Chapter 1

INTRODUCTION

Barley (*Hordeum vulgare* L.) belongs to the family, Gramineae; tribe, Hordeae and genus Hordeum (Hitchcock, 1951). The cultivated types are *Hordeum vulgare* (6-row) and *Hordeum distichum* (2-row) and their closest wild relatives are *Hordeum spontaneum* and *Hordeum agrocrithon*. Very little is known about the origin of the crop. Vavilov (1951 and 1957) concluded that Ethiopia was a secondary centre isolated from the main stream of barley evolution.

1.1 Economic Importance

In Nigeria, barley is mainly used for malt preparations. All the existing brewing and distilling industries in the country rely solely on imported malt as their source of raw material. The Nigerian Breweries Limited alone imported about 80,000 tons of malt valued at an estimated sum of ₦38 million in 1979 (Asenime *et al.*, 1980). During the 1983 brewing workshop held in Benin, Bendel State, it was reported that the Federal Ministry of Industries had so far approved a total of 58 breweries in the country with a brewing capacity of 13.1 million hectolitres. The projected demand of the product for the year 1983 was given as 11.5 million hectolitres leaving a surplus of 1.6 million hectolitres (Okunola, 1983). Considering the number of breweries and the demand for malt products in the country at present, the amount spent for the importation of malt is

estimated at ₦2,200 million in foreign currency.

The present administration has emphasized the need to achieve self-sufficiency by making greater use of local material. To this end, efforts have been directed towards finding ways of using local raw materials in brewing. In addition to the continuing search for suitable local cereal sources of malt from guinea corn (Sorghum bicolor), millet (Pennisetum americanum) and rice (Oryza sativa) which may not compete barley due to its high enzyme content and presence of hull which protects the germinating seed during malting process, the production of barley locally would go a long way in conserving the foreign exchange in relation to the importation of barley malt for the brewing industries. The North Breweries Limited, Kano, has succeeded in using locally cultivated sorghum (guinea corn) as a substitute to brew its 'Double Crown' lager beer and saves the country ₦2 million annually (Fowowe, 1983). The local sorghum constituted only 10% of the total raw material used, because the investigation showed that a different product would result if the substitution was higher (Fowowe, 1983). Thus, in order to maintain the quality of product from malt, it is essential to identify suitable barley varieties adapted to local conditions which could be converted to malt locally for brewing industry.

1.2 Areas of Production

Barley probably has the widest range of adaptation compared with any cultivated plant species. It is grown in nearly all cultivated areas of the temperate zone (winter barley), in many sub-tropical areas and at high altitudes of the tropical zones (spring barley). It is mostly grown as a rainfed crop but in the semi-arid regions of the world, barley is grown as irrigated crop. In Nigeria, it can be grown under irrigation in the same region as wheat from 10 to 14^{0}N latitude and 240 to 360 metres altitude (Olugbemi, 1973).

The various irrigation schemes in the country when fully developed by 1991, will irrigate approximately 345,000 hectares. About half of this area will be planted with wheat and the remaining half will go into the production of barley, vegetables, maize, rice and other crops. In its area of production in the Sudan savanna zone, barley yields as much as wheat and should be preferred to wheat under medium to severe water stress and late seeding conditions because of its better internal water balance at all levels of moisture stress (Singh and Kumar, 1981). Also high temperature during ripening caused less damage to barley for feed than wheat (Nuttonson, 1957).

1.3 Uses

The crop has many uses. It is used as feed for

livestock. It is pearled and used for soup making. Barley flour is an important product and barley bread is highly valued in some parts of the world like Turkey where it is said to be the "stuff of life". Probably, the greatest amount of the barley crop on a global basis goes for making of malt products such as beer, whiskey, maltina, shandy, beverages, pastries, breakfast cereals, baby foods, confections and drugs.

Barley research in Nigeria is still in its infancy. Past work on varietal selection concentrated on the yield of 2-row barley varieties imported mostly from European countries. To broaden the scope of selection for high yield, low protein content and hence high malt yield, there is the need to screen a large number of cultivars in 2- and 6-row barley species obtained from different sources. The experiment was, therefore, designed with the following objectives:-

1. To evaluate the agronomic performance of a large number of barley cultivars in the Sudan Savanna ecological zone.

2. To study the yield and yield components and other characteristics of these 2-row and 6-row species.

3. To assess the grain quality of 2-row and 6-row cultivars under trial.

Chapter 2

LITERATURE REVIEW

Research work on barley in Nigeria is scanty. The crop is still relatively new in the country compared with other cereal crops in which a lot of work has been done. However, a lot of literature is available in many countries where barley is widely grown.

2.1 Adaptation

Barley has a wide range of adaptation and is grown from the Arctic circle to the tropical plains of northern India (Weaver, 1950). Arab farmers grew barley in the dry areas of north Africa where irrigation water was lifted from open wells in goat-skins (Wiebe, 1968). Wilten (1975) reported the adaptation of 79 imported malting barley varieties under irrigation during the dry season at the Kano River Irrigation Project, and proved the possibility of growing malting barley varieties successfully in Nigeria. Similarly, Ahmed et al., (1977) reported the detailed characteristics and yield of 15 elite barley varieties in two locations in Nigeria. Subsequently, Falaki (1980) successfully carried out investigation on the performance of malting barley varieties at Samaru and Kadawa, respectively. In another experiment, Ahmed et al., (1983a and 1983b) studied malt characters of four malting barley varieties under varying fertilizer levels and

concluded that it is possible to grow barley with acceptable malting quality in Nigeria by selecting suitable varieties. During the 1983/84 growing season, the Nigerian Breweries Limited and the Guinness Nigeria Limited jointly financed a barley project at New Marte in Lake Chad basin area of Borno State and reported that the performance of malting barley varieties was satisfactory in that region (Anon, 1984).

2.2 Climatic Conditions

Barley grows particularly well where the ripening season is long and cool and where the rainfall is moderate. (Wiebe, 1968). Harlan and Martini (1936) reported that barley can stand high temperatures if the humidity is low, but it does not do well where both temperature and humidity are high due to the greater prevalence of disease in such climates. In their work in the Sudan and Northern Guinea savanna zones of Nigeria, Kumar et al., (1982) reported that the optimum temperatures for germination, growth and grain development of barley were (15 to 22), (16 to 18) and (18 to 20^{0}C), respectively. The crop requires fairly warm temperature for germination, cool temperature for growth and cool to warm temperature for ripenning. Temperatures as high as 40^{0}C during ripening were reported to have caused less damage to feed barley than to wheat (Nuttonson, 1957).

2.3 Soil Conditions

Ayers (1953) reported that clayey soils especially in humid regions were not suitable for barley production due to impeded drainage. He observed that moderately fertile soils favoured a rapid vigorous growth, but barley grown on soils high in nitrogen often lodged and resulted in low grain yield. Barley grows particularly well where the soil is well drained but not sandy (Wiebe, 1968). The optimum pH range for barley growth ranged between pH 6.0 to 8.0. Varieties exhibited better tolerance to salinity than to sodicity (Mishra, 1983). Wicke et al., (1983) reported that yields approached maximum values at the nitrogen level (70kg N/ha) for malting barley. The nitrogen rate used depended on soil conditions, climatic factors and varietal characteristics.

2.4 Varietal Differences

Aberg and Wiebe (1946) and Wiebe and Reid (1961) described two main cultivated species of barley - Hordeum vulgare (six-rowed barley) and Hordeum distichum (two-rowed barley). The 6-row barley has a tough rachis and all florets are fertile and develop grains of normal germinating capacity. In the 2-row species, the rachis is tough and all of the central florets are fertile while the lateral florets are either male or sexless. Only the florets in the central rows develop grains with normal germinating capacity.

2.5 Malting Varieties

A suitable variety is the most important factor which controls malting quality (Lund, 1967). Two-row varieties generally were reported to have better malting quality than 6-row varieties because of plumpy grains and low protein content whereas 6-row varieties have more kernels and generally yielded higher than 2-row varieties (Von der Pahlen and Goldberg, 1971). The quality and yield of varieties were also reduced due to moisture stress (Pendleton et al., 1953) and by high temperatures at maturity (Mack, 1965). Among the cultural factors, the seeding rate and spacing are very important. Meredith et al., (1942) observed that the rate of seeding did not influence malting quality. The protein content, grain weight and proportion of plump grains were not affected. Guitard et al., (1961) reported from their seeding rate experiment, that as seeding rates were increased, the number of spikes per plant and grain weight decreased, but Stickler and Pauli (1964) indicated that some varieties were responsive and others were not, to seeding rates. In another investigation with malting varieties, Ahmed et al., (1977) reported that the number of spikes per square metre and grain weight were significantly affected by seeding rates. They observed that increasing seed rate progressively increased the number of spikes per square metre and decreased 1,000-grain weight. On sowing date, Abdel-Raouf et al., (1983) reported

that early sowing of barley cultivar Giza 119 resulted in highest number and weight of grains per ear, ear length and 1,000-grain weight, while late sowings recorded shrivelled grains with high protein content. Similarly, Stapleton (1984) reported that lodging and leaning of malting varieties increased as sowing was delayed. In sowing date trial at Kadawa, malting varieties recorded higher yields when sown either on 18 November or 2 December. Lowest yield was obtained with crop sown on 4 November (Anon, 1984).

2.6 Plant Growth

2.6.1 Plant height

Plant height is an index of crop growth. It is governed by genetic factor as well as by crop nutrition. Tall growing varieties have normally weak straw and lodge when nitrogenous fertilizer is applied. Dwarf varieties on the contrary, are stiff-strawed and respond to fertilizer well. Application of fertilizer also has a direct bearing on the quality of malting barley. Gregory (1975), working with 12 varieties of barley, reported that Schuylar produced consistently higher yields than the other 11 varieties and gave an average grain yield of 7,464 kg/ha. Schuylar was short-stemmed and resistant to lodging while the other 11 varieties were tall and lodge at high levels of nitrogenous fertilizer. However, Jennings and Aquino (1968) noted that

in mixed populations of tall and short plants, the tall plants intercepted more light and gave the higher yields than the short types; short plants were poor competitors and it was only in pure stands that their advantageous yield physiology was expressed. In their investigation, Pyzhov et al., (1981) suggested that 90-95cm appeared to be the optimum height for ensuring high yield combined with lodging resistance. However, optimum height for ensuring high yield will depend on variety and environment and their interaction. Ekeberg (1982) and Anderson et al., (1983) reported that semi-dwarf varieties gave high response to nitrogenous fertilizer and recorded high grain yields, but they observed that grains were high in protein content which made them unsuitable for malting.

2.6.2 Maturity

Number of days to maturity is an important growth attribute of barley varieties. Earliness is an essential character for barley cultivation in marginal areas with short growing season. Ahmed et al., (1977) and Falaki (1980) reported that Ketch is an early maturing variety suitable for Borno and Sokoto States where the growing season is short. Lee et al., (1983) observed that the new early maturing and high yielding variety Jopungbori matured about five days earlier than the standard variety Olbori and gave 8% higher grain yield. Rasmusson and

Wilcoxson (1983) reported that Robust a medium to late variety waw superior to Morex, the most widely grown cultivar in Minnesota in grain yield, grain plumpness and lodging resistance. Robust was two to three days later in maturity than Morex and had high resistance to Puccinia graminis. Fejar et al., (1984) recommended Leger, a mid-season, six-rowed variety for growing at Ontario, Canada. It has outyielded standard varieties and has large grains.

2.7 Yield Components

2.7.1 Spikes per square metre

An important yield component of barley is the number of effective tillers (spikes) per unit area. Verma and Gulati (1981) reported that green parts above the flag-leaf node such as the spikes number and awn contributed directly or indirectly to grain yield. Similarly, Negut (1982) observed that the 2-row variety, Victoria, was the most productive due to a high spikes number which was associated with the high grain yield of the variety. Other workers that have reported positive correlation of spikes number with yield included Berta (1982), Abdel-Raouf et al.,(1983), Gales (1983), and Scheffer and Struve (1983).

2.7.2 Grains per spike

Among the most important yield contributing characters of barley is the number of grains per spike.

Ahmed et al., (1977) and Falaki (1980) both reported that number of grains per spike significantly increased grain yield of varieties. Fyzhov et al., (1981) showed that the character that was most closely correlated with yield per plant was the number of grains from the ear. Researchers that have reported positive and significant correlation of seed number with yield included Berta (1982), Gu et al., (1983) and Hadjichristodoulou (1983). Others were El-Shama and Ahmed (1968), Verma and Gulati (1981) and Negut (1982).

2.7.3 One thousand grain weight

Various researchers have reported work on the yield components of barley. According to Bakhshi et al., (1973), Ewertson (1974a) and Ahmed et al., (1977), 1,000-grain weight was an important yield attribute of barley. They variously reported that high 1,000-grain weight had contributed to high grain yield of varieties. Other workers that had reported on 1,000-grain weight included Falaki (1980) and Negut (1982). Varieties Clipper, Tellus, Ingrid and Ketch consistently produced high 1,000-grain weight (Gu et al., 1983).

2.8 Yield

2.8.1 Grain yield

A lot of researchers have reported that differences in grain yield varied with varieties. Brun (1964) showed

that out of 20 varieties tested at Voil, Norway, four varieties gave yields averaging 3,000 kg/ha of dry grain, similar to the yields of the standard varieties Verda and Mori. Bockstaelle and Maddens (1965) compared 11 varieties over one year period and reported that varieties, Conbrinus and Carlsberg II produced higher grain yield than Ingrid (the standard variety). Morrison and Slacketh (1965) compiled results of 21 trials and came to the conclusion that varieties Mentor, Vada, W.5573 and 5492 gave yields comparable with standard variety, Ymer. Maddens and Bockstaelle (1968) in field trials with 23 varieties observed that the control variety was inferior in grain yield to Delisa, Mauric, Britta and Zephyr by 9, 8.5, 0 and 5.9%, respectively. Similarly, Cottier et al., (1971) in their experiments with four varieties concluded that Zephyr produced the highest grain yield of 5,200 kg/ha while Walsh, (1971) found that, at several sites in his trials, Clipper yielded 20% higher grain than the standard variety, Prior. Also Zephyr out-yielded the established varieties Kenta, Research, and Carlsberg II by 90, 85 and 66%, respectively of trials in New Zealand (Malcolm and Thompson, 1972). According to Ahmed et al., (1977), and Falaki (1980), of the 15 elite malting varieties studied at Kadawa and Samaru, respectively, Zephyr, Clipper and Ketch recorded the highest grain yield. Using several 2-row and 6-row varieties, Cho et al., (1982) observed that 2-row varieties had similar

yields to 6-row, but had fewer grains per ear. Kandera and Kandera (1983) reported that Horal recorded the highest grain yield of 7,960 kg/ha with 70kg N/ha as urea. Similarly, Giuliari and Padovan (1983) observed that varieties Tania, Gerbal, Robur and Salvaggie recorded highest grain yield ranging from 7,730 to 8,220 kg/ha. New varieties Pirate and Mikado yielded well at 7,700 and 7,200 kg/ha, respectively. Other researchers that reported on grain yield of varieties included Keller et al., (1981), Farnworth and Said, (1982), Bianchi et al., (1983), Bengtsson (1983) and Jones and Read (1983).

2.9 Grain Quality

Among the grain quality parameters of barley are the 1,000-grain weight and crude protein content. Grains with low crude protein content have good malting quality. Wilten (1969) in trial with 20 varieties of barley concluded that Zephyr, Berac and Mazurka produced lower grain protein content than the standard variety Cambrinus. Also Zephyr in 21 trials at New Zealand gave lower crude protein content compared to that of the standard malting varieties. Bakhshi et al., (1973) reported that in trials at seven sites, Clipper recorded an average grain protein content of 10.7%. Similarly, Ewertson (1975) concluded that variety Tern in 151 trials yielded an average grain protein content of 11.9% thus rendering the variety unacceptable for malting.

Falaki (1980) reported that the high grain protein content of 15.2% recorded in Ketch at Samaru was due to the failure of the irrigation pump during the grain filling stage which resulted in moisture stress at that stage. Welch and Gosden (1983) observed that the 2-row winter varieties had higher grain protein content than the 6-row varieties but their grain protein yields on hectare basis were similar. Kandera (1981), Brun (1982), Ribokaite (1982), Bengtsson (1983) and Siman (1983) all have variously reported on grain protein content of barley and indicated that increasing nitrogen level increased crude protein content of grain. Plumpy seeds are of high quality for malting as they contain more starch (Falaki, 1980).

Chapter 3

MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted under irrigation during the 1983/84 dry season at Kadawa irrigation sub-station of the Institute for Agricultural Research, Ahmadu Bello University, Kadawa ($11^{0}39^{'}$N, $08^{0}02^{'}$E, 500 metres above sea level) located in the Sudan Savanna ecological zone of Nigeria. The climatic and soil conditions of the location and the cropping history of the field in which the experiment was conducted are stated in appendices A, B and C. There was no rainfall during the period. Low night temperatures were observed between December and January. Also, the low night temperature during February enhanced grain filling. About the middle of February, day temperature began to rise gradually, but this did not adversely affect yield. The low percentage of relative humidity that prevailed during the season, enhanced the performance of the crop as no disease incidence was recorded throughout the season.

The soil was a well-drained sandy-loam with low fertility and a pH of 6.5. The crop was sown after a fallow period of eight months following a maize crop.

3.2 Land Preparation

The experimental field was ploughed once and harrowed twice to get a fine seedbed. The land was subsequently marked out into required plots with irrigation channels and borders where necessary, before planting.

3.3 Fertilizer Application

Phosphorus was broadcast uniformly and worked into the seedbed before harrowing at the rate of 40kg P_2O_5/ha in the form of single superphosphate. Nitrogen at the rate of 60kg N/ha as urea was applied in two equal splits - at planting and four weeks after planting.

3.4 Treatments and Experimental Design

The trial was conducted using 169 barley lines/varieties in a 13 x 13 simple lattice design replicated twice. The crop was hand-sown in 25cm rows using a seed rate of 100 kg/ha on 17 November, 1983. The gross plot size was 5m x 4 rows and yield was assessed from net plot measuring 5m x 2 rows. The list of lines/varieties entered in the trial is given in appendix D.

Out of the 169 lines/varieties tested in this experiment, 80 belonged to 2-row species and the rest 89 were chosen from 6-row hulled type. Therefore, 168 degrees of freedom for treatment was further split to compare the two species (1 degree of freedom) and lines/varieties were

further compared within each species. That is, 79 and 00 degrees of freedom for 2-row and 6-row species, respectively. For brevity in the comparison of treatment means, letters were abbreviated (a - j) to mean abcd through e and f to j.

3.5 Irrigation

The experimental plots were irrigated by gravitational method whereby water was conveyed from the main channel into the plots through siphon system. Plots were irrigated at seven days interval. About 60mm of water was applied at each irrigation.

3.6 Insect and Pest Control

There was a minor incidence of aphid infestation on the crop which prompted the application of menazon at the rate of 294 g/ha a.i. sprayed three times at weekly intervals beginning on 21 January, 1984. There was no disease attack. Bird scarers were engaged to protect the crop from bird damage. The plots were hand-weeded twice on 30 November and 14 December, 1983, respectively.

3.7 Observations Recorded

3.7.1 Spikes number per square metre

The data on yield components were recorded from 10 plants taken at random and marked for observation. The number of ear-bearing tillers was recorded from 10 plants

and number was calculated per square metre therefrom.

3.7.2 Heading date

This refers to the number of days from sowing to the date when 50% of the heads in a plot had completely emerged from the flag-leaf sheath.

3.7.3 Maturity

Number of days to heading plus number of days when about 80% of the plants in a plot had turned straw yellow and the grain rachis had dried.

3.7.4 Plant height

Plant height (cm) was based on the mean of 10 randomly selected plants per plot measured from ground level to the tip of the plant (excluding awn).

3.7.5 Awn characteristics

This was determined by testing whether the awn was deciduous when it could be easily detached from the grain, or persistent when it was hard to detach.

3.7.6 Number of grains per spike

The number ofgrains was also counted from above 10 marked plants and the average taken.

3.7.7 One thousand grain weight (g)

The counted grains in the above observation were weighed carefully on a balance (Metler M. 140) and 1,000 grain weight was calculated therefrom.

3.7.8 Grain yield (kg/ha)

Grain yield was obtained from the yield of individual net plot which was recorded in grams. Yield in kilograms per hectare was worked out therefrom.

3.7.9 Crude protein content

Nitrogen was estimated from composite sample using micro Kjeldahl method as described by Jennings (1961). Nitrogen per cent was multiplied by 6.25 to convert it into protein content (Jackson, 1962).

3.7.10 Statistical analysis

Data recorded were statistically analysed using analysis of variance as described by Cochran and Cox (1967). Treatment means were compared using Duncan's Multiple Range Test (Duncan, 1955).

Chapter 4

RESULTS

4.1 Plant Height

The difference in the mean plant height for 169 entries is shown in tables 4.1a, b and the analysis of variance in appendix E-1. The differences due to the entries were highly significant. The 2-row barley produced significantly taller plants than 6-row type and the difference was significant at 1% level. The tallest entries were CI 16170 (126.9 cm) and CI 2208 (110 cm) and the shortest height was recorded by CI 15172 (50.2 cm) and CI 16538 (44.6 cm) in 2- and 6-row barley, respectively.

Within each group, it was observed that the differences in the mean height within 2- and 6-row varieties were highly significant. It was interesting to note that the two species behaved similarly with respect to their heights. These could be classified into three groups of tall, intermediate and short varieties. In 2-row varieties, the height ranged from 50-84, 85-93 and 94-127cm and for the short, intermediate and tall varieties and their relative proportion was 39, 21 and 40% of the 2-row population. In 6-row varieties, height ranged from 45-79, 83-91 and 93-110 for the three groups mentioned above with a proportion of 39% for each of tall and short varieties and 22% for intermediate varieties.

Table 4.1a: Plant height (cm) of 2-row barley lines/ varieties grown at Kadawa during 1983/84 dry season.

Entry No.	Plant Height (cm)	Entry No.	Plant Height (cm)	Entry No.	Plant Height (cm)
153	126.0a*	61	96.4a-j	125	00.3d-l
95	125.0ab	141	94.6a-j	09	80.2d-l
97	121.2ab	14	94.3a-j	167	79.3d-l
83	110.0abc	81	94.1a-j	169	79.2d-l
140	107.5a-d	50	92.8b-k	104	78.0d-l
102	106.7a-e	117	97.2b-k	33	70.5d-l
15	106.2a-f	151	04.5c-k	164	77.9d-l
70	105.6a-f	119	09.5c-k	146	77.6d-l
90	104.7a-g	160	08.1c-k	32	77.0d-l
52	104.2a-h	150	08.1c-k	66	75.9d-l
101	101.6a-h	159	08.0c-k	34	72-6e-l
116	101.5a-h	110	08.0c-k	136	72.5e-l
71	101.3a-i	132	08.0c-k	1	71.2f-l
122	100.9a-i	123	87.7c-k	134	70.4g-l
150	100.0a-i	154	88.0c-k	73	70.3g-l
49	100.6a-i	147	87.3c-k	131	70.2g-l
87	100.4a-i	148	86.6c-k	162	70.2g-l
137	100.3a-i	23	86.1c-k	139	70.2g-l
128	90.0a-j	156	03.4c-k	3	69.4h-l
57	98.6a-j	59	05.4c-k	11	66.3i-l
135	98.3a-j	105	84.8c-k	24	66.2i-l
47	97.0a-j	166	03.7d-l	161	64.2jkl
44	97.6a-j	107	83.4d-l	157	64.1jkl
106	97.5a-j	78	81.8d-l	29	58.2kl
84	97.4a-j	165	82.0d-l	138	50.21
75	97.2a-j	168	81.4d-l		
142	97.2a-j	112	81.3d-l		

SE = ± 13.84; Mean = 00.2cm

*Means followed by the same letter(s) are not significantly different.

Table 4.1b: Plant height in (cm) of 6-row barley lines/ varieties grown at Kadawa during 1983-84 dry season.

Entry No.	Plant Height (cm)	Entry No.	Plant Height (cm)	Entry No.	Plant Height (cm)
77	110.0a*	10	94.9a-j	38	75.1d-n
02	115.9ab	53	94.5a-j	36	75.1d-n
58	111.6abc	63	93.7a-j	103	74.3d-n
144	110.5abc	152	93.2a-j	96	73.9d-n
4	107.4a-d	45	93.2a-j	121	72.6d-n
56	106.5a-d	130	91.2b-k	54	72.6d-n
64	106.7a-d	22	90.9b-k	35	70.3e-n
7	106.3a-d	127	90.6b-k	37	70.1e-n
51	105.0a-d	155	90.0b-k	20	70.1e-n
76	106.1a-d	41	89.2b-l	99	68.0f-n
85	105.0a-d	43	89.0b-l	2	68.6f-n
62	105.7a-d	30	88.8b-l	12	67.7f-n
129	105.3a-e	76	87.9b-l	10	67.5f-n
46	105.3a-e	65	87.1b-l	86	67.5f-n
9	105.3a-e	48	86.5b-l	8	66.2g-n
111	103.9a-e	74	86.4b-l	88	64.0h-n
90	104.4a-e	149	86.4b-l	109	62.9i-n
113	103.5a-e	100	86.3b-l	19	62.7i-n
124	102.5a-f	94	85.9b-l	40	63.3i-n
68	102.1a-f	55	85.4b-m	79	61.7j-n
126	101.5a-f	28	85.0b-m	42	60.9j-n
145	101.4a-f	120	83.5b-m	39	60.0j-n
67	100.8a-g	17	83.5b-m	92	60.0j-n
110	100.5a-g	115	82.8b-m	108	58.0k-n
31	100.2a-g	93	79.7c-n	69	56.2k-n
5	98.8a-h	13	78.0c-n	16	55.9k-n
6	98.7a-h	26	77.7c-n	114	54.1lmn
143	98.7a-h	25	77.1c-n	133	49.8mn
60	98.7a-h	80	77.6c-n	27	44.6n
91	98.1a-i	21	76.d-n		

SE = 13.84; Mean = 85.7cm

*Means followed by the same letter(s) are not significantly different.

4.2 Maturity

The data on the mean number of days taken to maturity for the 169 entries is depicted in Tables 4.2a, b and the corresponding analysis of variance is shown in Appendix E-2. Analysis of data showed that the difference in the mean number of days to mature of all the entries was highly significant. When the two species were compared, the mean number of days to mature was not statistically significant. The difference between the two groups was only one week, the 6-row group matured earlier.

When the data was analysed further to study the differences within each group, it was observed that the differences in the mean number of days to mature were highly significant. The varieties were classified into short (80-89 days), medium (90-99 days) and long (more than 100 days) duration. The relative percentage in each species was 29, 34 for short, 49 each for medium, 22 and 17% in long duration varieties for 2- and 6-row species, respectively. It was striking to note that there was only 5% difference in the short and long duration varieties. Also the upper limit of long duration varieties was very close (111 and 112 days) but in the lower limit of short duration varieties, there was a difference of one week earlier in maturity of 6-row.

Table 4.2a: Days to maturity of 2-row barley lines/ varieties grown at Kadawa during 1983-04 dry season.

Entry No.	Days to Maturity	Entry No.	Days to Maturity	Entry No.	Days to Maturity
107	112a*	106	96b-j	90	91d-l
128	110ab	61	96b-j	57	91d-l
150	110ab	131	96b-j	101	90e-l
160	100abc	123	96b-j	15	89e-l
110	105a-d	151	95c-k	139	89e-l
106	105a-d	119	95c-k	29	89e-l
135	103a-e	163	95c-k	70	89e-l
168	103a-e	154	95c-k	138	89e-l
159	103a-e	162	95c-k	89	89e-l
134	103a-e	148	95c-k	141	88f-l
132	103a-e	167	94c-l	157	88f-l
44	103a-e	33	94c-l	146	88f-l
122	103a-e	49	94d-l	117	85g-l
142	102a-f	24	93d-l	32	85g-l
140	101a-f	147	93d-l	34	84h-l
105	101a-f	125	92d-l	87	84h-l
59	100a-f	156	92d-l	11	84h-l
165	100a-f	78	92d-l	104	83i-l
166	99a-g	14	92d-l	136	83i-l
52	99a-g	116	92d-l	97	83i-l
47	98a-h	73	92d-l	1	82jkl
169	98a-h	102	92d-l	3	82jkl
150	97b-i	71	92d-l	112	81kl
50	97b-i	83	92d-l	153	81kl
137	97b-i	84	92d-l	75	81kl
95	97b-i	23	91d-l	161	80l
66	96b-j	81	91d-l		

SE + 6.0; Mean = 93.8

*Means followed by the same letter(s) are not significantly different.

Table 4.2b: Days to maturity of 6-row barley lines/ varieties grow at Kadawa during 1983-84 dry season.

Entry No.	Days to Maturity	Entry No.	Days to Maturity	Entry No.	Days to Maturity
118	111a*	67	96b-k	22	89e-m
113	109ab	51	95b-k	54	89e-m
108	106abc	46	95b-k	91	89e-m
9	106abc	155	95b-k	16	89e-m
7	106abc	41	94c-l	133	88f-m
124	105a-d	88	94c-l	27	99f-m
130	103a-e	20	94c-l	21	88f-m
152	103a-e	115	94c-l	60	88f-m
76	103a-e	82	93c-m	86	88f-m
129	103a-e	30	93c-m	74	87g-n
144	103a-e	45	93c-m	96	87g-n
42	103a-e	100	93c-m	37	86g-n
68	102a-f	85	93c-m	99	86g-n
4	102a-f	31	92c-m	143	86g-n
149	100a-g	10	92c-m	13	85h-n
20	99a-h	53	92c-m	121	84i-n
145	99a-h	58	92c-m	56	84i-n
14	98a-i	17	92c-m	69	84i-n
98	98a-i	25	92c-m	65	83j-n
35	97a-j	120	91d-m	94	83j-n
40	97a-j	63	91d-m	143	83j-n
72	97a-j	43	91d-m	10	83j-n
6	97b-j	55	91d-m	80	83j-n
38	96b-k	26	91d-m	64	82k-n
126	96b-k	39	91d-m	8	82k-n
5	96b-k	36	90e-m	2	80lmn
79	96b-k	127	90e-m	12	79mn
19	96b-k	93	90e-m	109	73n
40	96b-k	62	90e-m	114	73n
92	96b-k	77	89e-m		

SE = 6.0, Mean = 92.6

*Means followed by the same letter(s) are not significantly different.

4.3 Number of Spikes per Square Metre

Differences in mean number of spikes per square metre for the different varieties were significant at 1% level (Tables 4.3a, b and Appendix E-3). The difference in mean number of spikes per square metre of the two species was also highly significant, 6-row species recorded significantly higher number of spikes per square metre (611.5/m^2) than 2-row species (593.3/m^2). Statistical analysis further revealed that the number of spikes per square metre within each species was also significant at 1% level. The highest number of spikes per square metre (795/m^2 and 780/m^2) were counted in CI 15694 and EXLORI99 in 2- and 6-row barley species whereas the lowest number of spikes were 223 and 120/m^2 obtained from CI 15772 and CI 16530 in 2- and 6-row species, respectively.

When the number of tillers per square metre in the two species were compared, the highest number of tillers was very close in both species, whereas there was wide range of difference at the lowest number of spikes per unit area. Also when the relative distribution of the species was considered in respect to significant group, it was observed that the highest number of tillers per square metre of significant group included 80 and 82% of the varieties in 2- and 6-row barley, respectively; while the lowest and intermediate groups were 20 and 3%, 0 and 15% for 2- and 6-row barleys, respectively.

Table 4.3a: Number of spikes per square metre of 2-row barley lines/varieties grown at Kadawa during 1983-84 dry season.

Entry No.	Spikes/m^2	Entry No.	Spikes/m^2	Entry No.	Spikes/m^2
120	795a*	1	615a-f	162	569a-f
66	791a	140	613a-f	29	550a-f
135	783ab	117	610a-f	57	541a-f
151	783ab	164	608a-f	139	540a-f
150	757abc	166	603a-f	81	540a-f
23	754abc	110	600a-f	137	538a-f
125	730a-d	73	600a-f	131	530a-f
141	710a-d	154	598a-f	32	514a-f
47	708a-e	15	596a-f	122	512a-f
34	707a-e	104	595a-f	33	512a-f
159	703a-e	105	594a-f	123	502b-g
160	700a-f	102	593a-f	158	501b-g
134	689a-f	44	593a-f	157	500b-g
167	684a-f	87	592a-f	95	491c-g
24	684a-f	163	591a-f	83	484c-g
147	682a-f	71	591a-f	89	484c-g
61	679a-f	161	590a-f	70	483c-g
107	677a-f	116	590a-f	136	482c-g
50	673a-f	52	590a-f	90	481c-g
112	666a-f	132	586a-f	153	477c-g
119	652a-f	169	585a-f	146	456d-g
75	643a-f	97	585a-f	84	454d-g
101	641a-f	3	581a-f	148	450d-g
156	637a-f	106	580a-f	142	424efg
59	633a-f	165	579a-f	49	415fg
78	621a-f	14	570a-f	138	223g
168	619a-f	11	570a-f		

SE = ± 107.5; Mean = 593.3

*Means followed by same letter(s) are not significantly different.

Table 4.3b: Number of spikes per square metre of 6-row barley lines/varieties grown at Kadawa during 1983-84 dry season.

Entry No.	Spikes/m^2	Entry No.	Spikes/m^2	Entry No.	Spikes/m^2
99	788a*	26	670a-g	63	506a-g
144	780a	96	670a-g	12	505a-g
21	786ab	86	666a-g	113	505a-g
56	780abc	155	658a-g	64	503a-g
54	770a-d	10	653a-g	13	501a-g
69	770a-d	16	653a-g	5	500a-g
36	749a-e	67	653a-g	6	571a-g
100	745a-e	40	650a-g	53	570a-g
115	735a-e	92	650a-g	51	554a-g
60	719a-e	2	635a-g	18	552a-g
22	705a-f	39	619a-g	152	524a-g
30	705a-f	65	618a-g	94	507a-g
149	701a-f	4	610a-g	120	505a-g
127	701a-f	118	614a-g	130	502b-h
55	700a-f	9	606a-g	143	502b-h
103	700a-f	35	605a-g	124	501b-h
91	699a-f	126	602a-g	72	500c-h
42	696a-f	111	601a-g	100	500c-h
17	695a-f	37	601a-g	82	497c-h
25	694a-f	109	601a-g	121	495c-h
93	691a-f	43	600a-g	114	495c-h
20	685a-g	4	599a-g	77	494d-h
62	684a-g	60	599a-g	90	490d-h
145	683a-g	31	596a-g	129	490d-h
19	681a-g	74	596a-g	38	484e-h
79	678a-g	48	594a-g	46	423fgh
80	676a-g	80	591a-g	45	401ghi
85	673a-g	76	591a-g	133	240hi
58	672a-g	7	590a-g	27	120i
8	670a-g	20	509a-g		

SE = ± 107.5; Mean = 611.5

*Means followed by same letter(s) are not significantly different.

4.4 Number of Grains Per Spike

The mean number of grains per spike for 169 varieties/lines is shown in Tables 4.4a, b and the analysis of variance is in Appendix E-4. Analysis of data revealed that differences due to 169 entries were highly significant.

When entries in the two species were compared, 6-row barley produced significantly higher number of grains per spike than 2-row barley. The differences within each species of 2- and 6-row barley groups were also highly significant. The highest number of grains was recorded by EX-LCRI30 and CI 15244 (35.5 and 27.7) and the lowest number of grains was observed in CI 15766 and CI 15772 (8.3 and 6.0) in 6- and 2-row barley, respectively. The entries which were at par with the highest number of grains per spike constituted 69.7 and 90% in 6- and 2-row groups, respectively; while in the low significant groups they were 30.3 and 10% for 6- and 2-row species, respectively.

4.5 One Thousand Grain weight (g)

The data on mean 1,000 Grain weight (g) of 169 varieties/lines belonging to 2- and 6-row barley groups is given in Tables 4.5a, b and the analysis of variance is shown in Appendix E-5. The statistical analysis of data showed that differences due to varieties/lines were significant at 1% level. Also the differences between the means of 2- versus 6-row species were highly significant;

Table 4.4a: Number of grains per spike of 2-row barley lines/ varieties grown at Kadawa during 1983-84 dry season.

Entry No.	Grains/spike	Entry No.	Grains/spike	Entry No.	Grains/spike
66	27.67a*	160	20.67a-e	161	16.09a-e
75	27.46ab	160	20.54a-e	15	15.83a-e
125	27.38ab	87	20.36a-e	158	15.67a-e
128	26.30ab	147	20.20a-e	102	15.40a-e
47	26.63abc	101	19.53a-e	106	15.39a-e
3	25.44a-d	123	19.48a-e	89	15.26a-e
34	24.72a-d	52	19.43a-e	105	15.03a-e
151	24.67a-d	112	19.15a-e	169	15.00a-e
135	24.37a-d	156	19.07a-e	57	14.75a-e
159	24.00a-d	81	19.00a-e	132	14.71a-e
150	23.95a-d	29	18.87a-e	162	14.52a-e
50	23.94a-d	166	18.60a-e	154	14.33a-e
23	23.85a-d	164	18.60a-e	137	13.75a-e
61	23.60a-d	32	18.56a-e	84	13.44a-e
14	22.73a-d	165	18.44a-e	49	13.39a-e
11	23.70a-d	83	18.05a-e	97	12.67a-e
119	22.30a-d	110	18.00a-e	73	12.53a-e
24	22.00a-e	90	17.34a-e	131.	12.59a-e
134	22.00a-d	104	17.22a-e	95	11.60b-e
167	21.84a-d	140	17.22a-e	148	11.50b-e
71	21.63a-e	116	17.14a-e	146	11.07cde
141	21.63a-e	163	16.96a-e	157	11.06cde
107	21.30a-e	117	16.80a-e	136	11.06cde
44	21.19a-e	122	16.80a-e	153	10.42cde
59	21.12a-e	70	16.45a-e	142	9.70de
33	20.75a-e	1	16.43a-e	130	5.96e
78	20.68a-e	139	16.23a-e		

SE = ± 6.214; Mean = 18.5

*Means followed by same letter(s) are not significantly different.

Table 4.4b: Number of grains per spike of 6-row barley lines/ varieties grown at Kadawa during 1983-84 dry season.

Entry No.	Grains/spike	Entry No.	Grains/spike	Entry No.	Grains/spike
30	35.50a*	65	25.49a-d	53	19.97a-f
116	30.15ab	79	25.48a-d	43	19.57a-f
22	30.11ab	68	25.44a-d	39	19.37b-f
60	30.09ab	10	25.05a-d	62	19.34b-f
28	29.96ab	2	24.70a-d	18	19.00b-f
26	28.74abc	92	24.45a-d	72	10.32b-f
149	28.26abc	58	24.47a-d	143	17.86b-f
21	20.09abc	12	24.20a-e	82	17.63b-f
8	20.04abc	126	24.15a-e	77	17.52b-f
56	27.87abc	85	23.00a-e	41	17.52b-f
54	27.83a-d	74	23.00a-e	109	17.31b-f
55	27.74a-d	80	23.34a-e	98	17.10b-f
99	27.57a-d	9	22.55a-e	152	16.93b-f
17	27.13a-d	120	22.54a-e	37	16.63b-f
25	27.00a-d	42	22.43a-e	51	16.52b-f
115	27.06a-d	40	22.42a-e	20	15.87b-f
67	27.02a-d	13	22.19a-f	35	15.73b-f
69	26.02a-d	31	21.00a-f	5	15.20b-f
36	26.72a-d	19	21.69a-f	76	14.70b-f
86	26.60a-d	130	21.54a-f	114	14.65b-f
100	26.50a-d	96	21.47a-f	100	14.43b-f
145	26.41a-d	80	21.35a-f	121	13.92c-f
155	26.41a-d	63	21.25a-f	64	13.83c-f
4	26.32a-d	40	21.05a-f	129	13.37c-f
103	26.31a-d	111	20.60a-f	30	13.21c-f
127	26.14a-d	124	20.67a-f	46	13.06c-f
93	25.81a-d	113	20.66a-f	45	11.87def
144	25.56a-d	94	20.47a-f	27	8.35ef
110	25.52a-d	6	20.39a-f	133	8.33f
91	25.50a-d	7	20.07a-f		

SE = ± 6.214; Mean = 22.1

*Means followed by same letter(s) are not significantly different.

Table 4.5a: Thousand grain weight (g) of 2-row barley lines/ varieties grown at Kadawa during 1983-84 dry season

Entry No.	1000-grain weight(g)	Entry No.	1000-grain weight (g)	Entry No.	1000-grain weight (g)
160	59.04a*	116	46.51b	75	39.07c
150	59.05a	104	46.50b	71	39.06c
120	50.21a	133	41.13bc	44	39.03c
125	50.15a	59	45.52bc	32	39.01cd
151	55.07a	161	45.50bc	153	30.04cd
119	55.05ab	154	45.11bc	150	37.53cd
159	51.12ab	140	45.09bc	90	37.13cd
135	52.50ab	131	45.07bc	14	47.11cd
112	52.40ab	123	45.03bc	148	36.50cd
66	52.35ab	110	45.01bc	09	36.51cd
141	52.23ab	24	45.00bc	11	36.50cd
134	51.59ab	165	44.24c	70	35.50de
107	51.43b	75	44.15c	142	35.11de
160	50.55b	34	44.10c	75	35.05de
101	50.51b	163	44.00c	3	35.02de
167	50.06b	169	42.57c	01	34.50de
147	50.04b	122	42.53a	49	34.14de
70	50.03b	106	43.12c	29	34.00de
50	50.01b	1	42.00c	57	33.51de
164	49.57b	139	41.50c	15	33.50de
166	49.51b	07	41.47c	130	33.49de
117	49.45b	165	41.14c	97	31.54de
132	40.17b	33	40.50c	52	31.42de
23	40.10b	162	40.03	47	31.07de
102	47.59b	157	40.02c	03	30.05de
61	47.10b	146	40.02c	04	27.05e
156	46.54b	136	40.01		

SE = ± 3.760; Mean = 43.5

*Means followed by same letter(s) are not significant different.

Table 4.5b: Thousand grain weight (g) of 6-row barley lines/ varieties grown at Kadawa during 1983-84 dry season.

Entry No.	1000-grain weight (g)	Entry No.	1000-grain weight (g)	Entry No.	1000-grain weight (g)
103	40.02a*	55	39.14ab	20	32.03c
149	47.50a	20	39.01ab	109	31.57c
144	47.03a	10	37.59b	31	31.40c
145	46.21a	7	37.40b	53	30.59c
115	46.15a	111	37.26b	60	29.57c
99	46.10a	42	37.15b	74	29.47c
93	46.00a	21	37.00b	43	20.59c
100	45.50a	0	37.03b	152	20.55c
91	45.22a	5	37.00b	133	20.49c
06	44.15a	130	36.91b	90	20.47c
22	44.07a	120	36.53b	10	27.50c
127	43.50a	67	36.41b	63	27.09cd
79	43.30a	155	36.05b	41	27.04cd
110	43.10a	2	36.03b	12	27.03cd
96	43.09a	124	35.59b	100	26.50cd
69	43.04a	62	35.47b	76	26.43cd
56	42.01a	40	35.31b	37	26.40cd
17	42.00a	26	35.29b	35	26.06cd
60	41.57a	19	35.19b	114	24.00d
00	41.00ab	6	35.07b	02	24.05d
54	41.06ab	94	35.07b	72	24.04d
9	41.03ab	65	35.04b	51	22.07d
36	40.55ab	25	35.03b	64	21.54d
30	40.55ab	16	35.01b	27	21.50d
92	40.07ab	39	34.09bc	46	21.06d
05	40.04ab	143	33.07bc	30	21.05d
00	39.93ab	121	33.05bc	129	21.02d
4	39.49ab	13	33.02bc	45	20.01d
120	39.37ab	113	32.05bc	77	20.00d
50	39.31ab	40	32.04c		

SE = ± 3.760; Mean = 34.6

*Means followed by same letter(s) are not significantly different

as expected, 2-row barley yielded significantly higher 1,000-grain weight than 6-row barley. The differences within each species of 2- and 6-row barleys were also highly significant. When significant groups of grain weight were compared with the other yield components of spikes per metre square and number of grains per spike, it was observed that the significant groups carry one to two letters in 1,000-seed weight as against six to seven and five to six in spikes per square metre and grains per spike, respectively. Also the top significant groups contain only 15 and 36% of varieties in grain weight, as compared with 60 to 90% in top groups of other yield components.

4.6 Grain Yield (kg/ha)

The data on mean grain yield of 169 varieties/lines belonging to 2- and 6-row barley species is given in Tables 4.6a, 6 and the corresponding analysis of variance is shown in Appendix E-6. The differences due to varieties/lines were highly significant. On the contrary, the difference between the means of 2- versus 6-row species was not significant. The differences in the mean grain yield within the 2- and 6-row barley varieties were significant at 5 and 1% level in 2- and 6-row barley species, respectively.

This being a preliminary trial involving 169 entries, the significance worked out on the basis of individual treatments involved 23 letters of the alphabets in a complete table of

Table 4.6a: Grain yield (kg/ha) of 2-row barley lines/ varieties grown at Kadawa during 1983-84 dry season.

Entry No.	Grain yield (kg/ha)	Entry No.	Grain yield (kg/ha)	Entry No.	Grain yield (kg/ha)
160	6611a*	59	4233a-g	107	3357b-h
118	5809ab	161	4198a-g	139	3274b-h
66	5782abc	101	4184a-g	122	3259b-h
135	5760abc	147	4161a-g	157	3247b-h
151	5555a-d	110	4027a-g	33	3244b-h
47	5508a-d	132	4021a-g	106	3241b-h
167	5478a-d	117	4000a-g	29	3229b-h
150	5339a-d	163	3946a-g	32	3155b-h
168	5307a-d	87	3909a-g	61	3112c-h
159	5218a-d	169	3886a-g	90	3112c-h
23	5129a-d	14	3779a-g	57	3091c-h
141	4932a-e	116	3775a-g	11	3064c-h
125	4890a-e	73	3744b-g	97	2990c-h
134	4841a-e	131	3728b-g	153	2969c-h
34	4797a-e	123	3676b-h	158	2891c-h
164	4753a-e	137	3642b-h	136	2860d-h
166	4623a-e	102	3588b-h	83	2805d-h
24	4620a-e	15	3585b-h	146	2757d-h
50	4587a-e	104	3567b-h	95	2754d-h
1	4586a-e	165	3542b-h	70	2596e-h
112	4551a-f	154	3519b-h	89	2428e-h
119	4482a-f	105	3514b-h	142	2066e-h
61	4434a-f	71	3496b-h	84	2045a-h
140	4384a-f	52	3472b-h	49	1671fgh
75	4270e-g	162	3471b-h	148	1466gh
156	4270a-g	3	3460b-h	138	875h
78	4253a-g	44	3367b-h		

SE = ± 1133.5; Mean = 3840

* Means followed by same letter(s) are not significantly different.

Table 4.6b: Grain yield (kg/ha) of 6-row barley lines/ varieties grown at Kadawa during 1983/84 dry season.

Entry No.	Grain yield (kg/ha)	Entry No.	Grain yield (kg/ha)	Entry No.	Grain yield (kg/ha)
22	6014a*	92	4478a-j	20	3568a-k
30	6007a	17	4467a-j	74	3533a-k
149	5847ab	85	4456a-j	94	3522a-k
99	5724ab	16	4448a-j	63	3484a-k
36	5637abc	67	4436a-j	13	3482a-k
115	5532a-d	25	4431a-j	6	3410a-k
54	5494a-d	30	4364a-j	124	3349a-k
56	5486a-d	96	4379a-j	43	3334a-k
21	5467a-d	155	4343a-j	143	3249a-k
55	5373a-d	9	4343a-j	109	3176a-k
69	5248a-d	62	4285a-j	98	3154a-k
144	5235a-d	118	4222a-j	113	3112a-k
100	5059a-e	39	4184a-j	51	3064b-k
91	5035a-e	65	4094a-j	72	2997b-k
127	5014a-e	41	4050a-j	18	2958b-l
79	5008a-f	31	4026a-j	64	2789c-l
93	5000a-f	38	4015a-j	152	2786c-l
42	4945a-f	68	4006a-j	121	2770c-l
103	4928a-f	35	3996a-j	76	2776c-l
8	4895a-g	111	3980a-j	114	2741c-l
10	4798a-g	48	3980a-k	77	2678d-l
60	4782a-g	4	3929a-k	45	2169e-l
28	4778a-g	126	3899a-k	129	2104f-l
19	4729a-h	12	3783a-k	82	2006g-l
145	4701a-h	88	3778a-k	108	1853h-l
2	4598a-i	130	3717a-k	53	1739i-l
40	4597a-i	5	3765a-k	46	1667jkl
26	4550a-j	7	3676a-k	133	1094kl
58	4513a-j	120	3657a-k	27	1691
86	4500a-j	37	3581a-k		

SE = ± 1133.5; Mean = 3980.

*Means followed by same letter(s) are not significantly different.

2- and 6-row species. A detailed description of significance of these individual treatments may result in a complicated statement of facts. The results were, therefore, classified for each species separately. Also, instead of further discussing the significance of individual variety within a species, the two significance groups consisting of the highest and the lowest yield groups were indicated.

In 2-row species, the highest yield of 6,611 kg/ha was recorded by CI 16105. The yield ranged down to 3775 kg/ha produced by CI 16495. The lowest yielding group consisted of CI 15772 yielding 075 kg/ha with its upper range recorded by CI 16492 yielding 3,675 kg/ha. The entries which were excluded from both groups were CI 15724 yielding 3,720 kg/ha and CI 16173 yielding 3,744 kg/ha.

In 6-row barley species the highest yield of 6,014 kg/ha resulted from EX-LCRI22 and the lowest yield in this significant group was 3,112 kg/ha recorded from CI 15703. The lowest yielding variety in this experiment was found to be CI 16530 yielding only 169 kg/ha. The highest yield (2950 kg/ha) in low significant group was obtained from CI 16533. The two entries that did not fall into any of these groups were CI 15470 and CI 16172 yielding 3,064 and 2,997 kg/ha, respectively.

4.7 Crude Protein Content

The grain crude protein content was obtained from the composite samples of each variety. Statistical analysis was, therefore, not done using analysis of variance. However, the standard error and fiducial limits were worked out to see the range for each species. The data is shown in Tables 4.7a and b.

The mean grain protein content and standard error were found to be 8.91, ± 0.2013 and 8.48, ± 0.2594 in 2- and 6-row barley species, respectively. The grain protein content of 2-row barley ranged from 4.62 to 15.54%. In 6-row species, the protein content was from 5.04 to 13.06%. In 2-row barley about 82.5% of the entries yielded less than 10% crude protein, whereas in 6-row species 96% yielded less than 11.5% crude protein.

When the 2 species were compared using t-test of significance, it was observed that the difference between the two species was not statistically significant. Therefore, it was concluded that as far as grain protein was concerned, there was no varietal difference.

4.8 Correlation Studies

Correlation studies were carried out in 2- and 6-row barleys between yield, yield components and within yield components themselves, Table 4.8.

Table 4.7a: Crude protein content (%) of the grains of 2-row barley lines/varieties grown at Kadawa during 1983-84 dry season.

Entry No.	Crude protein(%)	Entry No.	Crude protein(%)	Entry No.	Crude protein(%)
160	7.56	59	6.30	107	8.02
120	9.41	161	8.02	139	11.76
66	7.90	101	7.90	122	10.50
135	9.74	147	9.41	157	10.92
151	7.14	110	8.40	33	6.72
47	7.01	132	8.32	106	9.66
167	8.00	117	9.50	29	10.92
150	7.90	163	7.40	32	5.00
160	4.62	87	8.40	01	8.40
159	7,90	169	8.02	90	15.54
23	9.00	14	8.57	57	8.40
141	9.03	116	8.57	11	9.24
125	8.91	73	11.51	97	12.09
134	8.91	131	7.56	153	7.14
34	5.04	123	10.00	150	7.64
164	8.02	137	9.24	136	8.40
100	8.40	102	8.65	83	13.06
24	11.60	15	7.56	146	7.14
50	6.30	104	8.02	95	14.20
1	7.56	165	9.24	70	9.66
112	11.34	154	9.66	09	11.34
119	9.66	105	10.50	142	9.16
61	8.40	71	7.90	84	8.57
140	8.40	52	8.02	49	8.02
75	8.02	162	8.60	140	7.90
156	8.40	3	8.02	130	8.40
70	7.56	44	7,57		

SE = ± 0.201; Mean = 8.9.

Table 4.7b: Crude protein content (%) of the grains of 6-row barley lines/varieties grown at Kadawa during 1983-84 dry season.

Entry No.	Crude protein(%)	Entry No.	Crude protein(%)	Entry No.	Crude protein(%)
22	10.50	92	8.57	28	10.08
30	7.64	17	7.56	74	8.40
149	8.40	85	7.08	94	8.40
99	6.47	15	9.24	63	7.23
36	7.67	67	6.72	13	8.02
110	9.24	25	7.09	6	10.08
54	6.72	96	11.34	124	8.99
56	5.46	80	9.66	43	8.99
21	7.56	155	8.02	143	13.06
55	7.50	9	8.40	149	7.56
69	9.24	62	8.02	98	7.56
149	9.24	118	9.24	113	7.31
100	10.00	39	7.56	51	6.72
91	6.30	65	7.56	72	7.56
121	9.24	41	5.46	10	9.66
79	9.50	31	7.67	64	6.30
93	8.02	30	6.72	152	8.06
42	6.72	60	11.51	121	10.92
103	9,24	35	5.04	76	9.66
0	8.02	111	7,56	114	10.08
10	8.40	48	7.14	77	8.40
60	7.64	4	8.65	45	6.30
20	9.24	126	8.40	129	9.24
19	10.08	12	10.08	82	7.23
145	7.56	88	13.70	100	7.90
2	8.37	130	8.40	53	7.56
40	7.14	5	9.24	46	7.64
26	9.49	7	7.98	133	9.16
50	7.14	120	9.24	27	5.08
86	7.14	37	8.15		

SE = ± 0.259; Mean = 8.4

Table 4.8: Simple, partial and partial multiple correlation coefficient between yield and yield components and within yield components of 2-row and 6-row barley lines/varieties.

COMPONENTS	2-Row Barley	6-Row Barley
Simple Correlation		
Yield vs grain weight	0.52**	0.72**
Yield " number of grains/spike	0.55**	0.02**
Yield " spikes/m^2	0.46**	0.04**
Grain weight, vs number of grains	0.55**	0.70**
Grain weight, " number of spikes	0.72**	0.74**
Grain number " spikes number	0.02**	0.77**
Partial Correlation		
Yield vs grain weight, keeping grain no. constant	0.31**	0.23**
Yield " " " " spikes no. "	0.30**	0.20**
Yield " " number " grain weight "	0.37**	0.59**
Yield " " " " spikes no. "	0.33**	0.49**
Yield " spikes " " grain wt. "	0.29**	0.66**
Yield " " " " grain no. "	0.03NS	0.59**
Partial Multiple Correlation		
Yield vs grain wt. and grain no., keeping spikes no. constant	-0.10NS	0.49**
Yield vs grain wt. and spikes no., keeping grain no. constant	0.57**	0.35**
Yield vs grain no. and spikes no., keeping grain wet. constant	0.73**	0.45**
Yield vs grain wt., keeping grain no. and spikes no. constant	0.35**	0.27**
Yield vs grain no., keeping grain wt. and spikes no. constant	0.14NS	0.43**
Yield vs spikes no., keeping and st. and grain no. constant	0.04NS	0.55**

** = Significant at 1% level.

NS = Not significant.

All simple correlations were positive and significant at 1% level in both species. A close study of coefficients of correlation (r values) revealed that the correlation values were higher in 6-row species than in 2-row except in seed weight, versus spike number where the correlation values in the two species were very close (0.72 and 0.74) and for grain weight versus spike number, the coefficient of correlation was higher in 2-row than 6-row species, (0.82 and 0.77).

All partial coefficients of correlation were also highly significant except yield versus spikes number, keeping the grain number constant. A critical study of partial correlation revealed that coefficients were higher in 2-row than in 6-row species for yield versus seed weights, keeping grain number and spike number constant (0.31, 0.30; 0.23, 0.20), but values of partial coefficients between yield and grain number were higher in 6-row (0.59, 0.49) when compared with 2-row species (0.37, 0.33) when [illegible] weight and tiller number were held constant. When the coefficients for partial correlation were studied between yield and spikes number, keeping grain weight and seed number constant, the values of coefficient were again higher in 6-row species (0.66, 0.59) when compared with 2-row species (0.29 and 0.03).

The partial multiple coefficient of correlation between yield versus seed weight and grain number keeping spike number

constant, was negative and insignificant in 2-row species (-0.10) but positive and highly significant (0.49) in 6-row species. The coefficients between yield versus grain weight and spikes number, keeping seed number constant were higher in 2-row species (0.57) than in 6-row (0.35) and both were significant at 1% level. Similarly, the values of coefficient were higher in 2-row species from yield versus grain number and spikes number, keeping grain weight constant (0.73) when compared with 6-row (0.45). Both coefficients were highly significant. Also the partial multiple coefficient of correlation between yield versus grain weight, keeping seed number and spike number constant, were positive and highly significant (0.35 and 0.27) in 2- and 6-row species, respectively. Correlation was not significant statistically in 2-row species for yield versus grain number, keeping seed weight and spike number constant (0.14) but highly significant in 6-row species (0.43). Similarly, partial multiple coefficient of correlation between yield versus spikes number, keeping grain weight and seed number constant was not significant in 2-row (0.04) but highly significant in 6-row species (0.55).

Chapter 5

DISCUSSION

5.1 Adaptation

Barley varieties showed reasonably high grain yield potential at Kadawa during 1983-84 dry season. Some of the entries, for example, CI 16185, EX-LCRI 22, EX-LCRI 30 and CI 15694 yielded 6,611, 6,014, 6,007 and 5,009 kg/ha, respectively, under irrigated conditions. These yield levels were 30 to 40% higher than the best cultivars of wheat grown under similar conditions at Kadawa (Anon, 1984). This superiority of barley over wheat can be explained as the former is more drought resistant and heat tolerant than the leter. Comparing wheat and barley under identical water stress condition, Singh and Kumar (1981) also reported barley as the more efficient in water use and with high grain yield potential. Similarly, diurnal and seasonal changes in leaf water potential were more favourable in barley compared to wheat under variable water stress conditions indicating barley as a more drought resistant and heat tolerant crop compared to wheat (Singh and Kumar, 1979). It is thus apparent that barley is more adapted to semi-arid tropics especially in the northern Nigeria under the condition of high day time temperature, low relative humidity and abrupt rise in temperature (30-40^{0}C) during the reproductive stage (February to March) of barley

(Kumar et al., 1982). However, such high temperatures impaired the malting quality (Ahmed et al., 1983a).

The world's mean grain yield of barley in 1980 and 1983 was 1,952 and 2,120 kg/ha, respectively (FAO 1980 and 1984). In the present investigation, the mean grain yield was 3040 and 3900 kg/ha for 2- and 6-row barley species, respectively, and was higher than the world's average. This higher grain yield was obtained from small and well-cared-for irrigated plots. Wilten (1975) and Faloki (1980) similarly reported good adaptation of barley to this zone.

5.2 Crop Growth

5.2.1 Plant height

In the present investigation, nutritional, cultural and environmental factors were the same for all treatments. Therefore, the differences in the mean height were due to genetic variability expressed in terms of variation in height of different entries. The significantly higher height in 2-row varieties was due to their upright (spring) growth habit inherent in them, unlike in 6-row varieties in which the initial growth was prostrating (winter type) and most of them in that group started upright growth from jointing stage. The medium height group consisting of 85 - 93 and 83 - 91cm in 2- and 6-row types contained most of the top yielding varieties. This was an optimum height for achieving yield in the varieties under trial.

Shorter varieties lacked this yield potential and the taller ones lodged easily. Fyzhov et al., (1981) also arrived at similar conclusion that varieties attaining a height between 90 - 95cm were found to be the highest yielding. This range in height combined yield with lodging resistance.

5.2.2 Maturity

When maturity was considered in relation to yield, it was observed that 11 and 17 varieties from 2- and 6-row groups yielded more than 5,000 kg/ha. The 11 high yielding varieties in 2-row consisted of five long and six medium duration varieties. In the 6-row barley group, there were two long, nine medium and six short duration varieties yielding more than 5,000 kg/ha. This indicated that yield potential in general with 6-row was higher than with 2-row and that medium and short duration varieties have good potentials for high yield in 6-row varieties. Faloki (1980) also reported that Ketch, in addition to high yield has a desirable characteristics of short duration and has the scope of growing in areas with short growing season like Borno and Sokoto States where the hot season commences early.

5.3 Yield Components

5.3.1 Number of spikes per square metre

Number of spikes (ear-bearing tillers) is a varietal

character and is influenced by a number of factors such as exposure to cool temperature, soil nutrient status especially nitrogen and spacing. These factors were the same for all the varieties and, therefore, the differences observed in the mean number of spikes per unit area could be attributed to varietal differences inherent in their genetic make up. Number of spikes per square metre contributed to the high yields observed as indicated by the coefficients of correlation, which were positive and highly significant. The association between yield and number of spikes was higher in 6-row than in 2-row species. Entries with high number of spikes per square metre were also among the top yielders recorded in this experiment. The lowest number of spikes per unit area of the highest yielding group was found to be 512 and 505/m^2 for 2- and 6-row barleys, respectively. Therefore, it is reasonable to assume that satisfactory yield would be obtained if there were 500 spikes/m^2 as indicated in this experiment. Other workers who reported positive association of spikes number with yield included Varma and Gulati (1961), Negut (1962) and Abdel-Raouf et al., (1983).

5.3.2 Number of grains per spike

Several factors influence the number of grains per spike. These include, soil moisture and nutritional status at the time of floral primordia initiation and the variety. In this investigation, a uniform irrigation and dose of fertilizer were

given to all plots. Hence, the differences in the number of grains per spike was mainly due to variety. The effect of seed number on yield was manifested in the form of high yield recorded by entries with high number of grains per spike. This was expressed more in 6- than in 2-row barley where entry EX-LCRI 22 and EX-LCRI 30 produced the highest number of grains per spike and in the same manner topped the list of grain yield in that species. The association of grain number with yield was again stronger in 6- than in 2-row barley as evidenced by their coefficients of correlation. The varieties recording the low number of grains per spike also recorded low yields in both groups. These findings are in conformity with those of Gu et al., (1983) and Hadjichristodoulo (1983) who had earlier reported positive association of grain number with yield.

5.3.3 One thousand grain weight

The grain weight (1,000-kernel weight) is one of the important characters for malting quality, as well as a yield contributing component. Differences were observed in grain weight with different varieties. It is also influenced by number of grains per spike, soil moisture content and temperature during the ripening period. Ahmed et al., (1977) Falaki (1980) and Gu et al., (1983) reported that generally the lower the number of grains per spike, the heavier the seed and vice versa. Similar phenomenon was observed in this investigation. The 2-row barley which produced a lower mean

number of grains per spike, had heavier seeds per thousand grains when compared with 6-row species. Entry CI 16105 (2-row barley) which produced the heaviest 1,000-grain weight (59.0g) also recorded the highest grain yield (6,611 kg/ha) in this experiment. This showed that there was a high correlation between grain weight and grain yield of barley varieties under trial.

5.4 Climatic Effect on Yield Components

When the yield component factors were critically analysed in relation to climatic factors, it was observed that at about the time of sowing on 17 November, 1983, both the day and night temperatures were getting cooler (mean maximum 29.7 and mean minimum 17.9^{o}C) which produced an ideal temperature for germination and establishment of seedlings for most of the entries in the trial. The short, medium and long duration varieties started tillering in mid December, end of December and early January, respectively, when the mean maximum temperature was 32.5, 28.4 and 26.6 and mean minimum was 11.8, 12.2 and 12.2^{o}C, respectively. It was evident that the medium and long duretion varieties tillered during the period when climatic conditions were more favourable and as a result these two groups were found to produce more tillers per unit area than the short duration varieties.

The floral initiation occurred towards the end of December, early January and mid January in short, medium and

long duration varieties when the maximum and minimum temperatures were found to be 20.4, 26.6 and 25.9 and 12.2, 12.2 and 12.1, respectively. The temperatures for medium and late varieties were more favourable than short duration varieties. This resulted in higher number of grains in medium and long duration when compared to short duration varieties.

The heading and grain filling stage took place from mid January to early February in short duration varieties when the mean maximum and minimum temperatures were 25.9, 27.9 and 12.1 and 11.9°C, respectively. In the medium duration varieties, heading and grain filling took place from end of January to middle of February and in the long duration varieties, it occurred during middle of February to early March. The mean maximum and minimum temperatures were 26.9, 30.8 and 12.3 and 14.9°C for the medium duration varieties and 30.8, 35.1 and 14.9, 17.6°C for the long duration varieties. The grain filling temperatures for the long duration varieties were not conducive. Therefore, most of the medium and short duration varieties had produced heavier grains in both species. Due to low night temperatures, the respiration in medium and short duration varieties was reduced, resulting in more photosynthates produced during the day being deposited in the form of carbohydrate in the grain. This conclusion was supported by the results of experiments by Thorne (1973) in which he reported that warming ears only enhanced their early growth but caused them to mature sooner,

with a smaller final dry weight, than cool ears.

5.5 Yield

5.5.1 Grain yield

Yield is a complex character that depends upon a number of interacting factors. Number of grains per spike, weight of 1,000 kernels and number of effective tillers (spikes) per unit area are among the main yield contributing components of barley.

The grain yield of first four entries in 2-row barley, CI 16105, CI 15694, CI 15244 and CI 16509 was found to be 6,611, 5,009, 5,702 and 5,760 kg/ha, respectively. When grain yield was considered in relation to the respective yield components of individual varieties within each species, it was observed that in 2-row species entry CI 16105 recorded the highest grain weight of 59.0g per 1,000 kernel. It was also in the highest significant group of both seed number and spikes per square metre. The variety next in rank was CI 15694 which produced the highest number of spikes per square metre (795) and ranked third and fourth for grain weight and number of grains per spike, respectively. Variety CI 15244 was third in rank and topped the list in number of grains per spike, second for number of spikes per square metre and tenth for grain weight. Similarly, entry CI 16509 ranked third, eighth and ninth for spikes per square metre, seed

weight and number of grains per spike, respectively.

In the 6-row species, the top four high yielding entries included EX-LCRI 22 (6,014) and EX-LCRI 30 (5,007 kg/ha) which ranked third and first in number of grains per spike, respectively. Entry CI 16505 (5,047) ranked second for seed weight and EX-LCRI 99 (5,724 kg/ha) topped for number of spikes per square metre in this species.

When the grain yield, yield components and the ranks of entries were considered with the 2-row standard variety, Ketch, it was found that Ketch yielded 4,190 kg/ha, it produced 590 spikes per square metre and 16.1 seeds per spike with 1,000 grain weight of 45.5 g. The ranks of these three components were 44th, 54th and 32nd, respectively. In this experiment, 70 entries yielded higher than Ketch and 23% of the population yielded statistically the same as variety Ketch. In 6-row entries, there was no standard variety included as all varieties grown thus far in Nigeria, are 2-row type. In general, entries having high yield components resulted in high yield. This was further supported by the coefficients of correlation which were positive and highly significant between the yield and all the yield components for both 2- and 6-row barleys. Similar associations of yields with yield components, have been reported by Varma and Gulati (1901), Negut (1902) and Kandera and Kandera (1903).

Varieties yielding more than 5,000 kg/ha were 11 and 17 in number for 2- and 6-row species, respectively. In 2-row species, five long duration and six medium duration entries were found to yield more than 5,000 kg/ha. All entries were of medium height. In the 6-row species, the high yielding entries consisted of two long duration, nine medium duration and six short duration cultivars. When the heights of these high yielding entries were considered, two were tall, nine medium and six short in height. In general, medium to short duration and medium to short statured entries from 6-row species were among those which yielded more than 5,000 kg/ha. Because of their height, they were more responsive to fertilizer. Tall varieties lodge in application of fertilizer (Pyzhov et al., 1981).

When the grain yield was estimated by using yield component data, it was observed that estimated mean yield was 4,772 and 4,690 kg/ha as against 3,040 and 3,900 kg/ha of observed yield for 2- and 6-row species, respectively. This indicated that yield recovery in both species was very high.

5.5.2 Coefficient of variability

Coefficients of variation were worked out to study the relative variation in the three yield components. The coefficients of variation revealed that grain weight was the least variable among the three yield components. When the

two species were compared, grain weight was found to be more variable in 6-row than in 2-row species. This also explains partially why malsters prefer 2-row barley to 6-row. Besides its low grain protein content, the grain weight is less variable when compared with 6-row barley. The variability of number of spikes per square metre was found to be intermediate among the three yield components and was more or less the same for the two species. The number of grains per spike was found to be the most variable character among the three yield components. It was found to be more variable in 2- than in 6-row varieties.

Among the two barley types, 6-row barley outyielded the 2-row by a margin of about 5% which was not significant. The higher grain yield from 6-row was reflected in a number of growth and yield component characteristics like early maturity, higher number of seeds per spike and spikes per unit area. The 2-row barley was superior to 6-row in the weight of 1,000 kernels. This component had a compensatory effect on the grain yield of 2-row species which was inferior to 6-row in the other two yield parameters. Kumar and Mayaki (1982) have also reported that number of grains per head and 1,000 grain weight were most closely related to grain yield of wheat and accounted for more than 99% variation in grain yield.

5.6 Grain Quality

5.6.1 Grain protein content

Grain protein content is one of the quality factors in barley especially when it is used for malting purposes. First of all, a high grain protein replaces the starch content of the grain which is essential for conversion of starch into maltose and finally into alcohol. Secondly, grain protein is important because during brewing, wort nitrogen is hydrolysed to certain compounds which are not desirable for their aroma in the alcohol. Generally, 2-row barley is considered to be of better quality because of their low grain protein content and high starch content. In the present investigation, 6-row barley varieties were found to have lower grain protein than the mean of 2-row barley varieties the difference not being statistically significant. This result has a direct bearing with the source of seeds. The entries has a direct bearing with the source of seeds. The entries were derived from the United States Department of Agriculture, Scientific and Technical Exchange, Washington, D.C., and in United States, most of the 6-row barley varieties are used for malting purposes. Therefore, these entries were selected for their low grain protein. Most of the 6- and 2-row barley entries in this investigation were within the maximum norms of grain protein content for malting barley, which is, 10.0 for 2-row and 11.5% for 6-row species.

5.6.2 Grain weight

Another important barley character for malting purposes is grain weight. Malstars prefer plump seeds because of their high starch and high germinative capacity. Small and shrivelled seeds germinate at slower rate and the rate of activity of amylase enzyme is also slower. As a result, the malting process is delayed.

In the present investigation, it was observed that 2-row varieties yielded significantly heavier grains than 6-row. When the grain protein content of 2-row was compared with standard variety, Ketch (8.0%) it was observed that 37.5% was less than the standard variety. Similarly, when the seed weight of Ketch, which has good malting quality was considered in relation to other entries, 30.0% had heavier grain, showing that entries produced heavy grains with good malting quality. This result confirmed earlier work by Wilten (1975) who reported that the seed weight of barley grown in Nigeria was of good malting quality.

Chapter 6

SUMMARY AND CONCLUSIONS

The investigation was carried out at Irrigation Station of the Institute for Agricultural Research, Ahmadu Bello University, Kadawa, under irrigation during 1983-84 dry season. Kadawa is located in the Sudan Savanna ecological zone of Nigeria. Mean maximum and minimum temperatures recorded from November, 1983 to March, 1984, did not exceed 37.1 and 19.6°C, respectively and mean relative humidity ranged from 21.9 to 34.0%. There was no rainfall during this period.

The differences in mean plant height due to entries were highly significant. The 2-row barley produced significantly taller plants than 6-row barley and the difference was significant at 1% level. The differences in the mean height within 2-row and 6-row varieties were also highly significant. In 2-row species, plant height ranged from 94-127, 85-93 and 50-84cm for the tall, intermediate and short varieties, while the corresponding heights in 6-row were from 93-110, 82-92 and 45-70cm for the three groups mentioned above.

The differences in the mean number of days taken to maturity for all the entries were significant at 1% level. When the two species were compared, the difference in maturity was only one week and was not statistically significant. Within each species, the differences in the

mean number of days to mature were highly significant. The entries were classified into short (80-89 days), medium (90-99) and long (more than 100 days) duration. The relative percentages in each species were 29, 34, for short; 49 each for medium and 22, 17% in long duration varieties, for 2- and 6-row barley species, respectively.

The differences in the mean number of spikes per square metre for all the entries were significant at 1% level. The comparison in the mean number of spikes per square metre for the two species was also highly significant, 6-row producing significantly more spikes per square metre than 2-row. Similarly, within each species, the differences in the mean number of spikes were significant at 1% level.

When the number of grains per spike was considered, the differences due to entries were highly significant. The 6-row barley produced significantly higher number of grains per spike than 2-row and this difference was significant at 1% level. The differences within each species of 2- and 6-row barley were also highly significant. The highest number of grains was recorded by EX-LCRI 30 and CI 15244 (35.5 and 27.7) and the lowest number was counted in CI 15766 and CI 15772 (0.3 and 6.0) in 6- and 2-row barley, respectively.

Analysis of data revealed that differences due to entries were highly significant when 1,000-grain weight was considered.

Also 2-row barley species produced significantly heavier grains than 6-row with mean kernel weight as 43.5 and 34.6g for 2- and 6-row species, respectively.

Differences due to the mean grain yield of 169 entries were highly significant, but the difference between the means of 2- versus 6-row species was not significant. However, the differences in the mean grain yield within the 2- and 6-row species were significant at 5 and 1% levels, respectively. In 2-row, the highest grain yield (6,611 kg/ha) was recorded by CI 16105 and the lowest yield observed was 075 kg/ha produced by CI 15772. In 6-row, the highest grain yield of 6,014 kg/ha was recorded in EX-LCRI 22, while the lowest yield (169 kg/ha) recorded in this experiment was produced by CI 16530.

When grain yield was considered in relation to the respective yield components of individual varieties within each species, it was observed that in 2-row, entry CI 16105 (6,611 kg/ha) recorded the highest grainweight of 59.0g per 1,000 kernel. It was also in the highest significant group of both grainnumber and spikes per metre square. In 6-row species, the top two yielders EX-LCRI 22 (6,014 kg/ha) and EX-LCRI 30 (6,007 kg/ha) ranked third and first in number of seeds per spike, respectively. Ketch, the 2-row standard variety, yielded 4,190 kg/ha and ranked 44th and 32nd in spikes per unit area and 1,000 seed weight, respectively. It ranked 54th in grain number per spike.

Entries that yielded more than 5,000 kg/ha consisted of five long and six medium duration cultivars in 2-row barley. In the 6-row species, they were, two long, nine medium and six short duration cultivars. These high yielding entries generally belonged to medium and short plant groups.

The mean grain protein content was 0.91 and 0.40% in 2- and 6-row barley species, respectively which was not statistically significant. The protein content of 2-row barley ranged from 4.62 to 15.54%, while in 6-row, it was 5.04 to 13.06%.

Yield was highly associated with all the yield components as indicated in the coefficients of correlation which were positive and highly significant in both 2- and 6-row barley species.

From the present investigation, it was concluded that varieties have shown a good adaptation in the Sudan Savanna ecological zone of Nigeria as shown in their growth and yield. Furthermore, it was not only the high yield, but also that barley grown in this region was found to be of good malting quality due to low grain protein content. The grain protein content of 6-row barley was found to be lower than 2-row barley in this investigation. The low grain protein in 6-row was attributed to selection for a long time in the United States, where 6-row barleys are mainly used for malting

purposes. Heavy grains with good malting character were identified in this investigation and 119 varieties were selected on the basis of their yield, grain protein content, grain weight, plant height and duration for further work.

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Appendix A. Mean maximum and minimum temperatures (^{o}C) and relative humidity (%) at 10 day intervals during experiment (20-11-83 to 20-3-84) at Kadawa.

Month	Temperature		Relative Humidity
	Mean Maximum	Mean Minimum	
21 - 30 Nov.	29.7	17.9	-
1 - 10 Dec.	31.2	14.2	30.0
11 - 20 Dec.	32.5	11.0	29.6
21 - 31 Dec.	20.4	12.2	32.0
1 - 10 Jan.	26.6	12.2	33.0
11 - 20 Jan.	25.9	12.1	27.1
21 - 31 Jan.	26.9	12.3	24.0
1 - 10 Feb.	27.9	11.9	26.5
11 - 20 Feb.	30.0	14.9	20.0
21 - 29 Feb.	32.1	17.6	21.9
1 - 10 March	35.1	17.6	34.0
11 - 20 March	37.1	19.3	20.6

Appendix B. The physical and chemical properties of the soil collected at a depth of 30cm from the experimental site at Kadawa.

Soil Properties	Characteristics
Physical properties	
Sand %	52.40
Silt %	39.60
Clay %	8.00
Textural class	Sandy loam
Chemical properties	
pH in H_2O	6.5
pH in 0.01M$CaCl_2$	6.0
Exchangeable cations	
(meq/100g of soil)	
Na	0.150
K	0.112
Ca	3.360
Mg	0.997
Total P(ppm)	100.500
Total N(%) in 0.040N H_2SO_4	0.021
CEC (meq/100g)	5.05

Appendix C. Previous cropping history of the Experimental site at Kadawa.

Season		Crop	
Wet	Dry	Wet	Dry
1982	1982/83	Fallow	Maize
1983	1983/84	Fallow	Barley

Appendix D. List of barley lines/varieties tested at Kadawa during 1983/84 dry season.

Entry No.	CI. No.	Entry No.	CI. No.	Entry No.	CI. No.	Entry No.	CI. No/Var.
1	EX-LCRI1*	44	CI 15407*	86	EX-LCRI86	128	CI 15694*
2	EX-LCRI2	45	CI 15490	87	CI 15790*	129	CI 15722
3	CI 16520*	46	CI 15509	88	CI 15804	130	CI 15723
4	CI 16523	47	CI 15401*	89	CI 15855*	131	CI 15724*
5	CI 16524	48	EX-LCRI40	90	CI 15856*	132	CI 15725*
6	CI 16525	49	CI 15403*	91	CI 15857	133	CI 15766
7	CI 16529	50	CI 15477*	92	CI 16165	134	CI 16500*
8	EX-LCRI0	51	CI 15470	93	EX-LCRI93	135	CI 16509*
9	CI 16531	52	CI 15480*	94	EX-LCRI94	136	CI 16510*
10	EX-LCRI10	53	EX-LCRI53	95	CI 16160*	137	CI 15770*
11	CI 16551*	54	EX-LCRI54	96	EX-LCRI96	138	CI 15772*
12	EX-LCRI12	55	CI 15475	97	CI 16170*	139	CI 15775*
13	EX-LCRI13	56	CI 15214	98	CI 15706	140	CI 15776*
14	CI 16554*	57	CI 15215*	99	EX-LCRI99	141	CI 15777*
15	CI 16555*	58	CI 15216	100	EX-LCRI100	142	CI 15778*
16	EX-LCRI16	59	CI 15229*	101	CI 66106*	143	CI 16499
17	EX-LCRI17	60	CI 15230	102	CI 16107*	144	CI 16500
18	CI 16533	61	CI 15231*	103	EX-LCRI103	145	CI 16501
19	EX-LCRI19	62	CI 15232	104	CI 16189*	146	CI 16502*
20	CI 16544	63	CI 15240	105	CI 16190*	147	CI 16503*
21	EX-LCRI21	64	CI 15241	106	CI 16191*	148	CI 16504*
22	EX-LCRI22	65	CI 15243	107	CI 15779*	149	CI 16505
23	CI 16547*	66	CI 15244*	108	CI 15700	150	CI 16506*
24	EX-LCRI24*	67	CI 15245	109	CI 15701	151	CI 16507*
25	EX-LCRI25	68	CI 15536	110	CI 16192*	152	CI 16177
26	EX-LCRI26	69	EX-LCRI69	111	CI 16409	153	CI 16178*
27	CI 16538	70	CI 15550*	112	CI 16490*	154	CI 16179*
28	CI 16539	71	CI 16171*	113	CI 15703	155	CI 16180
29	EX-LCRI29*	72	CI 16172	114	CI 15704	156	CI 16181*
30	EX-LCRI30	73	CI 16173*	115	CI 15705	157	CI 16182*
31	EX-LCRI31	74	CI 10961	116	CI 16495*	158	CI 16183*
32	CI 16511*	75	CI 14005*	117	CI 16496*	159	CI 16184*
33	CI 16512*	76	CI 15213	118	CI 16497	160	CI 16185*
34	EX-LCRI34*	77	CI 2200	119	EX-LCRI119*	161	Ketch*
35	EX-LCRI35	78	CI 2270*	120	CI 15606	162	Berenice*
36	EX-LCRI36	79	EX-LCRI79	121	CI 15607	163	Clipper*
37	EX-LCRI37	80	CI 9107	122	CI 16491*	164	Printer*
38	EX-LCRI38	81	CI10122*	123	CI 16492*	165	Research*
39	EX-LCRI39	82	CI 10123	124	CI 16493	166	Athos*
40	EX-LCRI40	83	CI 592*	125	CI 16174*	167	Weeah*
41	CI 16514	84	CI 1246*	126	CI 16175	168	Proctor*
42	EX-LCRI42	85	CI 2203	127	CI 16176	169	Trumpf.*
43	EX-LCRI43						

* 2-Row barley entries.

Appendix E-1. Analysis of variance table for plant height (cm)

Sources	DF		SS	MS	F
Replications	1		6.02	6.02	-
Blocks	24		1295.91	63.99	-
Treatments	160		91033.73	541.07	27.273**
2-row VS 6-row		1	508.40	508.40	25.591**
Within 2-row		79	35746.10	452.40	22.774**
Within 6-row		08	54779.30	622.49	31.33**
Error	144		2861.20	19.07	-

** Significant at 1% level.

Appendix E-2. Analysis of variance table for days to maturity

Sources	DF		SS	MS	F
Replications	1		805.23	805.23	-
Blocks	24		3670.30	152.93	-
Treatments	160		10029.12	107.32	3.23**
2-row VS 6-row		1	120.10	120.10	3.05NS
Within 2-row		79	8361.30	105.84	3.18**
Within 6-row		00	9539.70	100.41	3.26**
Error	144		4700.09	33.26	-

** = Significant at 1% level.

NS = Not significant.

Appendix E-3. Analysis of variance table for spikes per square metre.

Sources	DF	SS	MS	F
Replications	1	6.54	6.54	-
Blocks	24	143.16	5.965	-
Treatments	160	4095311.06	24376.05	11056.031**
2-row Vs 6-row	1	31442.16	31442.16	15292.079**
Within 2-row	79	1715037.4	21719.46	10563.930**
Within 6-row	80	2348032.3	26602.19	12977.710**
Error	144	296	2.056	-

** Significant at 1% level.

Appendix E-4. Analysis of variance table for seeds per spike.

Sources	DF	SS	MS	F
Replications	1	125.55	125.55	-
Blocks	24	1440.90	60.037	-
Treatments	160	39271.76	233.760	6.336**
2-row Vs 6-row	1	4356.01	4356.01	118.075**
Within 2-row	79	14022.92	177.50	4.811**
Within 6-row	80	20893.03	237.42	6.436**
Error	144	5312.55	36.89	-

** Significant at 1% level.

Appendix E-5. Analysis of variance table for one thousand seed weight.

Sources	DF	SS	MS	F
Replications	1	44.04	44.040	-
Blocks	24	245.24	12.210	-
Treatments	160	12510.65	116.147	8179.366**
2-row Vs.6-row	1	260.94	260.74	18.362**
Within 2-row	79	9100.05	115.191	8.112**
Within 6-row	80	10151.69	115.362	8.124**
Error	144	2044.73	14.200	-

** Significant at 1% level.

Appendix E-6. Analysis of variance table for grain yield.

Sources	DF	SS	MS	F
Replications	1	70774.00	70774.00	-
Blocks	24	2902826.10	124204.42	-
Treatments	160	26974000.00	160559.52	2.087**
2-row Vs 6-row	1	111499.15	111499.15	1.449NS
Within 2-row	79	11791704.00	149262.07	1.94*
Within 6-row	80	15070796.00	171255.04	2.22**
Error	144	11077000.00	76929.37	-

* = Significant at 5% level.

** = Significant at 1% level.

NS = Not significant.

Appendix F. Barley yield (kg/ha) in major producing countries of the world during 1900 and 1983, respectively.

Country	Yield (kg/ha)	
	1900	1983
USSR	1304	1696
Canada	2202	2300
USA	2667	2019
Spain	2500	1000
India	926	1249
France	4440	4137
Turkey	1097	2036
U.K.	4406	4707
Australia	1100	1690
Morocco	1015	571
World	1952	2120

Source: FAO Production Year Book 1900, FAO Monthly Bulletin of Statistics June, 1904.

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Bishop Shanahan Secondary School, Orlu	1957	1961	W.A.S.C.
University of Nigeria, Nsukka	1966	1973	B.Sc. (Plant/Soil Science)
International Centre for Maize and Wheat Improvement (CIMMYT)	1979	1980	Diploma, Irrigated Wheat Agronomy.

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Organization	From	To	Position
National Cereals Research Institute, Ibadan.	1973	1977	Research Officer.
Lake Chad Research Institute, Maiduguri	1970	Date	Principal Research Officer.

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