Optimum sowing date, seed rate and harvesting stage of barley as a forage crop in the Gezira

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Abstract

An experiment was conducted in the Gezira Research Farm during the winter seasons of 2001-02, 2002-03, 2003-04 and 2004-05 to determine the optimum sowing date, seed rate and harvesting time of barley as a forage crop. The treatments comprised four seed rates viz 48, 96, 144 and 192 kg/ha and five sowing dates viz 1 Nov, 15 Nov, 1 Dec, 15 Dec and 1 Jan. For the assessment of the quality, the crop (1 Dec sowing) was sampled fortnightly for the proximate analysis. The results showed that, the highest dry matter yield (at milk stage) was obtained when the crop was sown on 1 Dec in 2001-02, 15 Nov and 1 Dec in 2002-03, 1 Dec and 15 Dec of each of 2003-04 and 2004-05 seasons. In addition, combined analysis over the four years showed that 1 Dec was the optimum sowing date. Regarding effects of the seed rate, no significant differences were observed in 2002-03 season, while 48 kg/ha produced significantly lower yield than the other three seed rates in the other seasons and in the combined analysis. Hence, 96 kg/ha could be considered as the best choice for planting barley as forage in winter. With respect to the quality, harvesting the crop at the milk stage resulted in the highest crude protein yield while the other quality attributes were not drastically affected in comparison to their values at earlier stages.

Introduction

More than 98% of the animal feed in Sudan is contributed by natural ranges and residues of rainfed crop. A considerable portion of that, however, is not accessible to livestock due to shortage of drinking water within grazing areas during the dry summer. The animal-forage relationships in Sudan, therefore, exhibit severe shortages particularly during summer. The situation is even more acute for the dairy cattle around big cities. A practical way to alleviate such shortages could be through forage production during the winter. This is highly possible because the national schemes (Gezira, Suki and New Halfa) are designed in such a way that a sizable area could be grown in the winter. In the White Nile schemes (specially north of Kosti) irrigation water is only available during and after September. This indicates that the winter is the most suitable growing season in the White Nile scheme.

Barley, Hordeum vulgare L. has shown good potential for dry matter yield of good quality during the winter in the Gezira Research Farm (Khair et al. 2001). Its dry matter yield was more than that of Abu Sabeen in winter (Khair, et al. unpublished) and over 75% of that of Abu Sabeen in summer (Khair, 1999).

The yield potential of barley grains in Sudan, is 3.4 t/ha in Hudeiba and 2.2 t/ha in Khartoum and Gezira state (Ibrahim and Imam, 1975). Using a harvest index of 50 % (Nordblom. 1987), the corresponding biomass yields for those mentioned above were 6.8 and 4.4 t/ha. For grain production, Lazim (1973), showed that sowing of barley at mid Nov had resulted in the highest yield in Hudeiba, where as no differences were reported among

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seed rates of 60, 120, 180 and 240 kg/ha (Imam, 1967). For forage production however, seed rate of 90-112 kg/ha was reported as optimum in U. S. A (Miller, 1984).

Inverse relationship between the yield and the quality of forages with the advancement in the crop age was demonstrated for forage sorghum (Khair, 1992) and temperate grasses (Corrall, 1979). A compromise between the quantity and quality of the forage therefore, has to be made in order to harvest the maximum possible quantity and quality forage. This however, could be achieved through periodical monitoring of both quantity and quality of the forage during the crop growth period.

In Sudan, detailed studies are still needed to develop agronomic package for growing barley as a forage crop. The objective of the current work was, therefore, to determine the optimum sowing date, seed rate and harvesting stage of barley as a forage.

Materials and methods

The study was carried out for four consecutive seasons (2001-02,2002-03, 2003-04 and 2004-05) in the Gezira Research Farm of the Agricultural Research and Technology Corporation (ARTC), Wad Medani, Sudan (Latitude 14° 24′ N, Longitude 33° 29′ E and altitude 406.9 m msl. The soil is vertisol with high clay content (54%-58%), pH (8.2 - 8.4), organic carbon (0.03-0.04%), total N (0.003%) and total P (406 -700 ppm).

The study involved barley *Hordeum vulgare* L. cv. Baldi type which is characterized by vigorous growth, high grain yield, moderate height, no lodging and short gestation period for grain yield (100 days) (Ibrahim and Imam, 1975).

The experiment was in a split-plot arrangement with three replications. The treatments comprised five sowing dates viz 1 Nov, 15 Nov, 1 Dec, 15 Dec of years 2001, 2002, 2003, 2004 and 1 Jan of years 2002, 2003, 2004, 2005 as mainplots and four seed rates; namely 48, 96, 144 and 192 kg/ha, as subplots. Subplot area was 3.0 × 7.0 m and consisted of 5 ridges spaced 60 cm apart.

Planting was by drilling the seeds to about 5 cm depth, on the top of the ridges. Nitrogen was added simultaneously with the seeds at the rate of 184 kg urea/ha. The crop was hand weeded twice. After the first irrigation, water was applied every 10-12 days throughout the growing season.

The two outer-most ridges were considered as borders. One of the three middle ridges was used for periodical destructive sampling (sample area) and the other two for the final yield. Starting 15 days after sowing (DAS) samples were collected fortnightly from an area of 0.5 x 0.6 m for the proximate analysis. The samples were taken from the sample area at 15, 30, 45, 60 and 75 DAS. For the final yield, the crop was cut from ground level in an area of 1.2 x 6 m at the milk stage. Plant height of the final yield was taken as the mean of 5 readings of the main shoot. The fresh matter was weighed in the field and a subsample of one kg fresh matter was oven dried at 85 ºC for 48 hours for dry matter determination.

Planting on 1 Dec in 2001-02 and 2002-03 was selected for proximate analysis, because it resulted in the highest dry matter yield. The destructive samples were oven dried at 85ºC for 48 hours and then weighed for the determination of dry matter yield. Prior to the drying, a subsample was taken and separated into leaves and stem to obtain the leaf/stem ratio. Both dry matter and the leaf/stem ratios in each sampling date, were statistically analyzed over the four seed rates, 3 replicates and 2 seasons (2001-02 and 2002-03). (split plot analysis where the season was the main plot and the seed rates were the sub plots). For the proximate analysis, at each sampling date, the tissues from the four seed rates in the three replicates were thoroughly mixed, ground and four sub samples were randomly taken for the proximate analysis.

The proximate analyses were carried out in the Feed Analysis laboratory of Elobeid Research Station of the ARTC. The dry matter (DM) was determined through overnight oven drying on duplicate samples of 2.5 grams at 105ºC. The rest of the sample was dried at 65ºC before being subjected to crude protein (CP) and crude fiber (CF) determinations. The CP was calculated from total nitrogen content, using Kejldahl method (AOAC, 1990). The CF was determined using the trichloroacetic acid (TCA) method (AOAC, 1990). Ash content was obtained through burning away all the organic matter (OM) of 2.5 grams duplicate samples at 540-550ºC in a muffle furnace for 3 hours (AOAC, 1990). Ether extract (EE) was low and considered as 1% at all ages. Nitrogen free extract (NFE) content was obtained through summing up CP + CF + Ash contents and subtracting them from OM contents.

The dry matter yield of each year was first analyzed for the split plot design. Following Bartlett variance homogeneity test, the combined analysis over the four years was performed. Means were separated by the Duncan Multiple Range test at 0.05 level. The data for each quality attributes were statistically analyzed over two years (2001-02 and 2002-03) using the split plot design and considering the years as main plot, sampling date as subplot and the four samples in each sampling date as replicates.

Results

Growth and Development

The progressive phonological stages of barley during 2001-02 season were slightly later than during 2002-03 (Table 1). Within each season, however, the sowing date had considerable impact on the pheonolgy and consequently on longevity of barley as a forage crop. The crop remained vegetative for a longer period when sown on 1 Nov of both seasons. That longevity was sharply shortened when sown after 15 Dec. Sowing on either 15 Nov or 1 Dec, however, resulted in a moderately longer vegetative stage. The reduction in the number of days to heading in response to earliest and latest sowing dates ranged from 10 days in 2001-02 to 7 days in 2002-03 season. The differences in sowing dates seemed to be reflected in the progressive phonological stages. The effect of the sowing date on the number of days to reach the milk stage (cutting stage) was even greater, amounting to about 12 days between the first and the last sowing dates in both seasons. Sowing on 1 Nov resulted in a gestation period (milk stage) of 75 days while sowing on 15 Nov and 1 Dec resulted in a gestation period of 72 days.

Forage dry matter yield

The forage dry matter yield in this study refers to the weight of the dry matter when the crop reached the milk stage. The yields at this milk stage were significantly affected by the sowing date (Table 2) as well as by the seed rate (Table 3). The yields of 2001-02 season were slightly higher than those of 2002-03 , 2003-04 and 2004-05.

The highest forage yield (4.2 t/ha) was obtained in season 2001-02 when barley was sown on 1 Dec. In 2002-03 season, sowing on 15 Nov out yielded all sowing dates except of 1 Dec while in 2003-04 and 2004-05 seasons the highest yields were obtained when the crop was sown on 1 Dec and 15 Dec. In addition, combined analysis over the four years showed that the highest significant dry matter yields were obtained exclusively when the crop was on 1 Dec.

The effect of the seed rate, even though significant in 2001-02, 2003-04 and 2004-05 seasons and in the mean over four seasons, was not as marked as that of the sowing dates.

Even the magnitudes of the difference were not as pronounced as for the sowing dates The lowest seed rate, of 48 kg/ha was significantly out yielded by 96, 144 and 192 kg/ha in 2001-02, 2003-04 and 2004-05 but the differences between the yields of the highest three seed rate were, however, not significant.

Forage quality

The time course profile for the barley yields and qualities in 2001-02 and 2002-03 seasons are shown in Table (4). The mean quality attributes over all plant ages and years were 2.5, 88, 7.5, 10.0, 21.7 and 55% for the leaf/stem ratio, OM, Ash, CP, CF and NFE respectively. The dry matter and crude protein yields progressively increased, while the leaf/stem ratio generally decreased with the advancement in the plant age (Table 4). The OM and CF during crop development had comparable values except when the crop was 45 days. At that age, they had reached their maxima where as the Ash % attained its minimum. Crude protein, on the other hand, attained its maximum value (11%) at the age of 60 days. Moreover, harvesting of barley at the milk stage showed that the advancement in the age of barley did not drastically affect the quality while it increased the quantity (Table 4).

Discussion

In temperate areas, high dry matter yield of barley, about ten t/ha in northern Syria (ICARDA. 1987) and 5.7 t/ha in northern United States (Carr, *et al*. 2000), were reported. The maximum yield in the present study was 4.2 t/ha, i.e., about 42% of that of Syria and 74% of that of the United States. This yield is, however, justifiable for only 75 days of growth and under relatively warm conditions, compared to that of Syria, which was obtained in a growth period of about 186 of relatively cooler days (ICARDA. 1987).

Excluding Dec and Feb, the monthly temperatures of season 2001-02 were slightly lower than those of other seasons (Table 5). The optimum temperature for barley growth is 29ºC (Bland. 1971). The variation in the dry matter yield of forage among the sowing dates (Table 2) as well as among the seasons of this study (i.e., 2.8 t/ha for 2001-02 and 2.1 t/ha for 2002-03, 1.6 t/ha for 2003-04 and 2.1 t/ha for 2004-05 seasons) could therefore, be attributed to the temperature differences.

Comparison among the sowing dates (Table 2) shows that the highest forage yields were obtained when the crop was sown on 1 Dec. in 2001-02, and on 15 Nov and 1 Dec in 2002-03 and on 15 Dec and 1 Dec in 2003-04 and 2004-05. It is noteworthy that the crop growth up to the stage of 75% heading in 15 Nov and 1 Dec sowing dates had occurred during the coldest months of the year, i.e., during Dec and Jan. The mean plant height for 15 Nov and 1 Dec was 73 cm in season 2001-02 compared to 59 cm in season 2002-03. The association of plant height with forage yield was reported for oats (Chapko, *et al*. 1991). In addition, those two sowing dates were characterized by relatively long vegetative growth periods (Table 1). Sowing on15 Dec. and 1 Jan., even though they subjected the plants to relatively lower temperatures during considerable period of the vegetative growth, their yields were limited by shorter vegetative phase and ultimately shorter growing periods. The crop at these two sowing dates was actually harvested in about 60 days only.

Regarding the effect of seed rates on barley yield, reports on barley for grain production in Sudan (Imam. 1967) showed no significant differences among seed rates of 60, 120, 180 and 240 kg/ha. In contrast, to those however, the data of this study showed that the dry matter yield of barley at the seed rate of 48 kg/ha was lower than that of all the other seed rates, especially in 2001-02, 2003-04 and 2004-05 (Table 3).

The CP% of barley in this study (Table 4) and in earlier reports (Khair *et al*, 2000) were by far higher than those reported for Abu Sabeen in summer (Khair, 1992) and in winter (Khair,*et al*, 2000). The CF% of barley in this study (Table 4) were lower compared to those of Abu Sbeen in winter (Khair, 2001, unpublished). This might necessarily indicate that the digestibility of barley would be higher than that of Abu Sabeen. In contrast to some temperate grasses (Corrall, 1979). The time course forage quality of barley has more or less been maintained up to the milk stage. That was particularly shown by the CP% which was maintained at 10% and above in all plant ages. Hence, harvesting barley at the milk stage resulted in the highest crude protein yield while the other quality attributes were not drastically affected in comparison to their values at earlier stages.

In conclusion, sowing barley on 1 Dec resulted in consistently relatively longer vegetative phase and ultimately high total dry matter forage yield in all seasons. All the tested seed rates gave higher forage dry matter yields than 48 kg/ha in all seasons except 2002-03. The seed rate of 96 kg/ha can therefore be considered as optimum. As far as the quality concerned, while the dry yield of barley increased progressively with time, its quality attributes were more or less remained stable throughout the growth period. At the milk stage, the dry matter and the crude protein yields were highest while the other quality attributes were not drastically affected as compared to those at the earlier stages.

Recommendations

Based on the forgoing discussion the following recommendations were proposed:

1. The forage dry matter yield of barley was significantly highest when the crop was sown on 1 Dec in all seasons. That superiority was shared by 15 Nov in 2001-02 and by 15 Dec in 2003-04 and in 2004-05. Hence, sowing of barley during a range of 30 days between 15 Nov and 15 Dec is recommended
2. The seed rate of 96 kg/ha is recommended as optimum for growing barley for forage in the Gezira.
3. Harvesting of barley at the milk stage resulted in highest dry matter yield, crude protein yield, high CP% and low CF%. Hence, it is recommended as a cutting stage of forage barley.

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Table 1. Effect of sowing date (in days) on phonological stages of barley in 2001-02 and 2002-03 seasons

Sowing date	Season 2001-02				Season 2002-03			
	SH	50 H	75H	MS	SH	50H	75H	MS
1 Nov	48	58	66	75	45	55	65	75
15 Nov	45	56	64	72	42	53	62	72
1 Dec	43	53	63	72	40	50	60	72
15 Dec	40	50	56	64	40	49	54	63
1 Jan	38	48	56	63	38	46	54	62

SH = Start heading, 50H = 50% heading, 5H = 75 % , heading, MS = Milk stage (harvesting date)

Table 2. Forage dry matter yield of barley (t/ha) in response to sowing date for the four seasons.

Sowing date	Season 2001-02	Season 2002-03	Season 2003-04	Season 2004-05	Means
1 Nov	3.30	1.95	0.63	1.28	1.79
15 Nov	2.89	2.68	1.28	2.07	2.23
1 Dec	4.23	2.28	1.96	2.78	2.81
15 Dec	2.14	1.97	2.45	2.61	2.29
1 Jan	2.85	1.59	1.51	1.46	1.85
SE±	0.25	0.21	0.23	0.18	0.16

Table 3. Forage dry matter yield of barley (t/ha) in response to seed rate for the four seasons

Seed rate (kg/ha)	Season 2001-02	Season 2002-03	Season 2003-04	Season 2004-05	Mean
48	2.53	2.04	1.24	1.68	1.87
96	3.04	2.12	1.55	2.01	2.18
144	3.18	2.01	1.79	2.25	2.31
192	3.57	2.31	1.68	2.23	2.42
S.E.	0.16	0.11	0.09	0.11	0.14

Table 4. Time course dry matter yield and quality of barley sown on 1 Dec 2001-02 and 2002-03

Plant age (days)	DM yield (t/ha)	Leaf stem ratio	OM	Ash	CP	CF	NFE	CP yield kg/ha
			%					
15	0.11	2.9	88	7.0	10.0	21.0	56	11
30	0.30	3.6	88	7.0	10.0	21.0	56	31
45	1.08	2.5	89	6.0	10.0	23.0	55	114
60	2.29	1.5	87	9.0	11.0	21.0	55	252
75	3.44	2.0	88	8.0	10.0	22.0	55	344
SE ±	0.064	0.20	0.29	0.16	0.19	0.34	0.97	6.22
Mean		2.5	87.8	7.5	10.02	21.7	55	

DM = Dry matter; OM = Organic matter; CP = Crude protein; CF = Crude fibre; NFE = Nitrogen free extract.

Table 5. Mean maximum and minimum temperature for the winters of 2001-02, 2002-03 and 2004-05 seasons

	Season	Nov.	Dec.	Jan.	Feb.
Mean max. air temp.°C	2001-02	37.1	35.7	31.6	36.8
	2002 /03	38.1	33.8	34.5	36.7
	2004 /05	38.1	33.8	32.1	37.4
Mean min. air temp .°C	2001-02	18.8	17.5	13.2	17.8
	2002-03	20.2	15.4	15.7	17.6
	2004-05	20.1	16.6	14.9	21.0

Source: Wad Medani Meteorological Station