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Critical Sowing Date for Crop Choice among Winter Forage Cereals in Khartoum (Sudan)

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Abstract: An experiment was conducted for two consecutive winter seasons (2004/05 and 2005/2006) at Shambat Research Farm, Khartoum State (Sudan) to study the performance of three winter sown forage cereal cultivars at five sowing dates. The objective of the study was to enable the farmers to choose the most suitable forage crop for each sowing date in Khartoum State. The treatments comprised three cultivars, v*iz.* a local variety of barley (*Hordeum vulgare*), referred to as 'Baladi', a local variety of maize (*Zea mays*) referred to as 'Higeri' and sorghum (*Sorghum bicolor*) cultivar 'Abu Sabeen', sown at five sowing dates *viz.* 1 and 15 December, 1 and 15 January and 1 February in each season. A split-plot design with three replicates was used to execute the experiment. The sowing dates were assigned to the main plots and the cultivars to the subplots. At harvest, data were collected on the number of culms/m^2, number of days to harvest, plant height and the forage dry matter yield. The results indicated that the dry matter yields of barley were the highest in each of the first three sowing dates, whereas those of sorghum were the highest in the last two sowing dates. The dry matter yield of maize was comparable to that of sorghum during the first three sowing dates but was markedly lower during the last two sowing dates. Hence, 15 of January could be considered as a critical sowing date for the crop choice between barley and sorghum in Khartoum State.

Key words: Forage; barley; maize; sorghum sowing dates

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INTRODUCTION

Irrigation water from the River Nile in Sudan is more readily available during December and January than during February through May (A.W. Abdelhadi, personal communication). In fact, while the long term Blue Nile water flow during Feb.-May, as measured at Eldeim (Sudan/Ethiopian border), is only 40 million cubic metres/day (m^3 /day), those of December and January are 117 and 63.7 million m^3/day. To utilize such potential in Khartoum State, short duration annual forages seem to be the most appropriate crops to grow.

The optimum temperature for the growth of sorghum (*Sorghum bicolor*) is 30ºC (Skerman and Riveros 1990), and higher yields of Sudan grass (*Sorghum sudanensis*) were obtained at 27.5ºC- 32.5ºC than at 21^0C (Sullivan 1961). In contrast, the maximum temperature for the growth of barley (*Hordium vulgare*) is 27ºC (Bland 1971). For maize, however, varietal differences seem enormous. For instance, the optimum temperature for the growth of the crop was reported to be 18ºC-21ºC (Skerman and Riveros 1990). In contrast, however, despite the high temperature of Sudan (Adam 1996), substantially high yields were obtained in different parts of the country. In Khartoum State, the highest forage yields of maize were obtained by Kambal (1983) when winter sown and by Salih (1994) when sown in May. For grain production, however, higher yields were obtained when October sown in Hudeiba (Mohammed *et al.* 2008).

Despite the higher forage yield of barley than other winter sown cereal forages (Khair *et al.* 2007), its production, however, in central Sudan is limited by the short winter season. In fact, it has a narrow optimum sowing time (Salih *et al.* 2006) beyond which reduction in yield is drastic. Forage sorghum, which is often grown untimely during winter in Khartoum, does germinate adequately when winter sown in the Gezira (Babiker and Khair 2006), but its subsequent growth is seriously impaired especially when sown in December. Incidentally, the only case when the yield of the second cut of sorghum surpassed its first cut in the Gezira was when sown early in December (Eltalib 2009).

Hence, sowing of forage sorghum during winter in Khartoum, apparently, needs to be in late January to coincide with the rising temperature and the increasing day length in February onwards. The current experiment, therefore, aimed at studying the differential performance of barley, sorghum and maize sown in five sowing dates during winter in Khartoum to enable the farmers to choose the most suitable forage cereal crops for each sowing date.

MATERIALS AND METHODS

The experiment was carried out for two consecutive seasons (2004/2005 and 2005/2006) in the Experimental Farm of Shambat Research Station in Khartoum State (latitude 15º37`N, longitude 32º32`E., altitude 380 m above sea level). The soil is deep cracking, moderately alkaline clays with pH 7.5-8.0. The clay content ranges from 48% to 54% with very low permeability (Saeed 1968).

The treatments comprised three crop cultivars, *viz.* a local variety of barley (*Hordeum vulgare*) referred to as 'Baladi', a local variety of maize (*Zea mays*) referred to as 'Higeri' and a sorghum (*Sorghum bicolor*) cultivar 'Abu Sabeen', sown at five sowing dates, *viz.* 1 and 15 December, 1 and 15 January and 1 February in each season. A split-plot design with three replicates was used to execute the experiment. The sowing dates were assigned to the main plots and the crops to the subplots

The land was prepared by disc ploughing, disc harrowing, leveling and ridging to 60 cm apart. Planting was by hand drilling on the top of the ridge with seed rates of 48, 48 and 96 kg/ha for sorghum, maize and barley, respectively. Nitrogen in the form of urea was added simultaneously with the seed at the rate of 184 kg/ha. Irrigation was every 10-12 days, and the plots were hand weeded as needed.

The subplot size was 7x3 m and consisted of 5 ridges, each 7 m long and 0.6 m apart. At harvest, the two outer ridges as well as 0.5 m from each of the northern and southern sides of the three middle ridges in each subplot were left as margins. The net harvested area was, therefore, 10.8 m^2. At harvest, culm density was determined by counting the number of culms in an area of 0.6 m^2, earmarked in one metre along the central ridge and presented as culms/m^2. Plant height (measured from the soil surface to the tip of the plant at harvest) was calculated as a mean of five plants randomly chosen from the central ridge.

In each sowing date, forage yield was taken from the central three ridges. The plants were harvested at the milk stage, at the ground level. The fresh matter yield was weighed in the field immediately after cutting. A sub sample of one kilogramme fresh matter was oven dried at 85°C for 48 hours to determine the dry matter yield. Standard statistical analysis of the split plot design was performed for the data in each season.

RESULTS

Growing temperature

Inter-seasonal differences in the mean monthly temperatures of the growing seasons were apparent (Fig. 1). Season 2004/05 was characterized by relatively low temperature during both December and January, followed by an abrupt rise during February through April. Season 2005/06, on the other hand, showed relatively high mean temperature during both December and January, followed by a small rise during February through April. The mean temperature of December and January on one hand and those of February-April on the other hand were reversed between the two seasons.

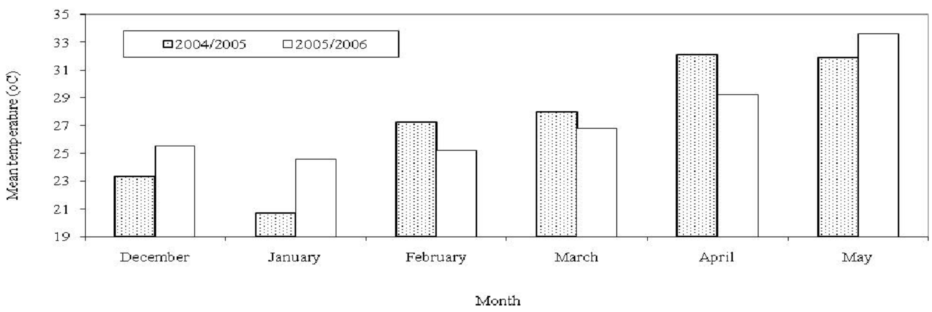

Fig. 1. Monthly mean tempertaure of the experimental site during the two growing seasons

Crop age at harvest

The crops differed considerably in attaining the harvesting stage (milk stage) (Table 1). In all sowing dates, barley was the earliest, followed by maize then sorghum. For the three crops, the longest crop ages to harvest were attained when sown on 1st December, followed by small reductions up to the last sowing date. The shortest crop ages to harvest forage sorghum (75 days on 01/01) was the same as the longest one for maize (on 01/12) but was longer than the longest for barley (72 days on 01/12)

Table 1. Effect of sowing date on the mean (across two seasons) harvesting age (days after sowing) of three winter sown forage cereals in Khartoum State

Sowing date	Barley	Sorghum	Maize
01/12	72	84	75
15/12	68	83	75
01/01	66	75	71
15/01	65	78	67
01/02	65	78	66

Culm density (CD) at harvest

Substantial variations in the CDs were evident between barley on one hand and sorghum and maize on the other (Fig.2). Barley had the highest CDs in all sowing dates of both seasons. The highest CD for barley in both seasons was above 250/m^2 compared with about 60/m^2 and 25/m^2 for sorghum and maize, respectively. In addition, the species varied in the sustainability of the CDs in all sowing dates. While barley showed systematic reductions from the first through the last sowing date, sorghum varied in a non-systematic trend. On the contrary, the CDs of maize remained more or less the same in all sowing dates.

Plant height

The plants of the three crops were taller in 2005/06 than in 2004/05 season (Table 2). Neither the trend of the effect of the sowing date on each crop nor the magnitude of such differences were consistent between the seasons. However, barley was consistently the shortest, while sorghum was the tallest in all sowing dates. Maize, on the other hand, had intermediate heights in both seasons. In barley, the tallest plants were obtained when it was sown on either 1 or 15 December, while its shortest plants were obtained when sown on 1 February. The tallest plants of sorghum and maize were obtained when sown on 1 February and 1 December, respectively.

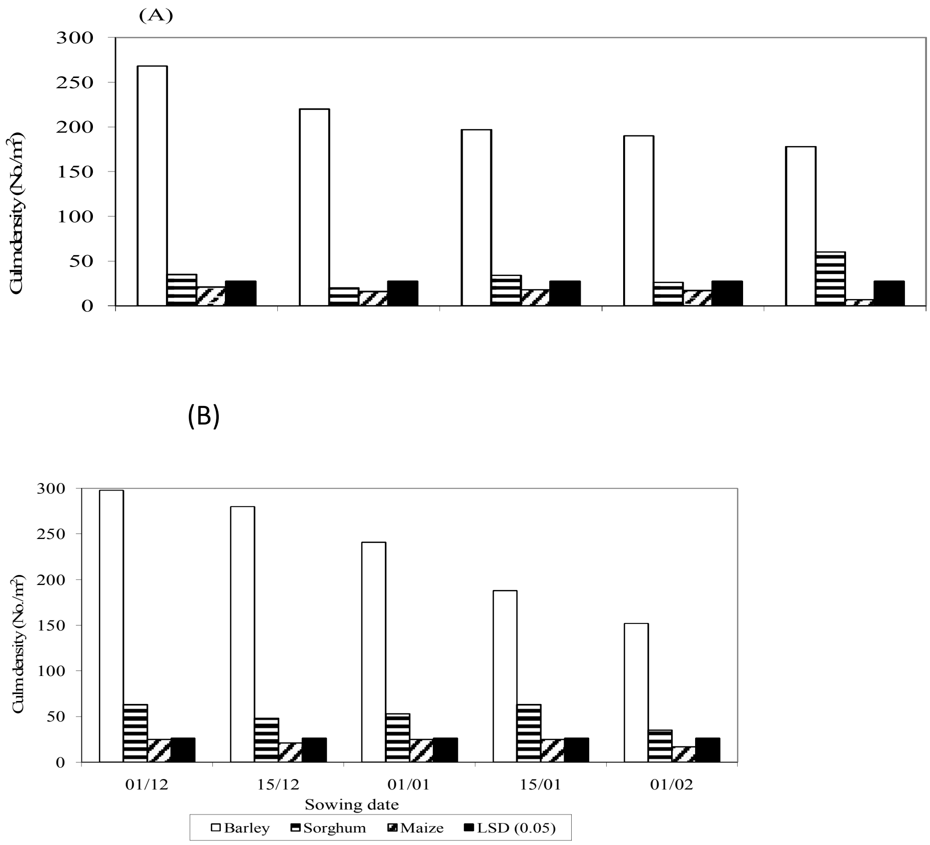

Fig. 2. Culm density at harvest of winter sown forage cereals as affected by sowing date in 2004/05 (A) and 2005/06 (B) seasons

Table 2. Plant height (cm) at harvest of three winter sown forage cereals as affected by sowing date in 2004/05 and 2005/06 seasons

Sowing date	Barley	Sorghum	Maize
		2004/05	
01/12	57	103	103
15/12	54	99	77
01/01	44	107	82
15/01	38	111	89
01/02	41	145	69
SE±		2.14	
		2005/06	
01/12	65	149	147
15/12	79	136	120
01/01	64	134	104
15/01	58	144	133
01/02	48	158	89
SE±		3.12	

Dry matter (DM) yields

The DM yields of the three cultivars in 2005/06 were higher than in 2004/05. In fact, the overall mean DM yields of barley, sorghum and maize in 2004/05 were 52%, 83% and 44%, respectively, of those of 2005/06. The three species could be divided into two distinct groups. Barley and maize started with high DM yields when sown on 1st December, then declined progressively with delayed sowing dates. On contrast, sorghum started with low DM yields in 1st December (across both seasons) sowing, stayed low during the next two sowing dates then sharply increased by January 15 and February 1 sowing(Table 3 and Fig. 3).

Table 3. Effect of sowing date on the dry matter yield (t/ha) of three winter sown forage cereals in Khartoum in 2004/05 and 2005/06 seasons

Sowing date	Barley	Sorghum	Maize
		2004/05	
01/12	2.6	1.9	2.0
15/12	2.6	1.5	1.3
01/01	1.9	1.5	1.5
15/01	1.2	5.0	1.1
01/02	1.9	7.2	0.8
SE±		0.15	
		2005/06	
01/12	5.1	4.1	3.7
15/12	5.5	3.2	3.2
01/01	3.8	2.4	2.2
15/01	3.3	5.7	3.3
01/02	1.2	4.9	0.9
SE±		0.23	

The highest DM yields of barley (across both seasons) were attained when the crop was sown on either 1st or 15th of December. During the last thee sowing dates, however, it showed tangible reductions in the dry matter yields. Across both seasons, the highest and the lowest DM yields of maize (Fig. 3) were attained in 1st December and 1st February sowings, respectively.

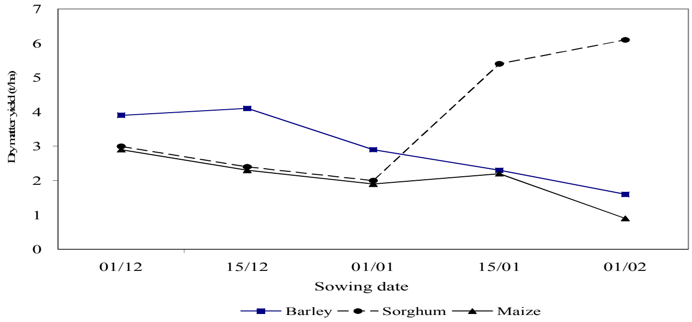

Fig. 3. Effect of sowing date on the mean dry matter yield (across two seasons) of three winer sown forage cereals in Khartouim State

The DM yields of sorghum during the first three sowing dates were equally low in 2004/05. In 2005/06, however, the DM yields of sorghum started relatively high in the first sowing date then declined through the next two sowings dates. The DM yields of sorghum in the last two sowing dates of both seasons showed remarkable increase.

Interspecific comparisons in the first three sowing dates (SD) revealed that barley had the highest DM yields, while no differences were found between the other two species. Maize, however, had higher DM yields than sorghum in the 1st December sowing in 2004/05. The DM yields of sorghum were mostly the highest in each season (Table 2) and across both seasons (Fig. 3), when sown on either 15th January or 1st February.

DISCUSSION

In contrast to the long hot season, which extends from March to October, winter season in Sudan is extremely short and rather warm. In fact, the long-term mean temperatures of the coldest months, *viz.* December and January at Shambat, where the study was conducted, are 23.5ºC and 22.1ºC, respectively (Adam 1996). Under such relatively cold conditions, the performance of winter sown warm-season crops, such as sorghum (*Sorghum bicolor*), clitoria (*Clitoria tenatea* L.) and philipesara (*Vigna trilobata*), even though showed adequate germination in the Gezira

(Babiker and Khair 2006), their subsequent growth is impaired probably due to the unsuitable temperature (Khair 1999) or relatively shorter day length (Salisbury and Ross 1978; Adam 1996). Even for winter crops, such as barley (Salih *et al.* 2006) and field peas (Ali 2007), the optimum sowing date is short resulting in substantial yield reduction if the sowing date is delayed beyond 15 December. The significance of this study, therefore, stems from determining the optimum sowing date for winter sown forage sorghum, maize and barley in Khartoum State.

The differential performances of the cultivars to varying sowing dates could be attributed to the rise in temperature with the advancement in sowing date from 1st December to 1st February. This is highly plausible as the relatively low mean temperatures, to which December 1 and 15 sowings were subjected, were closer to those required for the growth of maize (Skerman and Riveros 1990) and barley (Bland 1971). On the contrary, the rising mean temperatures, to which 15th January and 1st February sowings were subjected, were closer to those required by sorghum (Skerman and Riveros 1990).

Within the studied sowing dates of this experiment, sowing before 15 January was suboptimal for sorghum, probably due to the low mean temperature before 15 January. In consistence with this, substantially higher dry matter yield of summer versus winter sown crops were reported for sorghum by Kambal (1983) and Pannar 888 by Nour *et al.* (1998).

Khair *et al.* (2007) reported that the forage yield and quality of barley are the best among several winter sown forage cereals in the Gezira. However, the data of this study as well as those of Salih *et al.* (2006) indicated that the high yields of barley were obtained only if the crop was sown on either 1st or 15th of December. The optimum sowing period for forage barley in the central Sudan is apparently very narrow due to the extremely short winter. The optimum sowing date for forage maize was 1st December. This is in agreement with the data reported by Kambal (1983), but contradicts with that reported by Mohammed *et al.* (2008). The forage yield of 1st December sown maize at Shambat (in this study) and the grain yield of 4th December sown maize in Hudeiba (Mohammed *et al.* 2008) were significantly higher than those sown in all subsequent sowing dates of either studies.

The dry matter yields of barley in the first three SDs were higher than those of the other species. This could be attributed to its high number of culms. The differences of dry matter yield between maize and sorghum in the first three SDs were not great but the comparatively high quality of maize (Khair *et al.*2007) could make maize a second choice to barley during the first three SDs. Following 15 January sowing, sorghum was significantly superior to both barley and maize.

The three crops under study could be divided into those which are more productive if sown after a critical sowing date and those which are more productive if sown before. In this regard, 15th January seemed to be a critical sowing date. The production of sorghum was better when sown after 15 January and barley when sown before 15th January. Maize, on the other hand, being of better quality than sorghum (Khair *et al.* 2007), could be a second choice to barley when sown on either 1st or 15th of December. Hence, it could be concluded that 15th January is a critical winter sowing date for the crop choice among winter sown forage cereal crops in Khartoum State.

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تاريخ فاصل للزراعة للأختيار من بين الأعلاف النجيلية المزروعة شتاء فى الخرطوم (السودان)

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المستخلص: أجريت تجربة لموسمين متتاليين خلال شتاء موسمى 05/2004 و 06/200 فى محطة بحوث شمبات (ولاية الخرطوم) لدراسة أداء ثلاثة من محاصيل الأعلاف النجيلية مزروعة فى خمسة مواقيت للزراعة. هدفت الدراسة لتمكين المزارعين فى ولاية الخرطوم من إختيار محصول العلف المناسب لأى من مواقيت الزراعة قيد الدراسة. المحاصيل التى خضعت للدراسة هى صنف محلى من الشعير (*Hordeum vulgare*) يشار اليه بالصنف البلدى، وصنف محلى من الذرة الشامية (*Zea mays*) يشار إليه بالصنف الحجيرى والصنف ابو سبعين من محصول الذرة الرفيعة (*Sorghum bicolor*). زرعت المحاصيل فى الأول والخامس عشر من ديسمبر، والأول والخامس عشر من يناير، والأول من فبراير. استخدم تصميم القطع المنشقة بثلاثة متكررات لتنفيذ التجربة ووزعت المعاملات كالأتى: تواريخ الزراعة للقطع الرئيسية والمحاصيل للقطع الفرعية. عند الحصاد جمعت بيانات عن عدد السيقان/المتر المربع، وعدد الأيام للحصاد، وطول النبات، والإنتاجية من المادة الجافة. دلت النتائج على أن إنتاجية الشعير من المادة الجافة فى التواريخ الثلاثة ألأولى للزراعة كانت الأعلى بينما إنفردت الذره الرفيعة بأعلى إنتاجية فى التاريخين الأخيرين للزراعة (الرابع والخامس). كانت إنتاجية الذرة الشامية من المادة الجافة مقاربة لإنتايجة الذرة الرفيعة فى الثلاثة تواريخ الأولى للزراعة ولكنها تدنت بصورة ملحوظة فى التاريخين الرابع والخامس. وعليه يمكن إعتبار الخامس عشر من يناير تاريخاً فاصلاً بحيث يمكن زراعة الشعير قبله وزراعة ابو سبعين بعده.

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