Effect of Seeding Rates, Sowing Methods and Fertilizer Application on the Performance of Fodder Sorghum (*Sorghum bicolor* (L.) Moench) Grown on a Saline-Sodic Soil*

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Abstract : A field experiment was conducted over two years (1979 and 1980) to investigate the effect of seeding rates, sowing methods and manure and urea applications on the performance of forage sorghum (*Sorghum bicolor* (L.) Moench var. Abusabein) grown on a saline-sodic soil in the Sudan. The results revealed that planting on shoulders of the ridge proved to be a superior practice to avoid salinity hazards affecting the early stages of growth. More plants per unit area and higher yields were recorded on plants grown on shoulders of the ridge compared to those grown on top of the ridge. The application of farmyard manure alone or in combination with urea to salty soils significantly increased forage fresh and dry yields and improved forage quality.

INTRODUCTION

Reports of the Soil Survey Administration, Sudan, estimated that about one million feddans (feddan = 0.42 ha.) in Northern Sudan are salt-affected soils. In Khartoum State alone, more than 125,000 ha. are considered as marginal lands because of salinity and/or sodicity (Elkarouri and Mansi, 1980). This is in addition to sizable tracts of such lands which occur south of Khartoum between the Blue and the White Niles in the northern extremity of the Gezira which is within easy access to Khartoum.

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The potential of utilizing these lands for agricultural production is very great due to their proximity to large consumption centres like Khartoum and Medani. Moreover, the availability of good quality irrigation water from the two Niles in addition to the presence of some basic infrastructure such as roads, power supply, telecommunications, railways, ...etc. justify giving these areas high priority in development programmes. This situation encourages agriculturists to look into the problems of such land with the view of finding out the ideal methods for their reclamation and management.

Among the crops suited for these areas is forage sorghum (*Sorghum bicolor* (L.) Moench) locally known as Abusabein. It is classified as a moderately salt tolerant crop and is presently the most widely grown fodder crop in these areas.

The broad objective of this study was to contribute to the available knowledge pertaining to the use of husbandry practices which help reduce the unfavourable effects of salinity and in consequence enhance the utilization of these salt-affected areas. Moreover, the effects of nitrogen and manure applications and the method of sowing on emergence, plant survival, establishment and yield of this variety were the specific objectives of this study.

MATERIALS AND METHODS

The site chosen for this study was the salty part of the University of Khartoum Farm, Shambat, Sudan (latitude 15° 40'N and longitude 32° 32'E). This site was investigated as early as 1960 by Worral (1961) who reported that this site has a higher salt content than the average saline soils of Khartoum and Gezira areas. From this point of view, the site soil is as bad as can be found in most parts of Sudan, and it can be assumed that if a crop can be made to grow successfully in this soil, it will also grown in other saline soils of the country. Elamin (1980) investigated the soil of this site and his data revealed that the soil is a saline-sodic aridisol with a clay loam texture, a pH of 8.1 to 8.6 and CEC of 38 to 50 meq./100 g of soil.

The climate of the area is a semi-desert type with an average rainfall of 160 mm per annum, occurring mostly during July and August (Whiteman, 1971). Average minimum and maximum temperatures range between 13 and 21°C in January (winter season) and between 25 and 41 °C in May which is the hottest month of the year.

The experiment was conducted during two summer seasons over a two year period (1979 and 1980). In each season, the land was ploughed using a chisel plough which resulted in least inversion or disturbance of lower soil layers. The treatments consisted of eight combinations of seeding rates and sowing methods plus four levels of fertilizer treatments, which were nitrogen and manure in combinations and alone, plus a reference check.

A split-plot design with four replications was used. The main plot treatments were the seeding rate-sowing method combinations. Four levels of seeding rates, namely 71.4, 107.1, 142.9 and 178.6 kg/ha were used. These will be referred to, henceforth, as S1, S2, S3 and S4, respectively. Each seeding rate was sown one time on top of the ridge (M1) and one time divided between the two shoulders of the ridge (M2). The subplot treatments were nitrogen applied in a form of urea (46% N) at a rate of 96.1 kg. N/ha., farmyard manure at a rate of 23.8 tons/ha., a combination of farmyard manure and urea (48.05 kg. N/ha. + 11.9 tons/ha of manure) and a reference control. These are referred to as N, F, ½N½F and O, respectively. Cattle manure, taken directly from fences without pretreatment, was manually incorporated into the soil using a hand hoe, while urea was broadcast on the soil. Both urea and manure were applied at the time of sowing.

Each subplot (5.6 x 5 m) consisted of 6 ridges 80 cm apart. The two outer ridges were left as a guard area, the next inner ridge from each side for destructive sampling and the two middle ridges were used for plant counts and final harvest.

Irrigation was applied at weekly intervals during both seasons for the first crop and the ratoon crop. Adequate amount of water was given per irrigation for all treatments. Plots were hand weeded twice : one month after sowing for the first crop and one month after the first harvest for the ratoon crop, in both seasons.

One metre length (0.8 sq. m) was permanently marked in the centre, on each of the two middle ridges of each subplot, at the beginning of each season. Seedling emergence and plant survival were monitored on the above-mentioned areas at intervals of 1, 2, 6 and 10 weeks from sowing. Twelve weeks from sowing, the middle two ridges of each subplot were harvested for fresh and dry weights determinations for the first crop and twelve weeks later following the first harvest for the ratoon crop. The fresh weights were determined in the field using a spring scale, and a sub-sample of 0.8 m was taken from each subplot for dry weight determination. These sub-samples were oven dried at 70°C for 48 hours until they reached a constant weight. The same sub-samples used for dry weights were ground and used for chemical analysis to determine the nutritive value of the forage in terms of crude protein and crude fibre. The micro-Kjeldahl technique was used to determine the crude protein percent.

RESULTS AND DISCUSSION

Seedling emergence and plant survival

Number of shoots per unit area increased at each counting occasion for the first three counts, during both seasons (Table 1), but there was no further increase in the final count (10 weeks from sowing) and in some cases a slight drop was recorded. This is to be expected since plant numbers at the early stages of growth are, in the main, a reflection of the number of seeds sown. The slight drop during the final count was probably due to the fact that some tillers or mother plants failed to reach maturity. Moreover, it was observed that later in the growing season, some plants died as a result of infestation by stem borer (*Chilo partellus*, Swinch.). The magnitude of this drop was 13% for the first season and only 0.8% for the second season.

Sowing on shoulders of the ridge consistently resulted in significantly higher number of shoots per unit area than sowing on top of the ridge throughout the two growing seasons in all counting occasions (Table 1). The significant increase in the number of shoots in M2 over M1 is attributed to the fact that the same quantity of seeds which was sown in one line on top of the ridge (M1) was placed into two lines on both shoulders of the ridge (M2). Thus, the same number of seeds was distributed over a larger area, thereby reducing competition in the early stages of growth. In addition, the shoulders of the ridge offer a more favourable location for seedlings than the top of ridge with respect to salt concentration prevailing in the experimental site where evaporation rates are characteristically high. After each irrigation, dissolved salts from lower soil layers are carried upwards with the rising capillary water to the top of the ridge. The greater evaporation rate takes place at the apex of the ridge and consequently larger amounts of salts are deposited in that part of the ridge. This creates differential local salinity status within the ridge and the seedlings sown on shoulders have the relative advantage of growing in part of the ridge with low salt concentration (Figs. 1 and 2). Sowing on shoulders of the ridge has long been recognized as a superior practice in saline soils because it escapes the harmful effects of salt concentration on top of the ridge (Bernstein *et al.*, 1955; Dregne, 1973; Abusuwar, 1981).

The effect of nitrogen and manure applications on seedling emergence and survival was generally negative (Table 1). More shoots per unit area were produced under the control treatment (o). This was specially true during the second season when the highest number of shoots was consistently recorded for the control treatment. The lowest number of shoots per unit area in both seasons was observed under the manure treatments (F and ½N½F). This is unexpected since the manure improves soil physical conditions and consequently improves emergence. It was observed that all plots containing manure were attacked by birds in the seedling stage in preference to other plots. Manured plots attracted birds in search for seeds and other feeding materials, and the loosening of soil caused by manure application may have made it easy for birds to dig and uproot the seedlings, thus reducing plant population.

Table 1. Number of shoots per unit area as affected by seeding rates, sowing methods and fertilizer treatments.

Treatments	First count		Second count		Third count		Final count	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
S1	146.0 c	082.8 c	174.3 c	120.2 c	179.0 c	123.6 c	149.4 c	120.9 c
S2	191.8 b	105.3 bc	255.1 b	171.0 c	252.8 b	157.9 b	217.0 b	162.5 c
S3	225.0 ab	139.7 ab	295.9 ab	206.9 b	286.3 ab	224.1 b	261.8 ab	219.2 b
S4	243.3 a	164.7 a	314.3 a	265.5 a	315.2 a	282.7 a	285.0 a	282.4 a
M1	188.2 b	083.5 b	241.3 b	178.7 b	236.6 b	158.1 b	203.7 b	165.9 b
M2	214.8 a	162.7 a	278.6 a	223.1 a	280.0 a	236.0 a	253.1 a	226.5 a
O	234.8 a	138.5	270.9 ab	209.6 a	237.3	224.0 a	247.2	220.0 a
F	176.2 c	126.9	240.1 b	172.8 b	222.8	188.2 b	207.1	183.0 b
N	211.7 ab	118.3	279.8 a	189.7 ab	273.4	197.2 ab	234.3	188.8 ab
½N½F	195.6 bc	108.7	247.0 ab	191.4 ab	263.7	191.7 b	224.9	193.1 ab
		NS			NS		NS	

NS = Not significant

Figures followed by the same letter(s) for each group of treatments (seeding rate, sowing methods, and fertilizer treatments) are not significantly different at the 0.05 level using the Duncan's Multiple Range Test.

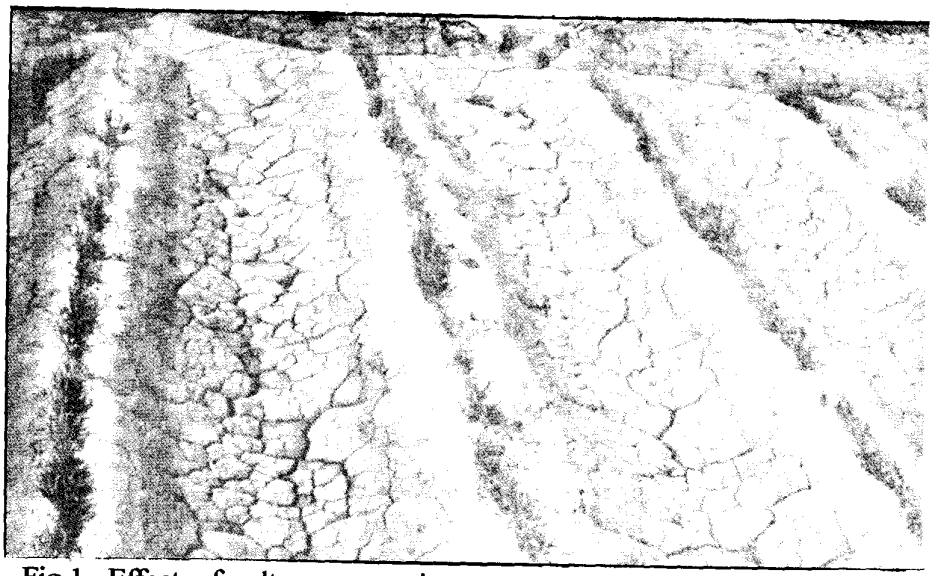

Fig.1. Effect of salt concentration on seedling growth when planting on top of ridge (M1)

Fig.2. Effect of salt concentration on seedling growth when planting on both shoulders of ridge (M2).

On the other hand, the application of nitrogen alone did not cause reduction of any statistical significance in the number of shoots in either season, however, the control (o) outnumbered the nitrogen treatment (N) in six out of eight counting occasions. The concentration of soil solution in saline soils is usually high and causes retardation in germination (Megsingh and Lal, 1972; More and Maliwal, 1988). The addition of urea as a fertilizer to such soils will add more to salt concentration and the imbibition of water necessary to germination of seeds will be retarded (Kovda, 1947). Moreover, free ammonia is produced following the formation of ammonium carbonate by hydrolysis of urea (Ernest and Massey, 1960). This free ammonia proved to be hazardous to germinating seeds (Low and Piper, 1961). Ferguson *et al.* (1984) associated the adverse effects of urea application with the accumulation of toxic levels of free ammonia and nitrite. Widdowson *et al.* (1965) observed that a great check to germination and growth of newly sown Italian ryegrass occurred when urea was applied than when ammonium nitrate, ammonium sulphate or calcium nitrate were used.

Forage yield

No significant differences were obtained in forage fresh yield as a result of different seeding rates during both seasons - for both the first crop and the ratoon crop (Table 2). Higher forage fresh yields were associated with sowing on shoulders of the ridge than sowing on top of the ridge, though it was significant only during the first season for both first and ratoon crops.

Manure and urea application resulted in significant differences in forage fresh yield (Table 2) except the ratoon crop of the second season. Manure application, whether alone or in combination with urea, always exceeded other fertilizer treatments in forage production.

To a great extent, the same trend, regarding the effect of treatments on forage fresh yield, was obtained in forage dry matter (Table 3) and total dry matter production (Table 4). It is not unusual to get more yields by sowing on shoulders of the ridge than by sowing on top of the ridge on

Table 2. Forage fresh yield (tons/ha) as affected by seeding rate, sowing methods and urea and manure applications during the two seasons (1979 and 1980) first and ratoon crops.

Treatments	First Crop		Ratoon crop	
	1st. season	2nd. season	1st. season	2nd. season
S1	10.87	12.03	5.41	9.41
S2	11.72	11.58	5.70	8.88
S3	10.53	11.46	4.35	9.32
S4	09.17	13.14	4.63	9.20
	NS	NS	NS	NS
M1	09.69 b	11.32	4.10 b	8.86
M2	12.26 a	12.78	5.95 a	9.54
		NS		NS
O	07.99 b	08.35 d	4.24 c	8.93
F	12.31 a	16.25 a	6.07 a	9.49
N	10.64 a	10.08 c	4.43 abc	8.86
½N½F	11.32 a	13.51 b	5.35 ab	9.52
				NS

NS = Not significant

Means within each group of treatments followed by the same letter(s) are not significantly different at the 0.05 level using the Duncan's Multiple Range Test.

Table 3. Dry matter yield (tons/ha) as affected by seed rate, sowing method and urea and manure applications during the two seasons (1979 and 1980) first and ratoon crops.

Treatments	First Crop		Ratoon crop	
	1st. season	2nd. season	1st. season	2nd. season
S1	4.04	3.73	2.08	3.15
S2	4.22	3.87	3.51	2.57
S3	4.28	7.77	3.06	2.92
S4	3.86	3.96	3.11	2.86
	NS	NS	NS	NS
M1	3.57 b	3.47 b	2.67 b	2.64
M2	4.63 a	4.19 a	3.57 a	3.11
				NS
O	3.12 c	2.93 b	2.36 d	2.77
F	4.91 a	4.50 a	3.95 a	3.00
N	4.03 ab	3.83 b	2.69 c	2.83
½N½F	4.33 ab	4.49 a	3.47 b	2.88
				NS

NS = Not significant

Means within each group of treatments followed by the same letter(s) are not significantly different at the 0.05 level using the Duncan's Multiple Range Test.

Table 4. Total dry matter production (1st crop + ratoon crop) in tons/ha as affected by seed rate, sowing method and manure and urea applications during the two seasons (1979 and 1980).

Treatments	1st season	2nd season
S1	6.83	6.87
S2	7.73	6.43
S3	7.32	6.69
S4	6.98	6.81
	NS	NS
M1	6.23 b	6.11 b
M2	8.19 a	7.29 a
O	5.47 c	5.71 b
F	8.87 a	7.50 a
N	6.72 bc	6.21 ab
½N½F	7.79 ab	7.38 a

NS = Not significant

Means within each group of treatments followed by the same letter(s) are not significantly different at the 0.05 level using the Duncan's Multiple Range Test.

such saline soils for the several reasons discussed before with respect to seedling emergence and survival. Moreover, there were more plants per unit area when sowing was on shoulders than when it was on top of ridges,and this was reflected in the higher forage yields on shoulders of ridges.

The superiority of farmyard manure over other fertilizer treatments regarding forage yield, eventhough less plants per unit area were recorded in this treatment, may be due to the improvement of soil physical conditions resulting from the application of manure. Farmyard manure, besides improving the soil physical conditions, supplies the plants with nutrient elements, thus resulting in healthier and vigorous plants to compensate for the low number of plants per unit area associated with the manure treatments (Parasad and Singh, 1980; Abusuwar, 1981; Ndaye-gamiya and Cole, 1989). Soil physical condition is well known as a major limiting factor in such saline-sodic soils. Similar findings were reported by Elkarouri *et al.* (1980) in their study on forage sorghum (Abusabein) under saline-sodic soils of Soba Research Station in Sudan. Their findings showed that farmyard manure gave the best results in terms of fresh and dry yields compared to gypsum and green manure. Hazra (1986) reported that application of farmyard manure alone increased the fresh yield of maize and cowpea. Fresh and dry matter yields obtained under nitrogen treatment, in this study, were generally less than those obtained under the farmyard manure treatments because nitrogen uptake is expected to decrease under water stress in such saline-sodic soils (Nath *et al.*, 1982). Moreover, the poor soil structure and the conditions of waterlogging in such soils encourage the denitrification losses of urea due to the anaerobic conditions created by waterlogging. On the other hand, farmyard manure aids in reducing such adverse conditions (Kesvan and Gupta, 1986).

Forage nutritive value

Fertilization appreciably improved the crude protein content of the forage (Table 5). It has been established that nitrogen fertilization increases the protein content in cereal forages (Lee and Seo, 1988;Schinde

Table 5. Effect of treatments on forage crude protein (%) and crude fibre (%) during the two seasons (1979 and 1980).

Treatments	% Crude Protein		% Crude Fibre	
	1st. season	2nd. season	1st. season	2nd. season
S1	4.35	4.43	30.44 a	28.36
S2	4.68	4.69	31.22 a	28.59
S3	4.10	4.60	29.08 b	29.22
S4	4.41	5.03	31.42 a	28.02
	NS	NS		NS
M1	4.67 a	4.73	30.29	28.58
M2	4.09 b	4.56	30.78	28.56
		NS	NS	NS
O	3.99	4.31 b	31.56 a	28.33
F	4.58	4.21 b	30.13 bc	28.19
N	4.34	4.92 ab	30.98 ab	29.15
½N½F	4.63	5.13 a	29.38 c	28.62
	NS			NS

NS = Not significant

Means within each group of treatments followed by the same letter(s) are not significantly different at the 0.05 level using the Duncan's Multiple Range Test.

et al., 1987), in sudangrass (Jung *et al.*, 1964) and in sorghum (Ishag and Babiker, 1972). In this study, although significant differences were not always obtained, all fertilized treatments exceeded the control in their crude protein content (Table 5). The highest crude protein percent was recorded for the combined nitrogen and manure treatment (½N½F) in both seasons. This is because the treatment, besides containing the manure which improves soil physical conditions, contains also readily available nitrogen in the form of urea.

It is worth noticing that the crude fibre content, under all treatments, was rather high and less affected by treatments. This could have been due to the fact that the proximate analysis was performed on a three month old crop when by that time lignification of cells and deposition of cellulose had taken place. In addition, by the end of the third month most of the leaves were shed and this would add to the crude fibre content at maturity. Crude fibre percent in cereal forages has been found to be more affected by time of harvest than by treatments used (Smith, 1969; Rao and House, 1972).

CONCLUSION

Fodder sorghum (Abusabein) can be successfully grown in saline-sodic soils when improved cultural practices to reduce the effects of salinity are adopted. These include planting on shoulders of ridges and the application of farmyard manure alone or in combination with urea. The results obtained in this study are encouraging as they stand, but their true value can only be appreciated when they are viewed within the context of two related facts : a) the yields have been obtained from the first year cropping of resting land, and b) the repeated irrigated cultivation using good quality irrigation water would progressively reduce the hazards of salinity, upgrade the soil class and increase productivity.

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مجلة جامعة الخرطوم للعلوم الزراعية : المجلد الثانى - العدد الأول ، يناير ١٩٩٤

أثر كمية البذور وطرق الزراعة والتسميد على آداء علف ابوسبعين فى الأراضى المالحة القلوية

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موجز البحث : تمت دراسة أثر كمية التقاوى وطرق الزراعة والتسميد على آداء علف ابوسبعين فى أرض ملحية - قلوية بمزرعة جامعة الخرطوم ، على مدى عامين متتاليين . اشتملت المعاملات على أربع كميات من التقاوى للفدان وطريقتين للزراعة هما الزراعة فى كتف السراب والزراعة فى رأس السراب بالإضافة الى أربع معاملات سماد هى يوريا وسماد بلدى ويوريا + سماد بلدى وشاهد وقد استعمل تصميم الأحواض المشطورة فى هذه التجربة .

أظهرت نتائج التجربة ازدياد كثافة النباتات بازدياد معدل التقاوى للفدان كما أثبتت الزراعة فى كتف السراب أنها طريقة فعالة لتجنب الأملاح المتراكمة فى رأس السراب ، وأدت هذه المعاملة الى زيادة معنوية فى انتاجية العلف مقارنة بالزراعة فى رأس السراب . أظهرت الدراسة أيضا أن استعمال السماد البلدى أدى الى زيادة معنوية فى انتاجية العلف وتحسين نوعيته .

خلصت الدراسة الى أن المعاملات الفلاحية مثل الزراعة فى كتف السراب والتسميد البلدى ذات أثر فعال فى انتاجية الأعلاف فى الأراضى المالحة القلوية .