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Forage yield potential of Sudan grass-cowpea irrigated mixtures in central Sudan

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ABSTRACT

The study was conducted at the Gezira University Farm, Wad Medani, Sudan, during the winter of 1998 and autumn of 1999 to investigate the effects of nine cropping systems, two rates of nitrogen and two harvesting dates on the quantity and quality of the forage produced by Sudan grass-cowpea mixtures. In both seasons, Sudan grass in around two months from sowing while cowpea flowered in about one month. Black seeded Sudan grass variety (SG2) outperformed the light brown seeded Sudan grass variety (SGI). The autumn forage yields were higher than those of winter. Mixing increased the per plant growth parameters of both crops and across seasons. In winter, the fresh forage yield of pure cowpea and the highest yielding mixture (40 SG2 + 20 CP) were comparable (averaging 6.6 t/ha), while in autumn, the highest yielding crop mixture was 30 SG2 + 30 CP (19.01 t/ha) which is not siB1ificantly different from that of pure SG2 (19.08 t/ha). The land equivalent ratio (LER) values exceeded 1.00, in both seasons, showing a clear advantage of mixtures over monocultures. The addition of 44 kg N/ha significantly increased the growth parameters and forage yield of sole Sudan grass and its mixtures with cowpea but not that of pure cowpea. Harvesting at 60 days from sowing appreciably increased growth parameters, fresh forage yield and quality of forage produced by all seeding combinations. Mixing showed significant effects on crude protein percentage, crude fibre percentage, total crude protein and total crude fibre.

INTRODCUTION

The importance of growing grasses in association with fodder legumes has been recognized throughout the world (Hazie 1974;

Kass, 1978; Willey, 1979; Ibrahim, 1995). Its merits include the efficient use of the scarce farm resources in the developing countries, the higher productivity than that even more achieved with mono-culture and the improvement in yield and nutritive value of the grass component through nitrogen fixation by associated legumes. These merits are great if the mixed crops are nutritionally complementary, well fertilized and harvested at the proper date.

In the Sudan, the acute shortage of green forages can be alleviated through growing irrigated forage mixtures, a practice not common in the country and found in very limited areas along the Nile banks in northern and central Sudan where usually lubia (Lablab purpureus L) and cowpea (Vigna unguiculata (L) Walp) are mixed with maize and gain sorghum grasses.

However, the merits of mixing forage crops compared to that of monocropping, in the Sudan, had been demonstrated through research work at the Gezira University (Ibrahim, 1995; Osman, 1995; Hussain, 2000), Khartoum University (Osman and Osman, 1982) and .the Agricultural Research Corporation of the (Khair, 1987).

It is thought quite reasonable to conduct research Work test the suitability of mixing cowpea with Sudan grass as Sudan grass is more palatable than Abu Sabeel. (a well known forage sorghum cultivar throughout the Sudan) and cowpea which is more palatable than lubia Primarily, the present study was initiated to examine the character-istics of growth and forage yield of nine irrigated Sudan grass-cowpea mixing systems under two levels of nitrogen fertilizer and at two harvesting dates during the wet and dry seasons of the year in central Sudan.

MATERIALS AND NETHODS

The research was initiated during the first week of November 1998 and July 1999, at the Gezira University Farm, Wad Medani, Sudan. The soil is a deep, cracking, heavy alkaline clay (pH 8.0), low in organic matter (0.02%) and nitrogen (0.25%). However, its phosp-horus (0.06%) and potassium (3.0%) contents were considered adequate for normal plant growth,

Nine cropping systems were compared: 60 kg/ha of sole Sudan grass (light brown seeds Sudan grass, SGI); 45 kg SGI + 15 kg cowpea (CP); 40 kg SGI + 20 kg Cp; 30 kg SGI + 30 kg CP; 60 kg/ha

of sole Sudan grass (black seeds Sudan SG2); 45 kg SG2 + 15 kg cowpea; 40 kg SG2 + 20 kg Cp; 30 kg SG2 + 30 kg Cp and 60 kg/ha of sole, small seeded forage cowpea, in conjunction with two levels of nitrogen as urea: O and 44 kg N/ha and two harvesting dates: 60 and 90 days from sowing. The treatment combinations were arranged in a randomized complete block design with four replications. The plot size was 6 x 7 .m.

The seeds of both crops were broadcast on flat and then covered with soil by ridging. The high seed rate of 60 kg/ha was used to cater for deep coverage of the seeds and for seeds and seedlings destroyed by birds. The nitrogen was broadcast as one dose immediately after ridging. The crops were surface irrigated every week and weeds were controlled by hand weeding.

At the respective harvesting dates (60 or 90 days), three plants were chosen at random from each plot and used to determine the following parameters of both crops: plant height (cm), fresh plant weight (g), leaf area/plant (cm^2) (LA), leaf area ratio (LAR)

$$LAR = \frac{\text{leaf area/plant}}{\text{plant weight}} \qquad (cm^2/g)$$

and specific leaf weight (SLW)

$$SLW = \frac{\text{weight of leaves}}{\text{area of leaves}} \qquad (g/cm^2)$$

Total fresh forage yield was measured on plot basis and then converted to tonnes per hectare. Then relative yields (R Y) and land equivalent ratios (LER) were calculated for both seasons. Relative yield is the mixture yield of each crop divided by its monoculture yield Land equivalent ratio is the sum of the RY for the two crops in the mixture (Willey, 1979). Crude protein and crude fibre percentages were determined in both years and total crude protein and total crude fibre were calculated.

RESULTS AND DISCUSSION

For the first week of November 1998 sowing (winter sowing), Sudan grass started flowering during the last week of December 1998, i.e., 55 days after sowing (DAS). In the second season (autumn

sowing) when the crops were sown during the first week of July 1999, Sudan grass started flowering during the last week of August 1999, i.e., 57 DAS, Cowpea (CP) started flowering at 31 and 35 DAS during the first and second seasons, respectively. The winter of 1998-1999 was characterized by relatively high temperature and an unpredicted amount of rain (14.4 mrn) distributed over a period of three consecutive, relatively, cool days during January 1999 with a minimum temperature of 1400 in Gezira area. The autumn of 1999 was characterized by relatively heavy rains, particularly during July and August. The frequency and distribution of this rain were quite conducive to crop growth. In this study, the winter favoured the growth of the cowpea more than that of Sudan grass while the autumn weather increased largely the growth parameters of Sudan grass.

Plant growth of parameters of Sudan grass

Black seeded Sudan grass (SG2) was taller than light brown seeded Sudan grass (SGI) by 64% in both seasons (Table 1). The plant height of SGI ranged from 20.31-25.95 cm in the first season and from 143.60-164,97cm in the second season while that of SG2 ranged from 32.66-41.71 cm and from 152.00-270.7 cm in the first and second seasons, respectively. In both seasons, and for the two types of Sudan grass, the mixture of 30 SG + 30 CP gave the tallest plants with the exception of pure SGI and SG2 in the second season.

The analysis of variance procedure depicted quite clearly that Sudan grass plant height was significantly affected by cropping system, harvesting date and the interaction of cropping system and harvesting date. Nitrogen effect on plant height was significant only during the autumn season. Delaying harvesting from 60 to 90 DAS almost doubled the plant height in November sowing and with an appreciable increase during the rainy season.

The reduced plant height of Sudan grass in winter can be attributed to the relatively low temperatures (140 C) which is in line with the findings of Kambal (1984) who attributed discrepancies in the plant height of different varieties of sorghum with different sowing dates to off seasonality.

Generally, the plant fresh weight of SG2 was higher than that of SGI, in the two seasons (Table 1). Autumn weights were more than 30 times heavier than winter weights with a range of 3.54-8.19g and 175.53-226.03g for both seasons, respectively, The per plant fresh

weights were heavier in the mixtures than the moncultures. This is quite expected since reducing the Sudan grass population in the mixture directly reduced the plant competition and increased the growth and size of the individual plant.

Plant fresh weight was greatly ($P < 0.05$) affected by the application of 44 kg N/ha in the second season. Harvesting at 90 DAS increased the per plant fresh weight in the first season with a significant decrease in the second season. This decrease could be explained by the fact that the plant reached maturity before 90 DAS in the second season and started senescing earlier, The second and tlird degee interacdons of the three factor effects were not siY1ificant and hence were not reported.

Leaf area is an important forage parameter as it is related to plant photosynthetic ability and forage quality. Leaf area per plant of Sudan grass was measured during autumn season only (Table). This parameter showed that SG2 was more leafy than SGI. Within SGI, the sole SGI gave the highest leaf area per plant (55769 cm2) while in SG2 the mixture 40 SG2 + 20 CP gave the highest leaf area (721.32 cm2). Though the effects of cropping system on leaf area per plant were highly significant (P<O.OI), they didn't give a definite, clear and known tend to answer the question of whether mixing is favouring high leaf area development or not.

The effect of nitrogen application on leaf area per plant was not significant, but harvesting at 90 DAS greatly reduced leaf area per plant by almost 50% due to leaf shedding with age.

Leaf area ratio (LAR) relates area to weight. In general, SG2 gave high LARs than SGI though the trend for the effect of mixing on LAR is not definite (Table), The highest LARs (10.57 and 10.33 cm2/g) were given by 60 SGI and 40 SG2 + 20 CP, respectively. The effects of mixing, nitrogen and harvesting date on LAR were similar to that of leaf area because leaf area per plant was the numerator for LAR.

Specific leaf weight (SLW) relates weight to area. Weight is an important product of many related physiological activities. The current results showed that SGI leaves gave high SLW than that of SG2 (Table 1). In both Sudan grass varieties, mixtures gave high SLW than monocultures. In SGI, 45 SGI + 15 CP and 30 SGI + 30 CP gave the highest SLW (171.10) while in SG2, 30 SG2 + 30 CP gave the highest SLW (162.85). Nitrogen fertilization had no effect on SLW while harvesting at 90 DAS significantly decreased SLW.

Table 1. Effect of cropping system, nitrogen level and harvesting date on plant height (cm), plant fresh weight (g), leaf area (cm^2), leaf area ratio (LAR) (cm^2/g) and specific leaf weight (SLW) (g/cm^2) of Sudan grass (SG) grown in monoculture and mixtures with cowpea for two seasons, 1998 and 1999.

Cropping system (kg/ha)	Plant height		Plant fresh weight		Leaf area	LAR	SLW
	1998	1999	1998	1999	1999	1999	1999
60 SG1	20.31 f	164.97 b	3.54 f	198.06 d	557.69 d	10.57 a	127.48 f
45 SG1+ 15 CP	21.68 e	143.60 e	3.82 ef	190.65 e	493.94 f	8.84 b	171.10 a
40 SG1 + 20 CP	24.16 d	148.25 d	4.25 e	175.53 f	424.24 g	7.69 c	151.16 c
30 SG1 + 30 CP	25.95 c	153.29 c	5.02 d	208.75 c	503.28 e	7.94 c	171.17 a
60 SG2	33.37 b	270.78 a	6.08 c	211.07 c	675.94 c	9.23 b	132.63 e
45 SG2 + 15 CP	32.66 b	154.31 c	5.73 c	219.14 b	704.62 b	9.55 b	145.09 d
40 SG2 + 20 CP	41.29 a	152.50 c	7.55 b	226.03 a	721.32 a	10.32 a	142.65 d
30 SG2 + 30 CP	41.71 a	164.59 b	8.19 a	188.10 e	494.85 f	8.89 b	162.85 b
Nitrogen level (kg/ha)							
0	29.70 a	152.98 b	5.25 a	188.58 b	580.55 a	9.70 a	149.19 a
44	30.59 a	160.79 a	5.79 a	215.75 a	563.43 a	8.57 a	151.84 a
Harvesting date (days)							
60	20.29 b	137.77 b	2.85 b	217.82 a	702.10 a	11.96 a	160.21 a
90	39.99 a	175.30 a	4.69 a	186.51 b	441.88 b	6.31 b	40.43 b

Means followed by the same letter(s) do not differ significantly at the probability level of 0.05 according to Duncan's Multiple Range Test (DMRT).

Plant growth parameters of cowpea

Cowpea plant height was greatly affected by season, i.e., taller in autumn (125.29-136.68 cm) than in winter (20.05-38.83 cm) (Table 2). Plant heights of Sudan grass and cowpea were almost similar in Wint, but that of Sudan grass exceeded the plant height of cowpea in autumn (Tables 1 and 2). The tallest cowpea plants were shown by 60 CP and 45 SGI + 15 CP in the first and second seasons, respectively. Such findings showed an erratic effect of mixing on plant height with a non-significant effect of cropping system.

The effect of nitrogen application on plant height of cowpea was not significant while that of harvesting date was quite pronounced, especially in the second season. Harvesting at90 DAS decreased plant height by 14% and increased it by 51%, in the first and second seasons, respectively.

The effect of cropping system on plant fresh weight of cowpea was highly siY1ificant, (P<O.OOI) (Table 2). Mixing pronouncedly increased this parameter in winter and decreased it in autumn, suggesting the large environmental effect on the growth of this crop. The autumn plant fresh weights were more than two folds that of winter weights suggesting that the plant exploited fully the favourable environmental conditions prevailing during the rainy season. Both nitrogen and harvesting date affected plant fresh weight significantly during the rainy season only with a non-significant increase during the winter.

Mixing significantly affected leaf area per plant of cowpea (Table 2). The highest (677.2 cm^2) and the lowest (481.1 cm^2) leaf area per plant were shown by 45 SGI + 15 CP and 45SG2+ 15 cp, respectively. Cowpea leaf area per plant is higher when grown in mixture with SGI than with SG2 indicating that SG2 is more competitive than SGI in reducing the availability of growth factors for cowpea. Nitrogen application had no siB1ificant effect on leaf area but harvesting at 90 days decreased it by 102% due to leaf shedding.

Leaf area ratio was greatly affected by mixing and the highest LAR of 27.78cm2/g was shown by 30 SG2+30CP while the lowest (18.59 cm2/g) was exhibited by pure cowpea (Table 2). Contrary to LA, LAR values of cowpea were higher when this crop was grown in mixtures with SG2. Neither nitrogen application nor harvesting date showed any significant effects on LAR of cowpea.

SLW trend was opposite to that of LA and LAR, i.e., highest SLW (57.28 g/cm^2) was given by pure cowpea and lowest (48.31 g/cm^2)

Table 2. Effect of cropping system, nitrogen level and harvesting date on plant height (cm), plant fresh weight (g), leaf area (cm^2), leaf area ratio (LAR) (cm^2/g) and specific leaf weight (SLW) (g/cm^2) of cowpea (CP) grown in monoculture and mixtures with Sudan grass (SG), for two seasons, 1998 and 1999.

Cropping system (kg/ha)	Plant height 1998	Plant height 1999	Plant fresh weight 1998	Plant fresh weight 1999	Leaf area 1999	LAR 1999	SLW 1999
45 SG1 + 15 CP	30.60 e	136.68 a	37.73 b	58.99 c	677.2 a	24.90 b	51.40 c
40 SG1 + 20 CP	36.25 bc	125.56 cd	39.22 a	71.05 e	588.3 c	25.02 b	52.21 c
30 SG1 + 30 CP	31.31 d	125.29 d	28.42 d	88.16 b	623.4 b	25.17 b	52.52 b
45 SG2 + 15 CP	31.54 d	126.71 c	30.83 d	62.25 f	481.1 f	26.98 a	48.31 d
40 SG2 + 20 CP	37.04 b	134.21 b	32.50 c	84.04 c	571.4 d	23.96 b	51.36 c
30 SG2 + 30 CP	20.05 e	135.47 ab	24.00 e	75.83 d	509.4 e	27.78 a	51.65 c
60 CP	38.83 a	127.23 c	19.25 f	93.47 a	509.0 e	18.59 c	57.28 a
Nitrogen level (kg/ha)							
0	31.22 a	128.88 a	27.39 a	81.83 a	558.84 a	22.43 a	54.92 a
44	36.45 a	126.47 a	31.00 a	76.78 b	565.69 a	24.87 a	51.20 b
Harvesting date (days)							
60	36.07 a	101.61 b	28.86 a	78.43 b	751.79 a	23.55 a	40.17 b
90	31.60 b	153.74 a	29.54 a	80.27 a	372.74 b	23.75 a	65.93 a

Means followed by the same letter(s) do not differ significantly at the probability level of 0.05 according to DMRT.

was shown by 45SG2 + 15CPdepicting a signi1ificant effect of mixing on SLW (Table 2). Nitrogen fertilization significantly decreased SLW while delaying harvesting appreciably increased it, This is expected since harvesting at 90 DAS decreased LA, and LA is the denominator for SLW.

Fresh forage yield of Sudan grass

The fresh forage yield of Sudan grass in autumn was ten time, that of winter (Table 3) confirming the fact that Sudan grass is a summer crop and its forage yield is greatly reduced when sown in winter. SG2 outyielded SGI, in both seasons. Sowing 60 kg/ha of Sudan grass seeds (sole crop) outyielded sowing 45 or 40 or 30 kg/ha in a mixture with cowpea, Most of the RYS were below 1.00. Sudan grass forage yield was pronouncedly increased by applying 44 kg N/ha in autumn but not in winter, a fact explained by the masking of the nitrogen effects during winter by the unfavourable environmental conditions. Harvesting after three months from sowing increased Sudan grass forage yield in winter and decreased it in autumn.

Fresh forage yield of cowpea

The fresh forage yield of cowpea when sown at a seed rate of 60 kg/ha (sole cowpea) were higher than when grown in the mixture with a seed rate for cowpea of 15 or 20 or 30 kg/ha, in both seasons (Table 3). The winter cowpea forage yield is higher than that of autumn season. Relative yields of cowpea were very low ranging from 0.23-0.76. The lowest RYS were those of autumn while the highest were those of winter. Nitrogen application effects on the forage yield of cowpea were not significant and decreased in autumn. The use of nitrogen in the management of grass-legume mixtures is controversial. In Sudan Gezira, Ibrahim (1994b) found that the application of nitrogen to sorghum-cowpea mixtures increased the growth parameters and forage yield of sole sorghum and the mixtures and reduced that of sole cowpea. In Nigeria, Ezumah et ale (1987) reported a reduction in cowpea yields and an increase in maize yields due to nitrogen fertilization. The use of nitrogen may aid in the establishment of both grasses and legumes (Vallis, 1978) but may suppress the growth and yield of the legume component (Mouat and Walker, 1959). Harvesting at 60 DAS increased fresh forage yield of cowpea in winter by 91% and that of autumn by 331%. Delaying harvesting

Table 3. Effect of cropping system, nitrogen level and harvesting date on fresh forage yield (t/ha) and relative yield (RY) of Sudan grass and cowpea grown in monoculture and mixtures for two seasons, 1998 and 1999.

Cropping system (kg/ha)	Sudan grass				Cowpea			
	Fresh forage yield		Relative yield		Fresh forage yield		Relative yield	
	1998	1999	1998	1999	1998	1999	1998	1999
60SG1	1.93 b	18.24 a	1.00	1.00				
45 SG1 + 15 CP	1.54 cd	11.48 d	0.87	0.65	3.97 c	3.70 bc	0.76	0.54
40 SG1 + 20 CP	1.37 d	10.21 e	0.70	0.60	4.51 b	4.02 b	0.62	0.52
30 SG1 + 30 CP	1.40 d	15.66 c	0.72	0.90	4.46 b	2.17 de	0.60	0.29
60 SG2	1.86 bc	19.09 a	1.00	1.00				
45 SG2 + 15 CP	1.38 d	12.24 d	0.68	0.66	3.28 d	3.31 c	0.45	0.41
40 SG2 + 20 CP	2.51 a	12.37 d	1.29	0.60	4.55 b	2.41 d	0.56	0.39
30 SG2 + 30 CP	1.27 d	17.21 b	1.63	0.88	4.55 b	1.80 e	0.76	0.23
60 CP					6.68 a	6.50 a	1.00	1.00
Nitrogen level (kg/ha)								
0	1.48 a	12.30 b			4.53 a	3.97 a		
44	1.67 a	16.83 a			4.65 a	3.63 a		
Harvesting date (days)								
60	1.48 b	16.05 a			6.02 a	6.17 a		
90	1.75 a	13.08 b			3.15 b	1.43 b		

Means followed by the same letter(s) do not differ significantly at the probability level of 0.05 according to DMRT.

Fresh forage yield of both Sudan grass and cowpea

The forage yield of pure Sudan grass was three times that of pure cowpea in autumn but the vice versa was true in winter (Table 4). The mixtures forage yield was higher in autumn than in winter because it was greatly affected by the Sudan grass forage yield component. In winter, pure cowpea forage yield (6.69 t/ha) exceeded the forage yields of all other cropping treatments. In autumn, the highest forage yields were given by 30 SG2 + 30 CP (19,01 t/ha) and pure SG2 (19.08 t/ha) while pure cowpea gave the lowest yield (6.56 t/ha). The highest yielding crop mixture for winter conditions is 40 SG2 + 20 CP and for autumn was 30 SG2 + 30 CP suggesting that SG2 is more suitable for mixing than SGI.

Table 4. Effect of cropping system, nitrogen level and harvesting date on fresh forage yield (t/ha) and land equivalent ratio (LER) for both Sudan grass and cowpea gown in monoculture and mixtures for two seasons, 1998 and 1999.

Cropping system (kg/ha)	Fresh forage yield (t/ha)		LER	
	1998	1999	1998	1999
60SG1	1.89 e	18.24 ab	1.00	1 .00
45 SGI + 15 CP	5.51 c	15.18 cd	1.63	1.19
40 SGI +20 CP	5.85 bc	14.22 e	1.32	1.12
30 SGI +30 CP	5.85 bc	17.83 b	1.32	1.19
60 SG2	1.86 e	19.08 a	1.00	1.00
45 SG2 + 15 CP	4.79 d	15.93 c	1.13	1.07
40 SG2 + 20 CP	6.50 a	14.78 de	1.05	1.01
30 SG2 + 30 CP	5.76 bc	19.01 a	2.39	1.11
60 CP	6.69 a	6.56 f	1.00	1.00
Nitrogen level (kg/ha)				
0	4.81 b	13.01 b		
44	5.32 a	16.46 a		
Harvesting date (days)				
60	6.19 a	17.79 a		
90	3.95 b	11.69 b		

Means followed by the same letter (s) do not differ significantly at the probability level of 0.05 according to DMRT.

The current study suggested that the mixture of 30 SG2 + 30 CP gave high forage yields comparable with that of pure cowpea in winter or that of pure Sudan grass in autumn besides that it gave a more

balanced diet than both of them if fed separately. The superiority in forage quantity and quality of the mixtures of grasses and legumes over monocultures has been reported by many workers (Elmore and Jackobs, 1984; Lightfoot and Tayler, 1987; Ibrahim, 1994 a and b; Ibrahim, 1995; Hussain, 2000).

In both seasons, the addition of 44 kg N/ha significantly increased the fresh forage yield of the different treatment combinations with the exception of pure cowpea. The effect of nitrogen was more pronounced with pure Sudan grass and particularly in the second season as shown by the significant interaction of cropping system and nitrogen. In autumn, the application of 44 kg N/ha to pure Sudan grass resulted in more than doubling its fresh forage yielde Harvesting at 60 DAS significantly increased fresh forage yield in both seasons. The land equivalent ratio (LER) values exceeded 1.00, in both seasons (Table 4), which showed a clear advantage of mixtures over monocultures. The range of LERs in 1998 (1.05-2.39) was wider than in 1999 (1.00-1$19). The range of LERs in 1999 was narrowed down by the relatively high yield of Sudan grass in autumn compared to that of winter.

LER ranges indicated that up to 139% and 19% more land would have to be planted to the sole crops to produce the same fresh forage yields as were produced in the mixture combination in winter and autumn seasons, respectively. Similar ranges of LERs have been reported from studies of intercropping (Elmore and Jackobs, 1984; Lightfoot and Tayler, 1987) and mixing (Ibrahim, 1994 a and b; Ibrahim, 1995; Hussain, 2000) cereals and legumes.

Crude protein and fibre

In general, mixing showed significant effects on crude protein and fibre percentages and also on total crude protein and fibre (Tables 5 and 6). The highest crude protein percentages were recorded with cowpea (17.06 and 17.98%) in the first and second seasons, respectively, compared with that of Sudan grass (8%). Neither nitrogen nor season had any significant effect on crude protein percentage of the two crops while delaying harvesting from 60 to 90 DAS reduced it.

Table 5. Mean crude protein and crude fibre percentages as affected by type of crops, nitrogen and harvesting date.

Harvesting date (day)	Crude protein (%)							
	1998				1999			
	SG1	SG2	Cowpea	Mean	SG1	SG2	Cowpea	Mean
60	8.30 c	7.88 cd	19.25 a	11.81 a	8.76 b	8.80 b	18.00 a	11.85 a
90	7.44 cd	6.78 d	14.88 b	9.70 b	7.45 c	7.90 bc	17.95 a	11.10 a
Nitrogen levels (kg/ha)								
0	7.86 c	7.88 c	17.94 a	11.23 a	7.45 d	8.80 c	17.10 b	11.11 a
44	7.88 c	6.78 c	16.19 b	10.28 b	8.76 c	7.90 cd	18.85 a	11.83 a
Mean	7.87 b	7.33 b	17.06 a		8.13 b	8.35 b	17.98 a	
	Crude fibre (%)							
Harvesting date (day)								
60	25.67 b	25.75 b	18.67 c	23.36 b	35.32 a	28.90 bc	26.75 d	30.32 a
90	26.00 ab	26.67 a	26.25 ab	26.31 a	28.20 c	24.45 e	29.53 b	27.39 a
Nitrogen levels (kg/ha)								
0	25.83 a	26.50 a	22.83 b	25.06 a	33.92 a	25.63 d	26.56 d	28.70 a
44	25.83 a	25.92 a	22.08 b	24.61 a	29.54 b	27.72 c	29.73 b	29.00 a
Mean	25.83 a	26.21 a	22.46 b		31.73 a	26.68 c	28.15 b	

Means followed by the same letter(s) do not differ significantly at the probability level of 0.05 according to DMRT.

The total crude protein of sole cowpea (256.60 kg/ha) exceeded that of sole Sudan grass (41 kg/ha) in winter; but in autumn Sudan grass (58226 kg/ha) produced more than two folds that of cowpea (244.75 kg/ha), a fact explained by the previously mentioned results concerning the seasonality of forage production of the two crops. Mixing siY1ificantly affected the amount of total crude fibre produced by the different cropping treatments but the effects of both nitrogen and harvesting date on total crude fibre were not significant (Table 6)

Table 6, Effect of cropping system, nitrogen level and harvesting date on total crude protein and crude fibre of Sudan grass plus cowpea.

Cropping system (kg/ha)	Total crude protein (kg/ha)		Total crude fibre	
	1998	1999	1998	1999
60 SGI	41.43 h	482.57 c	138.00 h	1780.67 b
45 SGI + 15 CP	187.40 e	370.14 f	314.40 c	1372.53 g
40 SGI + 20 CP	192.80 d	342.22 g	310.90 d	1282.21 h
30 SGI +30 CP	185.90 f	448.20 d	296.20 e	1644.93 d
60 SG2	41.70 h	582.26 a	153.80 g	1863.94 a
45 SG2 + 15 CP	140.80 g	423.98 e	262.60 f	1525.45 e
40 SG2 + 20 CP	203.30 c	388.13 f	378.30 a	1414.08 f
30 SG2 + 30 CP	208.90 b	510.81 b	328.30 b	1668.40 c
60 CP	256.60 a	244.75 h	326.20 b	461.24 i
Nitrogen level (kg/ha)				
0	168.21 a	374.05 b	276.87 a	1310.01 a
44	171.40 a	431.11 a	286.62 a	1502.37 a
Harvesting date (days)				
60	198.50 a	430.30 a	256.32 a	1283.52 a
90	141.10 b	375.85 b	310.92 a	1408.86 a

Means followed by the same letter(s) do not differ significantly at the probability level of 0.05 according to DMRT.

The present study displayed very clearly that the mixture of 30 Kg seeds/ha of SG2 + 30 kg seeds/ha of CP gave high forage yield and total crude protein if harvested at 60 days after sowing and fertilized with 44 kg N/ha. Such a crop mixture is recommended along with the suggested agronomic practices for the production of green forage in central Sudan throughout the year.

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