Forage yield of some grasses in monoculture and their mixtures with legumes under irrigation in central Sudan

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ABSTRACT

Mixed cropping system provides forage of higher yield than monoculture. This study was conducted during autumn, summer and winter seasons of 2014/15 and 2015/16 at the experimental farm of the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan. The objective of this study was to investigate the effects of monoculture of selected grasses and their mixtures with selected legumes on their fresh forage yield under irrigation in central Sudan. The experimental material consisted of three grasses, namely; Sudan grass (SG), maize (MZ) and Abu70 and three legumes, cowpea (CP), black-eyed bean (BB) and lablab bean (LB). Grasses were grown in pure stand or mixed with legumes in 1:1 and 2:1 ratios. The results showed that mixing significantly increased growth parameters during all seasons. The highest fresh forage yield of grasses was obtained by the mixture compared with monocultures. Land equivalent ratio exceeded 1.0 in all seasons which indicated clearly the advantage of mixtures over monocultures. Based on the results of this study, to obtain high forage yield of grasses, it was recommended to use seed combinations of 40 kg/ha MZ + 20 kg /ha LB, 40 kg /ha SG+ 20 kg /ha CP and 40 kg /ha SG + 20 kg /ha LB during autumn, summer and winter seasons, respectively.

INTRODUCTION

Mixing forage grasses with legumes is an alternative to mono-cropping and is defined as a system of growing two or more crops together on the same piece of land during whole or part of their growing cycles. (Tofinga *et al*., 1993).

Forage crops in the Sudan include both grasses and legumes and are grown in monoculture as well as mixtures. The main forage grasses in Sudan are Sudan grass (*Sorghum sudanense* (Piper) Stapf.), Abusabeen (*Sorghum bicolor* L. Moench), maize (*Zea mays* L.) and pearl millet (*Pennisetum americanum* L.). Tropical grasses are known to have high rates of growth under favorable conditions, resulting in high dry matter yields but low forage quality (Eskandari *et al.*, 2009).

The importance of growing grasses in association with fodder legumes has been recognized throughout the world. Ibrahim (1994) in the Sudan and Azraf *et al*. (2007) in Pakistan stated that mixing merits include the efficient use of the scarce farm resources in the developing countries, the higher productivity than that achieved with monoculture and the improvement in yield and nutritive value of the grass components through nitrogen fixation by associated legumes.

Forage yield of the mixture is determined by the effectiveness with which the community of the crop plants exploits its environmental resources for growth. This suggested that crop yield would be maximized by using heterogeneous populations that contain several crops whose environmental factors differ in space or time, thus encouraging a complementary and maximum exploitation of environmental resources. Such an idea supported the cultivation of mixtures of grasses and legumes (Willey, 1979).

In the Sudan, research dealing with forage production is of special importance due to the large number of animals and limited natural pasture especially during summer and winter seasons. Nomadic system of grazing in the Sudan doesn't allow proper management of natural pasture. This necessitates more efforts and research to solve the problem of forage shortage.

The objective of this study was to evaluate forage yield potential of pure Sudan grass, maize, forage sorghum Abu 70 and their mixtures with cowpea, black eyed bean and lablab bean under irrigation.

MATERIALS AND METHODS

The experiment was executed during March (summer), July (autumn) and November (winter) seasons of 2014/15 and 2015/16 at the experimental farm of the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan (latitude 14˚ 6 ' N, longitude 33˚ 38 ' E and altitude 407 masl). Monthly selected meteorological data recorded during March 2014 to February 2016 at Agricultural Research Corporation, Wad Medani, Sudan are shown in Table 1.

The soil was a typical central clay plain soil (58% clay), which is characterized by its deep cracking, heavy alkaline clay (pH 8.0), low in organic matter (0.02 %) and nitrogen (0.03 %). However, its available phosphorus (6 mg/kg soil) and potassium (3.0 %) values were considered adequate for normal plant growth (Soil Survey Staff, 1999).

The experimental material consisted of three grasses, namely; Sudan grass (SG) (*Sorghum sudanense* (Piper) Stapf.), maize (MZ) (*Zea mays* L.) and Abu70 (*Sorghum bicolor* (L) Moench), and three legumes, cowpea (CP) (*Vigna sinensis*), cowpea var. black-eyed bean (BB) (*Vigna unguiculata* Subsp. *unguiculata*. (L.) Walp) and lablab bean (LB) (*Lablab purpureus* (L.) Sweet). Grasses were grown in pure stand or mixed in 1 : 1 and 2 : 1 ratios with legume crops which made a total of 21 treatments. Seed rate of 60 kg/ha was used for the pure stand of grass crops and their mixtures with legumes as follows :

30 kg seeds/ ha (SG) + 30 kg/ha CP, 40 kg seeds/ ha SG + 20 kg/ha CP, 30 kg seeds/ ha SG + 30 kg/ha BB, 40 kg seeds/ ha SG + 20 kg/ha BB, 30 kg seeds/ ha SG + 30 kg/ha LB, 40 kg seeds/ ha SG + 20 kg/ha LB, 30 kg seeds/ ha MZ + 30 kg/ha CP, 40 kg seeds/ ha MZ + 20 kg/ha CP, 30 kg seeds/ ha MZ + 30 kg/ha BB, 40 kg seeds/ ha MZ + 20 kg/ha BB, 30 kg seeds/ ha MZ + 30 kg/ha LB, 40 kg seeds /ha MZ + 20 kg/ha LB, 30 kg seeds /ha abu70 + 30 kg/ha CP, 40 kg seeds /ha abu70 + 20 kg/ha CP, 30 kg seeds /ha abu70 + 30 kg/ha BB, 40 kg seeds /ha abu70 + 20 kg/ha BB, 30 kg/ seeds/ ha abu70 + 30 kg/ha LB, 40 kg seeds /ha abu70+ 20 kg/ha LB.

Seeds were obtained from the local market. The experimental site was disc ploughed, harrowed, leveled and ridged into 80 cm apart after broadcasting the seeds on flat land. The experiments were sown on the second week of March, July and November of 2014/15 and 2015/16 seasons. The experiments were irrigated immediately after sowing, then every 7-10 days intervals and according to the crop needs.

Treatment combinations were arranged in a randomized complete block design (RCBD) with four replicates. The plot area was 20 m².

Growth parameters measured

Plant fresh weight was weighed (g), and leaf area index (LAI) was determined by the following equation

$$\text{LAI} = \frac{\text{Area of leaves/plant in } (\text{m}^2)}{\text{Area of ground } (\text{m}^2)}$$

Fresh forage yield (t/ha) was determined and relative yield (RY) was calculated by the following equation

$$\text{RY} = \frac{\text{Yield of the crop in the mixture}}{\text{Yield of the sole crop}}$$

Land equivalent ratio (LER) is the sum of relative yield for the two crops included in the mixture (Willey, 1979) which was determined by the following equation

$\text{LER} = \text{RY1} + \text{RY2}$, where RY1 and RY2 are relative yields of crop1 and crop2, respectively.

Statistical Analysis

Data were subjected to the standard analysis of variance procedure. Means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Plant growth parameters and forage yield of grasses

Plant fresh weight (g)

Plant fresh weight of grasses and their mixtures is presented in Table 2. Mixing showed significant differences between treatments. Mixture of 30 MZ + 30 LB gave the highest plant fresh weight during autumn and winter seasons of both years. However, the highest fresh weight was obtained by the mixture of 30 MZ + 30 CP during the summer season.

The increase in plant fresh weight with mixing can be attributed mainly to the effect of favorable growth conditions for maize during autumn and winter (Table1), and due to nitrogen fixation by the legume (LB), which resulted in adequate nitrogen fixed that led to increased cell division and cell expansion. These results agreed with the findings of Adesoji *et al*. (2013) who worked with legume, fallow and nitrogen on maize growth and development in Nigeria and concluded that nitrogen increased cell division, cell expansion and led to an increase in the size of all morphological parts of maize. Alhaj (1995), working with maize and cowpea as influenced by intercropping pattern,

stated that plant fresh weight of maize was significantly increased with mixing. Ibrahim (1994), working with Sudan grass-lablab mixtures, stated that mixing significantly increased plant fresh weight of Sudan grass. Contradicting results were reported by Hussain (2000), working with grass-legume mixtures, who stated that plant weight of the sole grasses was higher than that obtained in the mixtures.

Table 1. Monthly selected meteorological data recorded during March 2014 to February 2016 at Agricultural Research Corporation, Wad Medani, Sudan.

Year	Month	Temperature (C^0)		Rainfall (ml)
		Max.	Min.	
2014	March	39.32	22.59	Nil
2014	April	41.42	25.70	Nil
2014	May	41.68	25.20	21.8
2014	June	40.99	25.62	24.4
2014	July	36.87	23.48	87.0
2014	August	32.78	22.67	97.8
2014	September	34.18	22.69	40.68
2014	October	37.62	22.02	12.9
2014	November	37.21	19.55	Nil
2014	December	35.57	17.23	Nil
2015	January	33.25	13.70	Nil
2015	February	38.39	17.65	Nil
2015	March	39.63	21.65	Nil
2015	April	40.56	20.92	Nil
2015	May	42.93	25.78	8.8
2015	June	40.94	25.99	12.6
2015	July	39.81	24.93	9.6
2015	August	37.45	23.17	33.2
2015	September	37.45	23.17	27.0
2015	October	39.08	23.67	2.0
2015	November	40.94	25.93	Nil
2015	December	31.98	13.24	Nil
2016	January	31.78	12.76	Nil
2016	February	35.45	14.23	Nil

Leaf area index (LAI)

Leaf area index (LAI) is an important forage parameter as it is related to the amount and weight of leaves per meter square, which indicated the leafiness percentage of the crop per unit of the cultivated area. This parameter showed that grasses mixed with legumes were more leafy during the summer season as compared with those in the autumn and winter seasons.

The highest LAI of 13.3 and 11.8 were given by 40 MZ + 20 LB during autumn seasons of 2014/15 and 2015/16, respectively. Leaf area index of 13.5 and 15.7 were recorded by 40 SG + 20 LB during summer seasons of the first and second years, respectively, and 10.4 and 10.8 by 40 SG + 20 kg LB in winter seasons of the first and second years, respectively (Table 3).

The increase in LAI with mixing can be attributed mainly to increasing plant fresh weight. These results were in agreement with those of Iqbal *et al*. (2006), working with forage maize-legume mixtures, who concluded that LAI for maize in mixture was higher than that recorded in the monocultures. However, contradicting results were reported by Rashid and Himayatullah (2003), working with sorghum-legumes intercropping, who reported that mixing decreased LAI of sorghum.

Table 2. Effect of mixing on plant fresh weight (g.) for Sudan grass (SG), maize (MZ) and Abu70 grown in monoculture and in mixture with cowpea (CP), black eyed bean (BB) and lablab bean(LB), during winter, summer and autumn seasons of 2014/15 and 2015/16

Treatments	2014/15						2015/16					
	Autumn		Summer		Winter		Autumn		Summer			
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	ean	Rank
SG mono	21.33 c	21	20.0 k	21	17.20 b	21	18.00 b	21	24.5 g	21	17.48 c	2
Maize mono	146.6 b	7	58.4 d	7	108.1 a	7	134.6 a	7	71.7 c	7	104.5 b	
Abu70 mono	31.90 c	14	28.5 fghij	14	23.50 b	14	29.90 b	14	29.8 defg	14	25.40 c	1
1 SG: 1CP	27.00 c	16	27.8 ghij	15	22.12 b	16	24.15 b	16	29.2 defg	15	22.30 c	1
2 SG: 1CP	23.00 c	19	24.2 ijk	18	19.30 b	19	20.45 b	19	27.2 efg	18	19.30 c	1
1 SG: 1BB	24.60 c	18	23.3 jk	19	20.05 b	18	22.20 b	18	26.3 fg	19	20.40 c	1
2 SG: 1BB	21.70 c	20	21.8 jk	20	18.10 b	20	19.50 b	20	25.8 fg	20	18.30 c	2
1 SG: 1LB	27.75 c	15	26.2 hijk	16	22.90 b	15	24.90 b	15	28.7 defg	16	22.93 c	1
2 SG: 1LB	26.20 c	17	25.8 hijk	17	21.03 b	17	22.90 b	17	27.6 defg	17	21.38 c	1
1 Maize :1CP	168.7 ab	2	75.9 a	1	118.7 a	2	149.5 a	2	86.8 a	1	123.0 a	
2 Maize :1CP	165.2 ab	3	74.1 a	2	117.1 a	3	146.6 a	3	84.6 ab	2	119.5 ab	
1 Maize:1BB	159.3 ab	5	67.0 bc	5	112.3 a	5	139.0 a	5	76.7 bc	5	112.7 ab	
2 Maize:1BB	153.0 ab	6	63.3 cd	6	110.0 a	6	137.0 a	6	74.9 c	6	111.3 ab	
1 Maize :1LB	171.9 a	1	71.4 ab	3	121.0 a	1	151.4 a	1	81.0 abc	3	126.8 a	
2 Maize :1LB	162.8 ab	4	70.5 ab	4	114.6 a	4	142.7 a	4	79.1 abc	4	116.7 ab	
1 Abu70:1CP	41.80 c	8	36.6 e	9	29.40 b	8	36.30 b	8	36.8 de	9	31.50 c	
2 Abu70:1CP	39.60 c	9	35.2 ef	10	27.80 b	9	34.50 b		35.1 def	10	30.20 c	
1 Abu70:1BB	36.40 c	11	32.5 efgh	12	25.83 b	11	32.90 b	11	32.2 defg	12	27.60 c	1
2 Abu70:1BB	34.40 c	13	30.6 efghi	13	24.20 b	13	30.80 b	13	31.1 defg	13	26.40 c	1
1 Abu70:1LB	37.80 c	10	37.4 e	8	27.05 b	10	33.80 b	10	37.5 d	8	28.90 c	1
2 Abu70:1LB	34.80 c	12	33.5 efg	11	24.55 b	12	31.70 b	17	33.3 defg	11	26.90 c	1
C.V.%	20.04		10.6				21.01		12.7		20.44	

Means followed by the same letter(s) are not significantly different at P = 0.5 according to Duncan's Multipe Range Test(DMRT

Table 3. Effect of mixing on leaf area index (LAI) for Sudan grass (SG), maize (MZ) and Abu70 grown in monoculture and in mixture with cowpea (CP), black eyed bean (BB) and lablab bean(LB), during winter, summer and autumn seasons of 2014/15 and 2015/16.

Treatments	2014/15						2015/16					
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
SG mono	8.80 jklm	17	10.0 gh	10	7.44 ijk	13	8.00lmn	17	11.5 fg	10	6.83 hij	
Maize mono	9.25 hijk	14	4.50 m	21	6.90 lm	17	8.70 jk	14	5.60 o	21	6.54 ij	
Abu70 mono	8.00 n	21	8.20 j	14	6.22 o	21	7.00 p	21	9.60 ijk	14	5.00 m	
1 SG: 1CP	9.43 ghij	13	11.7 cde	6	8.00 gh	10	9.00 ij	13	13.0 cde	6	7.33 gh	
2 SG: 1CP	12.0 cd	5	13.5 a	1	10.2 a	2	10.7 bcd	5	15.7 a	1	8.72 cde	
1 SG: 1BB	9.00 ijkl	16	10.6 fg	9	7.63 hij	12	8.21 klm	16	11.8 fg	9	7.85 fg	
2 SG: 1BB	11.7 de	6	13.0ab	3	9.50 bc	4	10.4 cde	6	14.0 bc	3	9.30 bc	
1 SG: 1LB	9.10 hijk	15	11.0 ef	8	7.74 hi	11	8.45 klm	15	12.5 def	7	7.24 gh	
2 SG: 1LB	12.6 bc	3	13.3ab	2	10.4 a	1	10.9 bc	4	14.5 b	2	10.8 a	
1 Maize :1CP	10.0 g	10	5.80 l	18	7.21 jkl	14	9.74fgh	10	7.30 mn	18	7.00hi	
2 Maize :1CP	12.3 cd	4	7.30 k	15	9.32 bcd	5	11.0 b	3	9.00 jk	15	9.70 b	
1 Maize :1BB	9.70 gh	11	4.80 m	20	7.00 klm	16	9.23 hi	12	6.20 o	20	7.52 lm	
2 Maize :1BB	13.0 ab	2	7.00 k	16	9.20 cde	6	11.5a	2	8.70 kl	16	9.00 cd	
1 Maize :1LB	9.55 ghi	12	5.30 lm	19	7.12 kl	15	9.42 ghi	11	6.50 no	19	6.90 hij	
2 Maize :1LB	13.3 a	1	6.70 k	17	9.70 b	3	11.8 a	1	7.90 lm	17	10.5 a	
1 Abu70 :1CP	8.64 klmn	18	9.50 hi	11	6.73 lmn	18	7.80 mno	18	10.8 gh	11	5.82 kl	
2 Abu70 :1CP	11.3 ef	7	12.0 cd	5	8.92 de	7	10.2 def	7	13.3 cd	5	8.43 def	
1 Abu70 :1BB	8.20 mn	20	8.50 j	13	6.33 no	20	7.42 op	20	10.0 hij	13	6.23 jk	
2 Abu70 :1BB	10.8 f	9	11.4 def	7	8.43 fg	9	10.0 ef	8	12.0 ef	8	8.00 f	
1 Abu70 :1LB	8.42 lmn	19	9.00 ij	12	6.54 mno	19	7.64 no	19	10.3 hi	12	5.53 lm	
2 Abu70 :1LB	11.1 ef	8	12.5 bc	4	8.74 ef	8	9.90 efg	9	13.7 bc	4	8.25 ef	
C.V. (±)	4.10		6.32		4.02		3.76		6.88		5.72	

Means followed by the same letter (s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test (DMRT).

Fresh forage yield of grasses (t/ha)

The analysis of variance procedure depicted clearly that fresh forage yield was significantly affected by mixing during all seasons. Generally, fresh forage yield was highest in autumn and lowest in summer in both seasons (Table 4). Generally, fresh forage yield was highest in autumn and lowest in summer in both years (Table 4).

The highest fresh forage yield was obtained by 40 SG + 20 CP during the summer season which is more than 25% and 39.6% when compared with the fresh forage yield of 40 SG+ 20 LB during the winter seasons of 2014/15 and 2015/16, respectively.

The highest fresh forage yield (76.0 and 68.3 t/ha) was given by 40 Abu70 + 20 CP during the autumn seasons of the first and second years, respectively, 75.1 and 88.4 t/ha by 40 SG + 20 CP, during summer seasons and 59.9 and 62.9 t/ha by 40 SG + 20 LB during the winter seasons.

The increase in fresh forage yield as a result of mixing during all seasons can be attributed mainly to the increase in plant fresh weight. These results were in agreement with the finding of Karanja *et al*. (2014) who stated that intercropping systems gave a higher productivity than the sole crop system across semi-arid areas of Africa. However, the results disagreed with those of Singh *et al*. (1970) in his work on fodder production of sorghum in association with different legumes who stated that the forage yield of sorghum grown alone was higher than that when grown as a mixture with cowpea and green gram.

Relative yield (RY) of grasses

Table 5 shows the relative yield (RY) of grasses during different seasons of 2014/15 and 2015/16. Relative yield is an important concept in comparing the mixtures yield with the monoculture yield and articulate the increasing ratio of the mixture yield over the monoculture. Relative yield during all seasons exceeded 1.0. which indicated clearly the advantages of the mixtures over monocultures.

During the first year, the highest RY of 1.49 and 1.46 were given by 40 MZ + 20 LB during autumn and winter seasons, respectively. While RY of 1.47 during summer season was obtained by 40 SG + 20 CP. During the second year, the highest RY of 1.42 and 1.51 were given by 40 MZ + 20 kg LB during autumn and winter seasons, respectively. However, RY of 1.42 during summer season was given by 40 Abu70 + 20 LB. These results support the findings of Hailemariam (2014), working with Sudan grass mixed with lablab and cowpea at eastern Ethiopia who reported higher relative yield of Sudan grass-legume mixture compared to Sudan grass alone (1:1 Sudan grass-cowpea combination) accounted for the maximum yield advantage of 93%.

Land equivalent ratio (LER)

Table 6 shows the land equivalent ratio of the different mixtures. Land equivalent ratio is the most generally useful single factor for expressing the mixture yield advantages over mono-crop and it is defined as the relative land area required for the sole crop to produce the same yield as intercropping. The highest LER of 2.17 and 2.13 during autumn seasons of 2014/15 and 2015/16, respectively, were obtained by 40 MZ+ 20 LB. Land equivalent ratio of 2.21 and 2.28 during summer seasons of the first and second years, respectively, were obtained by 40 SG + 20 CP, whereas LER of 2.18 and 2.20 during winter seasons of 2014/15 and 2015/16, respectively, were obtained by 40 SG + 20 LB.

Table 4. Effect of mixing on fresh forage yield (t/ha) of Sudan grass (SG), maize (MZ) and Abu70 grown in monoculture and in mixture with cowpea (CP), black eyed bean (BB) and lablab bean(LB), during winter, summer and autumn seasons of 2014/15 and 2015/16

Treatments													
SG mono	52.9fg	20	51.1 de	11	43.7fgh	14	46.5f	20	63.3 de	11	45.0 gh	14	50.42 j	14
MZ mono	50.0g	21	24.8 g	21	39.3 k	21	46.3f	21	28.8 h	21	40.6i	21	38.30 q	21
Abu70 mono	54.5 f	17	45.9 e	14	40.6ijk	19	47.5ef	17	52.6 f	14	42.0hi	19	47.18 m	17
1 SG: 1CP	54.6 f	16	57.9 cd	7	45.3 f	11	47.8ef	16	68.2 bcd	7	49.6 f	11	53.90 h	11
2 SG: 1CP	72.5ba	8	75.1a	1	57.5 b	3	64.3b	8	88.4 a	1	60.5abc	3	69.72 b	2
1 SG: 1BL	58.3 cde	12	56.2cd	10	44.2fg	13	50.6cde	12	66.2 cd	10	47.6 fg	13	53.85 h	12
2 SG: 1BL	72.2b	9	73.3a	3	56.6 b	4	64.1b	9	86.4 a	3	60.3 abc	4	68.82 c	3
1 SG: 1Lab	58.8 cd	11	57.1cd	8	44.9 f	12	51.7 cd	11	67.3 bcd	8	48.4 f	12	54.70 g	10
2 SG: 1Lab	74.3ab	4	74.9 a	2	59.9 a	1	65.6 ab	4	88.1 a	2	62.9 a	1	70.95 a	1
1 MZ :1CP	60.7c	10	26.2 g	18	42.9 fgh	10	52.2 c	10	35.7 gh	18	50.5 f	10	44.70 n	18
2 MZ :1CP	73.4ab	7	34.7 f	15	56.4bc	5	64.5 b	7	40.7 g	15	59.5bc	5	54.87 g	8
1 MZ :1BB	53.8 f	19	25.0g	20	42.9 fghi	15	47.0f	19	29.3 h	20	44.6gh	15	40.43 o	19
2 MZ :1BB	75.0ab	3	33.3f	16	55.5 bcd	6	65.9 ab	3	40.2g	16	58.8 bcd	6	54.78 g	9
1 MZ :1LB	54.4f	18	25.5 g	19	40.2jk	20	47.3 ef	18	30.2 h	19	41.8hi	20	39.90 p	20
2 MZ :1LB	75.5ab	2	33.0f	17	57.9 ab	2	66.5ab	2	39.0g	17	61.3ab	2	55.53 f	7
1 Abu70 :1CP	56.0def	13	48.2 e	12	42.3ghij	16	49.3cdef	13	57.8 ef	12	44.3h	16	49.65 k	15
2 Abu70 :1CP	76.0a	1	63.1 bc	5	54.1 cde	7	68.3 a	1	73.1bc	5	57.5cde	7	65.35 d	4
1 Abu70 :1BB	54.8ef	15	56.6cd	9	41.3hijk	18	48.0ef	15	66.6bcd	9	42.5hi	18	51.63 i	13
2 Abu70 :1BB	73.7 ab	6	62.5 bc	6	52.5 e	9	65.0ab	6	72.3 bc	6	55.6e	9	63.60 e	6
1 Abu70 :1LB	55.1ef	14	47.9e	13	41.7 ghijk	17	48.5def	14	55.4 f	13	42.9 hi	17	48.58 l	16
2 Abu70 :1LB	73.9ab	5	66.8 b	4	53.6 de	8	65.2ab	5	74.6 b	4	56.3de	8	65.07 d	5
C.V. %	3.60		8.87		3.33		3.79		8.70		4.0		5.88	

Means followed by the same letter (s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test (DMRT

Table 5. Relative yield (RY)for Sudan grass (SG), maize and Abu70 grown in mixture with cowpea (CP)black eyed bean (BB), and lablab bean (LB), during winter, summer and autumn seasons of 2014/15 and 2015/16.

Treatments	2014/15						2015/16						
	Autumn		Summer		Winter		Summer		Winter				
	Autumn						Overall						
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean		
	Rank	Mean	Rank										
1 SG: 1CP	1.04	16	1.13	11	1.07	12	1.05	15	1.08	13	1.10	11	1.0
2 SG: 1CP	1.37	6	1.47	1	1.32	7	1.39	6	1.40	3	1.34	6	1.3
1 SG: 1BB	1.12	12	1.10	13	1.02	17	1.08	12	1.06	15	1.05	14	1.0
2 SG: 1BB	1.34	9	1.42	4	1.29	8	1.37	9	1.34	8	1.32	8	1.3
1 SG: 1LB	1.11	11	1.12	12	1.03	15	1.11	11	1.07	14	1.08	13	1.0
2 SG: 1LB	1.40	4	1.46	2	1.37	4	1.41	4	1.38	5	1.40	4	1.4
1 MZ :1CP	1.21	10	1.07	14	1.09	10	1.13	10	1.24	11	1.24	10	1.1
2 MZ :1CP	1.47	3	1.40	5	1.44	2	1.40	5	1.41	2	1.47	2	1.4
1 MZ :1BB	1.09	14	1.01	18	1.08	11	1.02	13	1.02	18	1.09	12	1.0
2 MZ :1BB	1.48	2	1.33	8	1.40	3	1.41	3	1.39	4	1.43	3	1.4
1 MZ :1LB	1.08	14	1.03	17	1.02	16	1.02	16	1.01	16	1.04	16	1.0
2 MZ :1LB	1.49	1	1.32	9	1.46	1	1.42	1	1.33	9	1.51	1	1.4
1 Abu70 :1CP	1.05	15	1.06	15	1.06	13	1.06	14	1.10	12	1.05	15	1.0
2 Abu70 :1CP	1.39	5	1.37	6	1.33	5	1.44	2	1.37	6	1.37	5	1.3
1 Abu70 :1BB	1.01	18	1.23	10	1.04	18	1.01	18	1.27	10	1.01	18	1.1
2 Abu70 :1BB	1.34	8	1.36	7	1.29	9	1.37	8	1.36	7	1.31	9	1.3
1 Abu70 :1LB		17		16		14		17		1		17	
	1.03		1.05		1.05		1.04		1.05	7	1.03		1.0
2 Abu70 :1LB	1.36	7	1.45	3	1.31	6	1.38	7	1.42	1	1.32	7	1.3

Table 6. Land equivalent ratio (LER) for Sudan grass (SG), maize, Abu70, cowpea (CP), black eyed bean (BB), and lablab bean(LB) mixtures during winter, summer and autumn seasons of 2014/15 and 2015/16

Treatments	2014/15						2015/16				
	Autumn		Summer		Winter		Summer				
	Autumn Mean	Rank Mean	Rank		Mean	Rank	Winter Mean	Rank	Mean	Rank	
1 SG: 1CP	1.94	16	2.13	4	1.94	17	1.95	15	2.10	6	1.92
2 SG: 1CP	1.95	15	2.21	1	2.03	10	1.96	14	2.28	1	2.01
1 SG: 1BB	1.90	18	2.06	7	1.97	15	1.89	18	1.99	17	1.91
2 SG: 1BB	1.91	17	2.15	2	1.98	14	1.94	16	2.14	3	1.94
1 SG: 1LB	2.07	6	2.09	5	2.07	6	2.08	3	2.01	15	2.03
2 SG: 1LB	2.13	2	2.14	3	2.18	1	2.10	2	2.12	4	2.20
1 MZ :1CP	2.06	7	2.00	13	2.08	5	2.00	10	2.07	9	2.08
2 MZ :1CP	2.11	4	2.05	8	2.09	4	2.01	9	2.23	2	2.17
1 MZ :1BB	1.96	14	1.94	18	2.01	12	1.98	12	1.98	18	1.98
2 MZ :1BB	2.10	5	1.97	16	2.06	7	1.99	11	2.08	8	2.04
1 MZ :1LB	2.12	3	2.03	10	2.05	8	2.05	6	2.04	12	2.07
2 MZ :1LB	2.17	1	2.04	9	2.16	2	2.13	1	2.06	10	2.13
1 Abu70 :1CP	1.98	12	1.98	15	1.96	16	2.06	5	2.02	14	1.97
2 Abu70 :1CP	2.03	8	2.01	12	2.04	9	2.07	4	2.05	11	1.99
1 Abu70 :1BB	1.97	13	1.96	17	1.89	18	1.92	17	2.00	16	1.89
2 Abu70 :1BB	2.00	11	2.07	6	2.02	11	1.97	13	2.03	13	1.93
1 Abu70 :1LB	2.01	10	1.99	14	1.99	13	2.02	8	2.09	7	2.00
2 Abu70 :1LB	2.02	9	2.02	11	2.15	3	2.03	7	2.11	5	2.02

The results showed clearly that the best LER was shown by the maize-lablab mixture during autumn, Sudan grass-cowpea during summer and Sudan grass-lablab during winter. Generally, it is suggested that lablab bean is the best legume for mixing, whereas black eyed bean is an inferior legume for mixing. Results were consistent with those of Khan *et al*. (1992), in an experiment involving maize and soybean, who recorded high LER of 1.40 as a result of sowing them in the same rows, while a low LER of 0.95 involving the same crops was noted but in alternate rows.

RECOMMENDATION

It is recommended to grow mixture combinations of 40 kg/ha MZ + 20kg/ha LB, 40 kg/ha SG +20 kg/ha CP and 40 kg/ha SG + 20 kg/ha LB during autumn and winter seasons, respectively.

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في أواسط السودان إنتاجية العلف لبعض الحشائش النجيلية ومخاليطها بالبقوليات تحت ظروف الري

نصر الدين عبده سيد أحمد و على صالح جانقي و أبو الحسن صالح إبراهيم و إبراهيم البشير محمد

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الخلاصة

2014/15 يؤدي الخلط إلى زيادة في إنتاجية العلف. أجريت هذه الدراسة خلال صيف و خريف وشتاء بالمزرعة التجريبية، كلية العلوم الزراعية، جامعة الجزيرة، السودان. تهدف هذه الدراسة لتقييم أثر 2015/16و الخلط علي إنتاجية العلف لبعض الحشائش النجيلية ومخاليطها بالبقوليات تحت ظروف الري في أواسط السودان. تضمنت الدراسة ثلاثة محاصيل نجيلية هي حشيشة السودان وأبوسبعين والذرة الشامية وثلاثة محاصيل بقولية 1:2و1:1هي اللوبيا الحلو واللوبيا البيضاء واللوبيا العفن. زرعت المحاصيل النجيلية منفرده وفي مخاليط بنسبة أظهرت نتائج التحليل أن كل من الإنتاج ومكوناته قد زادت زيادة معنوية كنتاج للخلط. تحققت الإنتاجية العالية للعلف الأخضر عند زراعة الاعلاف النجيلية في مخاليط مقارنة بزراعتها منفرده. قيم نسبة مكافئ الأرض فاقت (خلال كافة المواسم مما يؤكد تفوق نظام الخلط علي زراعة المحصول نقيا. بناء علي نتائج 1.0الواحد الصحيح هذه الدراسة ولتحقيق إنتاجية أعلاف نجيلية عالية نوصي بزراعتها في مخاليط بنسبة 40 كجم بذور/هكتار ذرة شامية + 20 كجم بذور/هكتار لوبيا عفن و 40 كجم بذور/هكتار حشيشة السودان + 20 كجم بذور/هكتار لوبيا حلو و 40 كجم بذور/هكتار حشيشة السودان + 20 كجم بذور/هكتار لوبيا عفن خلال مواسم الخريف والصيف والشتاء على التوالي.