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

Nasreldein A. Sid Ahmed, A.S. Gangi, A.E.S. Ibrahim and I. E. Mohamed

Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan

ABSTRACT

The study was conducted during summer, autumn 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, to investigate the effect of mixing on forage yield of selected three legumes namely: cowpea (CP), black-eyed bean (BB) and lablab bean (LB) and their mixtures with three selected grasses, Sudan grass (SG), maize (MZ) and forage sorghum (Abu70). Legumes were grown in pure stand and mixed with grasses in 1:1 and 1:2 ratios. Treatment combinations were arranged in a randomized complete block design (RCBD) with four replications. The results showed that mixing significantly increased plant fresh weight, LAI, and fresh forage yield during most seasons and decreased number of branches per plant during different seasons. Land equivalent ratio mostly was greater than one. Based on the results of this study to obtain high forage yield, it was recommended to use seed combinations of 30 kg seeds/ha LB + 30 kg seed/ha MZ during autumn and winter and 30 kg seeds/ha BB + 30 kg seed/ha SG during summer season.

INTRODUCTION

Major forage legumes in the Sudan include alfalfa (*Medicago sativa* L.), kordofan pea (*Clitoria ternatea* L.), lablab bean (*Lablab purpureus* (L.) Sweet). and philipesara (*Vigna trilobata* Verd.). Forage legumes have better quality than forage grasses, since they are rich in proteins, vitamins and minerals (Giller, 2001). In the Sudan, forage legumes especially alfalfa are grown mainly under irrigation in large schemes and around cities.

Mixed cropping system provide a forage of higher yield and nutritive value than in monocrops because the legumes reduce the danger of grass tetany and give better nutrient balance. Moreover, the deep-rooted legume species provide more production during the drought period of the year (Lithourgidis and Dordas, 2010). Legumes utilize different soil strata that enable them to benefit from water and nutrients at different soil depths.

Hussain (2000) reported that mixed cowpea, lablab bean and phlipisara in a 1:1 ratio with Abusabeen (*Sorghum bicolor* L) and two hybrids of sorghum had no significant effects on plant height of legume crops and number of branches per plant as a result of mixing. Plant dry weight was higher for sole legumes. The highest yielding mixture in winter (8.30 t/ha) was that of Speed Feed + lablab bean, whereas in autumn Pioneer 988+ lablab bean (6.72 t/ha) was the best producing mixture. He concluded that lablab bean was the best legume for mixing.

Ibrahim *et al*. (2006) working with legume-maize mixtures concluded that, plant height of maize was affected significantly by legume species for example Sesbania grown in mixture with maize had a depressing effect on plant height of maize while cowpea and cluster bean had beneficial effects. Differences in plant height of maize sown with legumes might be due to the different growth behavior of the companion legumes. Alhaj (1995) studied the growth and yield of intercropped cowpea and maize as influenced by intercropping pattern, reported that cowpea plant height, plant dry weight, leaf area per plant, leaf area index and dry matter production were decreased as a result of intercropping. Elobaid (2001) working with lablab and forage sorghum Abu70 mixtures concluded that mixing significantly decreased number of branches per plant, plant fresh weight and fresh forage yield of the lablab bean. He recorded highest fresh forage yield by the combination of 40 kg seeds/ha of Abu70 + 40 kg seeds/ha of lablab. Osman (1995) working with selected cultivars of sorghum under mixing with lablab bean at Gezira University Farm concluded that taller cultivars of sorghum compete quite well with lablab bean for growth factors and reduced its yield and yield components through shading.

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 winter season. This fact necessitates more efforts and research to solve the problem of forage shortage.

The general objective of this study was to evaluate forage yield potential of pure cowpea, black eyed bean and lablab bean and their mixtures with Sudan grass, maize, forage sorghum Abu70, under irrigation. The specific objective was to identify the most suitable combination of the mixtures forage yield during autumn, summer and winter seasons.

MATERIALS AND METHODS

The experiment was executed for six seasons during, summer (March), autumn (July) and winter (November) seasons of 2014/2015 and 2015/2016 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). The 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 legumes, cowpea (CP) (*Vigna sinensis*), black-eyed bean (BB) (*Vigna unguiculata* subsp *unguiculata*. (L.) Walp) and lablab bean(LB) (*Lablab purpureus* (L.) Sweet) and three grasses, namely: Sudan grass (SG) (*Sorghum sudanense* (Piper) Stapf.), maize (MZ) (*Zea mays* L.) and forage sorghum Abu70 (*Sorghum bicolor* (L) Moench). Legume crops were grown in pure stand and mixed in 1: 1 and 1:2 ratios with grasses, which made a total of 21 treatments. Seed rate of 60 kg/ha was used for the pure stand of cowpea, black eyed bean and lablab bean and as follows for mixtures.

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 BB and 40 kg seeds /ha Abu70 + 20 kg/ha LB.

Seeds were obtained from the local market. The experimental site was disc plowed, harrowed, leveled and ridged into 80 cm apart after broadcasting of the seeds on flat land. The experiments were sown on the second week of March, July and November in the two seasons. The experiments were irrigated immediately after sowing, then every 7-10 days intervals according to the crop needs. Treatment combinations were arranged in a randomized complete block design (RCBD) with four replications. The plot size was 20m².

Data for number of branches per plant and plant fresh weight (g) were taken and leaf area index (LAI) was determined as follows:

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

In addition to fresh forage yield (t/ha), relative yield (RY) and land equivalent ratio (LER) were determined according to the following equations

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

$$LER = RY1 + RY2$$

where RY1 and RY2 are relative yields of crop1 and crop2, respectively.

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 legume crops

Number of branches per plant

The effect of mixing on number of branches per plant of legumes is shown in Table 2. Results showed significant differences among treatments for number of branches per plant. The highest number of branches per plant was obtained by the sole black eyed bean during all seasons, whereas the lowest number of branches per plant was recorded by lablab bean when mixed in 40 Abu70 + 20 LB, 40 SG + 20 LB and 40 SG + 20 CP during autumn, summer and winter seasons, respectively.

The increase in number of branches per plant of the sole black eyed bean during all seasons can be attributed to the less competition for nutrients and light and because of the physiological branching habit of the crop especially in monoculture. Results were in agreement with the findings of Ofori and Stern (1987) working with cereal-legume intercropping systems who reported that growth parameters of the legume were higher in monoculture and decline normally with mixing by about 52% of the sole crop. Elobaid (2001) working with lablab-sorghum mixture found that mixing significantly decreased number of branches per plant of lablab bean.

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

Plant fresh weight

Significant differences among treatments on plant fresh weight of legumes as affected by mixing were observed (Table 3). The highest plant fresh weight of (173 and 135.8 g.) and (156.3 and 145.5 g.) during autumn and winter seasons of 2014/15 and 2015/16, respectively, were obtained by 30 LB + 30 MZ, whereas plant fresh weight of 120 and 139.2 g during summer seasons of the first and second years, respectively, were obtained by 30 LB + 30 SG.

As affected by cropping system, the increase in plant fresh weight with mixing can be attributed to the effect of favorable growth conditions on lablab bean during autumn and winter (Table 1). These results corroborate with the findings of Ibrahim (1994) working with Sudan grass-lablab mixtures who stated that mixing significantly increased plant fresh weight of lablab bean. Albakri *et al*. (2003) stated that mixing significantly increased plant fresh weight of cowpea. Results were in disagreement with the finding of Osman (1995), working with selected cultivars of sorghum under mixing with lablab bean at Gezira University Farm, who concluded that taller cultivars of

sorghum compete quite well with lablab for growth factors and reduced its yield and yield components through shading.

Table 2. Effect of mixing on number of branches per plant of cowpea (CP), black eyed bean (BB) and lablab bean (LB) grown in monoculture and in mixture with Sudan grass (SG), maize (MZ) and Abu70 during autumn, summer and winter seasons of 2014/2015 and 2015/2016.

Treatments	2014/15						2015/16			
	Autumn		Summer		Winter		Autumn		Summer		Winter	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
CP mono	9.60 f	8	8.50 de	8	5.0 lm	16	9.5 de	8	8.0 e	8	4.7 lm	16
BB mono	13.8 a	1	11.0 a	1	10.5 a	1	12.4 a	1	10.5a	1	9.9 a	1
LB mono	6.90 jkl	15	5.20 ij	15	8.0 fg	8	7.5 gh	13	5.5 ijk	15	7.3 fg	8
1CP : 1 SG	8.43 ghi	11	8.00 ef	9	4.5 mno	18	9.0 ef	9	7.5 ef	10	4.0 no	18
1CP : 2 SG	7.90 hij	12	5.50 ij	14	3.5 p	21	8.0 fg	12	6.0 hij	14	3.0 p	21
1BB : 1 SG	12.4 cd	4	0.9 a	2	10.0 ab	2	12.0 a	2	10.2a	2	9.5 ab	2
1BB : 2 SG	11.5 de	6	.0.0 abc	4	9.8 abc	3	10.5 bc	6	9.0 cd	6	9.0 bc	3
1LB : 1 SG	6.20 lm	17	4.50 jkl	17	7.6 gh	9	5.0 kl	18	4.4 lm	18	7.0 fg	9
1LB : 2 SG	6.50 klm	16	3.50 l	21	6.8 hij	12	4.4 lm	19	3.3 n	21	6.0 ij	12
1CP : 1 MZ	9.35 fg	9	7.50 fg	10	5.7 kl	15	8.6 ef	10	7.0 fg	11	5.0 kl	15
1CP : 2 MZ	7.53 ijk	13	6.70 gh	12	4.8 mn	17	6.9 hi	14	6.5 gh	12	4.5 mn	17
1BB : 1 MZ	12.6 bc	3	.0.5 ab	3	9.0 cde	5	11.5 ab	3	9.8 abc	4	8.4 cd	5
1BB : 2 MZ	11.8 cde	5	9.40 cd	6	9.5 bcd	4	10.8 bc	5	9.3 bcd	5	8.7 c	4
1LB : 1 MZ	5.50 mno	19	4.00 kl	18	7.3 gh	10	6.0 ij	16	5.0 kl	17	6.7 gh	10
1LB: 2 MZ	5.00 no	20	3.70 l	20	6.4 ijk	13	4.0 m	20	4.0 mn	19	5.5 jk	13
1CP : 1Abu70	8.80 fgh	10	7.00 g	11	4.0 nop	19	8.3 fg	11	7.8 ef	9	3.6 op	19
1CP : 2 Abu70	7.00 jkl	14	6.00 hi	13	3.7 op	20	6.4 ij	15	6.2ghi	13	3.3 p	20
1BB : 1Abu70	13.5 ab	2	9.70 bc	5	8.8 def	6	11.0 bc	4	10.0ab	3	8.0 de	6

1BB : 2Abu70	11.0	e	7	9.00	cd	7	8.5	ef	7	10.0	cd	7	8.8	d	7	7.6	ef	7
1LB: 1Abu70	6.00	lmn	18	4.90	jk	16	7.0	hi	11	5.5	jk	17	5.2	jkl	16	6.3	hi	11
1LB : 2Abu70	4.50	o	21	3.90	kl	19	6.0	jk	14	3.0	n	21	3.7	mn	20	5.3	kl	14
C.V. %	7.87			9.41			8.1			8.2			7.69			7.2		

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

Table 3. Effect of mixing on plant fresh weight (g.) of cowpea (CP), black eyed bean (BB) and lablab bean (LB) grown in monoculture and in mixture with Sudan grass (SG), maize (MZ) and Abu70 during autumn, summer and winter seasons of 2014/2015 and 2015/2016

Treatments	2014/15								2015/16					
	Autumn			Summer			Winter		Autumn			Summer			Winter	
	Mean		Rank	Mean		Rank	Mean		Rank	Mean		Rank	Mean		Rank	
CP mono	91.7	b	8	72.6	fgh	12	65.8	ghi	15	81.4	c	8	80.9	ghij	14	67.4	ef	14
BB mono	82.1	bc	10	79.6	ef	9	84.5	d	8	76.6	cd	9	91.0	efg	10	87.9	d	8
LB mono	166.7	a	3	115	ab	2	131.6	ab	2	151.1	ab	3	132	ab	3	141.6	ab	2
1CP : 1SG	76.20	bcd	13	78.0	efg	10	58.2	ij	18	73.4	cd	10	92.5	ef	9	55.8	fgh	18
1CP : 2SG	65.4	cd	20	46.7	k	21	41.9	k	21	54.7	ef	20	59.9	l	21	44.0	h	21
1BB : 1SG	72.3	cd	16	85.1	e	8	77.4	def	11	67.8	cdef	14	98.9	e	8	80.1	de	10
1BB : 2SG	63.1	d	21	70.3	ghi	13	67.6	fgh	14	53.9	f	21	80.1	hij	15	66.6	ef	15
1LB : 1SG	169.9	a	2	120	a	1	123.9	bc	5	153.2	ab	2	139.2	a	1	137.5	abc	3
1LB : 2SG	161	a	6	100	d	7	118.4	c	7	142.2	ab	6	117.3	d	7	124.2	c	7
1CP :1MZ	83.0	bc	9	70.2	ghi	14	62.5	hij	16	71.3	cdef	12	86.0	fgh	12	62.0	fg	16
1CP :2MZ	69.9	cd	17	54.6	jk	19	52.0	jk	20	62.0	def	18	67.3	kl	20	48.9	gh	20
1BB :1MZ	75.4	bcd	14	67.4	hi	16	74.3	def	12	66.1	cdef	15	86.6	fgh	11	78.6	de	11
1BB :2MZ	69.1	cd	18	63.0	ij	17	71.8	efg	13	59.7	def	19	76.9	hijk	17	69.7	ef	13
1LB :1MZ	173	a	1	113.3	ab	3	135.8	a	1	156.3	a	1	134.9	ab	2	145.5	a	1

1LB:2MZ	162.4	a	5	108.5	bcd	5	126.2	abc	4	145.0	ab	5	128.8	bc	4	134.4	ab	4
1CP:1Abu70	79.3	bcd	11	67.9	hi	15	60.2	ij	17	68.1	cdef	13	79.2	hij	16	59.0	fg	17
1CP :2Abu70	72.4	cd	15	61.0	ij	18	56.1	ij	19	64.8	cdef	16	72.0	ijk	18	52.1	gh	19
1BB :1Abu70	79.2	bcd	12	73.9	fgh	11	81.6	de	9	72.4	cde	11	82.5	fghi	13	84.8	d	9
1BB :2Abu70	66.9	cd	19	51.2	k	20	79.0	de	10	62.9	def	17	71.3	jk	19	76.4	de	12
1LB :1Abu70	165.1	a	4	111.6	abc	4	129.4	abc	3	148.2	ab	4	125.0	bcd	5	131.6	abc	5
1LB :2Abu70	157	a	7	103.0	cd	6	120.3	c	6	138.2	b	7	121.0	cd	6	128.5	bc	6
C.V. %	10.4			7.10			8.31			1.4			6.85			.21		

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

Leaf area index (LAI)

Leaf area index (LAI) for legumes as affected by mixing is shown in Table 4. The highest leaf area index was obtained by 30 MZ + 30 LB during autumn seasons of both years. However the highest LAI was obtained by 30 SG + 30 CP and by 30 SG + 30 LB during summer seasons of the first and second years, respectively, and by mono LB during winter seasons of both years. The increase in LAI was due to the increase in plant fresh weight. Autumn and summer results were in agreement with the finding of Iqbal *et al*. (2012) working with cowpea- maize mixture, who reported higher LAI for cowpea sown in alternate rows with forage maize.

Fresh forage yield of legume crops

Significant differences among treatments for fresh forage yield of legumes as affected by mixing were found (Table 5). The highest fresh forage yield during autumn and winter seasons of both years were achieved by 30 LB + 30 MZ, whereas the highest fresh forage yield during summer seasons of the first and second years were attained by 30 CP + 30 SG.

The increase in fresh forage yield can be attributed mainly to the increase in plant fresh weight as a result of mixing and favorable growth condition for lablab during autumn and winter seasons and for cowpea during summer season. These results concur with the findings of Elobaid (2001) working with sorghum-lablab mixtures who reported that mixing significantly increased fresh forage yield of lablab bean. However, the results disagreed with Singh (1981) working with sorghum-cowpea mixtures and Ofori and Stern (1987) working with cereal-legume intercropping systems who reported that yield of the legume was higher in the monoculture than in mixtures.

Relative yield (RY) of legumes

Table 6 shows the relative yield (RY) of legumes during the different seasons. The highest relative yield during autumn and winter seasons were achieved by the mixtures of lablab bean and maize when grown in 30 LB + 30 MZ (1:1 ratio), whereas the best RY during summer seasons were attained by the mixture of 30 BB and 30 SG (1:1 ratio).

Relative yield during the different seasons ranged between 1.13 to 0.57 and mostly less than one, which indicated that the mixtures yield was lower than the monocultures yield. The decrease in RY of most legumes was mainly due to the reduction in mixtures forage yield due to shading by forage grasses , whereas the increase in RY of lablab could be explained by the increase in forage yield of lablab in the mixture over the sole crop, which indicated the suitability of lablab bean for mixing. These results agreed with those of Hussain (2000) who worked with some grass and legume mixtures and found that mixtures out-yielded the sole crops in dry matter yield and concluded that lablab was the best legume crop for mixing.

Land equivalent ratio (LER)

Table 7 shows the land equivalent ratio of the mixtures during different growing seasons. The highest LER during autumn seasons of the first and second years were obtained by 20 LB +40 MZ, whereas the highest LER during summer seasons were obtained by 20 CP +40 SG, whereas the highest land equivalent ratio during winter seasons were obtained by 20 LB + 40 SG.

Table 4. Effect of mixing on leaf area index (LAI) of cowpea (CP), black eyed bean (BB) and lablab bean (LB) grown in monoculture and in mixture with Sudan grass (SG), maize (MZ) and Abu70 during autumn, summer and winter seasons of 2014/2015 and 2015/2016

Treatments	2014/15						2015/16					
	Autumn		Summer		Winter		Autumn		Summer		Winter	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
CP mono	6.0bc	6	5.1 cd	4	4.8 d	5	7.9 cd	6	4.3 efg	8	4.5 d	5
BB mono	2.5 hi	15	2.0 j	15	1.8jklm	15	2.5 klm	15	2.6 k	15	1.7 lmn	15
LB mono	9.8a	3	5.0 cd	5	7.8 a	1	9.0 abc	3	5.7 b	3	6.8 a	1
1CP : 1SG	4.5 def	9	6.3 a	1	2.8 hi	11	5.5 fg	9	5.5 bc	4	2.8 hij	11
1CP : 2SG	3.2 gh	14	2.8 i	14	2.0 jkl	14	3.0 jkl	14	3.2 j	14	2.0 klm	14
1BB : 1SG	1.8 ij	17	1.3 kl	18	1.5kl mn	17	1.8 lmn	17	2.0 lm	18	1.3 nop	17
1BB : 2SG	1.0 j	21	0.94 l	21	0.9 n	21	0.95 n	21	1.2 n	21	0.8 p	21
1LB : 1SG	10.0a	2	6.0 ab	2	6.7 c	4	9.3 ab	2	6.5a	1	5.5 c	4
1LB : 2SG	5.3 cd	7	4.0 ef	8	3.6fg	8	7.0 de	7	3.7 hij	11	3.5 efg	8
1CP :1MZ	3.9 efg	11	4.5 de	7	3.2 gh	9	4.5 fgh	11	5.0 cd	5	3.3 fgh	9
1CP :2MZ	3.5 fgh	13	3.2ghi	12	2.3 ijk	13	3.5 ijk	13	3.6 ij	12	2.2 jkl	13
1BB :1MZ	2.0 ij	16	1.5 jk	17	1.6kl mn	16	2.0 lmn	16	2.1 kl	17	1.5 mno	16
1BB :2MZ	1.2 j	20	0.97 l	20	0.95 n	20	1.0 n	20	1.5 mn	20	0.9 op	20
1LB :1MZ	10.5a	1	5.5 bc	3	7.5 ab	2	9.7 a	1	6.0 ab	2	6.5 ab	2
1LB: 2MZ	6.6 b	5	3.7fg	10	4.5 de	6	8.2 bc	5	4.2 fgh	9	4.0 de	6
1CP:1Abu 70	4.0 efg	10	3.9 ef	9	3.0 ghi	10	5.0 fgh	10	4.8 de	6	3.0 ghi	10

1CP : 2Abu70	3.7 fg	12	3.5 fgh	11	2.5 hij	12	4.0 hij	12	3.9 ghi	10	2.5 ijk	12
1BB : 1Abu70	1.4 ij	18	1.6 jk	16	1.3l mn	18	1.5 mn	18	2.1 kl	16	1.2 nop	18
1BB : 2Abu70	1.3 j	19	1.1kl	19	1.0 mn	19	1.3 mn	19	1.8 lm	19	1.0 op	19
1LB : 1Abu70	9.5a	4	4.9 cd	6	7.0 bc	3	8.6 abc	4	4.5 def	7	6.0 bc	3
1LB : 2Abu70	5.0 cde	8	3.0 hi	13	4.0 ef	7	6.0 ef	8	3.4 ij	13	3.7 ef	7
C.V.%	16.4		12.9		15.3		16.2		10.5		14.18	

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. Effect of mixing on fresh forage yield (t/ha) of cowpea (CP), black eyed bean (BB) and lablab bean (LB) grown in monoculture and in mixture with Sudan grass (SG), maize (MZ) and Abu70during autumn, summer and winter seasons of 2014/2015 and 2015/2016.

Treatments	2014/15						2015/16					
	Autumn		Summer		Winter		Summer		Winter			
	Autumn						Combined					
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
CP mono	50.8 b	5	48.2 a	2	34.6 b	5	45.1 bc	5	55.1 a	2	37.5 c	5	45.21 c	5
BB mono	31.7 d	13	30.2 cd	15	24.6 cdef	12	26.9 g	14	34.3 cd	15	26.3 gh	12	29.0 h	12
LB mono	60.9 a	3	38.3 b	7	40.4 a	2	49.8 a	3	43.3 b	8	44.7 b	2	46.23 b	3
1CP : 1 SG	47.3 b	7	48.6 a	1	33.6 b	8	40.0 d	7	56.0 a	1	33.7 de	8	43.20 de	7
1CP : 2 SG	29.5 d	15	30.3 cd	14	21.3 gf	18	24.8 g	15	35.4 cd	14	21.7 i	18	27.17 k	18
1BB : 1 SG	28.7 d	17	31.4 c	11	23.3 ef	14	24.1 g	17	36.6 c	11	23.6 hi	15	27.95 j	15
1BB : 2 SG	18.4 e	21	19.9 f	20	15.0 h	21	15.4 h	21	23.3 f	20	15.0 j	21	17.83 m	21
1LB : 1 SG	62.1 a	2	39.0 b	5	42.0 a	4	50.7 a	2	45.4 b	5	42.1 b	4	46.88 b	2
1LB : 2 SG	40.9 c	10	25.2 e	18	28.0 cd	10	33.4 e	10	28.5 e	18	30.2 f	10	31.03 g	10
1CP : 1 MZ	46.9 b	8	47.4 a	3	34.5 b	6	39.0 d	8	54.8 a	3	34.9 cd	6	42.92 e	8
1CP : 2 MZ	30.2 d	14	31.6 c	10	21.5 fg	17	28.0 fg	12	36.7 c	10	22.4 i	17	28.40 i	14
1BB : 1 MZ	28.3 d	18	30.5 cd	12	24.0 def	13	23.8 g	18	35.6 cd	12	23.8 hi	14	27.67 j	17
1BB : 2 MZ	19.2 e	20	20.0 f	19	15.0 h	20	16.1 h	20	23.4 f	19	15.6 j	20	18.22 m	20
1LB : 1 MZ	62.7 a	1	38.9 b	6	45.8 a	1	51.1 a	1	45.2 b	6	48.5 a	1	48.70 a	1
1LB: 2 MZ	41.3 c	9	27.4 de	16	29.0 c	9	33.8 e	9	31.8 de	16	30.8 ef	9	32.35 f	9
1CP : 1 Abu70	47.4 b	6	47.0 a	4	34.0 b	7	44.5 c	6	52.1 a	4	34.8 cd	7	43.30 d	6
1CP : 2 Abu70	32.3 d	12	31.9 c	9	22.0 fg	16	27.2 g	13	37.1 c	9	22.7 hi	16	28.87 h	13

1BB 1Abu70	:	29.1 d	16	30.4 cd	13	23.0 f	15	24.4 g	16	35.5 cd	13	24.3 hi	13	27.78 j	16
1BB Abu70	:2	19.6 e	19	19.4 f	21	18.0 gh	19	16.5 h	19	22.6 f	21	16.2j	19	18.72 l	19
1LB: 1Abu70	1	60.3 a	4	38.1 b	8	44.0 a	3	49.1 ab	4	44.3 b	7	44.1 b	3	46.65 b	4
1LB: 2Abu70		40.0 c	11	25.5 e	17	27.6 cde	11	32.2 ef	11	29.7 e	17	29.5 fg	11	30.75 g	11
C.V. %		8.82		6.43		10.05		9.06		7.13		7.91		8.29	

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

Table 6. Relative yield of cowpea (CP), black eyed bean (BB) and lablab bean(LB) grown in mixture with Sudan grass (SG), maize (MZ) and Abu70 during autumn, summer and winter seasons of 2014/2015 and 2015/2016.

Treatments	2014/15								2015/16			
	Autumn		Summer		Winter		Autumn		Summer		Winter	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	verall Mean	Rank	Mean	Rank
	Mean	Rank										
1CP : 1SG	0.92	5	1.00	4	0.97	7	0.90	6	1.00	7	0.90	7	0.93	7
1CP : 2SG	0.58	17	0.60	17	0.62	16	0.56	18	0.62	18	0.58	17	0.59	18
1BB : 1SG	0.89	8	1.04	1	0.95	8	0.89	7	1.07	1	0.88	9	0.94	6
1BB : 2SG	0.57	18	0.64	13	0.60	18	0.57	17	0.67	13	0.57	18	0.60	17
1LB : 1SG	1.02	2	1.02	2	1.04	3	1.02	2	1.05	2	0.94	3	1.02	2
1LB : 2SG	0.67	11	0.63	14	0.69	12	0.67	11	0.64	16	0.68	11	0.67	11
1CP : 1MZ	0.91	6	0.96	8	1.00	4	0.88	8	0.99	8	0.93	4	0.95	5
1CP : 2MZ	0.59	16	0.65	12	0.63	15	0.63	13	0.65	15	0.60	15	0.63	15
1BB :1MZ	0.90	7	0.99	5	0.98	6	0.87	9	1.03	4	0.89	8	0.94	8
1BB :2MZ	0.61	15	0.62	15	0.61	17	0.60	16	0.68	12	0.59	16	0.62	16
1LB :1MZ	1.03	1	1.01	3	1.13	1	1.03	1	1.04	3	1.09	1	1.06	1
1LB :2MZ	0.68	10	0.72	10	0.72	11	0.68	10	0.73	10	0.69	10	0.70	10
1CP:1Abu70	0.93	4	0.95	9	0.99	5	1.01	3	0.95	9	0.92	5	0.96	4
1CP:2Abu70	0.64	13	0.66	11	0.64	14	0.62	14	0.66	14	0.61	14	0.65	13
1BB:1Abu70	0.88	9	0.98	6	0.93	9	0.91	5	1.01	6	0.91	6	0.93	9
1BB:2Abu70	0.62	14	0.61	16	0.73	10	0.61	15	0.63	17	0.62	13	0.64	14
1LB:1Abu70	0.99	3	0.97	7	1.09	2	0.99	4	1.02	5	0.99	2	1.00	3
1LB:2Abu70	0.66	12	0.59	18	0.68	13	0.65	12	0.69	11	0.66	12	0.66	12

Table7. Land equivalent ratio (LER) for cowpea (CP), black eyed bean (BB), lablab bean (LB), Sudan grass (SG), maize (MZ) and Abu70, mixtures during winter, summer and autumn seasons of 2014/2015 and 2015/2016.

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

These results were in line with those of Raposo *et al*. (1995), working in intercropping of maize and beans in different plant arrangements and densities, who recorded high LER in intercrop involving 2:2 row arrangements than with monocrop. Fininsa (1997) reported that LER for intercrop was far above that of monocrop with maximal relative yield advantage of 28%.

CONCLUSION

The highest forage yield was obtained when the ratio 1:1 (30 kg seeds /ha for each legume and grass) for lablab bean and maize was used in autumn (62.5 and 51.1 t/ha for 2014 and 2015, respectively) and winter (45.8 and 45.5 t/ha for 2014 and 2015, respectively) and 1:1 for cowpea and Sudan grass in summer (48.6 and 56 t/ha for 2014 and 2015, respectively) was practiced.

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إنتاجية بعض الأعلاف البقولية ومخاليطها تحت ظروف الري في أواسط السودان

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

كلية العلوم الزراعية، جامعة الجزيرة، واد مدني، السودان

الخلاصة

نفذت هذه الدراسة خلال صيف، خريف وشتاء 2015/2014 و2016/2015 بالمزرعة التجريبية لكلية العلوم الزراعية، جامعة الجزيرة، السودان. تهدف هذه الدراسة لتقييم أثر الخلط علي إنتاجية المحاصيل البقولية المختارة وهي اللوبيا الحلو واللوبيا البيضاء واللوبيا العفن ومخاليطها مع المحاصيل النجيلية حشيشة السودان، أبوسبعين والذرة الشامية تحت ظروف الري في أواسط السودان. زرعت المحاصيل البقولية منفرده وفي مخاليط بنسبة 1 : 1 و 1 : 2. تم استخدام تصميم القطاعات العشوائية الكاملة بأربعة مكررات. الخلط أدى إلى زيادة معنوية لكل من وزن النبات الرطب، دليل مساحة الأوراق وإنتاجية العلف الأخضر خلال معظم المواسم بينما أدى الخلط إلى نقصان عدد الأفرع في مختلف المواسم. كانت قيم نسبة مكافئ الأرض في أغلب المواسم أعلى من الواحد الصحيح. بناءً على نتائج هذه الدراسة ولتحقيق إنتاجية أعلاف عالية نوصي بزراعة المحاصيل البقولية في مخاليط بنسبة خلط 30 كجم بذور/هكتار لوبيا عفن + 30 كجم بذور/هكتار ذرة شامية خلال فصلي الخريف والشتاء وبنسبة 30 كجم بذور/هكتار لوبيا حلو + 30 كجم بذور/هكتار حشيشة السودان خلال فصل الصيف.