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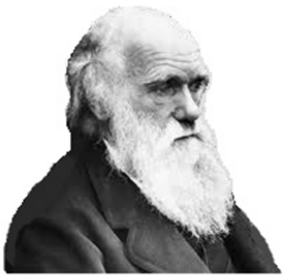

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Effect of mixing velvet bean (*Mucuna pruriens* (L.)) with selected some grasses on forage yield

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ABSTRACT

Velvet bean (*Mucuna pruriens* (L.)) can be used as food, feed (forage and seeds) and environmental services. Also, the plant can be a cover crop and green manure. Experiments was carried out during the seasons of 2017/18 and 2018/19 at the Experimental Farm of the Faculty of Agricultural Sciences, University of Gezira. Experiment aimed to investigate the effect of mixing of Abu 70, Sudan grass, Pioneer 988 and Sweet sorghum with velvet bean on forage yield. These crops were grown in pure stand and mixed in 1:1 and 1:2 ratios. The treatment combinations were arranged in a Randomized complete block design with three replications. Effect of mixing velvet bean with some grasses on forage yield showed that the fresh forage yield (ton/ha), relative yield and land equivalent ratio was highly significantly. The highest fresh forage yield (37.23 ton/ha) was recorded by velvet bean when mixed with Sudan grass (20 kg seeds /ha velvet been + 40 kg seeds /ha Sudan grass (1:2)). In mono culture the highest fresh forage yield was recorded by Pioneer 988, followed by Sudan grass. Depending on the results of this study, it could be recommended that to obtain high forage mixing with Sudan grass should be adopted.

***Keywords*:** Velvet bean, sowing date, plant spacing and yield

1. INTRODUCTION

Velvet bean (*Mucuna pruriens* (L.) belongs to the legume family Fabaceae, which is the third largest among flowering plants consisting of approximately 650 genera and 20,000 species

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[1]. Fabaceaeis the second most important plant source of human and animal nutrition [2]. Velvet bean originated from southern Asia and Malaysia and is now widely distributed in the tropics [3]. It requires a hot moist climate with annual rainfall ranging from 650 to 2500 mm and a long frost-free growing season during the wet months. It can grow on a wide range of soils, from sands to clays, but thrives on well-drained, light textured soils of appreciable acidity [3 and 4]. It is annual or sometimes short-lived perennial. Velvet bean can be used as food, feed (forage and seeds) and environmental services. Also, the plant can be a cover crop and green manure. It is a valuable fodder and feed legume. Vines and foliage can be used as pasture, hay or silage for ruminants, while pods and seeds can be ground into a meal and fed to both ruminants and monogastrics [5 and 6]. The crop gives reliable yields in dry farming and low soil fertility conditions that do not allow the profitable cultivation of most other food legumes [7]. Yields of green fodder may be up to 10-35 t/ha resulting in 8.2-16.4 t DM/ha and yields of hay average 2.8-3.6 t/ha [8].

Velvet bean hay has been successfully substituted for dairy concentrates in Zimbabwe without decline in milk yield or quality and has been recommended for this purpose [9]. Velvet bean is suitable in intercropping systems, where it is grown with maize [10], pearl millet, sorghum or sugarcane for support [11]. The use of velvet bean is relatively limited because of presence of a range of anti-nutritive substances. Despite the presence of anti-nutritional compounds however, there is evidence that velvet bean grains can be fed to ruminant animals as a supplement without apparent problems.

The main idea of mixed cropping is to get improved productivity per unit land area and time, and also impartial and judicious exploitation of land resources and farming inputs including labour. Most studies on intercropping focused on productive and sustainable system, i.e. on the legume-cereal intercropping [12]. [13] evaluate the effects of maize-legume cropping systems on forage, maize grain yield and gross margins. Results showed that Maize-mucuna (4134 kg ha^{-1}) and maize-cowpea (3999 kg ha^{-1}) intercrop systems significantly increased forage yield compared to Conservation agriculture sole maize (3 646 kg ha^{-1}) and continuous sole maize (3 076 kg ha^{-1}). [14] investigated field trials were conducted with lablab (*Lablab purpureus* L.), pigeon pea (*Cajanus cajan* L.) and cowpea (*Vigna unguiculata*), grown with sorghum as mixed 1:1 (sorghum: legumes) and 2:2 (sorghum: legumes) rows. Cowpea and lablab are potential intercrops for improving sorghum mixtures and the nutritive value of the silage. Also, the results suggested that sorghum planted at normal populations with paired rows of lablab or cowpea can improve sorghum–legume intercrop productivity.

In Sudan, there is always scarcity in forage at the end of winter and during the summer seasons. At the same time there is a high need for feed during this time of the year. Hence there is a need to bridge this feed gap. Velvet bean eventuality stands as a promising option, but information about it is limited. The main objective of these study is to determine the effect of the mixing ratio of Abu 70, Sudan grass, pioneer 88 and Sweet sorghum with velvet bean that gave the highest forage yield.

2. MATERIALS AND METHODS

2. 1. Experimental site

The experiments was conducted at the experimental farm of the Faculty of Agricultural Sciences, University of Gezira, which is located at an altitude of 405 m+MSL (mean sea level),

latitude 14.4° N and longitude 33 5° E in Wad Medani in Central Sudan, during the summer seasons of 2017/18 and 2018/19. The soils are predominantly typical vertisols that expand and shrink markedly with changes in moisture content and develop deep vertical drying cracks. These soils developed from deposits carried by the Blue Nile from the Ethiopian Highlands. Clay content may reach 60% or more throughout the soil profile. The content of organic carbon and nitrogen is very low [15 and 16].

Experiment

The study was carried out during the autumn season of 2018/19 and 2019/20 to investigate the effect of mixing Abu 70 (*Sorghum bicolor*), Sudan grass (*Sorghum sudanense*), pioneer988 and Sweet sorghum with velvet bean (*Mucuna pruriens* (L.)) on forage yield. These crops were grown in pure stand and mixed in 1: 1 and 1: 2 ratios. Seed rate of 60 kg/ha was used for the pure stand of Sudan grass, Sweet sorghum, pioneer and abu70 and their mixtures with velvet bean.

Treatments

The experiment comprised of thirteen treatments as follow:

T1 = 30Kg velvet bean + 30 Kg sweet sorghum (1:1).

T2 = 20 Kg velvet bean + 40 Kg sweet sorghum (1:2).

T3 = 30 Kg velvet bean + 30Kg Sudan grass (1:1).

T4 = 2 0Kg velvet bean + 40Kg Sudan grass (1:2).

T5 = 30 Kg velvet bean + 30Kg pioneer 988 (1:1).

T6 = 20 Kg velvet bean + 40 Kg pioneer 988 (1:2).

T7 = 30 Kg velvet bean + 30 Kg Abu sabeen (1:1).

T8 = 20 Kg velvet bean + 40 Kg Abu sabeen (1:2).

T9 = sole velvet bean.

T10 = sole sweet sorghum.

T11 = sole Sudan grass.

T12 = sole pioneer988.

T13 = sole Abu sabeen.

Cultural practices

The experimental site was disc ploughed, harrowed, leveled and ridged into 80 cm apart after broadcasting of the seeds on flat. The plot size was 5m×4m. In the first and second seasons, the sowing date was done on the 23th and 25th July, respectively. The experiment was irrigated immediately after sowing, then every 7-10 days intervals according to the crop need. The treatment combinations were arranged in a Randomized Complete Block Design (RCBD) with three replications. The experiment was harvested at Abu 70 milk stage. The harvested area was two meter long from the middle of the ridge in plot (3.2 m^2).

Data collection

1. **Total fresh forage yield (ton/ha):** Fresh forage yield was immediately weighed in the field in kg/m^2 and then converted to tons/hectare.

2. **Relative yield (RY):** The RY was determined as the mixture yield of each crop divided by its monoculture yield.

$$RY = \frac{\text{Yield of the crop in the mixture}}{\text{Yield of the sole crop}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

3. **Land equivalent ratio (LER):** The LER was determined as the sum of the relative yield for the crop included in the mixture.

$$LER = RY1 + RY2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Statistical Analysis

Statistical analysis was done using Gen Stat software and Least significant differences (LSD) was used to show the significance differences between means.

3. RESULTS AND DISCUSSION

Fresh forage yield (ton/ha)

The effect of mixing of velvet bean with some grasses on fresh forage yield is shown in Table (1). The analysis of variance procedure depicted clearly that fresh forage yield was highly significant affected by mixing in both seasons. Generally, the fresh forage yield of grasses was better in mono culture than in mixing, this is due to twining velvet bean and shading. In contrary, the fresh forage yield of velvet bean was better in mixing than in mono culture. Concerning the mixture, the highest fresh forage yield was recorded by the velvet bean when mixed with Sudan grass in 40 kg seeds /ha velvet bean + 20 kg seeds /ha Sudan grass (1:2) (43.47 and 27.88 ton ha^{-1} in the first and second seasons, respectively) followed by velvet bean when mixed with Sudan grass in 30 kg seeds /ha velvet bean + 30 kg seeds /ha Sudan grass (1:1) (41.65 and 26.51 ton ha^{-1} in the first and second seasons, respectively). as a result of nitrogen fixation by assossiated velvet bean that led to increased growth parameters of the plant which resulted increasing forage yield. These results were in agreement with the [17] who reported that the forage sorghum intercropped with forage legumes under different planting patterns recorded high values of forage in mixtures. Contrary, the lowest fresh forage yield was recorded by velvet bean when mixed with Abu 70 in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Abu 70 (1:2) (21.68 and 15.04 ton ha^{-1} in the first and second seasons, respectively). On the other hand, in mono culture the highest fresh forage yield was recorded by Pioneer 988 (41.44 and 24.74 ton ha^{-1} in the first and second seasons, respectively).

The combined effect of mixing of velvet bean in mono culture and in mixture with some grasses on fresh forage yield was highly significant. Concerning the mixture, the highest fresh forage yield was recorded by velvet bean when mixed with Sudan grass in 20 kg seeds /ha velvet been + 40 kg seeds /ha Sudan grass (1:2) (35.47 ton ha^{-1}), followed by velvet bean when mixed

with Sudan grass in 30 kg seeds /ha velvet bean + 30 kg seeds /ha Sudan grass (1:1) (34.08 ton ha^{-1}). Contrary, the lowest fresh forage yield was recorded by the velvet bean when mixed with Abu 70 in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Abu 70 (1:2) (18.36 ton ha^{-1}). On the other hand, in mono culture the highest fresh forage yield was recorded by Pioneer (33.09 ton ha^{-1}), followed by Sudan grass (29.03 ton ha^{-1}). These results are in agreement with [18] found that Sudan grass in mixture gave high fresh forage yield. In contrast with [13] who evaluated the effects of maize-legume cropping systems on forage. Results showed that Maize-mucuna intercrop systems significantly increased forage yield compared to conservation agriculture sole maize.

Table 1. Effect of mixing of velvet bean (VB) in mono culture and in mixture with sweet sorghum (SS), Sudan grass (SG), pioneer988 (PIO) and Abu sabeen (Abu70) on fresh forage yield (ton ha^{-1}) grown during the summer season of 2018/19 and 2019/20

Treatments	Fresh Forage Yield (ton ha^{-1})					
	Season 2018/19	Rank	Season 2019/20	Rank	Combined	Rank
1VB:1 SS	35.98	7	19.69	5	27.84	7
1VB: 2SS	31.54	10	17.05	11	24.30	10
1VB: 1SG	41.65	2	26.51	2	34.08	2
1VB:2SG	43.47	1	27.88	1	35.47	1
1VB:1 PIO	36.68	6	19.61	6	28.14	5
1VB: 2PIO	26.29	11	17.58	9	21.93	11
1VB:1 Abu	34.58	9	20.22	4	27.40	8
1VB:2 Abu	21.68	12	15.04	12	18.36	12
Mono VB	20.35	13	8.29	13	14.12	13
Mono SS	38.30	5	17.57	10	27.94	6
Mono SG	38.52	4	19.55	7	29.03	4
Mono PIO	41.44	3	24.74	3	33.09	3
Mono Abu 70	34.62	8	19.27	8	26.95	9
Sig. level	***		***		***	
SE±	2.915		1.018		1.754	
C.V. (%)	14.5		9.1		16.0	

Relative yield of Sorghum (RYS)

The effect of mixing of velvet bean with some grasses on relative yield (RY) of sorghum is shown in Table (2). The analysis of variance procedure depicted clearly that relative yield was significantly affected by mixing in both seasons. Generally, the relative yield of velvet bean with Sudan grass (1:2 and 1:1) was better than in the other forage mixing. Concerning the mixture, the highest relative yield was recorded by the velvet bean when mixed with sudan grass in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Sudan grass (1:2) (1.2 and 1.32 in the first and second seasons, respectively), followed by the velvet bean when mixed with Sudan grass in 30 kg seeds /ha velvet bean + 30 kg seeds /ha Sudan grass (1:1) (1.15 and 1.20 in the first and second seasons, respectively). These results (RY>1) means that the mixture yield was higher than the mono-culture yield which indicated clearly the advantage of mixtures over mono-culture. Also, [18] found that sudan grass in mixture gave high relative yield. Contrary, the lowest relative yield was recorded by velvet bean when mixed with Abu 70 in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Abu 70 (1:2) (0.58 and 0.76 in the first and second seasons, respectively).

The combined effect of mixing of velvet bean in mixture with some grasses on relative yield was highly significant. Concerning the mixture, the highest relative yield was recorded by velvet bean when mixed with Sudan grass in 20 kg seeds /ha velvet been + 40 kg seeds /ha Sudan grass (1:2) (1.26), followed by velvet bean when mixed with Sudan grass in 30 kg seeds /ha velvet bean + 30 kg seeds /ha Sudan grass (1:1) (1.18). Contrary, the lowest relative yield was recorded by the velvet bean when mixed with Abu 70 in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Abu 70 (1:2) (0.67). RY values of <1 in mixtures (except in Mucuna – sudan grass mixture) meant that there was no advantage in intercropping the component crops.

Table 2. Effect of mixing of velvet bean (VB) with sweet sorghum (SS), sudan grass (SG), pioneer988 (PIO) and Abu sabeen (Abu70) on relative yield (RY) of sorghum during the summer season of 2018/19 and 2019/20.

Treatments	Relative Yield Sorghum (RYS)					
	Season 2018/19	Rank	Season 2019/20	Rank	Combined	Rank
1VB:1 SS	0.92	4	0.96	3	0.94	3
1VB: 2SS	0.83	6	0.95	4	0.89	6
1VB: 1SG	1.15	2	1.20	2	1.18	2
1VB:2 SG	1.20	1	1.32	1	1.26	1
1VB:1 PIO	0.93	3	0.88	6	0.90	4
1VB: 2PIO	0.62	7	0.79	7	0.71	7
1VB:1 Abu70	0.88	5	0.91	5	0.90	5
1VB:2 Abu70	0.58	8	0.76	8	0.67	8

Sig. L	**	*	***
SE±	0.053	0.098	0.057
C.V. (%)	10.4	17.5	14.9

Relative yield of Velvet bean (RYVB)

The effect of mixing of velvet bean with some grasses on relative yield (RY) of velvet bean is shown in Table (3). The analysis of variance procedure showed clearly that relative yield was highly significant affected by mixing in both seasons. Generally, the relative yield of velvet bean with Sudan grass (1:2 and 1:1) was better than the other forage mixing. Concerning the mixture, the highest relative yield was recorded by the velvet bean when mixed with sudan grass in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Sudan grass (1:2) (0.283 and 0.255 in the first and second seasons, respectively), followed by velvet bean when mixed with Sudan grass in 30 kg seeds /ha velvet bean + 30 kg seeds /ha Sudan grass (1:1) (0.280 and 0.172 in the first and second seasons, respectively). In contrary, the lowest relative yield was recorded by the velvet bean when mixed with Abu 70 in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Abu 70 (1:2) (0.12 and 0.045 in the first and second seasons, respectively). Also, [18] found that Abu70 and Lablab in mixture gave lowest relative yield.

The combined effect of mixing of velvet bean in mixture with some grasses on relative yield of velvet bean was highly significant. Regarding the mixture, the highest relative yield was recorded by the velvet bean when mixed with Sudan grass in 20 kg seeds /ha velvet been + 40 kg seeds /ha Sudan grass (1:2) (0.27), followed by velvet bean when mixed with Sudan grass in 30 kg seeds /ha velvet bean + 30 kg seeds /ha Sudan grass (1:1) (0.23). Contrary, the lowest relative yield was recorded by the velvet bean when mixed with Abu 70 in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Abu 70 (1:2) (0.08). RY values of <1 in mixtures (except in Mucuna – sudan grass mixture) meant that there was no advantage in intercropping the component crops. The relative yield values wireless than one, which indicated that the mixture yield was lower than the mono-culture yield. It may be due to insufficient light and competition by grasses and high rain fall.

Table 3. Effect of mixing of velvet bean (VB) with sweet sorghum (SS), sudan grass (SG), pioneer 988 (PIO) and Abu sabeen (Abu70) on relative yield (RY) of velvet bean during the summer season of 2018/19 and 2019/20.

Treatments	Relative Yield Velvet Bean (RYVB)					
	Season 2018/19	Rank	Season 2019/20	Rank	Combine	Rank
1VB:1 SS	0.223	4	0.152	5	0.19	4
1VB: 2SS	0.143	6	0.123	6	0.13	6

1VB: 1SG	0.280	2	0.172	2	0.23	2
1VB:2 SG	0.283	1	0.255	1	0.27	1
1VB:1 PIO	0.243	3	0.168	3	0.21	3
1VB: 2PIO	0.140	7	0.085	7	0.11	7
1VB:1 Abu70	0.180	5	0.154	4	0.17	5
1VB:2 Abu70	0.120	8	0.045	8	0.08	8
Sig. L	***		***		***	
SE±	0.016		0.013		0.010	
C.V. (%)	13.3		15.5		14.4	

Land equivalent ratio (LER)

The effect of mixing on land equivalent ratio of velvet bean was highly significant (Table 4). The highest land equivalent ratio was obtained by the velvet bean when mixed with Sudan grass in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Sudan grass (1:2) (1.49 and 1.58), followed by the velvet bean when mixed with Sudan grass in 30 kg seeds /ha velvet bean + 30 kg seeds /ha Sudan grass (1:1) (1.43 and 1.37) in the first and second seasons, respectively).

This results (LER>1) means that the mixture forage yield was higher than the mono-culture yield which indicated clearly the advantage of mixtures over mono-culture. These results in line with the findings of [18] who found that Sudan grass with cowpea mixture gave the highest land equivalent ratio.

On the other hand, the lowest land equivalent ratio was obtained by the velvet bean when mixed with Abu sabeen (Abu70) in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Abu 70 (1:2) (0.70 and 0.81 in the first and second seasons, respectively). These results in line with the findings of [18] who found that Abu70 with black eyed bean mixture gave the lowest land equivalent ratio.

The combined effect of mixing of velvet bean in mixture with some grasses on land equivalent ratio was highly significant. Concerning the mixture, the highest LER was recorded by velvet bean when mixed with Sudan grass in 20 kg seeds /ha velvet been + 40 kg seeds /ha Sudan grass (1:2) (1.53), followed by velvet bean when mixed with Sudan grass in 30 kg seeds /ha velvet bean + 30 kg seeds /ha Sudan grass (1:1) (1.40). In contrary, the lowest LER was recorded by the velvet bean when mixed with Abu 70 in 20 kg seeds /ha velvet bean + 40 kg seeds /ha Abu 70 (1:2) (0.75).

These results are in conformity with the [19] Alemayehu *et al* (2018) who reported that maize/common bean intercropping could increase incomes obtained by smallholder farmers, through enhancing efficient utilization of land.

Table 4. Effect of mixing of velvet bean (VB) with sweet sorghum (SS), sudan grass (SG), pioneer (PIO) and Abu sabeen (Abu70) on land equivalent ratio (LER) of velvet bean grown during the summer season of 2018/19 and 2019/20.

Treatments	Land Equivalent Ratio (LER)					
	Season 2018/19	Rank	Season 2019/20	Rank	Combine	Rank
1VB:1 SS	1.15	4	1.10	4	1.13	4
1VB: 2SS	0.98	6	1.05	5	1.02	6
1VB: 1SG	1.43	2	1.37	2	1.40	2
1VB:2 SG	1.49	1	1.58	1	1.53	1
1VB:1 PIO	1.18	3	1.04	6	1.18	3
1VB: 2PIO	0.76	7	0.88	7	0.82	7
1VB:1 Abu	1.06	5	1.12	3	1.09	5
1VB:2 Abu	0.70	8	0.81	8	0.75	8
Sig. L	***		***		***	
SE±	0.178		0.107		0.064	
C.V. (%)	9.2		16.5		14.0	

4. CONCLUSION AND RECOMMENDATION

All grasses (Abu 70, Sudan grass, pioneer and Sweet sorghum) gave higher forage yield in mono culture than in mixture. Highest forage yield in mixture was was produced by velvet bean + Sudan grass in 2:1 ratio. Highest LER produced by velvet bean + Sudan grass in 2:1 ratio.

Based on the experimental results obtained from this study it could be recommended that: When mixing velvet bean for forage, Sudan grass, should be used with a seed rate of 40 kg/ha and 20 kg/ha for velvet bean. Velvet bean and Grass velvet bean mixtures need further research to fill the gaps in information about these forage in mixtures.

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