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Influence of cutting height and plant spacing on Sesbania (*Sesbania aegyptiaca* [Poir]) productivity under hyper-arid conditions in El-kharga Oasis, El-Wadi El-Gaded, Egypt

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Abstract

Search for an adapted forage species for feed production under existing marginal lands and harsh conditions is needed to overcome sever feed shortage in Egypt. Sesbania, *Sesbania aegyptiaca* (*Sesbania sesban*, L) has shown potential for forage production and being included in grazing systems, especially on marginal lands and salt–affected soils. An experiment was conducted in the summer of 2004 and 2005 under artesian irrigated water conditions where four cutting heights (10, 20, 30, and 40 cm above ground level) and three plant spacing (10, 20 and, 30 cm between plants) were investigated. The highest average accumulated fresh and dry forage yield obtained from cutting at 10 cm from ground surface whereas the 40 cm cutting level produced the lowest yield and no significant difference was observed between 20 and 30 cm cutting levels. Highest yield was obtained from second cutting. The CP% in forage harvested from 10 cm spacing was highest followed by 20 and 30 cm spacing, respectively. Forage from 1st cutting had the highest CP% followed by 2nd and 3rd cutting. The response of CF% in *Sesbania aegyptiaca* to cutting level and time was opposite to those of CP %.

Keywords: Sesbania; cutting level; Spacing; Crude protein and crude fiber.

Introduction

Search for an adapted forage species for feed production under existing marginal lands and harsh conditions is needed to overcome sever feed shortage in Egypt. *Sesbania aegyptiaca* (formerly *Sesbania sesban)* grows widely as a wild plant under Egyptian condition (Singh, 1990). Cultivation of *Sesbania aegyptiaca* in marginal soils can be considered as one effective solution to the feed crisis. Sesbania as fodder is one of the promising green forage under marginal lands including salt-affected soils (1997 and El-Nahrawy and Soliman, 1998). Several reports have considered Sesbania as a good quality feed for small ruminant (Reed et al., 1990 and Soliman, et al., 1997).

Sesbania aegyptiaca is a multi-branched, soft-wooded tree that grows rapidly and is useful for fodder and green manure. This species has long been used for browse and soil improvement in India and Africa. Recent interests in multipurpose, nitrogen fixing trees caused that this species to be collected, studied, and recommended for fodder "banks" and alley cropping (Dommergues, 1981).

S. aegyptiaca thrives under repeated cuttings and coppices readily with many branches arising from the main stem below cutting height. Cutting frequencies have generally been in the order of three or four cuts per annum but up to eight cuts per year have been reported in some areas (Gore and Joshi, 1976). Yields have ranged from 4 to 12 ton dry matter/ha/year depending upon location (Galang et al., 1990).

Sesbania sesban regrow rapidly after cutting or grazing. In south Asia and Africa it is widely used as forage in 'cut and carry' livestock -feeding systems. It has been reported to grow over a wide range of climatic and edaphic conditions (National Academy of Sciences, 1983). It tolerates extreme conditions including soil pH, water logging (Galang, 1988), and soil salinity up to 1.4% soil salt concentration (Hansen and Munns, 1985).

Cutting height can also influence yield in *S. sesban.* Mune Gowda and Krishnamurthy (1984) reported higher yields can be obtained at low cutting height of 50 cm. However, in southeast Queensland, cutting height of 100 cm for *S. sesban* var. *nubica produced* higher yields compared to cutting heights of 150 and 50 cm (Galang et al., 1990).

Topark-Ngrm and Gutteridge (1989) reported that the protein content of Sesbania foliage is often above 25%. Digestibility of Sesbania forage is more than 70% from dry matter in sheep and goats which makes it high quality forage as a ruminant feed (Singh et al., 1980; Onim et al., 1989).

The aim of the present study was to investigate yield performance of *Sesbania aegyptiaca* as affected by population density and cutting height under El-Kharga oasis, El-Wadi El-Gaded, Egypt condition.

Materials and Methods

Two field experiments were conducted during summer seasons of 2004 and 2005 at El-Wadi Al-Gaded, Egypt. (El-kharga Oasis, research station, Desert Research Center), 25º 27′ 22″ N and 30º 32′ 27″ E.

The soil of the experimental site was sandy clay loam (sand 51.00, Clay 30.45, and silt 18.15%) with the pH of 8.3. Artesian irrigation water analysis indicated that EC was1.3 mmohs with pH 7.6.

For this study the monthly average of maximum temperature in April, May, June, July and August were 34.7, 38.4, 39.3, 42.8, and 44.3 and minimum average temperature were 16.9, 21.2, 22.8, 23.9 and 26.1 °C, respectively.

Treatments were consisted of 4 cutting levels (10, 20, 30, and 40 cm above soil surface) and spacing rates (10, 20, and 30 cm) between plants while row width was kept constant at 15 cm. The experiment was laid out as factorial experiment in randomized complete block arrangement design with 5 replications. Plot size was 5×6 m (30 m^2). Collected data were analysed using M-STAT C, (Russell, Freed 1991). The differences among the means were performed by least significant difference (LSD) at 5% level.

Sesbania used in this experiment was *Sesbania aegyptiaca* (*Sesbania sesban*, L.). No fertilizer or manure was used in this experiment. Seeds were directly seeded in the soil. The experiments were laid out in April 3rd, in both growing seasons and three cuts were made, on May 30, July 15 and August 30. For each cut, plant height, fresh and dry weight, number of tillers per plant, crude protein and crude fiber were determined. Crude protein was measured by kjeldahl procedure (CP%= N%×6.25) and crude fiber was determined by acid detergent (AOAC, 1990).

Results and Discussion

The effects of the treatments on the studied characters of *Sesbania aegyptiaca* (*Sesbania sesban*, L) are presented in Table 1, and results of average accumulation fresh and dry forage yields are summarized in Table 2.

Table 1. Effect of cutting levels and spacing rate on growth and yield attributing parameters of Sesbania (pooled data of 2 seasons 2004 and 2005).

	Spacing rate (cm)											
	1st cut				2end cut				3rd cut			
Cut level (cm)	10	20	30	Ave.	10	20	30	Ave.	10	20	30	Ave.
Fresh Yield (t/ha)												
10	5.923	5.720	5.203	5.615	6.048	5.795	5.318	5.720	4.968	4.725	3.920	4.538
20	5.528	5.100	4.765	5.131	5.835	5.359	5.271	5.488	5.120	4.575	3.990	4.562
30	5.025	4.753	4.380	4.719	5.375	5.250	5.295	5.307	5.023	4.583	4.180	4.595
40	4.476	4.095	4.015	4.195	5.296	5.140	4.953	5.130	5.043	4.305	4.155	4.501
Ave.	5.238	4.917	4.591	4.915	5.638	5.386	5.209	5.411	5.038	4.547	4.061	4.549
$LSD_{0.05}$	Cut=0.206	Sp.=0.179		Int.= NS	Cut=0.187	Sp.=0.162		Int.= NS	Cut= NS	Sp.=0.372		Int.= NS
Dry Yield (t/ha)												
10	1.191	1.191	1.157	1.180	1.485	1.378	1.322	1.395	1.188	1.168	1.003	1.120
20	1.107	1.079	1.070	1.086	1.317	1.293	1.305	1.305	1.213	1.199	1.021	1.144
30	1.006	1.000	0.990	0.999	1.195	1.257	1.300	1.251	1.187	1.131	1.073	1.130
40	0.833	0.872	0.916	0.873	1.183	1.230	1.213	1.209	1.186	1.058	1.070	1.105
Ave.	1.034	1.035	1.033	1.034	1.295	1.289	1.285	1.290	1.194	1.139	1.042	1.125
$LSD_{0.05}$	Cut=0.059	Sp.= NS		Int.= NS	Cut=0.064	Sp.= NS		Int.= NS	Cut= NS	Sp.=0.102		Int.= NS
Plant Height (Cm)												
10	113.7	108.2	102.5	108.1	111.2	107.2	101.2	106.5	110.6	104.2	97.9	104.2
20	113.9	108.0	100.1	107.3	113.9	105.3	102.1	107.1	109.8	104.4	98.6	104.3
30	111.0	108.6	104.1	107.9	117.3	105.3	104.6	109.1	106.4	106.4	102.9	105.2
40	109.4	105.9	103.0	106.1	119.3	113.2	100.6	111.1	109.0	106.0	102.2	105.7
Ave.	112.0	107.7	102.4	107.5	115.4	107.8	102.1	108.5	109.0	105.3	100.4	104.9
$LSD_{0.05}$	Cut=NS	Sp.= 4.35		Int.= NS	Cut=3.08	Sp.= 2.671		Int.= NS	Cut= NS	Sp.= 2.57		Int.= NS
Branches No.												
10	8.83	8.33	10.33	9.17	7.33	10.83	13.33	10.50	10.17	15.33	22.83	16.11
20	6.83	9.50	10.00	8.61	9.67	12.83	14.67	12.39	12.83	18.17	26.00	19.00
30	6.83	9.17	9.83	8.61	10.50	13.83	16.83	13.72	13.33	18.67	27.50	19.83
40	7.50	9.17	9.83	8.83	11.00	13.17	18.67	14.28	13.00	20.67	29.19	20.94
Ave.	7.38	9.04	10.00	8.80	9.63	12.67	15.88	12.72	12.33	18.21	26.38	18.97
$LSD_{0.05}$	Cut=NS	Sp.= 1.19		Int.= NS	Cut=1.53	Sp.= 1.32		Int.= NS	Cut=1.784	Sp.= 1.55		Int.= NS
Crude Protein %												
10	23.63	23.73	22.50	23.26	19.83	18.18	19.23	19.08	18.87	18.33	17.80	18.33
20	23.50	23.30	23.00	23.28	20.07	19.12	18.37	19.19	19.20	18.03	17.73	18.32
30	24.06	23.26	22.57	23.30	20.40	19.65	19.07	19.71	19.07	18.40	18.00	18.49
40	23.80	23.90	22.93	23.54	20.70	19.87	18.87	19.81	19.13	18.50	18.17	18.60
Ave.	23.75	23.55	22.75	23.35	20.25	19.21	18.89	19.45	19.07	18.32	17.93	18.44
$LSD_{0.05}$	Cut=NS	Sp.= 1.020		Int.= NS	Cut= NS	Sp.= 0.645		Int.= NS	Cut= NS	Sp.=0.345		Int.= NS
Crude Fiber %												
10	20.77	21.78	23.80	22.12	22.32	24.45	25.83	24.20	25.30	26.35	27.28	26.31
20	20.87	21.95	23.72	22.18	22.35	24.27	25.65	24.09	25.17	26.55	27.22	26.31
30	20.76	21.98	23.97	22.24	22.48	24.30	25.45	24.08	25.41	26.30	27.20	26.30
40	20.98	22.05	23.73	22.26	22.18	24.25	25.43	23.95	25.43	26.22	27.00	26.22
Ave.	20.85	21.94	23.81	22.20	22.33	24.32	25.59	24.08	25.33	26.35	27.18	26.29
$LSD_{0.05}$	Cut=NS	Sp.= 0.601		Int.= NS	Cut= NS	Sp.= 0.407		Int.= NS	Cut=NS	Sp.=0.350		Int.= NS

Int. = interaction Sp. = spacing

Table 2. Accumulated fresh and dry forage yield for *Sesbania aegyptiaca* (Average of 2004 and 2005).

	spacing rate (cm)							
Cut level	Fresh yield				Dry yield			
(cm)	10	20	30	Ave.	10	20	30	Ave.
10	16.804	16.240	14.440	15.828	3.851	3.737	3.482	3.690
20	16.470	15.091	14.026	15.196	3.660	3.472	3.395	3.509
30	15.435	14.608	13.855	14.633	3.363	3.329	3.363	3.352
40	14.815	13.553	13.123	13.830	3.677	3.161	3.199	3.346
Ave.	15.881	14.873	13.861	14.872	3.638	3.425	3.360	3.482
$LSD_{0.05}$	Cut=0.574	Sp.=0.497		Int.=NS	Cut=0.208	Sp.=0.180		Int.=NS

Int. = interaction Sp. = spacing

Fresh yield

The effect of cutting level and plant spacing on the fresh yield of Sesbania (*Sesbania aegyptiaca)* is presented in Table 1. In each cut, the maximum fresh yield was obtained from 10 cm spacing followed by 20 and 30 cm averaged over two growing seasons. The result is due to the increased plant density in lower spacing. Yield improvement associated with low spacing has been reported in other crops (Widdicombe and Thelen, 2002, Shapiro and Wortmann, 2006 and Biabani et al., 2008). Sesbania produces finer branches which are considered better forage quality with increasing planting density. Therefore, unlike many agronomic crops that soon reach a yield platue with increasing planting density, Sesbania yield improves both quantitatively as well as qualitatively when it is planted densely.

Effect of cutting heights on fresh yield was significant only in the first and second cut. Cutting at 10 cm above the ground level produced the highest green yield followed by the 20 cm cutting The positive response to lower cutting levels is because meristematic region in this perennial shrub is located at soil level which can grow rapidly into new tissues once being harvested.

The lowest fresh yield was found in the 3rd cut (4.549 ton /ha) while the second cut had the highest yield (5.411 t/ha). The low yield of 3rd cut can be attributed to adverse climatic condition where the average temperature in this cutting period was 42.8 ^{0}C and 44.3 ^{0}C in July and August, respectively.

The interaction effect between the cutting level and plant spacing on fresh yield was not significant in all cuts as well as average total accumulation yield (Table 1).

Dry yield

Plant spacing effect on dry yield data is presented in Table 1. No significant differences were found among plant spacing in the 1st and 2nd cuts while yield difference appeared in the 3rd cuts only. In terms of accumulation dry yield, spacing of 10 cm between plants out yielded the spacing of 20 and 30 cm. The second cut produced the highest average yield (1.290 ton ha^{-1}).

Effect of cutting levels on dry yield showed the same trend as for of green yield, where significant effect was found only within in the 1st and 2nd cuts. This might be due to the fact that Sesbania plants were succulent in the early stage of growth, while in the 3rd cut harsh environmental condition and probably frequent cuttings had a significant impact on yield reduction Whiteman and Lulham (1970) suggested that the severe check in growth caused by frequent cutting results in mobilization of sugars and amino acids from the roots to support development of new leaves, thus severely suppressing root and nodule formation, and further limiting the production of subsequent foliage.

Karim et al., 1991 found that the average dry matter yields of the trees cut at monthly intervals were not significantly affected by cutting height. Where as, at the three-monthly interval, the 75 cm cutting height was significantly superior compared to 25 and 50 cm, while 100 cm was only significantly better than the 25 cm cutting height.

Seid et al., 2005 found that the alfalfa harvesting at 5 or 10 cm produced more herbage than those harvested at 15 and 20 cm.

Heering, (1995) studied the effect of cutting height of six *Sesbania sesban* accessions and stated that most accessions reached their maximum production before or at the second regrowth and dry matter yields decrease rapidly thereafter.

Plant height

Table 1 indicates that the plant height of *Sesbania* was significantly decreased with increased plant spacing in all cuts in both years. The closer spacing between plants caused comparatively lesser availability of space around the plants for lateral development therefore, forced plants to grow vertically (Patel, et al., 1980). Raper and Kramer (1987) mentioned that longer plants may develop in widely spaced because closer spacing within the row resulted in partial shading at earlier growth stages, which can change the light quality in the canopy. The decrease in plant height of sesbania due to the increase in plant spacing obtained in this study was earlier reported on guar (*Cyamopsis tetrgoudobe*) (El-Labban et al., 1991)

Cutting level showed no significant effect on plant height and the interaction between cut level and plant spacing was not significant.

Number of tillers

Effect of spacing on the number of tillers is presented in Table 1. Frequent forage harvests significantly encouraged the tiller capacity of Sesbania where the clipping treatments produced 8.8, 12.72, and 18.97 tillers in the first, 2^{nd} and 3^{rd} cuts, respectively.

Tiller number was significantly increased as space between plants was increased. Plants which were 30 cm apart had highest tiller number while the 10 cm planting space produced the least number of tillers.

The effect of cutting levels on tiller number was not significant in the 1^{st} and 3^{rd} cuts, while in 2^{nd} cut the difference among cutting levels was significant. In general, as plants were cut at higher level more tillers were produced. This seems very logic since there will be more food reserve (less competition) available for tiller production. Abd El-Satter (1996) reported that successive cutting encouraged the tillering capacity of Lecucaena plants irrespective of the clipping treatments, where the number of tillers increased from about 2 to 5 tillers plants^{-1}. Also, within each cut, more tillers were obtained with cutting to 50 cm above the ground, followed by clipping at 25 cm.

Crude protein percentage

Crude protein percentage (CP %) of *Sesbania* plants (as percentage of dry matter) is shown in Table 1. It seamed that CP% decreased with delayed cuttings.

The highest CP% was detected in the 1st cut with 23.35% followed by 2nd and 3rd cuts which had 19.45% and 18.44% respectively. As spacing between plants decreased and therefore population density increased CP% elevated. The improvements of CP % in Sesbania were found significant in all cuts of both years. The highest value of CP % (23.54) was obtained in 1st cut at 10 cm level

The importance of CP% in higher planting densities can be attributed to higher leaf ratio associated with lower plant spacing. Similarly Ella (1988) reported that, for *Leucaena, Gliricidia, Calliandra* and *Sesbania*, leaf yield per unit area increased with increasing planting density. In other words, when high leaf yield is targeted for fodder production, high planting densities are recommended.

Crude fiber percentage

The crude fiber percentage (CF %) of *Sesbania* showed an opposite response to cuttings compared to CP %. The highest value of CF% observed at the 3rd cut (26.29 %) while, CF% for 1st cut was 22.20 %.

Also, increase of CF % was found as spacing between plants increased. The highest CF% obtained from 30 cm spacing followed by 20 and 10 cm. respectively. The effect of spacing on the CF % was significant for all cuts. Maximum CF value (27.18 %) was found in the 3rd cut with 30 cm spacing.

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