FORAGE AND SEED YIELDS, MORTALITY AND NUTRITIVE VALUE OF *SESBANIA SESBAN* UNDER UNIMODAL RAINFALL IN TANZANIA

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KARACHI, M. & MATATA, Z. 2000. Forage and seed yields, mortality and nutritive value of *Sesbania sesban* under unimodal rainfall in Tanzania. Fifteen *Sesbania sesban* accessions were assessed for edible forage and seed production, plant survival and fodder nutritive value over a three-year period. Plants were cut at six months to estimate edible yield while seed was harvested for up to eight months from undisturbed growth, and plant survival was assessed from both cut and intact plants at ten months from transplanting. Considerable differences were recorded in all parameters examined. Edible yields varied from 0.2 to 2.0 t ha^{-1} with a major decline in production when rainfall was < 450 mm. Seed production varied from 7 to 483 kg ha^{-1} and was least affected by moisture stress. Plant mortality ranged 25–95% (cut) and 28–82% (intact) in 1991, and 28–73% (cut) and 17–68% (intact) in 1993 when rainfall was > 700 mm; and 71–100% (cut) and 62–96% (intact) when rainfall was <450 mm in 1992. The nutrient contents in the forage ranged as follows: nitrogen 2.2–3.0%, phosphorus 0.15–0.20%, potassium 0.9–1.9%, calcium 1.0–1.4% and magnesium 0.2–0.4% in the dry matter. It was concluded that all nutrients except phosphorus were adequate for ruminant animal production and that inadequate moisture was one of the major factors that limited edible forage production.

Key words: *Sesbania sesbans* - fodder - seed production - survival rate - nutrient content - agroforestry

KARACHI, M. & MATATA, Z. 2000. Hasil makanan ternakan dan biji benih, kematian dan nilai khasiat makanan *Sesbania sesban* di bawah hujan unimod di Tanzania. Perolehan lima belas *Sesbania sesban* untuk makanan, ternakan dan pengeluaran biji benih, kemandirian pokok dan nilai khasiat makanan bagi tempoh tiga tahun ditaksirkan. Pokok ditebang pada usia enam bulan untuk menganggarkan hasil yang boleh dimakan manakala biji benih dituai sehingga usia lapan bulan daripada

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pertumbuhan yang tidak rosak, dan kemandirian pokok ditaksirkan daripada kedua-dua pokok yang ditebang dan pokok yang tidak ditebang pada usia sepuluh bulan daripada pindah tanam. Perbezaan yang besar dicatatkan dalam kesemua parameter yang diperiksa. Hasil bagi makanan ternakan berubah-ubah daripada 0.2 kepada 2.0 t ha^{-1} dengan pengurangan yang besar dalam pengeluaran apabila hujan <450 mm. Pengeluaran biji benih berubah-ubah daripada 7 hingga 483 kg ha^{-1} dan paling kurang dipengaruhi oleh tekanan lembapan. Kematian pokok berjulat antara 25 hingga 95% (pokok yang ditebang) dan 28–82% (pokok yang tidak ditebang) pada tahun 1991, dan 28–73% (pokok yang ditebang) dan 17–68% (pokok yang tidak ditebang) pada tahun 1993 apabila hujan <700 mm; dan 71–100% (pokok yang ditebang) dan 62–96% (pokok yang tidak ditebang) apabila hujan adalah <450 mm pada tahun 1992. Kandungan nutrien dalam makanan ternakan berjulat seperti yang berikut: nitrogen 2.2–3.0%, fosforus 0.15–0.20%, kalium 0.9–1.9%, kalsium 1.0–1.4% dan magnesium 0.2–0.4% dalam bahan kering. Kesimpulannya kesemua nutrien kecuali fosforus mencukupi untuk pengeluaran haiwan ruminan dan kekurangan kelembapan merupakan salah satu faktor utama yang mengehadkan pengeluaran makanan ternakan.

Introduction

Sesbania species are fast-growing multi-purpose trees/shrubs with potential to provide fodder, wood and improve soil fertility (NAS 1979, Evans & Rotar 1987a, Jama *et al.* 1989, Tothill *et al.* 1989). Because of these attributes extensive germplasm collections and research efforts have been directed towards understanding their production capabilities and limitations (Otieno *et al.* 1987, ICRAF-NFTA 1989, Mengistu 1990, Kategile & Adoutan 1993). The initial studies under unimodal rainfall conditions in Tanzania evaluated germplasm collected from bimodal rainfall regions in Kenya and Tanzania (Karachi *et al.* 1989). Evaluation of this material revealed a wide variation in yield, coppicibility and survival rates after cutting, indicating that there was a possibility to select for high yields and persistence. This was in contrast to the behaviour of the sesbania species which are adapted to this environment and behave as annuals or biannuals unless when growing close to a permanent source of water.

Seed production characteristics are important in the evaluation and development of a new species. This is important for sesbania which is currently being promoted for use in agroforestry technologies in east and southern Africa (Cooper *et al.* 1996); yet no commercial supply of sesbania seeds exists. Heering (1995) reported that it was possible to produce substantial amounts of sesbania seed under irrigation. There is, however, limited documentation on the seed production potential of sesbania growing under unimodal rainfall conditions.

The experiments reported here investigated the forage and seed production, plant survival and forage nutritive value of *Sesbania sesban* accessions that were outstanding in yield in the multi-locational testing sites conducted by the African Feed Resource Network in the semi-arid and sub-humid regions of east and southern Africa (Kategile & Adoutan 1993).

Materials and methods

Site

The study was conducted at Tumbi-Tabora (5° 03 ' S, 32° 41' E; 1150 m above sea-level) in western Tanzania. The soil was a sandy loam (ferric acrisols - FAO) with a pH of 4.3 (1:1:25 soil : water), organic C, 0.4%, total N, 0.03% and extractable P (Bray 1), 10 ppm. The mean daily maximum and minimum temperatures for the area were approximately 28 °C and 16 °C respectively. The mean long-term rainfall averages 880 mm and is unimodal in distribution with 93% falling between November and April. Rainfall during the experimental period was 720, 442 and 770 mm in 1990/91, 1991/92 and 1992/93 respectively.

Procedures

The forage and seed production trials were established simultaneously in adjacent blocks of land each year. Seedlings (Table 1) that had been raised in polythene tubes in the nursery for six weeks were transplanted on 8 December 1990, 21 December 1991 and 17 December 1992 in randomised complete blocks with three replications. Seedlings were planted in 3 × 6.75 m plots in rows 1 m apart and 75 cm between plants with a single row of a local annual sesbania planted 1 m from the experimental material surrounding each block that served as the guard row. The plots were kept clean weeded.

Edible forage yields (leaf + stem < 5 mm diameter and pods) were estimated at six months from transplanting. Seven plants in each row, excluding one plant from each end of row, were cut back to 75 cm height and sorted into edible and wood (stem > 5 mm diameter) yields. Edible yield thereafter was estimated when regrowth attained 30 cm from the initial cutting height. Edible yield was weighed fresh in the field, then a representative sub-sample was oven dried at 75 °C for 48 h for dry matter (DM) determination. In 1992, another set of sub-samples were taken and oven dried at 35 °C to constant weight and hammer-milled to pass through a 1-mm screen for chemical analysis (AOAC 1984). The remaining plants, including the guard row, were cut back to the same height and material discarded.

Seed yields were estimated from seven undisturbed plants per row excluding one plant from each end of row. Pods were harvested as they ripened on weekly basis up to eight months from transplanting. After the last harvest, pods were bulked on basis of replicates, threshed and then seeds were sun-dried (about 27 °C) for 24 h and weighed. These plants remained uncut throughout the trial. The number of surviving plants was counted from the same plants as the above estimates ten months after transplanting and percentage survival calculated.

Results

Edible dry matter (EDM) yield

Yield differences ($p < 0.05$) occurred among some of the accessions (Table 1). Mean edible DM yield in 1991 varied from 0.2 to 2.0 t ha^{-1} whereas those in 1992 were generally reduced to less than half of those in 1991 and the variation between the accessions was less pronounced ($p < 0.05$). In 1993, the performance of the accessions was comparable to that in 1991. For the three years, accessions 15021 and T1 were consistently superior in yields while accessions 10521 and 10865 were the lowest yielding.

Table 1. Edible dry matter (DM) yields of *Sesbania sesban* accessions grown in a unimodal rainfall environment in Tanzania

Accession ILCA No.	DM yield (t ha^{-1})		
	1991	1992	1993
15021	2.0	0.7	1.8
15020	1.4	0.3	1.3
15077	1.4	0.2	1.5
15491	1.4	0.2	1.4
15036	1.3	0.5	1.4
15022	1.1	0.3	1.1
9043	0.8	0.4	1.5
13144	0.7	0.2	0.7
15019	0.6	0.2	0.4
13887	0.6	0.2	0.9
10639	0.4	0.2	0.4
15024	0.4	0.6	0.4
10521	0.2	0.2	0.3
10865	0.2	0.2	0.3
T1[a]	1.7	0.6	1.5
Mean	1.0	0.3	1.0
LSD ($p < 0.05$)	0.4	0.2	0.3

[a]Local land race.

Seed yield

There were large and significant ($p < 0.05$) variations in seed production among some of the accessions (Table 2). Seed yields varied from 7 to 483 kg ha^{-1} but there were no significant variations in mean yields between years although fluctuations in accession performances were observed. The highest yields were recorded from accessions 15021 and 15022 (early flowering entries) and the lowest from accessions 15077, 15019, 15491 and 10865 which also were those that initiated flowering late in the wet season.

Plant survival

Plant survival varied significantly ($p < 0.05$) among some accessions. Plant mortality ranged 25–95% (cut) and 28–82% (intact) in 1991, 71–100% (cut) and 62–96 % (intact) in 1992; and 28–73% (cut) and 17–68% (intact) in 1993; (Table 3). There were no consistent trends on the survival rates of individual accessions across years and treatments although a tendency for higher mean survival for undisturbed plants was recorded. Overall, the best mean survival rates (> 50%) were recorded for accessions 15036, 15021 and 15022 for both cut and undis-turbed plants when rainfall in the growing season exceeded 700 mm (1991 and 1993). All entries recorded < 40% survival in 1992 with a higher mean survival rate obtained from intact plants.

Table 2. Seed production (kg ha^{-1}) of *S. sesban* accessions grown in a unimodal rainfall environment in Tanzania

Accession ILCA No.	DM yield (t ha^{-1}) 1991	1992	1993
15021	483.0	395.3	312.7
15022	138.5	112.1	127.8
15036	136.4	105.8	104.0
13144	87.3	127.6	108.8
15020	78.4	78.8	72.1
15024	77.6	73.0	49.3
9043	59.3	73.0	95.6
13887	24.5	30.1	29.3
10639	24.3	14.5	27.8
10521	23.8	12.9	35.2
15077	17.2	10.1	10.8
15019	16.5	11.6	18.3
15491	15.9	13.0	19.3
10865	7.3	10.8	11.6
T1[a]	133.8	116.3	122.9
Mean	88.3	79.3	76.4
LSD ($p < 0.05$)	28.0	23.7	24.4

[a]Local land race.

Nutrient content

There were significant ($p < 0.05$) variations in the nitrogen (2.2 to 3.0% DM) and potassium (0.9 to 1.9 %) levels among some accessions whereas the concentrations of phosphorus (0.15 to 0.20 % DM), calcium (1.0 to 1.4% DM) and magnesium (0.2 to 0.4% DM) did not vary significantly (Table 4). The highest nitrogen content was found in accession 10639 and the lowest in 15020 while potassium levels were highest in 15022 and the lowest in 15077. The combination of low phosphorus and high calcium concentrations resulted in high calcium:phosphorus ratios which were also significantly ($p < 0.05$) different between some accessions.

Table 3. Plant survival (%) of *S. sesban* accessions grown in a unimodal rainfall environment in Tanzania

Accession	Plant survival (%)					
	1991		1992		1993	
ILCA No.	Cut	Intact	Cut	Intact	Cut	Intact
15036	75 (25)	72 (28)	29 (71)	17	50	56
15021	65	59	4	8	50	72
15022	55	52	17	38 (62)	67	78
13887	65	36	0	38 (62)	72 (28)	72
15020	45	45	0	20	63	61
15491	40	65	17	21	56	67
15077	35	45	0 (100)	4 (96)	67	83 (17)
13144	35	43	25	23	47	33
15024	33	25	12	19	33	32 (68)
9043	33	18 (82)	8	17	32	50
15019	15	34	20	36	29	33
10521	10	34	4	8	44	35
10865	10	20	0	8	39	33
10639	5 (95)	20	4	21	27 (73)	38
T1[a]	33	40	19	18	38	33
Mean	37	40	11	20	48	53
LSD($p < 0.05$)	8.7	10.2	4.9	6.3	9.3	7.8

[a]Local land race.
Figures in parentheses show the highest and lowest mortality values in each column.

Table 4. Mineral nutrient composition in *S. sesban* accessions grown in a unimodal rainfall environment in Tanzania

Accession ILCA No.	N	P	K	Ca	Mg	Ca:P ratio
10639	3.0	0.20	1.8	1.2	0.3	6.0
10521	2.9	0.18	1.8	1.0	0.3	5.6
15022	2.7	0.15	1.9	1.3	0.3	8.7
15036	2.6	0.15	1.4	1.0	0.2	6.7
13144	2.6	0.16	1.3	1.2	0.2	7.5
15024	2.6	0.19	1.4	1.2	0.3	6.3
15018	2.6	0.19	1.4	1.2	0.3	5.3
15021	2.5	0.15	1.6	1.1	0.2	7.3
15077	2.5	0.15	0.9	1.3	0.3	8.7
13887	2.5	0.15	1.4	1.4	0.4	9.3
15491	2.4	0.15	1.4	1.0	0.2	6.7
9043	2.4	0.15	1.5	1.3	0.4	8.7
15019	2.4	0.17	1.1	1.2	0.3	7.1
15020	2.2	0.15	1.2	1.1	0.3	7.3
T1[a]	2.4	0.17	1.3	1.1	0.2	6.5
Mean	2.4	0.16	1.4	1.2	0.3	7.2
LSD($p<0.05$)	0.4	ns	0.4	ns	ns	0.8

[a] Local land race.

Discussion

The data show considerable variation among some of the accessions in the attributes studied which is consistent with the observations by Tothill *et al.* (1989). Edible yields were lower than those reported by several authors (Gutteridge & Akkasaeng 1985, Evans & Rotar 1987 b, Karachi *et al.* 1994). In our study yields were affected by rainfall and indicate that reasonable production can only be expected when seasonal rainfall is above 700 mm. Accessions 15021 and T1 out-performed the other entries including 15019 which was found highly productive in Ethiopia and Hawaii (Evans & Rotar 1987 b, Heering 1995). Lack of adaptation to our site or experimental conditions by some accessions was also evidenced by fluctuations in yield (15077) and consistent low yields (10521 and 10865) unlike their better performance in some other sites (Kategile & Adoutan1993) indicating that location specific screening of introduced sesbania is necessary.

Seed yields were lower than those reported by Heering (1995) under irrigation and in contrast to the report by Heering (1995), accession 15019 was amongst the lowest seed producers. Our results indicate that accessions 15021, 15022 and 15036 which were consistently superior in seed production may be considered as reliable sources of seed under a similar environment. Low amounts of seed were produced by the late flowering accessions and few seeds were formed in all flowers that developed late in the wet season. The moisture stress, which usually occurs in June/July months, resulted in floral and immature pod abortion indicating that a management strategy that aims at producing both forage and seed is unlikely to succeed in this environment without supplemented water.

Plant survival was not consistent between and within an accession regardless of treatment. Survival rate was also drastically reduced in all entries (< 40%) by the low precipitation in 1992. Galang *et al.* (1990) found that cutting treatments did not affect survival rates while Mune Gowda and Krishnamurthy (1984) reported higher mortality in long stubble heights. Evans and Rotar (1987a) further suggested that leaving 5 to 25% of leaves for photosynthetic purposes after a cut would facilitate regrowth rates. Several other authors (ILCA 1986, Catchpoole & Blair 1990, Karachi *et al.* 1994) have observed the lack of longevity as a major problem in the use of sesbania as a long-term source of fodder. Therefore, the use of the available materials in smallholder farms would entail frequent and costly re-establishments. There is clearly a need for the search of persistent materials.

The high nutrient content in the forage except that of phosphorus is consistent with other reports (Topark-Ngam & Gutteridge 1989, Reed *et al.* 1990). The variation in nitrogen and potassium concentrations has probably no biological bearing in terms of ruminant animal production, since the levels were high (NRC 1984). Tothill *et al.* (1989) reported high concentrations of polyphenolic compounds in sesbania forage. These compounds may lower the nutritive value of forage when they form indigestible complexes with proteins and starches (Akin 1989) which probably explains the observations of Khalili and Varvikko (1992). There is need for more studies to determine the level of tolerance to these antinutritive factors by livestock. All accessions had phosphorus levels below the recommended minimum requirements in cattle (NRC 1984). The low phosphorus levels were compounded by high calcium concentrations which were five to nine times greater than phosphorus levels. Nutritional recommendations suggest that calcium: phosphorus ratio should be near 1:1 and no more than 2:1. Ratios other than this lead to low feed intake, bone abnormalities and reduced fertility, even if the minimum requirements for both minerals are met (Butterworth 1985). Therefore, using these sesbania accessions as feed will require mineral phosphorus supplementation.

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