GROWTH AND FODDER YIELD OF THE *Gliricidia sepium* PROVENANCES IN ALLEY CROPPING SYSTEM IN DRYLAND FARMING AREA IN BALI, INDONESIA

I. W. Sukanten[1], I. M. Nitis, K. Lana, M. Suarna and S. Uchida[2]

Department of Nutrition and Tropical Forage Science, Faculty of Animal Husbandry, Udayana University, Denpasar, Bali, Indonesia

Summary

The design of this field experiment was a completely randomized block arrangement, consisted of 16 treatments (*Gliricidia sepium* provenances) and 6 blocks as replications with 12 plants per provenance. Of the 16 gliricidia provenances, six were from Mexico (M), four were from Guatemala (G), and one each was from Colombia (C), Indonesia (I), Nicaragua (N), Panama (P), Costa Rica (R), and Venezuela (V). After 12 months establishment the gliricidia were lopped regularly 4 times a year, twice during the 4 months wet season and twice during the 8 months dry season at 150 cm height. There was variation ($p < 0.05$) in stem elongation from 22 to 80 cm, leaf retained from 118 to 209%, branch number from 13 to 24, fodder yield from 1,015 to 1,671 g DW/plant and wood yield from 792 to 1,662 g DW/plant among the provenances; and such variations were affected by the seasons. Belen (N14), Retalhuleu (G14) and Bukit Bali (I) provenances were ranked first, second and third, respectively, measured in terms of leaf retention, stem elongation, fodder and wood yields during the wet and dry seasons.
(**Key Words**: Gliricidia Provenances, Seasonal Variation, Branch Distribution, Leaf Retention, Shoot Yield, Fodder Supply)

Introduction

Gliricidia sepium (Jacq.) Walp., a deep rooted shrub legume, native to Central America, is now wide spread in Asia, South-east Asia, the Caribbean and West Africa (Wiersum and Nitis, 1992). It differs from *Gliricidia maculata* (HBK) Steud by having paler and smoother leaves rather than darker and spotted leaves, whitish-pink or purple flowers rather than white flowers and bigger pods and seeds (Wiersum and Nitis, 1992).

The gliricidia is extensively used in different cropping systems, as shade trees, as live stakes, as hedges, and green manure crops (Wiersum and Nitis, 1992). The international workshop on shrub and tree fodder for farm animals showed that gliricidia has been tested and used as fodder in Central America, Africa, Asia and South-east Asia (Devendra, 1989). In Indonesia *Gliricidia sepium* provides useful forage in the form of leaves, green stem and bark, and is commonly used to supplement poor quality and low protein roughage, especially in dry seasons when it may become a major source of fodder for goats and cattle in dryland cropping areas (Rangkuti et al., 1984). *Gliricidia sepium* is also being tested in the three strata forage system (Nitis et al., 1989) and in the alley cropping system (Nitis et al., 1991)

Growth and yield of gliricidia is affected to a varying degrees by frequency and interval of cuttings (Glover, 1987), by association with other plant species (Nitis et al., 1989), by topography, land utilization and climatic zones (Nitis et al., 1980). Climatic and soil fertility also exerted some effects (McIlroy, 1976).

Oxford Forestry Institute, United Kingdom, has collected and preserved 29 provenances (accessions) of *Gliricidia sepium* from eight Latin American Countries covering different time of harvest, altitude, latitude, rainfall, temperature and soil (Hughes, 1987). Experiment in Nigeria (Cobbina and Atta-Krah, 1992), Indonesia and Australia (Bray et al., 1993) showed that Retalhuleu and Monterico provenances of Guatemala and Belen provenance of Nicaragua grew faster and produced more

[1]Address reprint request to Mr. I. W. Sukanten, Department of Nutrition and Tropical Forage Science, Faculty of Animal Husbandry, Udayana University, Denpasar, Bali, Indonesia.

[2]Department of Animal Science and Technology, Faculty of Agriculture, Okayama University, Okayama 700, Japan.

Received August 4, 1994
Accepted December 16, 1994

fodder than the other provenances of *Gliricidia sepium*.

This paper describes the establishment, growth and yield during the wet and dry seasons, of 16 provenances of *Gliricidia sepium* grown as alley crop in dryland farming area in Bali, Indonesia.

Materials and Methods

The field experiment was located in the dryland farming area at Bukit Peninsula, South of Bali island, Indonesia (8°45′ - 8°49′ S; 115° 5′ - 115° 13′ E), at 100 m elevation. The soil is classified as red-brown Mediteran type with 10-25 cm soil depth, calcareous base lime-stone with pH varied from 7.2-8.4 (Nitis et al., 1989). The average annual rainfall was 1,681 mm, with 96 rainy days distributed during the 4 months wet season (December to March) and 8 months dry season (April to November). The mean daily temperatures varied from 25℃ to 29℃ with relative humidity varied from 65 to 86%.

The 15 *Gliricidia sepium* provenances supplied by Oxford Forestry Institute (OFI) were collected from seven Latin America Countries with altitude varied from 0-1,100 m and with annual rainfall varied from 650-3,500 mm (table 1). One provenance was collected from Bukit peninsula Bali. Therefore, of the 16 provenances, six were from Mexico (M), four were from Guatemala (G), one each was from Colombia (C), Indonesia (I), Nicaragua (N), Panama (P), Costa Rica (R) and Venezuela (V).

TABLE 1. PARTICULARS OF THE 16 *G. SEPIUM* PROVENANCES[1]

Provenance code	Origin		Time of harvest (19 . .)	Altitude (m)	Rain fall (mm)	Temperature (℃)	Soil
	Country	Site					
G13	Guatemala	Volcan	84	950	1,060	22.5	Sandy loam
G14	Guatemala	Retalhuleu	84	330	3,500	27.5	Sandy gravel
G15	Guatemala	Gualan	84	150	700	26.8	Very sandy
G17	Guatemala	Monterrico	84	5	1,650	27.1	Saline sand
M33	Mexico	Los Amates	85	1,100	650	24.6	Regosol
M34	Mexico	Palmasola	85	10-50	1,130	27.5	Regosol
M35	Mexico	SanMateo	85	10-30	950	27.2	Unstratified sand
M38	Mexico	Playa Azul	85	0-30	900	27.5	Coarse regosol
M39	Mexico	SanJose	85	30	1,400	27.5	Unstratified regosol
M40	Mexico	Arriaga	85	30	1,796	27.6	Alluvial
V1	Venezuela	Mariara	86	520	800	24.6	Deep black clay
R12	Costa Rica	Playa	86	0-10	1,927	24.8	Saline sand
P13	Panama	Pedasi	86	0-20	860	26.7	Drained sand
N14	Nicaragua	Belen	86	75	1,650	26.6	Heavy clay
C24	Colombia	Pontezuelo	86	20-50	950	27.7	Black vertisol
I	Indonesia	Bukit Bali	87	0-150	1,000	27	Red-brown Mediteran

[1] Adapted from Nitis et al. (1991).

The gliricidia were planted in the field in alley cropping system with completely randomized block design arrangement, consisted of 16 treatments (*Gliricidia sepium* provenances) with 6 blocks (replicates). The 16 provenances were randomly assigned in each block. Each block consisted of four rows and the length of each row was 24 m with 4 m spacing between 2 rows. Each row consisted of 4 provenances, and each provenance occupied a row of 6 m length. Each provenance consisted of 12 plants with 0.5 m spacing between the two plants. Corn, soybean and cassava were the food crop grown in the alley. No fertilizer was applied either to the food crop or the gliricidia.

Eight weeks old gliricidia in plastic bag pots were transplanted to the field in the early wet seasons. At 8 weeks after transplanting, the gliricidia were thinned into one plant per hill; and then were let to establish for 40 weeks. In the first harvest, at the end of the dry season, each plant was lopped at 150 cm height and the branches were lopped at 25 cm from both sides of the gliricidia row. Subsequent lopping was carried out regularly 4 times a year, twice during 4 months wet season (January and March) and twice during 8 months dry season (July and November), over a period of one year. Number of primary branches at 30, 60, 90 and 150 cm height were recorded at the same time. Sub-samples of stem, branch and leaf rachis, were dried in forced drought oven at 70℃ to constant dry weight (DW).

Data were analyzed with analysis of variance and then subjected to new Duncan multiple range test (Steel and Torrie, 1960).

Results and Discussion

Both during the wet and dry seasons the longest stem elongation was in G13; while the shortest stem elongation during wet and dry seasons was in P13 and M34, respectively (table 2). In general, stem elongation during the 4 months wet season was faster than those during the 8 months dry season, except for the R12, N14, G13, G14 and G15 the reverse was true. During the wet season the highest leaf retention was in G14 and the lowest was in M40, while during the dry season the highest leaf retention was in N14 and the lowest was in G15 (table 3).

TABLE 2. STEM ELONGATION (cm)[1] OF *G. sepium* DURING THE WET AND DRY SEASONS IN THE ALLEY CROPPING SYSTEM

Provenance code	Wet season Dec. '87 to March '88 I II	Dry season April to Nov. '88 I II
G13	64.13[a2]	80.07[a]
G14	58.12[a]	68.93[ab]
G15	57.60[a]	67.21[ab]
G17	40.55[a]	24.81[e]
M33	55.73[a]	41.88[cde]
M34	46.13[a]	22.57[c]
M35	50.23[a]	39.51[cde]
M38	55.80[a]	45.36[cd]
M39	53.28[a]	36.00[de]
M40	47.90[a]	33.28[de]
V1	51.58[a]	28.65[e]
R12	47.57[a]	53.27[bcd]
P13	31.65[a]	24.13[e]
N14	55.48[a]	66.07[ab]
C24	59.30[a]	58.30[bc]
I	62.57[a]	52.19[bcd]
SEM[3]	5.57	6.46

[1] II-I.
[2] Values in the same column with different superscripts differed ($p < 0.05$).
[3] SEM = Standard error of the treatment means.

TABLE 3. LEAF RETAINED (%)[1] OF *G. sepium* DURING THE WET AND DRY SEASONS IN THE ALLEY CROPPING SYSTEM

Provenance code	Wet season Dec. '87 to March '88 I II	Dry season April to Nov. '88 I II
G13	144.98	21.31
G14	208.84	38.80
G15	148.74	−11.72
G17	167.42	26.56
M33	128.39	16.95
M34	156.60	0.44
M35	156.20	30.61
M38	170.84.	−9.09
M39	166.50	2.62
M40	117.75	0.95
V1	187.43	24.43
R12	152.67	6.37
P13	141.79	24.26
N14	151.05	42.94
C24	131.75	11.30
I	149.23	32.97

[1] $(II - I)/I \times 100$.

TABLE 4. YIELD (g DW / plant) OF *G. sepium* AT THE END OF THE 40 WEEKS ESTABLISHMENT PERIOD IN THE ALLEY CROPPING SYSTEM

Provenance code	Branch	Leaf	Shoot (branch + leaf)
G13	102.99	76.52	179.51[bcd]
G14	105.02	97.41	202.43[ab]
G15	78.60	62.72	141.32[bc]
G17	36.15	29.86	66.01[c]
M33	32.73	28.63	61.36[bc]
M34	55.88	35.62	91.50[bc]
M35	48.71	36.86	85.57[bc]
M38	59.58	45.23	104.81[bc]
M39	53.93	42.73	96.66[bc]
M40	87.71	49.07	136.78[bc]
V1	38.51	55.50	94.01[bc]
R12	53.74	55.10	108.84[bc]
P13	26.35	29.36	55.71[c]
N14	187.61	112.41	300.02[a]
C24	83.84	61.38	145.22[bc]
I	73.31	58.82	132.13[bc]
SEM[2]	–	–	37.18

[1] Values in the same column with different superscripts differed ($p < 0.05$).
[2] SEM = Standard error of the treatment means.

As expected, number of leaf retained during the wet season was more than those during the dry season. During the wet season the leaf retained varied from 117.8 to 208.8%, while during the dry season it went down to as low as -11.8% to as high as 42.9%. This indicated that during the wet season there were no leaf shedding, while during the dry season, G15 and M38 showed leaf shedding and M34, M39 and M40 showed very little leaf formation. The higher shoot (branch + leaf) yield of the N14 and G14 in that order than the other provenances at 40 weeks after transplanting was due to its branch and leaf components (table 4). Although the stem elongation of G14 and N14 during the wet and dry seasons were not the longest, however, they can maintained the highest leaf retention; which resulted in the higher shoot yield compared with the other provenances during the establishment period. Eventhough these two provenances come from area with higher annual rainfall, its ability to perform better during the establishment period at lower annual rainfall than the others, indicated that either N14 or G14 has genetic capability to adapt quickly the new environment.

During 12 months growth, number of branches was the highest in G17 and the lowest in G15 (table 5). In terms of branch distribution along the stem, P13, G17 and M35 produced more branches at the bottom (0-30 cm); M34, M38, M39 and C24 produced more branches in the middle (30-90 cm); V1, I, R12 and G14 produced more branches at the top (90-150 cm); while in the other provenances the branches were evenly distributed along the stem. Puger et al. (1993) reported that the provenances with more branches at the bottom might be more effective as weed control, those with more branches in the middle could be used as windbreaks, those with more branches on the top could be used as supports for estate crops, while those evenly branching along the stem could be used as a live fence.

As a whole year fodder supply, N14 could become the highest, while M38 could become the lowest fodder supply (table 6). However, season-wise, for the early and late wet seasons, M34 and N14 were the best, while N14 and G17 were the best at early and late dry seasons, respectively. For the whole year period, N14 produced the highest branch yield and M38 produced the lowest (table

TABLE 5. BRANCH NUMBER AND DISTRIBUTION AT 12 MONTHS GROWTH OF *G. sepium* IN THE ALLEY CROPPING SYSTEM

Provenance code	Branch location on the stem (cm from the ground)				Whole plant
	0-30	30-90	90-150	> 150	
G13	0.17	2.92	3.04	9.00	15.13^{def1}
G14	0.44	4.21	4.00	11.54	20.19^{abcd}
G15	0.42	2.58	2.00	6.67	13.67^{f}
G17	1.90	5.58	5.71	10.83	24.02^{a}
M33	0.71	2.00	2.21	9.62	14.54^{ef}
M34	1.17	4.96	4.08	9.54	19.75^{abcd}
M35	1.31	3.54	3.79	9.75	18.39^{bcde}
M38	1.05	4.79	3.88	7.96	17.68^{cdef}
M39	0.62	4.46	2.90	8.46	16.44^{def}
M40	0.67	3.54	3.33	8.46	16.00^{def}
V1	0.95	3.67	5.25	12.63	22.50^{abc}
R12	1.00	3.29	4.50	10.32	19.12^{abcde}
P13	1.42	5.21	4.04	12.41	23.08^{ab}
N14	1.25	3.38	3.67	11.00	19.30^{abcde}
C24	0.94	4.46	4.50	9.46	19.36^{abcde}
I	0.08	3.25	4.70	11.79	19.82^{abcd}
SEM[2]	–	–	–	–	1.55

[1] Values in the same column with different superscripts differed ($p < 0.05$).

[2] SEM = Standard error of the treatment means.

TABLE 6. LEAF YIELD (g DW / plant) OF *G. sepium* DURING THE WET AND DRY SEASONS IN THE ALLEY CROPPING SYSTEM

Provenance code	Wet season		Dry season		Whole year (1989)
	Jan.	March	July	Nov.	
G13	402	187	319	462	1,370^{a1}
G14	483	251	401	511	1,646^{a}
G15	520	191	229	462	1,402^{a}
G17	516	253	340	539	1,648^{a}
M33	395	173	162	369	1,099^{a}
M34	571	213	206	523	1,513^{a}
M35	513	198	259	456	1,426^{a}
M38	404	168	147	295	1,015^{a}
M39	522	242	240	509	1,512^{a}
M40	376	178	230	392	1,176^{a}
V1	462	253	351	483	1,549^{a}
R12	447	244	310	506	1,507^{a}
P13	429	212	157	352	1,150^{a}
N14	488	278	410	495	1,671^{a}
C24	517	269	355	461	1,602^{a}
I	483	261	283	426	1,453^{a}
SEM[2]					140.74

[1] Values in the same column with different superscripts differed ($p < 0.05$).

[2] SEM = Standard error of the treatment means.

7). Season-wise, G14 produced highest branch yield both during the early and late wet seasons, while N14 and V1 produced highest branch yield both during the early and late dry seasons, respectively. Similar trend was observed for the shoot yield (table 8). The higher shoot (branch and leaf) yield of the N14 and G14 during the dry season than those during the wet season indicated that there is potential for selecting gliricidia provenances as fodder crop with strategic lopping. In its natural condition, gliricidia shed its leaves during the dry season. However, with 2 months lopping interval during the 4 months wet season and 4 months lopping interval during the 8 months dry season give enough opportunity for regrowth, so that the gliricidia could produce green leaves all the year around (as standing green). Similar lopping treatment applied to local gliricidia (I) grown as fence in the three strata forage system, also showing similar result (Nitis et al., 1989).

The present data showed that N14 and G14 not only performed better during the establishment period, but also produced more fodder and wood after repeated lopping.

TABLE 7. BRANCH YIELD (g DW / plant) OF *G. sepium* DURING THE WET AND DRY SEASONS IN THE ALLEY CROPPING SYSTEM

Provenance code	Wet season		Dry season		Whole year (1989)
	Jan.	March	July	Nov.	
G13	394	71	164	314	942^{bc1}
G14	612	147	496	397	1,652^{a}
G15	446	90	220	307	1,063^{bc}
G17	491	105	235	288	1,118^{bc}
M33	396	69	113	270	848^{c}
M34	416	81	115	301	913^{bc}
M35	319	82	128	279	808^{c}
M38	404	101	97	189	792^{c}
M39	451	89	147	297	985^{bc}
M40	423	79	162	257	920^{bc}
V1	413	139	247	454	1,253^{abc}
R12	491	138	264	326	1,220^{bc}
P13	336	108	151	223	818^{c}
N14	452	143	627	440	1,662^{a}
C24	533	121	361	376	1,392^{ab}
I	529	141	253	334	1,257^{abc}
SEM[2]					156.41

[1] Values in the same column with different superscripts differed ($p < 0.05$).

[2] SEM = Standard error of the treatment means.

TABLE 8. SHOOT YIELD (g DW / plant) OF *G. sepium* DURING THE WET AND DRY SEASONS IN THE ALLEY CROPPING SYSTEM

Provenance code	Wet season		Dry season		Whole year (1989)
	Jan.	March	July	Nov.	
G13	796	258	483	776	2,312^{abcd1}
G14	1,095	398	897	908	3,298^{a}
G15	966	281	449	769	2,465^{abcd}
G17	1,000	358	575	826	2,766^{abc}
M33	791	242	275	639	1,947^{cd}
M34	987	294	321	824	2,426^{abcd}
M35	822	280	387	735	2,235^{abcd}
M38	809	269	245	484	1,806^{d}
M39	973	331	387	206	2,497^{abcd}
M40	799	256	392	648	2,096^{cd}
V 1	875	392	598	937	2,802^{abc}
R12	939	382	575	831	2,727^{abcd}
P13	765	320	309	575	1,968^{cd}
N14	941	420	1,038	935	3,333^{a}
C24	1,050	390	716	838	2,994^{ab}
I	1,012	402	535	760	2,709^{abc}
SEM[2]	–	–	–	–	267.70

[1] Values in the same column with different superscripts differed ($p < 0.05$).

[2] SEM = Standard error of the treatment means.

According to Cobbina and Atta-Krah (1992) experiment in Ibadan (Nigeria) showed that G14 and G17 were ranked first and second in growth and leaf yield and according to Bray et al. (1993) experiment in Utchee Creek (Australia) and Sie Putih (Indonesia) showed that G14 and G17 and G14 and N14 were respectively ranked first and second in leaf yield. Such discrepancy might be due to the different managements, soil acidity (pH) and rainfall (R), between Ibadan (pH 6.2, R 320 mm), Utchee Creek (pH 5.0, R 3,500 mm), Sie Putih (pH 5.0, R 1,900 mm) and Bukit Bali (pH 7.8, R 1,000 mm).

It is of interest to note that I (Bukit provenance) which was ranked third in this study was introduced from Sumatra (with 3,500 mm rainfall and acid soil) in 1970 (Nitis et al., 1991). Eventhough there was no fodder yield record of this I provenance as alley cropping in the past 17 years (1970-1987), it would be of interest to note as to whether productivity of N14 and G14 will increase more or drop down at the level of, or below the I productivity in the next 17 years.

Acknowledgements

The authors wish to thank OFI for supplying the gliricidia provenance seeds and the staff of the Department of Nutrition and Tropical Forage Science for their technical assistance. Data presented in this paper are part of the research project "Three Strata Forage (Indonesia)", financed by IDRC.

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