CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF THE *Gliricidia sepium* PROVENANCES IN DRYLAND FARMING AREA IN BALI, INDONESIA

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Summary

Alley cropping field experiment has been carried out for 24 months in lime-stone based dryland farming area of southern Bali to study the chemical composition and nutritive value of 16 provenances of *Gliricidia sepium*. The design was a completely randomized block arrangement, consisted of 16 treatments (*G. 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), 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 at 150 cm height regularly 4 times a year, twice during the 4 months wet season and twice during the 8 months dry season. The highest ash, mineral, total soluble phenol, prussic acid and digestibility were in V1; the highest crude fiber component was in M39; the highest gross energy was in P13, while the highest organic matter was in M35. Based on the highest nutritive constituents, V1, C24 and G14 were ranked first, second and third respectively, while based on the lowest non-nutritive constituents C24, V1 and N14 were ranked first, second and third, respectively. The importance of such provenances as source of nutrients for the ruminant during the dry season were discussed.

(**Key Words** : *Gliricidia sepium* Provenances, Chemical Compositions, Fiber Components, Mineral Concentrations, Non-nutritive Constituents, *in vitro* Digestibility)

Introduction

Gliricidia sepium (Jacq.) Walp., a deep rooted shrub legume, native to Central America, is now widely used as shade trees, live stakes, hedges, living fences, green manures and livestock fodder in Asia, South-east Asia, the Carribbean and West Africa (Wiersum and Nitis, 1992).

Since astringent ordour has been exhibited by the *G. sepium* leaves, adaptation period is required for the livestock did not used to eat such fodder (Nitis et al., 1989). However, with wilting the gliricidia fodder consumption by sheep can be increased (Merkel et al., 1994). There was no reported toxic effect to ruminant consuming gliricidia fodder, even though such gliricidia leaf has been reported to contain coumarin, hydrocyanic acid and tannin (Smith and Van Houtert, 1987). However, rat and guinea pigs fed diet containing gliricidia leaves progressively lost in live weight, emaciated and death (Sukanten et al., 1994).

It has been reported that *G. sepium* contained similar crude protein and gross energy but less digestible dry matter and organic matter than the *Leucaena leucocephala* (Nitis et al., 1985; Wanapat, 1990). Climatic zone, topography, land utilization and soil moisture condition have been reported to affect the chemical composition of the gliricidia leaves (Nitis et al., 1985).

Selection for higher fodder yield of the *G. sepium* provenances (accessions) is underway. Experiment in Nigeria (Cobbina and Atta-Krah, 1992), Australia (Bray et al., 1993) and Indonesia (Sukanten et al., in press) showed that of the 16-28 provenances tested, 3 provenances out-yielded the others. However, in terms of chemical compositions, certain *G. sepium* provenances with the highest contents of certain minerals in Nigeria, were not necessarily so in Australia.

The objective of this experiment was to determine the

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chemical composition and nutritive value of the 16 provenances of *G. sepium* grown as alley crop in dryland farming area in Bali, Indonesia.

Materials and Methods

Location and design of the field experiment and description of the 16 provenances of *G. sepium* have been described in detail elsewhere (Sukanten et al., in press), so that in this paper only the pertinent points were described.

Location

The field experiment was located in dryland farming area of southern Bali, at 100 m elevation with 3° slopping gradient, 1,681 mm average annual rainfall with 96 rainy days distributed during the 4 months wet season and 8 months dry season, 25-29℃ mean daily temperature and 65-86% relative humidity (Nitis et al., 1989). The soil is calcareous-based red-brown Mediteran type, 10-25 cm soil depth with soil pH of 7.2-8.4.

Gliricidia provenance seeds

The 15 provenances of *G. sepium* collected by Oxford Forestry Institute (OFI) from 7 Latin American Countries were tested (table 1). One provenance from Bali, Indonesia was used as control.

TABLE 1. PARTICULARS OF THE 16 GLIRICIDIA PROVENANCES[1]

Provenance code	Origin		Time of harvest (19..)	Altitude (m)	Rainfall (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	San Jose	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. (1989).

Design

The completely randomized block design experiment consisted of 16 treatments (*G. sepium* provenances) and 6 blocks as replications with 12 plants per provenance. The provenances were planted in alley cropping system with 0.5 m spacing within the row and 4.0 m spacing between the rows.

After 12 months establisment, all plants were lopped at 150 cm height 4 times a year; in early wet season (January), late wet season (March), early dry season (July) and late dry season (November).

Sample preparation

Samples used for laboratory analysis were those harvested at the late wet and dry seasons. At each harvest the leaf rachis (leaf blade and petiole) of the 6 replicates were pooled into 3 replications designated for the upper, middle and lower sloping gradients and each portion was mixed thoroughly. Five hundred grams of sub-samples were dried in forced drought oven at 70℃ to constant weight, ground in a micro-hammer mill to pass 1 mm screen and stored in a sealed plastic bag for analysis.

Chemical analysis

Dry matter (DM), organic matter (OM), ash, crude protein (CP), crude fiber (CF), and prussic acid (HCN) were determined according to the standard procedure of AOAC (1970), while the gross energy (GE) was determined according to the standard procedure of Gallenkamp (1976). Acid detergent fiber (ADF), neutral detergent fiber (NDF), cellulose, hemicellulose, acid detergent lignin (AD-lignin) and silica were determined according to the method described by Goering and Van Soest (1970). Macro- and micro-elements were determined according to Fick et al. (1976), except for the phosporus that was determined according to the method described by Boltz (1958). Total soluble phenol (TSP) was analyzed according to the method described by Reed et al. (1985).

Digestibility

The *in vitro* dry matter digestibility (IVDMD) and the *in vitro* organic matter digestibility (IVOMD) were determined according to the method described by Goto and Minson (1977) with some modifications. Two hundred fifty mgs of ground dried gliricidia leaves were incubated for 48 hours at 39℃ with 25 ml of 0.1 N HC1 containing 0.2% (w/v) pepsin (1 : 10,000) to remove the cell contents. After centrifuging (at 2,200 × g) for 10 minutes, the supernatant was removed, the residue was washed once with 25 ml cold water and the supernatant was removed after centrifuging. Twenty five ml of a 0.05 M acetate buffer solution (pH 4.6) containing chloramphenicol (100 μg/ml) as a bacteriostat and 2.5% (w/v) onozuka SS (P-1500) cellulase was added and incubated for 48 hours. The tubes were centrifuged, the supernatant was discarded and the residue was washed twice with water before being dried at 105℃, weighed and ashed at 500℃ for 3 hours. The IVDMD and IVOMD were the loss in weight expressed as a percentage of the weight of the original sample.

Statistical analysis

Data were analysed with analysis of variance and when significant ($p < 0.05$), it was further subjected to new Duncan multiple range test (Steel and Torrie, 1960).

Results

During the wet season, the highest content of ash, OM, CP, CF and GE were in provenance G13, M35, V1,

TABLE 2. CHEMICAL COMPOSITION AND GROSS ENERGY OF THE GLIRICIDIA LEAVES DURING WET SEASON

Provenance code	% DM				GE (kcal / kgDM)
	ASH	OM	CP	CF	
G13	9.87^{a}[1]	90.13^{d}	20.17^{cd}	15.78^{a}	$4,992^{ab}$
G14	9.57^{abc}	90.43^{cde}	22.33^{abc}	15.25^{a}	$4,978^{ab}$
G15	8.97^{bcde}	91.03^{abce}	20.30^{cd}	16.42^{a}	$4,994^{ab}$
G17	8.96^{cde}	91.04^{abce}	20.25^{cd}	14.73^{a}	$4,921^{ab}$
M33	8.76^{cde}	91.24^{abc}	22.01^{abc}	15.88^{a}	$4,986^{ab}$
M34	8.80^{cde}	91.20^{abc}	18.83^{d}	14.83^{a}	$4,879^{b}$
M35	8.27^{e}	91.73^{a}	21.25^{bcd}	15.16^{a}	$4,942^{ab}$
M38	9.20^{abcd}	90.80^{bcde}	22.70^{abc}	15.06^{a}	$4,936^{ab}$
M39	9.05^{abcde}	90.96^{abcde}	21.59^{abcd}	14.74^{a}	$4,909^{b}$
M40	9.02^{abcde}	90.98^{abcde}	20.72^{bcd}	14.89^{a}	$4,921^{ab}$
V1	9.80^{ab}	90.20^{de}	24.20^{a}	15.88^{a}	$5,032^{ab}$
R12	9.01^{abcde}	90.99^{abcde}	20.03^{cd}	17.29^{a}	$5,037^{ab}$
P13	8.63^{de}	91.37^{ab}	22.53^{abc}	15.41^{a}	$5,077^{a}$
N14	9.54^{abcd}	90.46^{bcde}	20.93^{bcd}	15.43^{a}	$5,072^{a}$
C24	8.72^{cde}	91.28^{abc}	23.57^{ab}	17.27^{a}	$5,077^{a}$
I	9.25^{abcd}	90.75^{bcde}	22.70^{abc}	14.91^{a}	$4,974^{ab}$
SEM[2]	0.27	0.27	0.85	0.90	46
Mean ± SD	9.09 ± 0.44	90.91 ± 0.44	21.51 ± 1.45	15.56 ± 0.83	4,982 ± 62

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

TABLE 3. CHEMICAL COMPOSITION AND GROSS ENERGY OF THE GLIRICIDIA LEAVES DURING DRY SEASON

Provenance code	% DM				GE (kcal / kgDM)
	ASH	OM	CP	CF	
G13	11.28^{abc}[1]	89.28^{bcd}	19.19^{ab}	22.54^{ab}	$4,709^{a}$
G14	10.92^{abcd}	87.93^{d}	18.11^{b}	22.96^{ab}	$4,606^{a}$
G15	10.61^{abcde}	89.17^{bcd}	18.50^{ab}	23.27^{ab}	$5,059^{a}$
G17	10.03^{de}	89.71^{abc}	17.80^{b}	19.88^{bc}	$4,899^{a}$
M33	10.30^{cde}	90.09^{abc}	17.31^{b}	20.69^{bc}	$5,050^{a}$
M34	10.22^{cde}	89.45^{bc}	17.42^{b}	21.27^{bc}	$4,670^{a}$
M35	9.63^{e}	91.00^{a}	17.94^{b}	20.61^{bc}	$4,926^{a}$
M38	10.82^{abcd}	89.01^{bcd}	18.58^{ab}	17.92^{c}	$4,721^{a}$
M39	11.20^{abce}	90.28^{abc}	18.74^{ab}	22.06^{ab}	$4,727^{a}$
M40	10.85^{abcd}	89.72^{abc}	21.72^{a}	22.63^{ab}	$4,750^{a}$
V1	11.62^{a}	89.15^{bcd}	18.89^{ab}	22.88^{ab}	$4,706^{a}$
R12	9.64^{e}	90.36^{ab}	18.30^{b}	22.12^{ab}	$4,855^{a}$
P13	10.17^{cde}	89.85^{abc}	17.88^{b}	22.03^{b}	$4,619^{a}$
N14	10.47^{bcde}	88.96^{bcd}	18.35^{b}	22.44^{ab}	$4,797^{a}$
C24	11.11^{abcd}	89.42^{bc}	20.71^{a}	26.10^{a}	$4,998^{a}$
I	11.45^{ab}	88.83^{cd}	20.33^{a}	22.53^{ab}	$4,822^{a}$
SEM[2]	0.34	0.44	0.60	1.21	142
Mean ± SD	10.65 ± 0.61	89.51 ± 0.73	18.74 ± 1.22	22.00 ± 1.76	4,807 ± 145

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

R12 and P13, respectively (table 2). During the dry season the highest content of such nutrients were in provenance V1, M35, M40, C24 and G15, respectively (table 3).

With regard to the fiber components, the highest content of ADF, NDF, cellulose and hemicellulose was in provenance M39, G15, R12 and C24, respectively during the wet season (table 4). During the dry season such highest fiber components were in provenance M39, M34, C24 and G14, respectively (table 5).

For the macro-element, the highest concentrations of Ca, Mg, P, K and Na were in provenance N14, G13, M35, V1 and R12 during the wet season, respectively (table 6), while during the dry season the highest concentrations of such macro-elements were in provenance M40, V1, V1, V1 and R12 (table 7). The pattern for the micro-element was that during the wet season the highest concentration of Fe, Mn, Zn, and Cu was in provenance I, G17, M38 and G13, respectively (table 8), while during the dry season, the highest concentration of such micro-element was in provenance V1, G13, M39 and G13 (table 9).

Digestibility measured in terms of IVDMD and IVOMD was the highest in provenance C24 and G15 during the wet season; respectively (table 10). During the dry season, on the other hand, the highest *in vitro* digestibility was in provenance V1 only.

The soluble non-nutritive constituents of total phenol and HCN were the lowest in provenance G15 and P13 during the wet season, respectively; while during the dry season the lowest concentrations of such non-nutritive constituents were in provenance G17 and C24, respectively (table 11). The lowest insoluble non-nutritive constituent of AD-lignin and silica was in provenance C24 during the wet season, respectively; while during the dry season the lowest concentration of such insoluble non-nutritive constituent was in provenance V1 and G17, respectively (table 12).

The present data showed that the proximate compositions, gross energy, fiber components, macro-and micro-element concentrations, digestibilities and non-

TABLE 4. FIBER COMPONENTS (% DM) OF THE GLIRICIDIA LEAVES DURING WET SEASON

Provenance code	ADF	NDF	Cellulose	Hemicellulose
G13	26.59^{cd}[1]	47.49^{bcde}	15.20^{a}	20.89^{ab}
G14	28.20^{bc}	51.85^{ab}	16.33^{a}	20.75^{ab}
G15	32.44^{a}	52.29^{a}	15.98^{a}	19.85^{ab}
G17	31.96^{a}	51.97^{ab}	16.69^{a}	20.02^{ab}
M33	31.64^{a}	50.77^{abc}	16.86^{a}	19.13^{abc}
M34	33.24^{a}	49.16^{abcd}	15.59^{a}	15.92^{c}
M35	31.85^{a}	50.68^{abc}	16.98^{a}	18.84^{abc}
M38	30.89^{ab}	51.67^{ab}	15.46^{a}	20.78^{ab}
M39	33.51^{a}	51.03^{abc}	16.32^{a}	17.52^{bc}
M40	28.51^{bc}	47.56^{bcde}	15.36^{a}	19.05^{abc}
V1	23.70^{d}	45.50^{e}	15.44^{a}	21.80^{a}
R12	32.55^{a}	51.36^{ab}	17.55^{a}	18.82^{abc}
P13	26.09^{cd}	46.58^{cde}	15.27^{a}	20.49^{ab}
N14	26.05^{cd}	47.67^{abcde}	15.71^{a}	21.62^{a}
C24	24.20^{d}	46.09^{de}	16.13^{a}	21.88^{a}
I	28.03^{bc}	48.69^{abcde}	15.77^{a}	20.66^{ab}
SEM[2]	1.07	1.40	0.96	1.12
Mean ± SD	29.34 ±3.31	49.40 ±2.32	16.04 ±0.70	19.88 ±1.61

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

TABLE 5. FIBER COMPONENTS (% DM) OF THE GLIRICIDIA LEAVES DURING DRY SEASON

Provenance code	ADF	NDF	Cellulose	Hemicellulose
G13	37.14^{bcd}[1]	48.67^{cdef}	18.22^{abcd}	11.53^{bc}
G14	34.91^{bcd}	52.00^{abcd}	20.52^{ab}	17.08^{a}
G15	37.42^{bc}	50.72^{bcde}	19.27^{abc}	13.30^{abc}
G17	35.74^{bcd}	49.39^{bcdef}	18.49^{abcd}	13.65^{abc}
M33	37.00^{bcd}	51.58^{abcde}	18.77^{abcd}	14.57^{abc}
M34	42.74^{a}	55.73^{a}	17.42^{cd}	13.00^{bc}
M35	37.43^{bc}	50.93^{abcde}	17.92^{bcd}	13.50^{abc}
M38	37.57^{b}	49.40^{bcdef}	16.28^{d}	11.83^{bc}
M39	43.06^{a}	54.17^{ab}	16.46^{d}	11.11^{c}
M40	35.88^{bcd}	46.57^{ef}	18.71^{abcd}	10.69^{c}
V1	30.63^{e}	44.38^{f}	20.46^{ab}	13.75^{abc}
R12	38.50^{b}	53.52^{abc}	19.08^{abc}	15.02^{ab}
P13	36.11^{bcd}	50.29^{bcde}	19.19^{abc}	14.17^{abc}
N14	33.55^{cde}	48.95^{cdef}	20.28^{ab}	15.40^{ab}
C24	33.43^{de}	47.25^{def}	20.64^{a}	13.81^{abc}
I	34.69^{bcd}	47.52^{def}	19.90^{abc}	12.84^{bc}
SEM[2]	1.18	1.55	0.80	1.14
Mean ± SD	36.61 ±3.15	50.07 ±2.96	18.85 ±1.36	13.45 ±1.66

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

TABLE 6. MACRO ELEMENT CONTENTS (g /kg DM) OF THE GLIRICIDIA LEAVES DURING WET SEASON

Provenance code	Ca	Mg	P	K	Na
G13	10.369^{abc1}	1.619^{a}	1.538^{ab}	25.385^{a}	0.269^{a}
G14	10.692^{ab}	1.480^{ab}	1.412^{bc}	23.160^{a}	0.379^{a}
G15	8.831^{abc}	1.062^{bcdef}	1.392^{bc}	23.326^{a}	0.360^{a}
G17	10.106^{abc}	1.021^{cdef}	1.477^{ab}	20.478^{a}	0.263^{a}
M33	7.928^{cd}	1.022^{cdef}	1.536^{ab}	22.634^{a}	0.246^{a}
M34	8.390^{bcd}	1.194^{abcde}	1.385^{bc}	23.317^{a}	0.301^{a}
M35	6.115^{d}	0.822^{ef}	1.620^{a}	25.148^{a}	0.334^{a}
M38	8.418^{bcd}	0.730^{f}	1.258^{c}	25.960^{a}	0.386^{a}
M39	8.743^{abc}	0.930^{def}	1.249^{c}	25.444^{a}	0.267^{a}
M40	9.879^{abc}	0.999^{cdef}	1.529^{ab}	22.043^{a}	0.169^{a}
V1	8.950^{abc}	1.362^{abcd}	1.559^{ab}	29.242^{a}	0.082^{a}
R12	8.416^{bcd}	1.383^{abc}	1.455^{ab}	25.477^{a}	0.466^{a}
P13	8.788^{abc}	0.818^{ef}	1.387^{bc}	22.843^{a}	0.319^{a}
N14	10.937^{a}	1.497^{ab}	1.469^{ab}	23.534^{a}	0.342^{a}
C24	8.488^{abcd}	1.249^{abcde}	1.348^{bc}	22.148^{a}	0.187^{a}
I	8.430^{bcd}	0.895^{ef}	1.419^{abc}	23.438^{a}	0.268^{a}
SEM[2]	0.747	0.139	0.064	1.405	0.083
Mean ±SD	8.968 ±1.202	1.130 ±0.266	1.440 ±0.101	23.974 ±2.59	0.290 ±0.092

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

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

TABLE 7. MACRO ELEMENT CONTENTS (g /kg DM) OF THE GLIRICIDIA LEAVES DURING DRY SEASON

Provenance code	Ca	Mg	P	K	Na
G13	12.584^{abcd1}	0.922^{bcd}	1.151^{abc}	23.007^{a}	0.230^{de}
G14	13.694^{abc}	0.963^{abcd}	1.131^{abcd}	21.611^{a}	0.283^{de}
G15	11.792^{bcd}	1.149^{abc}	1.016^{def}	23.425^{a}	0.830^{cde}
G17	14.597^{ab}	1.045^{abcd}	1.076^{bcde}	18.424^{a}	0.563^{cde}
M33	12.143^{bcd}	0.820^{bcd}	1.024^{def}	22.503^{a}	0.061^{e}
M34	13.009^{abc}	1.034^{abcd}	0.924^{f}	20.478^{a}	0.261^{de}
M35	10.625^{cd}	0.885^{bcd}	1.002^{ef}	22.071^{a}	0.392^{de}
M38	13.640^{abc}	0.569^{d}	0.978^{ef}	20.919^{a}	1.160^{bc}
M39	12.989^{abc}	0.651^{cd}	0.916^{f}	24.838^{a}	0.945^{cd}
M40	15.631^{a}	0.706^{bcd}	1.162^{ab}	20.987^{a}	0.198^{de}
V1	11.226^{bcd}	1.457^{a}	1.233^{a}	29.468^{a}	1.732^{ab}
R12	9.542^{d}	0.904^{bcd}	1.045^{cde}	23.046^{a}	2.363^{a}
P13	11.808^{bcd}	0.574^{d}	1.134^{abcd}	20.435^{a}	0.234^{de}
N14	12.984^{abc}	1.207^{ab}	0.972^{ef}	21.049^{a}	1.295^{bc}
C24	11.456^{bcd}	1.091^{abcd}	1.140^{abc}	27.396^{a}	1.277^{bc}
I	13.309^{abc}	0.802^{bcd}	1.150^{abc}	23.618^{a}	0.649^{cde}
SEM[2]	0.994	0.164	0.037	2.341	0.237
Mean ±SD	12.564 ±1.510	0.924 ±0.237	1.066 ±0.087	22.705 ±2.742	0.780 ±0.646

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

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

nutritive constituents of the leaves of *G. sepium* not only varied among the 16 provenances but also affected by the wet and dry seasons.

Discussion

As expected, provenance M35 with the highest OM content contained the lowest ash content, while provenance G13 with the highest ash content contained the lowest OM content. The higher OM was reflected by its higher CP and CF, while the higher ash was reflected by its higher Ca, Mg, P, K and Na macro-elements and Fe, Mn, and Cu micro-elements. In the fiber components, it can be expressed simply that the NDF was composed of hemicellulose and ADF, while the ADF was composed of cellulose and AD-lignin. Therefore, provenances with higher CF content can be either higher in NDF and hemicellulose or higher in ADF and cellulose. The higher IVDMD and IVOMD were related to the higher cellulose and hemicellulose contents of such provenances. Generally provenances with higher digestibility usually contained lower non-nutritive constituents, except for the provenance C24, G15 and V1. Its higher IVDMD and IVOMD were not seemed to be affected by its higher concentrations of AD-lignin, silica, total phenol and HCN. This confirmed the finding of Putra (1992) that showed no correlation between the gliricidia intake by goat and the tannin and HCN contents of such gliricidia leaves.

Of the 16 provenances tested, V1, C24 and G14 ranked first, second and third measured in terms of the concentrations of organic and inorganic-matter, gross energy, fiber components, macro- and micro-elements and *in vitro* digestibility (table 13). However, based on the highest nutrient contents, provenance V1, C24 and G14 ranked first, second and third, respectively; while based on the lowest non-nutrient contents, the first, second and third ranking order was C24, V1 and N14, respectively (table 14). Since the fodder production of provenance G14, G17,

TABLE 8. MICRO ELEMENT CONTENTS (mg /kg DM) OF THE GLIRICIDIA LEAVES DURING WET SEASON

Provenance code	Fe	Mn	Zn	Cu
G13	149.987^{a1}	42.933^{ab}	19.483^{a}	3.347^{a}
G14	100.249^{a}	44.733^{a}	18.161^{a}	3.001^{abc}
G15	38.699^{a}	33.991^{bcde}	17.783^{a}	2.898^{abc}
G17	154.799^{a}	45.635^{a}	18.469^{a}	2.739^{bcd}
M33	98.216^{a}	37.652^{abcd}	19.070^{a}	2.386^{cd}
M34	98.666^{a}	32.305^{ce}	17.573^{a}	2.440^{cd}
M35	52.651^{a}	28.610^{de}	19.965^{a}	2.606^{cd}
M38	91.489^{a}	27.903^{e}	55.044^{a}	2.225^{d}
M39	87.646^{a}	29.194^{de}	15.802^{a}	2.399^{cd}
M40	60.802^{a}	33.802^{bcde}	15.962^{a}	3.213^{ab}
V1	51.444^{a}	41.781^{abc}	17.330^{a}	2.588^{bd}
R12	130.204^{a}	36.742^{abcde}	16.149^{a}	2.841^{abc}
P13	114.890^{a}	37.677^{abcd}	20.813^{a}	2.552^{cd}
N14	106.248^{a}	37.330^{abcd}	25.565^{a}	2.921^{abc}
C24	64.241^{a}	40.852^{abc}	17.917^{a}	2.396^{cd}
I	167.403^{a}	40.707^{abc}	18.216^{a}	2.407^{cd}
SEM^{2}	35.138	2.851	9.361	0.181
Mean ± SD	97.977 ±38.776	36.990 ±5.642	20.831 ±9.463	2.683 ±0.328

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

TABLE 9. MICRO ELEMENT CONTENTS (mg /kg DM) OF THE GLIRICIDIA LEAVES DURING DRY SEASON

Provenance code	Fe	Mn	Zn	Cu
G13	166.886^{bc1}	54.698^{a}	13.984^{abcd}	3.470^{a}
G14	95.511^{c}	41.007^{bcd}	12.470^{de}	2.890^{a}
G15	103.175^{c}	32.406^{cdef}	12.726^{cde}	2.980^{a}
G17	101.741^{c}	49.135^{ab}	12.870^{bcde}	3.070^{a}
M33	215.533^{ab}	42.402^{bc}	14.420^{abcd}	2.920^{a}
M34	82.817^{c}	41.837^{cd}	13.231^{abcde}	2.783^{a}
M35	86.065^{c}	31.946^{cdef}	11.258^{e}	2.686^{a}
M38	100.336^{c}	27.345^{ef}	14.954^{abc}	2.665^{a}
M39	96.456^{c}	25.310^{f}	15.209^{a}	3.030^{a}
M40	100.482^{c}	41.855^{bcd}	13.946^{abcd}	3.443^{a}
V1	310.147^{a}	44.592^{abc}	13.698^{abcd}	3.149^{a}
R12	102.846^{c}	28.889^{def}	12.464^{de}	2.946^{a}
P13	86.695^{c}	34.788^{cdef}	14.958^{abc}	2.688^{a}
N14	126.735^{bc}	34.115^{cdef}	14.641^{abcd}	2.824^{a}
C24	122.036^{bc}	43.572^{abc}	14.262^{abcd}	3.274^{a}
I	179.732^{bc}	40.447^{bcde}	15.076^{ab}	2.968^{a}
SEM^{2}	34.060	4.030	0.667	0.218
Mean ± SD	129.830 ±61.120	38.397 ±8.121	13.745 ±1.134	2.987 ±0.247

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

TABLE 10. *IN VITRO* DIGESTIBILITY (%) OF THE GLIRICIDIA LEAVES DURING WET AND DRY SEASONS

Provenance code	Wet season		Dry season	
	IVDMD*	IVOMD**	IVDMD	IVOMD
G13	50.41^{b1}	52.64^{b}	46.94^{ef}	48.11^{c}
G14	51.61^{ab}	53.95^{ab}	48.49^{de}	50.46^{bc}
G15	51.82^{a}	54.35^{a}	42.41^{g}	43.89^{e}
G17	48.34^{d}	50.58^{cd}	43.61^{g}	45.85^{d}
M33	50.07^{c}	51.95^{bcd}	48.44^{de}	50.27^{b}
M34	50.34^{b}	52.66^{b}	42.88^{g}	46.13^{d}
M35	47.95^{d}	50.89^{cd}	43.33^{g}	45.03^{de}
M38	46.61^{ef}	49.28^{d}	45.67^{f}	48.01^{c}
M39	45.96^{f}	50.18^{cd}	43.21^{g}	46.86^{cd}
M40	48.38^{d}	51.41^{bcd}	47.29^{e}	48.75^{c}
V1	51.12^{a}	54.29^{ab}	54.12^{a}	54.72^{a}
R12	48.97^{cd}	51.84^{bcd}	46.31^{ef}	48.44^{c}
P13	47.81^{de}	50.05^{cd}	48.47^{de}	50.10^{bc}
N14	51.76^{a}	52.83^{ab}	48.94^{cd}	50.09^{bc}
C24	52.22^{a}	53.78^{ab}	52.27^{b}	53.42^{a}
I	51.37^{ab}	53.42^{ab}	50.08^{c}	51.16^{b}
SEM^{2}	0.40	0.52	0.48	0.49
Mean ± SD	49.73 ±2.04	52.13 ±1.62	47.03 ±3.44	48.83 ±2.94

* IVDMD = *In vitro* dry matter digestibility.
** IVOMD = *In vitro* organic matter digestibility.
[1] Values in the same column with different superscripts differed ($p < 0.05$).
[2] SEM = Standard error of the treatment means.

TABLE 11. SOLUBLE NON-NUTRITIVE CONSTITUENTS OF THE GLIRICIDIA LEAVES DURING THE WET AND DRY SEASONS

Provenance code	Total soluble phenol (% DM)		HCN (mg / kg DM)		Provenance code	Total soluble phenol (% DM)		HCN (mg / kg DM)	
	Wet season	Dry season	Wet season	Dry season		Wet season	Dry season	Wet season	Dry season
G13	23.15^{g}[1]	20.32^{bcdef}	22.72^{a}	15.35^{cde}	R12	25.94^{fg}	21.65^{bcd}	22.24^{a}	17.65^{abc}
G14	26.73^{efg}	17.11^{fghi}	24.75^{a}	16.26^{bcde}	P13	33.24^{abc}	18.48^{defgh}	20.93^{a}	15.58^{cde}
G15	19.00^{h}	18.50^{defgh}	21.66^{a}	16.92^{bcd}	N14	24.14^{g}	22.18^{bc}	22.28^{a}	17.68^{abc}
G17	24.50^{g}	14.51^{i}	23.08^{a}	20.34^{a}	C24	31.62^{bcd}	23.19^{ab}	27.22^{a}	13.03^{e}
M33	25.34^{fg}	15.84^{ghi}	28.32^{a}	20.40^{a}	I	29.78^{cde}	18.42^{defgh}	26.13^{a}	14.48^{cde}
M34	28.31^{def}	16.58^{ghi}	26.25^{a}	19.17^{ab}					
M35	25.63^{fg}	18.86^{cdefg}	21.05^{a}	15.84^{bcde}	SEM[2]	1.70	1.07	2.34	1.01
M38	36.37^{a}	15.11^{hi}	22.18^{a}	16.36^{bcde}					
M39	30.51^{cde}	17.98^{efgh}	22.04^{a}	15.02^{cde}	Mean	28.26	19.13	23.92	16.60
M40	31.77^{bcd}	21.19^{bcde}	23.30^{a}	17.68^{abc}	±SD	±4.83	±3.14	±2.58	±2.15
V1	36.15^{ab}	26.10^{a}	28.58^{a}	13.80^{de}					

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

TABLE 12. INSOLUBLE NON-NUTRITIVE CONSTITUENTS (% DM) OF THE GLIRICIDIA LEAVES DURING THE WET AND DRY SEASONS

Provenance code	AD-Lignin		Silica		Provenance code	AD-Lignin		Silica	
	Wet season	Dry season	Wet season	Dry season		Wet season	Dry season	Wet season	Dry season
G13	11.40^{ef}[1]	18.92^{bcd}	0.73^{a}	0.80^{ab}	R12	15.01^{abc}	19.42^{bcd}	0.43^{a}	0.43^{bc}
G14	11.84^{ef}	14.39^{fg}	0.73^{a}	0.47^{bc}	P13	10.83^{ef}	16.93^{def}	0.92^{a}	0.69^{bc}
G15	16.46^{ab}	18.15^{bcde}	0.69^{a}	0.44^{bc}	N14	10.34^{fg}	13.28^{gh}	0.62^{a}	0.69^{bc}
G17	15.27^{abc}	17.24^{cdef}	0.47^{a}	0.40^{c}	C24	8.07^{g}	12.79^{gh}	0.39^{a}	0.61^{bc}
M33	14.78^{bcd}	18.23^{bcde}	0.61^{a}	1.09^{a}	I	12.26^{def}	14.78^{cfg}	0.55^{a}	0.47^{bc}
M34	17.65^{a}	25.31^{a}	0.87^{a}	0.69^{bc}					
M35	14.86^{bcd}	19.50^{bc}	0.72^{a}	0.61^{bc}	SEM[2]	0.86	1.08	0.16	0.11
M38	15.43^{abc}	21.29^{b}	0.69^{a}	0.65^{bc}					
M39	17.20^{ab}	26.60^{a}	0.51^{a}	0.47^{bc}	Mean	13.30	17.76	0.65	0.59
M40	13.15^{cde}	17.17^{cdef}	0.68^{a}	0.58^{bc}	±SD	±3.00	±4.31	±0.15	±0.18
V1	8.25^{g}	10.17^{h}	0.74^{a}	0.41^{c}					

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

N14 and I out-yielded the other provenances (Cobbina and Atta-Krah, 1992; Bray et al., 1993; Sukanten et al., in press), there is indication that both for the higher fodder yield and fodder quality, the prefered provenance would be G14.

During the 2 months wet season the leaf grew faster and younger so that it contained more CP but less CF, while during the 4 months dry season the leaf grew slower and become older so that it contained lower CP but higher CF. However, variation in the mineral contents of some provenances during the wet and dry seasons might be due to the genetic ability of such provenances to mobilize certain minerals even under water stress. Soil pH might also had an influence since the Mg, P and Na contents of the provenances grown in acid soil (Bray et al., 1993) were higher than those grown in alkaline soil reported in the present experiment. This confirmed the finding of Adejumo (1992) that the macro and micro-element concentrations of gliricidia leaves varied according to the harvest date and plant age in the infertile alfisol soil.

The chemical composition and nutritive value of the 16 provenances of *G. sepium* shown in the present study generally fell within the ranges reported in the literatures (Cheeke and Raharjo, 1987; Rajaguru, 1990; Wanapat, 1990; Smith, 1992; Cobbina and Atta-Krah, 1992; Bray et al., 1993). However, nutrient values of 15 to 203% higher than the normal ranges have been shown by provenance G13 for Mg, Mn and Cu; G14 for hemicellulose; G17 for Mn; M38 for Zn; M39 for ADF; M40 for CP and Ca; V1 for Mg, P, K and Fe; R12 for Na; N14 for Ca; C24 for CF and I for Fe; while the non-nutrient values of 21 to 40% lower than the normal ranges have been shown by provenace G15 for TSP; G17 for HCN and silica; and C24 for HCN, AD-lignin and silica. Such high values become important source of nutrients, particularly during the dry season, when it is not uncommon that ruminant feeds consisted solely of gliricidia fodder. This confirmed the finding of Nitis et al. (1989 and 1993) that Bali cattle could maintain weight, while the goat could gain weight when fed sole diet of gliricidia fodder.

TABLE 13. THE HIGHEST AND LOWEST RANKING ORDERS OF THE 48 CHEMICAL COMPONENT AND DIGESTIBILITY PARAMETERS IN EACH PROVENANCE DURING THE WET AND DRY SEASONS

Provenance code	Highest ranking order			Lowest ranking order		
	1	2	3	16	15	14[1]
G13	5	1	6	2	1	3
G14	1	3	8	2	0	2
G15	3	1	4	4	0	2
G17	1	5	0	5	1	4
M33	2	3	1	2	2	1
M34	2	4	2	4	3	5
M35	3	1	0	4	6	3
M38	2	2	1	8	4	0
M39	4	2	2	5	5	4
M40	2	3	0	1	5	2
V1	12	6	3	5	5	1
R12	4	1	5	1	4	3
P13	2	1	3	1	7	5
N14	1	4	4	0	1	6
C24	3	9	4	4	3	6
I	1	2	5	0	1	1
n	48	48	48	48	48	48

[1] Order of the 16 provenances.

TABLE 14. GLIRICIDIA PROVENANCES APPEARED IN THE RANKING ORDER

No. Attribute	Highest ranking order			Lowest ranking order		
	1	2	3	16	15	14[1]
1 Organic matter (OM, CP, CF)	M35	C24	I	G13	M39	G14
2 Inorganic matter (ash)	V1	I	G14	M35	P13	C24
3 Gross energy (GE)	P13	C24	N14	M34	M39	M40
4 Fiber components (ADF, NDF, cellulose, hemicellulose)	M39	M34	R12	V1	C24	P13
5 Minerals (Ca, K, Mg, P, Na, Fe, Mn, Zn, Cu)	V1	N14	G13	M38	M40	C24
6 Insoluble non-nutritive constituents (AD-lignin, silica)	M39	M34	G15	C24	V1	N14
7 Soluble non-nutritive constituents (TSP, HCN)	V1	G17	M34	C24	G13	I
8 *In vitro* digestibility (IVDMD, IVOMD)	V1	C24	I	G15	M34	M39
9 Nutritive constituents (1+2+3+4+5+8)	V1	C24	G14	M38	P13	M34
10 Non-nutritive constituents (6+7)	M33	M34	G15	C24	V1	N14

[1] Order of the 16 provenances.

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Literature Cited

Adejumo, J. O. 1992. Effect of plant age and harvest date in the dry season on yield and quality of *Gliricidia sepium* in Southern Nigeria. Tropical Grasslands, 26:21-24.

Association of Official Analytical Chemist. 1970. Official Methods of Analysis. 11th Ed. AOAC Washington, DC. pp. 327-344.

Boltz, D. F. 1958. Colorimetric determination of non metals (ed). Interscience Publishers, Inc., New York, Interscience Publishers Ltd., London: Ⅷ. pp. 36-37.

Bray, R. A., Tatang Ibrahim, B. Palmer and A. C. Schlink. 1993. Yield and quality of *Gliricidia sepium* accessions at two site in the tropics. Tropical Grasslands, 27:30-36.

Cheeke, P. R. and Y. C. Raharjo. 1987. Evaluation of *Gliricidia sepium* forage and leaf meal as feedstuffs for rabbits and chickens. In: *Gliricidia sepium* (Jacq.) Walp. Management and improvement. Proceeding of a workshop, Turrialba, Costa Rica. NFTA Special Publication 87-01, pp. 193-198.

Cobbina, J. and A. N. Atta-Krah. 1992. Forage productivity of *Gliricidia sepium* accessions on a tropical alfisol soil in Nigeria. Tropical Grasslands, 26:248-254.

Fick, K. R., S. M. Miller, J. D. Funk, L. R. McDowell and R. H. Houser. 1976. Methods of minerals analysis for plant and animal tissues. University of Florida, Institute of Food and Agricultural Sciences. U.S.A.

Gallenkamp, A. 1976. Automatic Adiabadic Bomb Calorimeter. DHA ANAX PTY. LTD. London.

Goering, H. K., and P. J. Van Soest. 1970. Fibers analysis. Agriculture Handbook No. 379. Agriculture Research Service, USDA, Washington, DC, pp. 1-20.

Goto, I., and D. J. Minson. 1977. Prediction of dry matter digestibility of tropical grass using the pepsin cellulase assay. Animal Feed Science and Technology, 2:247-253.

Merkel, R. C., K. R. Pond, P. M. Horne, R. M. Gatenby, J. C. Burns and D. J. Fisher. 1994. Preference of *Gliricidia sepium* fed to sheep at 3 different wilting levels. In Sustainable Animal Production and the Enveronment. Proceeding of the 7th AAAP Animal Science Congress held in Bali, Indonesia, July 11-16. 1994. Ikatan Sarjana Ilmu-ilmu Peternakan Indonesia. Ⅱ:519-520.

Nitis, I. M., K. Lana, T. G. O. Susila, W. Sukanten and S. Uchida. 1985. Chemical composition of the grass, shrub and tree leaves in Bali. Supplementary Report no. 1 to IDRC: Canada. pp. 1-93.

Nitis, I. M., K. Lana, M. Suarna, W. Sukanten, S. Putra and W. Arga. 1989. Three strata system for cattle feeds and feeding in dryland farming area in Bali. Final Report to IDRC: Canada. pp. 1-252.

Nitis, I. M., K. Lana, M. Suarna, W. Sukanten, S. Putra, W. Bebas, W. Arga, I. N. G. Ustriyana and N. L. Arjani. 1993. Gliricidia for goat feeds and feeding in the three strata forage system. Final Report to IDRC: Canada. pp. 1-227.

Putra, S. 1992. Evaluasi komposisi kimia dan tingkat konsumsi 16 daun provenance gamal yang ditanam pada lahan kering di pro pinsi Bali. M. Sc. Thesis. Program Pasca Sarjana, IPB, Bogor. pp. 1-93.

Rajaguru, A. S. B. 1990. Availability and use of shrubs and tree fodders in Sri Lanka. In: C. Devendra (ed). Shrubs and Tree Fodders for Farm Animals. Proceeding of a workshop in Denpasar, Indonesia, July 24-29. 1989. IDRC, Ottawa, Canada. pp. 237-243.

Reed, J. D., P. J. Horvath, M. S. Allen, P. J. Van Soest. 1985. Gravimetric determination of soluble phenolics including tannin from leaves by precipitation with trivalent Ytterbium. Journal of the Science and Food of Agriculture, 36:255-261.

Smith, O. B. and M. F. J. Van Houtert. 1987. The feeding value of *Gliricidia sepium*. World Animal Review, 62:57-68.

Smith, O. B. 1992. Fodder trees and fodder shrubs in range and farming systems in tropical humid Africa. In: Legume trees and other fodder trees as protein sources for livestock. FAO Animal Production and Health Paper, 102:43-60.

Steel, R. G. D. and J. H. torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, New York.

Sukanten, I. W., S. Uchida, S. Hyotani and N. Nishino. 1994. Comparative study on chemical composition and nutritive value of Indonesian *Gliricidia sepium* leaves and alfalfa diets (In Japanese. Translated by the authors of this paper). Proceeding of Japanese Grassland Science Congress, Kumamoto, September 7-10, 1994. Japanese Society of Grassland Science, 39:203-204.

Sukanten, I. W., I. M. Nitis, K. Lana, M. Suarna and S. Uchida. *In press.* Growth and fodder yield of the *Gliricidia sepium* provenances in alley cropping system in dryland farming area in Bali, Indonesia. Asian-Australasian Journal of Animal Sciences.

Wanapat, M. 1990. Availability and used of shrubs and tree fodders in Thailand. In: C. Devendra (ed). Shrubs and Tree Fodders for Farm Animals. Proceeding of a workshop in Denpasar, Indonesia, July 24-29. 1989. IDRC, Ottawa, Canada. pp. 244-254.

Wiersum, K. F. and I. M. Nitis. 1992. *Gliricidia sepium* (Jacq.) Kunth ex Walp. In: IL. 't Mannetje and R. M. Jones (Eds). Plant Resource of South-east Asia. Forages. Pudoc Scientific Publishers, Wangeningen. 4, pp. 133-137.