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EVALUATION OF SELECTED LEGUME COVER CROPS FOR BIOMASS PRODUCTION, DRY SEASON SURVIVAL AND SOIL FERTILITY IMPROVEMENT IN A MOIST SAVANNA LOCATION IN NIGERIA

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ABSTRACT

The growth and development of eighteen legume cover crop species were evaluated at the University of Ilorin Teaching and Research Farm (8° 29'N, 4° 35'E) in the southern Guinea savanna zone during the 1993 – 1996 cropping seasons. Field establishment, ground cover, above ground biomass production, and seed yields of the legume species were monitored during each cropping season. This was followed by an *in-situ* bioassay to determine the residual effect of the sown legume on maize (*Zea mays* L.) production in the absence of added nitrogen at the end of one season of legume growth each year. The results show that field establishment was generally poor (<30%) for most of the legume species, particularly the small seeded species. This resulted in a significant correlation between seed size and percent germination ($r = 0.89$). Similarly, seed production was poor in most of the species with the exception of *Mucuna pruriens, Cajanus cajan* and *Crotalaria ochroleuca.* On the other hand, majority of the legume species gave satisfactory ground cover, biomass production, and N contribution to the succeeding non-legume crop. Using the rank summation index, the order of adaptation of the legume species to the study location on the basis of their ground cover, biomass production, seed yield, dry season survival and N contribution to the soil was as follows: *Cajanus cajan > Aeschynomene histrix > Stylosanthes guianensis > S. scabra > Crotalaria ochroleuca > C. verrucosa >Clitorea tarnatea > S. hamata > Pseudovigna argentea > Centrosema pascuorum > Pueraria phaseoloides > Lablab purpureus > Psophocarpus palustris > Chamaecrista rotundifolia > Macroptilium atropurpureum.* Management practices aimed at ameliorating the poor field establishment and seed yield are suggested.

Key Words: Field establishment, Guinea savanna, legumes, soil fertility improvement

RÉSUMÉ

Pendant les saisons de recolte de 1993 à 1996, le Centre de Formation et de Recherche de l'Université de Ilorin (8° 29" N, 4° 35" E) a mesuré l'accroissement et évalué le développement de dix-huit espèces de culture de plante au sud de la savane de Guinee. A chaque saison culturale, l'établissement de terrain, le couvert du sol, la production de la biomasse en surface, et le rendement de graines des differentes espèces des plantes ont été suivis de près. Un bio-essai en place a suivi ces études afin de déterminer les effets résiduaires des plantes semées sur la production de maïs (*Zea mays* L.) sans addition de nitrogene a la fin d'une saison annuelle de culture de plantes. Les résultats montrent que l'établissement de terrain était généralement pauvre (<30%) pour la plupart de espèces et particulièrement pour les petites espèces semées. Ceci a conduit a une forte correlation entre la taille de la graine et le pourcentage de germination ($r=0.89$). De même la production de graines était pauvre pour la plupart de espèces avec l'exception de *Mucuna pruriens, Cajanus cajan* et *Crotalaria ochroleuca.* D'autre part la majorité des espèces de plantes a donné des résultats satisfaisants pour le couvert du sol, la production biomasse, et les contributions N pour les cultures suivantes non légumineuses. En utilisant la base d'addition indexée ci-après, l'ordre d'adaptation des especes de plante (avec l'étude de l'emplacement basée sur le sol couvert, la production biomasse, le rendement de graines, la survie de saison sèche et la contribution N à la terre) est le suivant *Cajanus cajan > Aeschynomene histrix > Stylosanthes guianensis > S. scabra > Crotalaria ochroleuca > C. verrucosa, > Clitorea tarnatea > S. hamata > Pseudovigna argentea > Centrosema pascuorum > Peuraria phaseoloides > Lablab purpureus > Psophocarpus palustris > Chamaecrista rotundifolia > Macroptilium atropurpureum.* Les pratiques de gestion visant à l'amélioration des pauvres établissements en champs et le rendement en graines sont suggérées.

Mots Cles: Établissement de terrain, Guinea savanna, légumés, amélioration de la fertilite du sol

INTRODUCTION

Land degradation and declining soil fertility leading to decreasing total agricultural productivity is a problem in sub-Saharan Africa (Okigbo, 1985; Lal, 1989). Integration of leguminous cover crops into the existing cropping system has been reported to offer the potential for overcoming this problem. Legumes have the potential to improve soil fertility thereby boosting subsequent crop yield (Mohammed-Saleem, 1986; Maccoll, 1990; Tarawali, 1991). Legumes offer other benefits such as maintenance and improvement of soil physical properties, providing ground cover to reduce soil erosion, increasing soil organic matter, cation exchange capacity, microbial activity and reduction of soil temperature (Vallis and Gardner, 1984; Mohammed-Saleem, 1986; Mulongoy and Kang, 1986; Tarawali *et al.*, 1987). Another potential benefit of legume cover crops is their ability to suppress weeds (Akobundu, 1980, 1982) and nematodes (Sharma *et al.,* 1982).

Legumes can be integrated into the existing cropping system either as cover crops, live mulch, fodder or food crops through planted fallow or multiple cropping system (Kang, 1992). Although grain legumes such as cowpea (*Vigna unguiculata* L. Walp) and groundnut (*Arachis hypogeae* L.) have played important roles in food and animal feed, there is little likelihood that a significant portion of the N requirement of succeeding non-legume crops can be met from the residue of grain legumes (Mughogho *et al.,* 1982). Hence, there has been renewed interest in the use of leguminous cover crop, due to low capital base of farmers to purchase inorganic fertiliser as well as concern for the environment.

There are several species of tropical legumes, but only a few have been studied and mostly for their potential as fodder crops (Tarawali *et al.,* 1987; Tarawali and Mohammed-Saleem, 1994). Lal *et al.* (1979) reported the beneficial effects of growing *Psophocarpus palustris* on soil structure, while *Mucuna pruriens* var *utilis* has been found useful in improving the physiological properties of compacted alfisols (Hullugale *et al.,* 1986). In the northern territory of Australia, Bridge *et al.* (1983) reported that growing *Stylosanthes hamata* increased macro porosity and infiltration rate of the soil. On the other hand, Ile *et al.* (1996) have suggested that growing of *Mucuna pruriens* var *utilis* as a relay cover crop may reduce the need to apply synthetic N-fertiliser.

The most important task in this effort is to identify the most relevant legume species for integration into the farming systems. The present study therefore formed part of a series of studies initiated by the International Institute for Tropical Agriculture (IITA) in collaboration with the Nigerian Agricultural Research System (NARS) to evaluate and characterise some selected legume cover crop species for adaptation in the moist savanna zones of Nigeria. The broad objective of the study was to evaluate the potential of the selected legume species for establishment, growth characteristics, biomass and seed production, soil fertility improvement and weed suppression.

MATERIALS AND METHODS

The trials were located on the University of Ilorin Teaching and Research Farm at Bolorunduro (8^o 29'N, 4^o 35'E) in the southern Guinea savanna ecological zone of Nigeria. The area is characterised by a bimodal rainfall pattern with peaks in June and September and a dry spell between mid- July and August. The average annual rainfall for the area is 1000 – 1240 mm. The soil of the farm has been classified as *Typic Haplustalf.*

Thirteen legume species (Table 1) were compared during 1993, while 18 legume types were evaluated during 1994 and 1995. During 1993 one control was included, but there were two control plots per replicate during the 1994 and 1995 seasons. In 1993, the legume species were planted into rows that were 1000 mm apart, while the inter row spacing was reduced to 750 mm in the two subsequent years. *Cajanus cajan, Lablab purpureus, Mucuna pruriens* and *Psophocarpus palustris* were planted at intra- row spacing of 250 mm, while the other legume species were drilled with sand and lightly covered with soil in 1993. In 1994, the above legume species as well as *Centrosema brasilianum, C. pascuorum, Clitorea tarnatea, Macroptilium atropurpureum,* and *Pseudovigna argentea* were planted at the intra-row spacing of 250 mm, while others were drilled. In 1995, all the legume species were planted at regular intra-row spacing of 250 mm for the medium to large seeded legume species and 750 mm for the small seeded species. Plots measuring 12 m x 10 m, were used. In 1993, 14 of such plots were grouped together to make a replicate while in both 1994 and 1995 trials, there were 20 plots per replicate. The plots were arranged as a set of randomised complete blocks with four replicates.

Each year the trial sites were disc- ploughed and harrowed. The legume plots were hoe-weeded four weeks after planting (WAP) in 1993 and 3 and 7 WAP in 1994 and between 5 and 11 and 13 WAP in 1995. Phosphorus and potassium fertilisers, were applied at the rates of 15 kg P_2O_5 ha^{-1} as single super phosphate and 30 kg K_2O ha^{-1} as potassium chloride to the legume plots as side dressing 7 WAP each year. One of the control plots within each replicate was similarly weeded and fertilised as above in 1994 and 1995, while the other control plots for these years were left unweeded and unfertilised. At the beginning of the 1994, 1995 and 1996 cropping seasons, the legume plots planted the previous year (1993, 1994 and 1995, respectively) were weeded by hand pulling. When the rains had become well established, the surviving legume plants (if any) in one third of the plot (4m x 10m) were slashed, cut into small pieces, and left on the soil surface. Maize (*Zea mays* L.) var DMRSR-Y was

TABLE 1. Legumes evaluated in this study with an indication of their growth habit, seed size (mg per seed) and percent germination during the three seasons of study (1993-1995)

Legume species	Type	Seed size (mg)	Percent germination			
			1993	1994	1995	Mean
Aeschynomene histrix	Semi erect	1.2	6cde	9e	15def	10
Cajanus cajan	Erect	108.2	33b	26cd	52c	37
Centrosema brasilianum	Trailing	30.6	5cde	36cd	72b	38
Centrosema pascuorum	Trailing	20.8	6cde	34c	55c	32
Chamaecrista rotundifolia	Trailing	3.9	6cde	26cd	9f	19
**Clitorea tarnatea*	Semi erect	46.7	*	17de	21def	19
Crotalaria ochroleuca	Erect	15.5	8cde	14e	23def	15
Crotalaria verrucosa	Semi erect	17.7	1e	8e	19de	9
Lablab purpureus	Trailing	289.6	63a	63b	53c	60
**Macroptilium atropurpureum*	Trailing	12.6	*	13e	31d	22
Mucuna pruriens (black seeded)	Trailing	780.3	15c	79a	98a	64
**Mucuna pruriens* (white seeded)	Trailing	763.8	*	81a	92a	86
**Stylosanthes guianensis*	Semi erect	1.6	*	12e	20def	16
Stylosanthes hamata	Semi erect	3.4	4de	9e	9f	7
**Stylosanthes scabra*	Semi erect	1.7	*	8e	29de	18
Pseudovigna argentea	Trailing	46.8	6cde	14e	14ef	12
Psophocarpus palustris	Trailing	93.5	27b	27cd	30de	28

Not planted in 1993. Figures followed by the same letter(s) in a column are not significantly different at 5 percent probability level (LSD) subsequently planted in these mini plots, as test crops for monitoring the residual effects of the legumes on soil nitrogen supply. At the same time the control plots in the previous year's planting were each divided into three 4m x 10m subplots, planted with maize and each subplot was fertilised at the rate of 0, 30 or 60 kg N ha^{-1}. Germination percent was established for each replicate plot.

Phenological observations including onset of trailing or branching, onset of flowering, onset of podding, pod filling time and seed shedding were recorded on weekly basis starting from 4 WAP. Legume ground cover was evaluated using the beaded string method 14 WAP in 1993, and 4, 8, 12 and 20 WAP in the subsequent years. A nylon string, knotted at 10 cm intervals, was laid across the diagonal of the whole plots (8m x 10m). The number of knots touching a live legume plant was expressed as a percentage of the total number of knots laid in the plot. This was done for the two diagonals and means were computed. Samples of the above ground legume growth were harvested from randomly located $1m^2$ quadrants in the destructive sampling area (4m x 10m) to estimate biomass production 10, 12 and 14 WAP in the first year, but modified to 8, 12, 16 and 20 WAP in the subsequent years. Legume regrowth during the second year of establishment was assessed as ground cover by visual observation about 15 months after planting (MAP) while biomass production was determined 16 MAP for each legume species. Seeds were harvested from 1 m^2 within the whole plot, making sure that most of the shed seeds were collected. Ripe maize ears were harvested, sun-dried, threshed and weighed to give grain yield per plot. Samples of the threshed grain were oven dried at 65°C to determine the moisture content for evaluating grain weight at 14 % moisture content. Data collected were subjected to analysis of variance and separation of means was by the Least Significant Difference test at 5% probability level. Specific performance was evaluated using the Rank Summation Index (RSI) (Abayomi and Saliu, 1997).

RESULTS

Field establishment, phenology, diseases and pest incidence of legume species. Field germination was generally less than 30% in most species except *Mucuna pruriens*, Lablab, *Centrosema brasilianum, C. pascuorum* and *Cajanus cajan* (Table1). A three-year average germination of 86% was recorded for *Mucuna pruriens* (white seeded) with a seed weight of 763.1 mg, while the lowest germination of 7.2% was obtained with *Stylosanthes hamata* with a seed weight of 3.4 mg.

The three-year means of the phenological data are presented in Table 2. Onset of trailing started earliest in two varieties of *Mucuna pruriens* (14 DAP), and latest in *Macroptilium atropurpureum* (46 DAP). Branching in erect and semi erect species was earliest in *Cajanus cajan* (32 DAP) and latest in *Crotalaria verrucosa* (46 DAP). Flowering was earliest in *Chamaecrista rotundifolia* (37 DAP), relatively early in *Clitoria tartanea* (39 DAP) and *M. atropurpureum* (48 DAP), latest in *Pseudovigna argentea* and *Pueraria phaseoloides* (119 DAP). Podding followed a similar trend with pod formation occurring first in *Chamaecrista rotundifolia* (51 DAP), followed by *M. atropurpureum* (56 DAP) and *Clitorea tartanea* (60 DAP). However, pod filling time was shortest with *Centrosema pascuorum* (19 days) followed by *Sylosanthes guianensis, S. hamata* and *Pseudovigna argentea* (21 days). Duration of pod filling was longest with *Clitorea tarnatea* (42 days), *Crotalaria verrucosa* (40 days), *M. pruriens* (32-39 days) and *Psophocarpus palustris* (35 days). Although some legume species showed slight wilt symptoms caused by *Rhizoctania* and *Bacterium* spp. during the peak of rains in the first year of study, there were no severe diseases or pests incidence. The soil population of nematodes in general and *Meloidogyne incoginita* in particular were reduced by *Stylosanthes* spp. and *Crotalaria* spp., and these observations were further confirmed by the results of the root gall index (Data not shown).

Ground cover, biomass and seed production. Percent ground cover during the year of establishment was highest with the two varieties of *Mucuna pruriens,* which had almost perfect ground coverage 12 WAP (Table 3). Percent ground coverage was also high for *Centrosema pascuorum* (76%), *Lablab purpureus* (84%) and *Psophocarpus palustris* (61%) 12 WAP. Ground coverage during the year of establishment was

TABLE 2. Average days from planting to phenological events in legume species

Legume species	Branching/ Trailing (DAP)	Fowering		Podding	
		onset (DAP)	50% (DAP)	onset (DAP)	pod filling (days)
Aeschynomene histrix	45B	96	119	110	24
Cajanus cajan	32B	112	140	149	23
Centrosema brasilianum	39T	73	87	85	32
Centrosema pascuorum	32T	54	70	89	19
Chamaecrista rotundifolia	32B	37	63	51	24
Clitorea tarnatea	32T	39	64	60	42
Crotalaria ochroleuca	39B	68	79	84	23
Crotalaria verrucosa	46B	68	82	84	40
Lablab purpureus	25T	100	117	124	26
Macroptilium atropurpureum	46T	49	70	56	32
Mucuna pruriens (Black seeded)	14T	112	132	126	37
Mucuna pruriens (white seeded)	14T	84	95	98	39
Stylosanthes guianensis	39B	105	118	133	21
Stylosanthes hamata	39B	56	72	98	21
Stylosanthes scabra	39B	75	91	84	34
Pseudovigna argentea	14T	119	152	154	21
Psophocarpus palustris	32T	96	106	110	35

Data are means of three years. T = Trailing, B = Branching, DAP = days after planting

TABLE 3. Percent ground cover of spreading legume species 12 weeks after planting (*14 in 1993) in the year of establishment and 15 months after planting during the second year of establishment

Legume species	Percent ground cover establishment year				Second year of establishment			
	1993	1994	1995	Mean	1994	1995	1996	Mean
Aeschynomene histrix	25e	15e	14g	18	76ab	64ab	98a	79
Centrosema brasilianum	49d	28d	44c	40	79ab	57abc	94ab	77
Centrosema pascuorum	54cd	88b	85b	76	0d	11ef	25e	12
Chamaecrista rotundifolia	50d	57c	35cd	47	49c	33cde	77bc	53
Clitorea tarnatea	na	37d	20ef	28	na	15ef	55d	35
Crotalaria verrucosa	5f	12e	26de	14	9d	8ef	73c	30
Lablab purpureus	71b	98ab	77b	84	0d	14ef	3f	6
Macroptilium atropurpureum	na	36d	20ef	28	na	16ef	50d	34
Mucuna pruriens (black)	91a	99a	99a	96	1d	28cde	0f	10
Mucuna pruriens (white)	na	100a	100a	100	na	46bcd	5f	17
Stylosanthes guianensis	na	7ef	9gh	8	na	81a	96a	89
S. hamata	25e	15c	14fg	18	54c	54bc	55d	54
S. scabra	na	3f	4h	3	na	46bcd	45d	46
Pseudovigna argentea	47d	48c	34cd	43	86a	60ab	98a	81
Psophocarpus palustris	69bc	83b	33d	62	10d	9ef	5f	8
Pueraria phaseoloides	47d	16c	22c-f	28	65bc	69ab	95a	76
SED	8.3	7.2	7.9		7.9	10.2	8.8	

na = data not available

Figures followed by the same letter(s) in a column are not significantly different by LSD test at 5 percent probability level minimal with the three species of *Stylosanthes* and *Aeschynomene histrix*, all of which, however had between 46% to 79% ground coverage during the second year of establishment (Table 3). The second year ground cover was also high for *Centrosema brasilianum* (77%), *Pseudovigna argentea* (81%), *Cajanus cajan* (89%) and *Pueraria phaseoloides* (76%). Unlike the first year, however, legume ground cover was very poor for *Mucuna pruriens, Labalab purpureus, Crotalaria ochroleuca, Psophocarpus palustris* and *Centrosema pascuorum*, all of which showed poor dry season survival/ regrowth from shed seeds during the second year.

Cajanus cajan produced the highest dry matter (DM) per unit area during the year of establishment, in all the three years of this study, with best result in 1994 (Fig.1a). These values

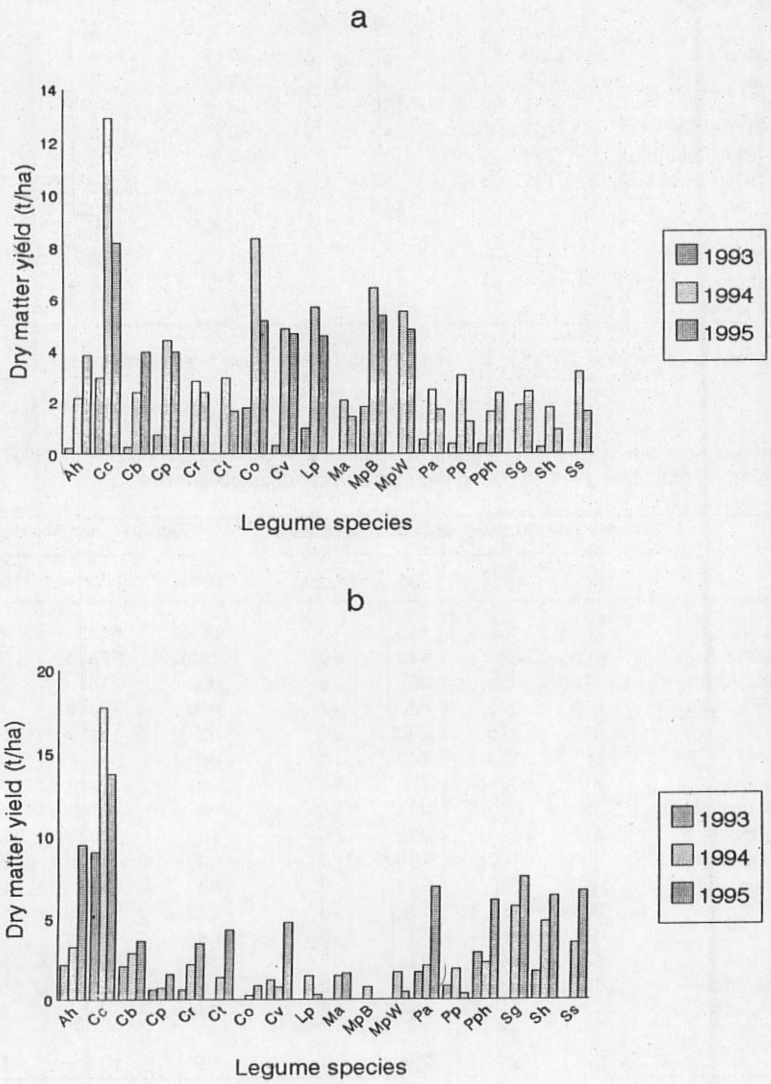

Figure 1. Above ground biomass yield of legume species during (a) the establishment year and (b) second year of growth during the three years of study.
Ah = *Aeschynomene histrix*, Cc = *Cajanus cajan*, Cb = *Centrosema brasiianum*, Cp = *Centrosema pascuoru*, Cr = *Chamaecrista rotunditolia*, Ct = *Clitorea tarnatea*, Co = *Crotalaria ochroleuca*, Cv = *Crotalaria verrucosa*, Lp = *Lablab purpureus*, Ma = *Macroptilium atropurpureum*, MpB = *Bucuna pruriens* (black seed) MpW = *Mucuna pruriens* (White seeded), Pa = *Pseudovigna argentea*, Pp = *Psophocarpus palustris*, Pph = *Pueraria phasedoides*, Sg = *Stylosanthes guianensis*, Sh = *Stylosanthes hamata*, Ss = *Stylosanthes scabra*.

were significantly higher than in the other species ($P<0.05$). This was followed by *Mucuna pruriens* (white seeded), *Crotalaria ochroleuca, M. pruriens* (black seeded) which had similar DM yield. Of the 18 species evaluated, only six had a three year mean DM less than 2.0 t ha $^{-1}$, with the lowest production from *Stylosanthes hamata.*

In the second year of establishment, the above ground DM was again highest with *Cajanus cajan* and the value was 67% higher than in the first year (Fig.1b) and lowest with *Mucuna* spp. which had a 95% decrease in DM yields compared to the year of establishment. DM production during the second year of establishment showed a reversal with that of the first year for *Stylosanthes* spp., *Aeschynomene histrix, Pueraria phaseoloides* and *Centosema brasilianum*, which had significantly higher DM yields than most other species during the year of establishment. *Mucuna pruriens* (white seeded) had the highest seed production averaged across three seasons (Fig. 2). This was followed by yields in *Cajanus cajan, M. pruriens* (black seeded), *Centosema pascuorum, Lablab purpureus* and *Clitorea tarnatea* in that order.

Persistence and residual N contribution to soil. Of the 18 legume species evaluated in this study, *Mucuna pruriens, Lablab purpureus, Centrosema pascuorum, Psophocarpus palustris* and *Crotalaria ochroleuca* showed no dry season survival and very little re-establishment from the shed seeds (Table 4). The remaining 12 species persisted by surviving the dry season and / or regrowing from shed seeds, and continued growing once the rains returned. Averaged over three years, excellent dry season survival and /or second year re-establishment from shed seeds were obtained from *Stylosanthes scabra, S. guianensis, Cajanus cajan, Pseudovigna argentea* and *Aeschynomene histrix.* Survival / re-establishment was also good (between 80% to 98%) for *Clitorea tarnatea, S. hamata* and *Pueraria phaseoloides* and fair (57% to 70%) for *Macroptilium atropurpureum, Chamaecrista rotundifolia* and *Crotalaria verrucosa.*

Maize grain yield following one year of legume growth show that yields from those legume plots with high biomass production were higher than those of the unfertilised control plots and similar

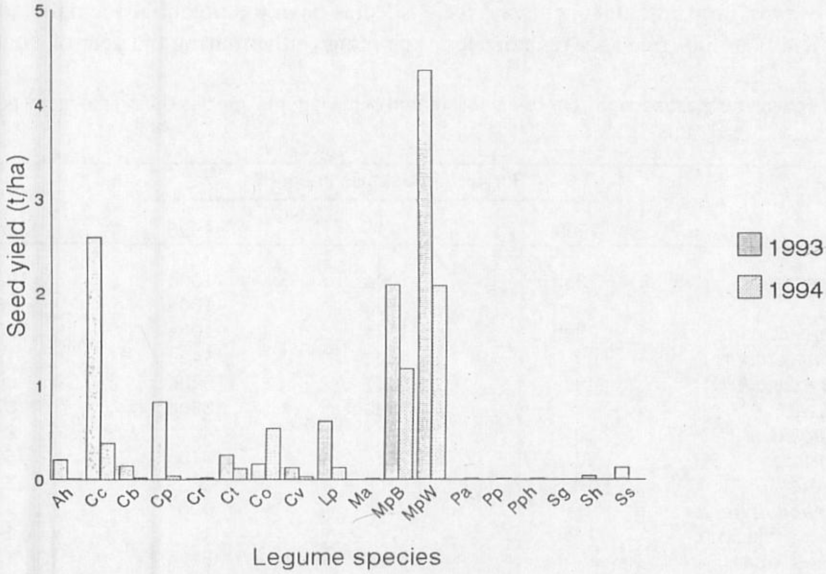

Figure 2. Seed yield in evaluated legume species during two cropping season.
Ah = *Aeschynomene histrix*, Cc = *Cajanus cajan*, Cb = *Centrosema brasiianum*, Cp = *Centrosema pascuoru*, Cr = *Chamaecrista rotunditolia*, Ct = *Clitorea tarnatea*, Co = *Crotalaria ochroleuca*, Cv = *Crotalaria verrucosa*, Lp = *Lablab purpureus*, Ma = Macroptilium atropurpureum, MpB = *Bucuna pruriens* (black seed) MpW = *Mucuna pruriens* (White seeded), Pa = *Pseudovigna argentea*, Pp = *Psophocarpus palustris*, Pph = *Pueraria phasedoides*, Sg = *Stylosanthes guianensis*, Sh = *Stylosanthes hamata*, Ss = *Stylosanthes scabra.*

to those of control plots that received various rates of N fertiliser in the two cropping seasons of assessment (Fig. 3). Grain yields due to legume were generally higher in 1995 than in 1996, while response to N application in control plots were better in 1996 than in 1995. Averaged over the two seasons, grain yields were highest in plots preceded by *Stylosanthes guianensis* and the value was higher than yields obtained from control plot fertilised with 60 kg N ha^{-1} by 43% . This was followed by grain yields from *Cajanus càjan, Aeschynomene histrix, Crotalaria ochroleuca* and *Psophocarpus palustris* plots which had similar yields to those of the control plots with an inorganic N application of 60 kg N ha^{-1}.

DISCUSSION

Ecological adaptation is an important factor in legume integration into the farming system (Anon, 1993). The present study has demonstrated that some of the legume cover crop species evaluated are well adapted to the prevailing conditions in the study location which are typical conditions in the southern Guinea savanna ecological zone of Nigeria. However, crop establishment may be problematic (if not carefully managed) as indicated by the generally poor 3-year average germination (<30%) in most species except *Mucuna* spp., *Lablab purpureus, Centrosema brasilianum, C. pascuorum* and *Cajanus cajan* (Table1). A significant correlation (r = 0.89) between seed size and percent germination showed the dependence of field establishment on seed size of the legume species. This might be an important factor affecting early ground cover and weed suppression in these species (Abayomi and Fadayomi, 1995). The problem of crop establishment in evaluated species, however, can be minimised by careful management practices including seed scarification, planting when rains are well established, and early weed control.

Even though leguminous cover crops have been shown to contribute N to the soil for subsequent crops (Peters *et al.*, 1994a, b; Tarawali, 1991, 1995; Ile *et al.,* 1996), it has, however, been pointed out that the major requirement to be met is whether there are legume species which grow rapidly to cover the soil during the rainy season and persist as live or dead mulch during the dry season (Carsky, 1993). The results of the present study have shown that some of the evaluated species have the potential for rapid soil surface coverage either during the year of establishment

TABLE 4. Dry season survival/second year re-establishment of the legume species during the study period (1993-1995)

Legume species	Survival/ re-establishment (%)			
	1993	1994	1995	Mean
Aeschynomene histrix	78ab	100a	100a	92
Cajanus cajan	93ab	100a	100a	98
Centrosema brasilianum	79ab	100a	100a	93
Centrosema pascuorum	0d	43d	14e	19
Chamaecrista rotundifolia	49c	68c	92bc	69
Clitorea tarnatea	-	85abc	89bc	87
Crotalaria ochroleuca	1d	2f	4f	2
Crotalaria verrucosa	9d	73c	91bc	57
Lablab purpureus	0d	6ef	2f	3
Macroptilium atropurpureum	-	90ab	50d	71
Mucuna pruriens (black)	1.0d	3f	1f	1
Mucuna pruriens (white)	-	15ef	6ef	11
Stylosanthes guianensis	-	98a	100a	99
S. hamata	53c	90ab	99ab	81
S. scabra	-	100a	100a	100
Pseudovigna argentea	86a	95a	100a	94
Psophocarpus palustris	10d	23e	1f	11

Figures followed by the same letter(s) in a column are not significantly different by LSD test at 5 percent probability level or the subsequent years. Following crop establishment, *Mucuna pruriens* and *Lablab purpureus* grew faster than the other species, covering ground rapidly. These results agree well with the reports of Carsky (1993) in Cameroon and Marilla *et al.* (1992) in Brazil. Ground cover during the year of establishment was also good with *Centrosema pascuorum* and *Psophocarpus palustris* but were relatively slower and poorer in *Stylosanthes* spp. and *Aeschynomene histrix*. The report of Marilla *et al.* (1992) also showed that *Stylosanthes* spp. were among the slowest growers of the evaluated 52 species in their study.

Although anthracnose is a major disease of *Stylosanthes* spp. (Skerman *et al.*, 1988; Tarawali, 1994), *S. hamata* and its accessions have been reported to show tolerance to this disease in the northern Guinea savanna zone of Nigeria (Tarawali, 1985). The present study found no evidence of anthracnose in species of *Stylosanthes* in particular and the legume species evaluated in general. *Stylosanthes* spp. and *Crotalaria* spp. appeared not to support nematode populations, and the root gall index suggests that these species are resistant to the root-knot nematode (*Meloidogyne incognita*). This is important when selecting legume for integration into food crops that are susceptible to nematode infection.

Of the most important traits usually sought in herbaceous legumes, especially for use as forage crop, is persistence (Peters *et al.*, 1994a, b; Tarawali, 1995). Of the 18 species evaluated, 12 persisted to the second year to varying degrees, although with little or no growth during the dry season. However, with the onset of the rains during the second year, they grew fast and covered the ground rapidly especially *Stylosanthes guianenses, Aeschynomene histrix, Centrosema brasilianum, Pseudovigna argentea, Cajanus cajan* and *Pueraria phaseoloides*. Excellent persistence has been reported for *C. brasilianum* (Peters *et al.*, 1994a), *Stylosanthes guianensis, S. hamata* and *Aeschynomene histrix* (Peters *et al.*, 1994b). Most of the other legume species (*Mucuna* spp., *Lablab purpureus, Crotalaria ochroleuca* and *Centrosema pascuorum*) died before the end of the dry season. The observation for *C. pascuorum* is consistent with the report of Peters *et al.* (1994a) for the northern Guinea savanna zone, while those for *Mucuna* spp. and *Crotalaria ochroleuca* are in contrast to an earlier report which showed that *Mucuna* and *Crotalaria* species survived dry season in Brazil (Anon, 1992).

For green manure legumes to contribute meaningfully to the soil N requirements of a succeeding crop, Marilla *et al.* (1992) suggested that it must produce at least 2000 kg ha^{-1} of above ground dry biomass or 40 kg N ha^{-1} for the incorporation into the soil so that a 50% recovery of the biomass N would affect the succeeding crop's yield. In this study, *Centrosema brasilianum, C. pascuorum, Clitorea, Lablab purpureus, Stylosanthes guianensis, S. scabra, Mucuna pruriens* (both white and black seeded), *Crotolaria ochroleuca, Cajanus cajan* and *Aeschynomene histrix* had biomass production well above the suggested minimum in the year of establishment (Fig.1a). Second year growth also resulted in biomass production in excess of 2000 kg ha^{-1} in *Stylosanthes* spp., *Cajanus cajan, Aeschynomene histrix* and *Pueraria phaseoloides* (Fig.1b). Most of the legume species evaluated in the present study have the potential to contribute more N than the minimum required to produce any real effect on subsequent crops.

However, in spite of the large above ground biomass production recorded for most species in this study, maize grain yield following legumes were lower than 1000 kg ha^{-1} (Fig. 3). Nevertheless, these yields were comparable to those obtained by Tarawali (1994) at the International Livestock Center for Africa (ILCA), Kaduna, Nigeria. The increased yield due to the previous legume residues over no legume suggest that there were residual effects of N from the legumes, but it was insufficient for optimum grain yield. The overall lower yield was probably due to the fact that the legumes were not incorporated but were left as surface residues. Lathwell (1990) observed that surface application of legume residues without incorporation may result in large losses of N, probably because of ammonia volatilisation from decomposing plant material. Palm (1988) had earlier reported that only 15% of the N in surface applied legume cuttings was recovered by a rice crop to which the cutting had been applied.

More importantly, there were variations in the potential of legumes to contribute residual N to succeeding non-legume crops. Thus, maize grain yield was highest in plot preceded by *Stylosanthes guianensis* (907.2 kg ha^{-1}), followed by yields from plots of *Cajanus cajan* (746.1 kg ha^{-1}) and *Crotalaria ochroleuca* (699.5 kg ha^{-1}), all of which were higher than yields from the control plots given 60 kg N ha^{-1} inorganic fertiliser (635.8 kg ha^{-1}). These results suggest that N contribution by these species may have been greater than 60 kg N ha^{-1}. Plots of other species including *Centrosema brasilianum, Clitorea tarnatea, Stylosanthes scabra, Psophocarpus palustris, Mucuna pruriens* and *Crotolaria verrucosa* had maize grain yields higher than that of the control given 30 kg N ha^{-1} inorganic fertiliser. Contrastingly, plots of *Centrosema pascuorum, Chamaecrista rotundifolia, Lablab purpureus, Macroptilium atropurpureum, Stylosanthes hamata* and *Pueraria phaseoloides* had maze grain yields lower than those of the control fertilised at 30 kg N ha^{-1}. These results are consistence with the report of Tarawali and Mohammed-Saleem (1994) who showed that the benefit of a legume to subsequent crops was a function of species used.

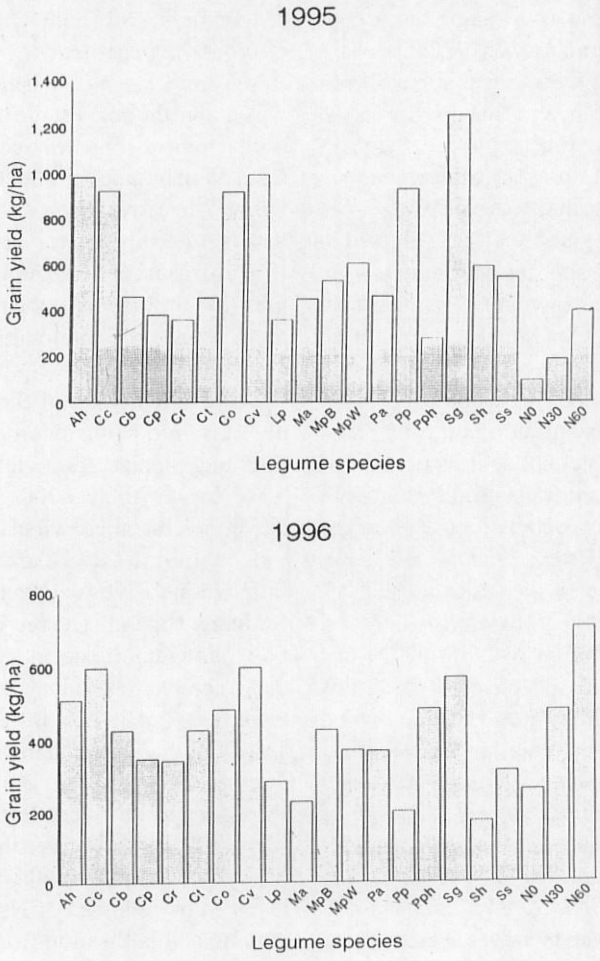

Figure 3. Maize grain yield in plots preceeded by different legume species and control plots given different levels of N fertiliser.

Ah = *Aeschynomene histrix*, Cc = *Cajanus cajan*, Cb = *Centrosema brasiianum*, Cp = *Centrosema pascuoru*, Cr = *Chamaecrista rotunditolia*, Ct = *Clitorea tarnatea*, Co = *Crotalaria ochroleuca*, Cv = *Crotalaria verrucosa*, Lp = *Lablab purpureus*, Ma = *Macroptilium atropurpureum*, MpB = *Bucuna pruriens* (black seed) MpW = *Mucuna pruriens* (White seeded), Pa = *Pseudovigna argentea*, Pp = *Psophocarpus palustris*, Pph = *Pueraria phasedoides*, Sg = *Stylosanthes guianensis*, Sh = *Stylosanthes hamata*, Ss = *Stylosanthes scabra*, NO = 0 kg ha^{-1} N, N30 = Control + 30 kg ha^{-1} N, N60 = Control + 60 kg ha^{-1}.

TABLE 5. Species ranking and rank summation index* (RSI) showing the performance of legume species at the trial location

Legume species	Ground cover		Biomass yield		Seed yield	Residual N contribution	Persistence	RSI	Final rank
	Year 1	Year 2	Year 1	Year 2					
Aeschynomene histrix	15	4	12	4	8	3	1	47	2
Cajanus cajan	5	1	1	1	2	2	5	17	1
Centrosema brasilianum	10	5	10	8	10	9	9	61	5
Centrosema pascuorum	4	14	7	15	5	15	16	76	13
Chamaecrista rotundifolia	18	8	13	11	13	16	13	82	17
Clitorea tarnatea	11	10	9	9	7	10	14	70	10
Crotalaria ochroleuca	7	18	3	17	4	4	11	64	7
Crotalaria verrucosa	16	12	6	10	11	6	6	67	8
Lablab purpureus	3	17	5	16	6	18	15	80	15
Macroptilium atropurpureum	12	11	14	12	14	17	12	92	18
Mucuna pruriens (black)	2	15	4	18	3	8	17	67	8
Mucuna pruriens (white)	1	13	2	13	1	7	18	55	4
Stylosanthes guianensis	17	1	11	2	18	1	1	51	3
S. hamata	14	7	18	5	12	13	1	70	10
S. scabra	18	9	8	3	9	11	4	62	6
Pseudovigna argentea	9	3	16	7	16	12	8	71	12
Psophocarpus palustris	6	16	15	14	15	5	10	81	16

* The smaller the figure, the better the performance

The results of this study have demonstrated that legumes can enhance soil fertility thereby boosting subsequent crop yields. However, in order for the selected species to be introduced into the farming systems, seeds must be available. Although seed yields recorded in this study were generally low (Fig. 2), it has been observed that under careful management *Stylosanthes hamata var Verano* can yield > 500 kg ha^{-1} (Kachelriess and Tarawali, 1994). Similar yields could be anticipated from the species evaluated.

The overall ranking of the legume species evaluate in this study (Table 5) in terms of potential for ground cover, biomass production, seed yield, persistence and residual N contribution to soil show that *Cajanus cajan* > *Aeschynomene histrix* > *Stylosanthes guianensis* > *Mucuma pruriens* (white seeded) > *Centrosema brasilianum* > *Stylosanthes scabra* > *Crotalaria ochroleuca* > *M. pruriens* (black seeded) > *Crotalaria verrucosa* > *Clitorea tarnatea* > *S. hamata* > *Pseudovigna argentea* > *Centrosema pascuorum* > *Pueraria phaseoloides* > *Lablab purpureus* > *Psophocarpus palustris* > *Chamaecrita rotundifolia* > *Macroptilium atropurpureum* .

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REFERENCES

Abayomi, Y.A. and Fadayomi, R.O. (1995). Agronomy report. In: *Legume Characterization in the moist savanna zone: Report of 1994 activities at Ilorin in the southern Guinea savanna zone*. Fadayomi, R.O. (Ed.), pp.11–22.

Abayomi, Y. A. and Saliu, L.O. 1997. Emergence and seedling vigour responses to simulated sub-optimal moisture conditions in twelve open-pollinated maize (*Zea mays* L.) varieties. *Bioscience Research Communications* 9:21-28.

Akobundu, I. O. 1980. Live mulch: A new approach in weed control and crop production in the tropics. In: *Proceeding of the 1980 British Crop Protection Conference*. pp. 377 – 382.

Akobundu, I. O. 1982. Live mulch crop production in the tropics.In: *World Crops*. pp. 125 – 145.

Allen, O. N. and Allen, E.K. 1981. *The Leguminosae*. University of Wisconsin Press, Wisconsin, U.S.A.

Annonymous , 1992. Screening legumes for dry-season survival. In: *Legume Green Manure: Dry season survival and the effect on succeeding maize crops*. Soil Management CRSP Bulletin No. 92-04. pp. 9-13.

Annonymous, 1993. Improvement of soil fertility and weed suppression through legume-based technologies. Collaborative group in maize based system research (COMBS). IITA Research Guide 48, International Institute of Tropical Agriculture, Ibadan, Nigeria. 52 pp.

Bridge, P. T., Mott, J. J., Inter, W. H. and Hewtigan, R. J. 1983. Improvement in soil structure resulting from sown pasture on degraded area in the dry savanna woodland of northern Australian. *Australian Journal of Agricultural Research* 31:83 –90.

Carsky, R. J. 1993. Screening multiple use cover crops for the semi-arid zone. Technical Note No. 13 TLU, Manova. 10 pp.

El-Swaify, S. A., Holdenhaver, W.C. and Lo, A. (eds). 1985. *Soil erosion and conservation.* Volume based on the international Conference on soil erosion conservation, January 16 – 22, 1983. Honolulu, Hawaii.

Ile, E., Hamadina, N.K., Zufa, K. and Henst, J. 1996. Note on effect of *Mucuna pruriens* var *utilis* crop on the growth of maize *(Zea mays)* on arid soils in Southern Nigeria. *Field Crop Research* 18:135-140.

Jensen, H.G.P. 1993. Ex-cute profitably of animal traction investment in semi-arid sub-Saharan Africa. Evidence from Niger and Nigeria. *Agricultural System* 43:333-349.

Kalchelriess, S. and Tarawali, S.A. 1994. ILCA's efforts towards the production of *Stylosanthes* seed in Nigeria. In: *Stylosanthes as a forage and fallow crop.* Kaduna, Nigeria. October, 1992. (International Livestock Centre for Africa, Addis Ababa).

Kang, B.T. 1992. Potentials of legumes for soil fertility improvement in the humid and sub-humid tropics. In: *Collaborative Group on Maize-based system Research (COMBS).* 1992 Report of the 2nd Workshop, Kumasi, Ghana, June, 1990. West African Farming System Research Network (WAFSR/ RESPAO), Ougadougou, Burkina Faso, and International Institute of Tropical Agriculture(IITA), Ibadan, Nigeria.

Lal, R. 1989. Agroforestry systems and soil surface management of a tropical Alfisol II. Changes in soil chemical properties. *Agroforestry System* 8:113-132.

Lal, R., Hullugalle, N.R. and Terkuile, CH. H. 1979. Changes in properties of all Alfisol produced by various cover crop. Tropsoils. *Soil Science* 127:337-382.

Lathwell, D.J. 1990. Legume green manure. Principles for management based on recent research. Tropsoils Technical Bulletin, No. 90-01.

MacColl, D. 1990. Studies on maize (*Zea mays*, L.) at Bunda, Malawi. III. Yield in rotation with pasture legumes. *Experimental Agriculture* 26:263-271.

Marilla, L. B., Jao, R. S., Dinas, P., Jose, V.S.R., Manod, R.R., Walter, S.C., David, B. and Douglas, J. L. 1992. Legume green manures: Dry season survival and the effect on the succeeding maize crops. *Soil Management CRSP Bulletin* 92-04.

Mohammed-Saleem, M. A. 1986. The ecology, vegetation and land use of subhumid Nigeria. In: *Livestock system research in Nigeria's sub-humid zone. Proceedings of second ILCA/ NAPRI Symposium held in Kaduna, Nigeria.* 29 October – 2 Nov. 1984. Von Kaufmann, R., Chater, S. and Belnch, R. (Eds.). ILCA(International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Mohammed-Saleem, M. A. and Otsyina, R. M. 1986. Grain yields and the nitrogen contribution following Stylosanthes pasture in the Nigeria sub-humid zone. *Experimental Agriculture* 22:207- 214.

Mohammed-Saleem, M. A., Suleiman, H. and Otsyina, R. M. 1986. Fodder Banks: for pastoralist or farmers. In: *Potential of forage legumes in farming systems of sub-saharan*

Africa. Hague, I., Jutzi, S. and Nestle, P. J. H. (Eds), pp. 420- 437. Proceeding of workshop held at ILCA, Addis Ababa, Ethiopia, September 16-19, 1985. ILCA(International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Mulongoy, K. and Kang, B. T. 1986. The role of potential forage legumes in alley cropping, live mulch and rotational systems in humid and sub-humid tropical Africa. In:*Potential of forage legumes in farming systems of sub-saharan Africa.* Hague, I., Jutzi, S. and Nestle, P.J.H. (Eds.), pp. 212-231. Proceeding of workshop held at ILCA, Addis Ababa, Ethiopia, September 16-19, 1985. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Mughoho, S.K., Awali, J., Lowendorf, H.S. and Lathwell, A.T. 1982. The effects of fertilizer nitrogen and Rhizobium inoculation on yield of subsequent crops of maize. In: *Biological nitrogen fixation for tropical agriculture.* Graham, P.H. and Harri, S.C. (Eds.), pp. 297-301. Proceedings of a workshop held at CIAT, March 9-13, 1981, Cali, Colombia.

Myers, R.J.K. 1976. Nitrogen accretion and other soil changes in Tundall clay loam townsuile stylo/grass pasture. *Australian Journal of Experimental Agriculture and Animal Husbandry* 16:94-98.

Okigbo, B. N. 1985. Land use productive potentials of Africa savanna. In: *Ecology and Management of the World's savanna.* Tothill, J.C. and Moh. J. J. (Eds), pp. 95-106. Australian Academy of Science, Camberra, Australia/ CAB (Commonwealth Agriculture Bureau), Farham Royal Bucks, U.K.

Palm, C.A. 1988. Mulch quality and nitrogen dynamics in an alley cropping system in the Peruvian Amazon. Ph.D. Thesis, North Carolina State University, Raleigh.

Peters, M., Tarawali, S.A. and Alkamper, J. 1994a. Evaluation of tropical legumes for fodder banks in sub-humid Nigeria 1: Accession of *Centrosema brasilianum, C. pascuorum, Chamaecrista rotundifolia* and *Stylosanthes hamata. Tropical Grassland* 28:65-73.

Peters, M., Tarawali, S.A. and Alkamper, J. 1994b. Evaluation of tropical legumes for fodder banks in sub-humid Nigeria 2: Accession of *Aeschynomene histrix, Centrosema acutifolium, C. pascuorum, Stylosanthes guianensis,* and *Stylosanthes hamata. Tropical Grassland* 28:74-79.

Sharma, F.D., Pereira, J. and Resk, D.V.S. 1982. Efficience de adubos verde no control de nematodes associadies a soja nos cerrdos. Boletin de Pešisa 13, EMBRAPA-CPAC Planeltina, Brazil.

Skerman, P.J., Cameron, D.G. and Riveros, F. 1988. *Tropical Forage Legumes.* 2nd edition. FAO Plant Protection and Production Series 2. FAO, Rome.

Tarawali, G. 1991. Residual effect of *Stylosanthes* fodder banks on grain yields of maize. *Tropical Grassland* 25:26-31.

Tarawali, S.A. 1994. Evaluating selected forage legumes for livestock and crop production in the sub-humid zone of Nigeria. *Australian Journal of Experimental Agriculture* 34:55-60.

Tarawali, S.A. 1995. Evaluation of *Stylosanthes hamata* (L) Tuab accessions for livestock and crop enterprises in sub-humid Nigeria. *Australian Journal of Experimental Agriculture* 35:375 – 379.

Tarawali, G., Mohammed-Saleem, M.A. and Von Kaufmann, R. 1987. Comparision of labour requirements for cropping maize on land previously used for *Stylosanthes* fodder banks and an adjacent fallow in the sub-humid zone of Nigeria. ILCA Bulletin 26: 36-39. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Vallis, J. and Gardner, C.J.1984. Nitrogen inputs into agricultural systems by *Stylosanthes.* In: *The biology and agronomy of Stylosanthes.* Stance, H.M. and Edye, L.A.(Eds.), pp. 359-380. Academy Press, Australia.