Research Article

Influence of Sowing Methods and Densities during Establishment on Growth, Dry Matter Yield and Persistence of *Tephrosia* Species

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ABSTRACT

The study was to investigate planting methods and seeding rates appropriate for early growth (height, dry matter and persistence of three *Tephrosia* species. It was a 3 x 3 x 2 factorial experiment in a split – split plot design replicated 4 times, at an altitude of 1300m a.s.l. The *Tephrosia* species were; *T. candida T. purpurea and T. vogelii*. Planting methods were broadcasting, drilling and space planting while planting densities were 10kg/ha and 20kg/ha. Leaf retention on the plant in the dry season was scored on scale of 0 (no leaves on the plant) to 9 (most or all leaves on the plant). The highest plant height (207.32 cm) was observed with *T. purpurea* and least (106.51 cm) with *T. candida.* Plants were tallest (172.59 cm) under drilling and least (106.51 cm) under broadcasting. Planting density did not significantly influence plant height. Leaf retention by *T. candida* was significantly higher (P <0.05) than those of *T. purpurea* and *T. vogelii*. Leaf retention was highest under broadcasting planting method. *T. purpurea* and *T. vogelii* produced more litter than *T. candida*. Planting methods did not influence the amount of litter produced by the species. In terms of growth as measured by plant height, and DM yields, *T. purpurea* and *T. vogelii* performed better than *T. candida*. *T. purpurea* and *T. vogelii* are recommended for soil fertility improvement while T. candida could be used as browse under adverse climatic conditions.

Key words: Dry matter, Growth, leaf scoring, litter fall, Seedling vigour, *Tephrosia* species.

INTRODUCTION

Multipurpose trees and shrubs (MPTS) are used as important feed resources for different species of ruminants and also as components of crop-livestock agro forestry technologies. *Gliricidia sepium* and *Leucaena leucocephala* are browse species for animal agro forestry in the tropics. The exotic browse species of *G. sepium* and *L. leucocephala* have been successfully used extensively for animal agro forestry on non-acid soils on lowland humid West Africa (kang *et al.,* 1990). However both species performed poorly on acid soils (cobbina et al., 1990). In the Western Highland of Cameroon (WHC) their growth is hampered by high altitude (1300m.a.s.l.) and the acid reaction (pH 5.3) of the soils. There is increasing awareness of the need to incorporate browse plants to the livestock feeding systems of the WHC. Hence there is a need to identify alternatives to *G. sepium* and *L. leucocephala* and broaden the genetic base of browse species. Species of *Tephrosia* offer an alternative. They are leguminous and nitrogen – fixing occurring naturally as trees and shrubs on hills, valleys and roadsiders of the WHC and are relished by ruminants. Shenkoru et al., 1991 have reported that *Tephrosia* species thrives in areas of up to 2880m above sea level with annual rainfall of 550-1900mm and soils of pH 4.9-8.2. However quantitative information on appropriate sowing methods and seeding rates on early growth, establishment, persistence and dry matter yields are needed.

The objective of the study was to evaluate sowing methods and seeding rate appropriate for early growth, DM yield and persistence of three *Tephrosia* species.

MATERIALS AND METHODS

Location

The experiment was conducted at the Institute of Agricultural Research for Development (IRAD), Mankon Station, Bamenda in the Western Highlands of Cameroon (WHC). The station lies at an altitude of 1300 m above sea level. The annual average rainfall ranges from 1500 to 2000 mm with some places exceeding 3000 mm. The average mean minimum and maximum temperatures at the experimental site were 10.6^{o}C and 25.1^{o}C, respectively. The zone is characterized by a unimodal rainfall pattern lasting from mid-March to October followed by a relatively cool dry season period (November to December) and a warm dry season (January to March).

The WHC is characterized by ferralitic soils derived from basic rocks, the texture ranges from sandy clay to clay. They are classified as haplic ferralsols in association with rhodic ferralsols (Yerima and Ranst 2005). The soils are acidic (pH 5 – 6), low in organic carbon content and total N, deficient in exchangeable K and available P.

Seed Treatment

Seeds were scarified to break dormancy by pouring four times their volume of boiling water (100^{o}C) and left immersed for one minute (IRAD, 1990).

Establishment

An experiment was conducted to determine the best planting method and the most appropriate planting density for the three Tephrosia spp. It was a 3 x 3 x 2 factorial experiment laid out in a split-split plot design replicated four times with species in the main plot, planting method and planting density in the subplots and sub sub-plots, respectively. The different planting methods were broadcasting, drilling and space planting and the planting densities were 10kg/ha and 20kg/ha. Each plot measured 4m x 5m. Treatments were randomly allocated to these plots. Plants were drilled at both densities with an inter row spacing of 50cm apart, while spacing for space planting method was 50×20cm for both densities.

Weeding

The plots and borders were kept weed free by regular manual weeding during plant establishment.
Considerable weeding was required at the early stages of establishment of the plants up to 10 weeks after planting (WAP). From 16WAP, the need for weeding varied among species and planting methods. For instance, T candida established slowest and therefore needed more frequent weeding.

Data Collection

Plant height was measured every two weeks after planting in the first year. Plant height was measured from the base of the plant to the node of the topmost or apical leaf. After one year of establishment plants were cut back to a height of 50cm above ground level, to promote uniform growth and cut forage was taken out of the plot and discarded. Regular 12-weekly harvest of biomass commenced thereafter for two growing seasons. A total of six harvests over two years were taken. Harvesting was done manually using a machete. At each harvest, total fresh herbage yield per plot was recorded. Fresh samples for each plot were sorted into subsamples of edible forage i.e. leaves together with stems of less than 6mm diameter (Tarawali et al., 1995). The samples were oven dried at 60^{o}C to constant weight for the determination of dry matter (DM) content and hence biomass yields. The dried samples were bulked according to treatments and milled for chemical analysis.

Leaf retention on the plant in the dry season was scored on scale of 0 (no leaves on the plant) to 9 (most or all leaves still on the plant). After one year of establishment at the end of the dry season i.e. in March samples of leaf litter or mulch were taken using a 0.5 x 0.5m quadrat and weighed to estimate the amount of litter on the soil surface.

Data Analysis

Data generated except for chemical analysis for the four-year study 2001-2005 was subjected to analysis of variance using the general linear model procedure of statistical analysis (SAS, 1995). Statistical differences among treatment means were declared at 5% level of significance. Means were separated using Duncan Multiple Range Test.

RESULTS

Seed germination

Germination was lowest (58%) for *T. candida* and highest (93%) for *T. purpurea* with *T. vogelii* registering 90% germination.

Growth

The trends in plant height for the three *Tephrosia* spp. in the year of establishment are shown in Fig.1

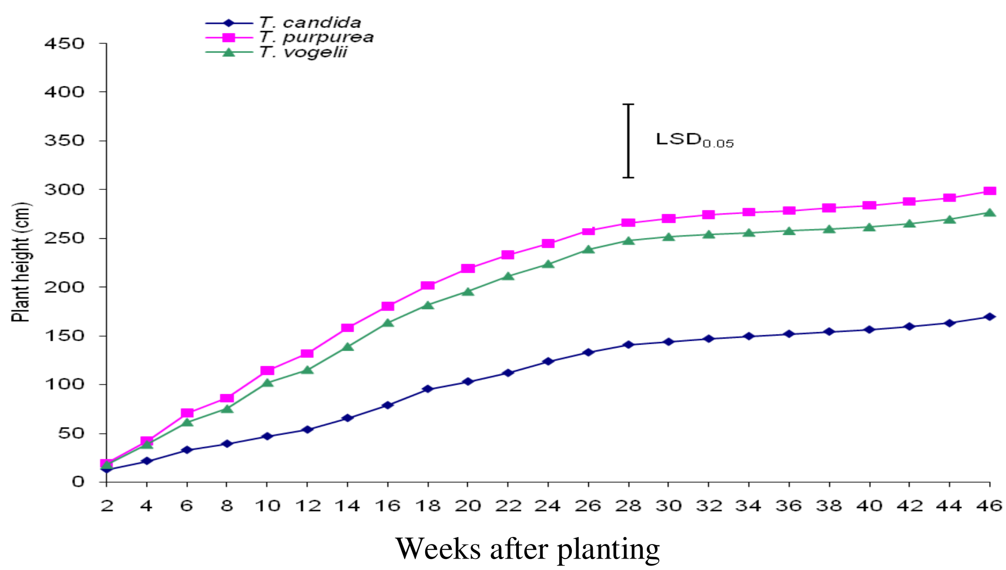

Fig 1: Trends in plant height of three *Tephrosia* species in year of establishment (Note: There was no flowering in the year of establishment)

Growth were rapid between 2WAP and 24WAP after which it was relatively slow. There was no significant difference ($p < 0.05$) in plant height between *T.pupurea* and *T.vogelii* at every stage of growth but there were significant differences between *T. candida* and the other two species. Generally, the greatest plant height (Table 1) was observed with *T. purpurea* (207.32cm) and the least with *T. candida* (106.51cm) when measurements were terminated 46 weeks after planting. Plant height was significantly different amongst species ($p < 0.05$). The plant height of *T. purpurea* was about twice that of *T. candida*.

Table 1: Effects of planting methods on plant height of three *Tephrosia* species 46 weeks after planting

Species	Planting method: Broadcasting	Drilling	Space planting	Mean
	---	cm	-----------------------------------	
T. candida	99.45 e	111.59 e	108.48 e	106.51b
T. purpurea	195.49 c	216.66 a	209.82 b	207.32a
T. vogelii	185.73 d	189.51 d	193.50 d	189.58a
Mean	160.22a	172.59b	170.6b	

Values with the same letters in rows and columns are not significantly different (P < 0.05)
Means in a row or column with same letters are not significantly different (P<0.05)

Planting method influenced the growth of *Tephrosia* spp. as measured by plant height. Plants were tallest (Table 1) under drilling averaging 172.59cm and least under broadcasting with an average of 160.22cm. The effect of planting method on plant height was not significant ($p < 0.05$).

Tephrosia spp. growth was also influenced by planting density (Table 2). Plant height was significantly greater when *Tephrosia* spp. were planted at a density of 10kg/ha (170.56cm) than at 20kg/ha (165.05cm)

Table 2: Effects of planting density on plant height of three *Tephrosia* species

	Planting densities		
Species	**10 kg/ha**	**20 kg/ha**	**Mean**
	--cm----------------------------		
T. candida	105.27 d	107.74 d	106.51 b
T. purpurea	215.28 a	199.36 b	207.32 a
T. vogelii	191.11 c	188.04 c	189.58 a
Mean	170.56 a	165.05 a	

Values with the same letters in rows and column are not significantly different ($P < 0.05$)
Means in a row or column with the same letters are not significantly different ($P<0.05$)

Plant height was significantly reduced for drilled and space planted seeds with increasing desity (Table 3). For broadcast method of planting, plant height increased with increasing density, but it was not statistically significant.

Table 3: Effects of planting methods and planting densities on plant height

Planting methods	**Planting density**		
	10 kg/ha	**20 kg/ha**	**Mean**
	----------------------------cm ----------------------------------		
Broadcasting	159.50 b	160.59 b	160.05 b
Drilling	178.09 a	167.09 b	172.59 a
Space planting	174.09 a	167.11 b	170.6 a
Mean	170.56 a	164.93 a	

Values with the same letters in rows and columns are not significantly different ($P < 0.05$)
Means in a row or column with the same letters are not significantly different ($P<0.05$)

The difference in plant height with respect to planting density was significant only for *T. purpurea*, accounting for the significant interaction revealed species and planting density (Table 4).

Table 4: Plant height of *Tephrosia* species established using different planting methods and planting densities in the year of establishment

		Planting density in kg/ha	
Species	**Planting Method**	**10**	**20**
		----------------------cm---------------------	
T. candida	Broadcasting	100.47 d	98.43 d
	Drilling	111.26 d	111.92 d
	Space planting	104.10 d	112.87 d
T. purpurea	Broadcasting	194.20 bc	196.78 bc
	Drilling	231.66 a	201.66 bc
	Space planting	220.00 ab	199.64 bc
T. vogelii	Broadcasting	183.83 c	187.64 c
	Drilling	191.34 c	187.68 c
	Space planting	198.18 bc	188.04 c

Values with the same letters in rows and columns are not significantly different ($P < 0.05$)
Species x methods ns
Species x density *
Method x density ns
Species x methods x density ns
* Significant at ($P<0.05$)

Dry matter yield

At the first harvest in July 2002, dry matter (DM) yield for *T. vogelii* was highest compared to *T. candida* and *T. purpurea* and was significantly different ($p < 0.05$). In October 2002, DM yield of *T. vogelii* decreased while yields of *T. candida* and *T. purpurea* increased but there was no significant difference among them (Fig. 2).

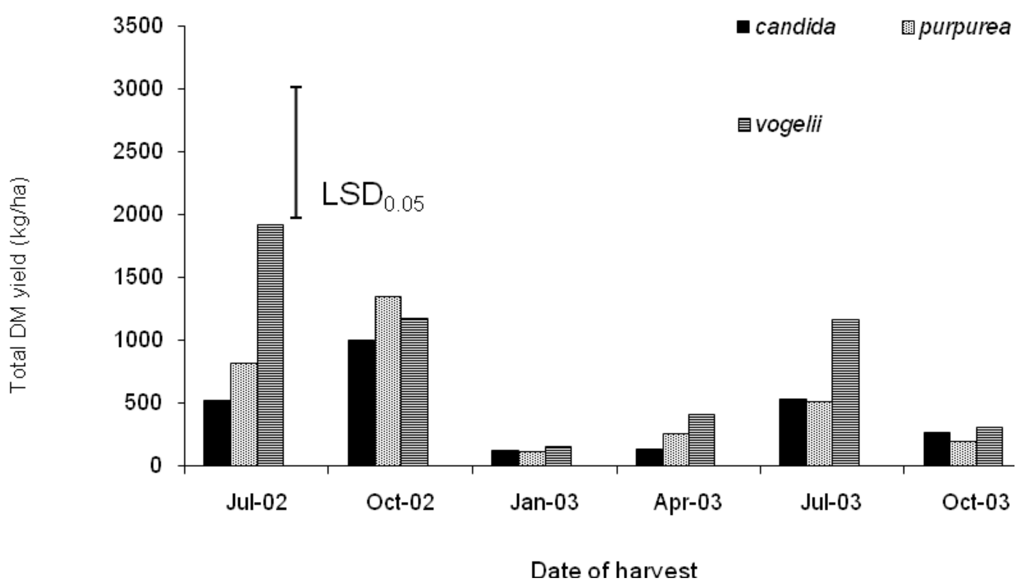

Fig 2: Variation in DM yield averaged over planting methods and densities of *Tephrosia* species at different harvests

Thereafter, up to the fourth harvest of April 2003, there was a fourfold decline. The decrease from October 2002 to January 2003 was about four times and coincided with the dry season. However, increase in DM yield was recorded from April to July 2003 in the rainy season. There was another drop/decline thereafter, in October 2003 with the approach of the dry season. DM yields were up to four times higher in the wet than in the dry season. Also, the species produced higher DM yields during the first year than during the second year after establishment. The differences in forage DM yield among species were statistically significant (p < 0.05). (Table 5).

Table 5: DM yields of *Tephrosia* species established using different sowing methods and planting densities averaged over two years

Species	**Planting density kg/ha Planting Method**	**10**	**20**
		----------------**kg/ha**---------------	
T. candida	Broadcasting	303.33 ef	197.50 f
	Drilling	450.83 de	748.33 bc
	Space planting	264.17 ef	602.50 cd
T. purpurea	Broadcasting	316.67 ef	320.83 ef
	Drilling	626.67 cd	668.33 c
	Space planting	739.17 bc	590.42 cd
T. vogelii	Broadcasting	579.33 cd	680.00 c
	Drilling	1081.25 a	919.17 ab
	Space planting	990.83 a	895.00b

Values with the same letters in rows and columns are not significantly different (P < 0.05)
Species x methods ns
Species x density *
Density x methods ns
Species x density x methods *
* Significant at (P<0.05)
ns not significant

T. vogelii produced the highest DM yield when drilled at 10kg/ha and *T. candida* produced the least when broadcast at 20kg/ha. There was no significant difference in DM yield (P < 0.05) between *T. candida* and *T. purpurea* when broadcasted and drilled at 10kg/ha. However, *T. vogelii* was significantly different (P < 0.05) when broadcasted and drilled at 10kg/ha. For space planting method the three species were significantly different at (P < 0.05) (Table 5).

Response to dry conditions

(a) Leaf retention

Leaf retention on the plant during the dry months (December-March) was considered as a measure of adaptation of the different *Tephrosia* spp. to dry conditions. Fig. 3 shows that at the start of the dry season in December, all three species still had most of their leaves with leaf retention scores of 5.5 to 7.2. At the end of the dry season in March, just before the onset of rains, *T.candida* retained more than one third of its leaves (score of 3.83) while *T.purpurea* and *T.vogelii* had less than one third (score of 2.46). Leaf retention by *T.candida* was significantly higher (p < 0.05) than those of *T.purpurea* and *T.vogelii* in three out of the four dry months.

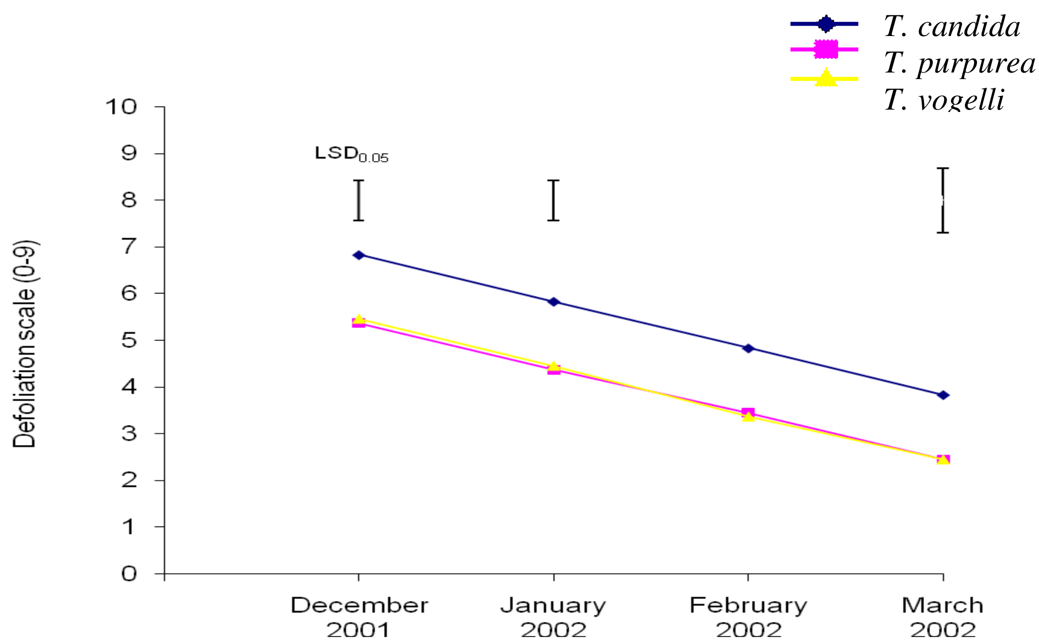

Fig 3: Leaf retention in the dry months during establishment year of three *Tephrosia* species.

In the dry months leaf retention was highest under broadcasting planting method compared to the others (Fig. 4.). Planting method significantly ($p < 0.05$) influenced leaf retention at the beginning (December) and at the end (March) of the dry season. At the peak of the dry season (January and February) there were no significant differences among planting methods in respect of leaf retention.

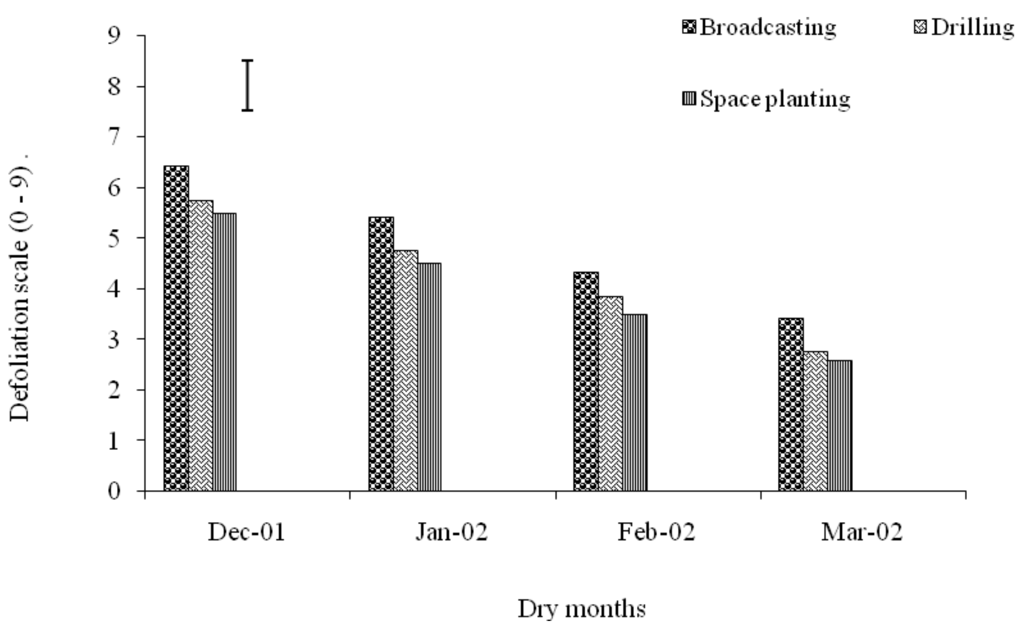

Fig 4: Effects of planting methods on leaf retention during the dry season

(b) Leaf litter

Early in March, at the end of the three months dry season i.e. December, January and February. The total amount of leaf litter mulch was measured. Fig. 5. shows the differences among species with respect to leaf litter production. The species were significantly different ($p < 0.05$), with *T. vogelii* and *T. purpurea* producing more litter than *T. candida*.

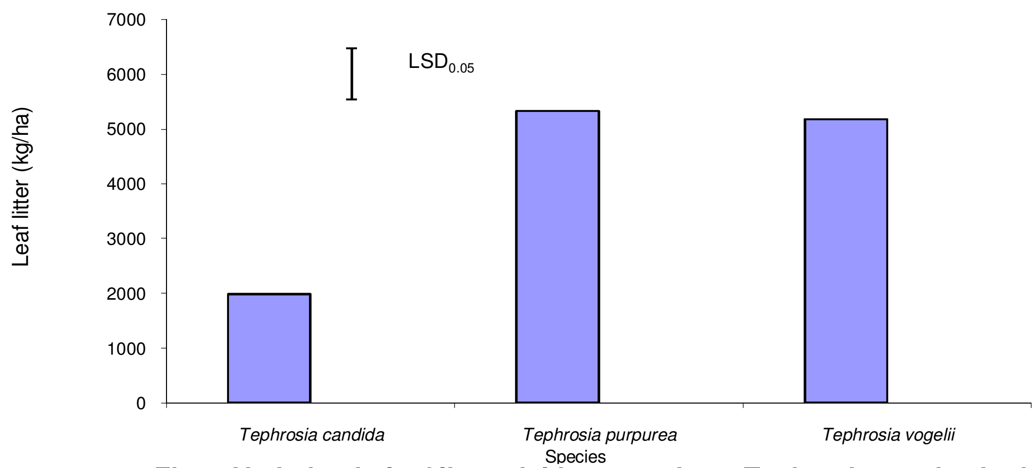

Fig 5: Variation in leaf litter yield among three *Tephrosia* species in the year of establishment

In addition, planting method did not influence the amount of litter produced by the species. Planting through drilling gave the lowest leaf litter yield averaged over species, while leaf litter yield was highest when *Tephrosia* spp. were space planted (Fig. 5).

DISCUSSION

In terms of growth as measured by plant height, *T. purpurea* and *T. vogelii* performed better than *T. candida*. The study was conducted in an area that is 1300m above sea level and *T. purpurea* and *T. vogelii* are adapted to altitudes of 1300 to 1600m. (IRAD, 2004) while *T. candida* is from an area of 200m altitude. Thus, *T. purpurea* and *T. vogelii are* better adapted to the location of the trial in terms of growth and establishment.

Broadcasting as a method of sowing exposes the seeds directly to environmental conditions that may not be favourable for growth and establishment. There is poor contact between the seeds and soil since seeds are not covered thereby hampering germination. Also, seeds can easily be blown away by wind, washed away by rain or consumed by pests. Drilling and space planting are not affected by these unfavourable conditions, since the seeds are covered thereby providing better protection less wastage and more favorable conditions for germination. The enhanced plant growth and DM yields under low planting density (10kg seeds/ha) may be attributed to limited competition for moisture and nutrients among the lower plant population of their density which are in low supply. Thus, in the presents study, 10kg seeds/ha planting density was on average not significantly different, in terms of DM yield from 20kg seeds/ha. With the attendant reduction in cost of seed, 10kg /ha is a suitable seeding rate for these species, so that emphasis would be on the use of good quality seeds.

The trend in DM production of the various species showed that apart from the general decline in DM yields between the dry and wet season yields were also lower in the second year compared to the first. The decline in yields in the second year may be due to a response to regular and relatively frequent harvests that result in a decline with time in reserve substances needed for regeneration after cutting.

In the present study it is noteworthy that the decline in DM yield was greatest in the dry month of January 2003. This would be the result of water stress leading to poor regrowth during the dry season. Cobbina *et al.* (1990) reported 82% and 35% reduction in regrowth yields for *Leuceana leucocephala* and *Gliricidia sepium,* respectively during the dry season in southeastern Nigeria. In the present study DM yields per hectare for October 2002 and

October 2003, respectively were: 500kg and 250kg for *T. candida*, 800kg and 400kg for *T. purpurea* and 900kg and 300kg for *T. vogelii*. This illustrates the decline in yield from that in the first year.

T. candida did not shed much of its leaves during the dry season. It retained more of its leaves than did *T. vogelii* and *T. purpurea*. This is in agreement with the findings of Nguyen and Thai (1993) who described *T. candida* as being tolerant to a range of soils and temperatures, preferring acid soils as in the present study and intolerant of waterlogging. With its high leaf retention in the dry season, *T. candida* would serve as a source of dry season feed. Nguyen and Thai (1993) also further reported that the greatest green manure biomass can be harvested in the first two years after planting, after which it becomes a good source of firewood.

CONCLUSIONS

Sowing methods which expose the seeds to harsh environmental conditions and poor soil contact, for example, broadcasting should be used minimally. Ten kilograms per hatre of good quality seed is a satisfactory seeding rate for establishing the three *Tephrosia* species. Most of the leaves of the three *Tephrosia* species are shed during the dry Season (December-March) when the plants are uncut. However, *T. candida* did not shed as much of its leaves during the dry season and so produced less leaf litter. In terms of growth as measured by plant height *T. purpurea* and *T. vogelii* performed better than *T. candida*. The study was conducted in an area that is 1300m above sea level and *T. purpurea* and *T. vogelii* are adapted to altitudes of 1300m to 1600m while *T. candida* is from an area of 200m altitude.

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