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Assessment of Some Leguminous Weeds as Potential Green Manure Crops under Mizoram, North East India

Jyoti Jopir[1], Kalidas Upadhyaya[1], Baby Lalhmangaihzuali[1], K. Pung Rozar[1]

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ABSTRACT

Background: This study aimed to evaluate the growth performance, biomass production and nutrient accumulation of three abundant leguminous weeds, namely *Crotolaria micans* Link., *Aeschynomene indica* L. and *Calopogonium mucunoides* Desv., found in Mizoram, India, to assess their potentiality as green manure crops.

Methods: The field experiment was conducted using a randomized block design. After 90 days of sowing, the growth performance of the plants and biomass accumulation was assessed. Accumulation of nutrients was estimated by analyzing the nutrient content using standard methods and multiplying it with dry biomass.

Result: The result revealed that *Crotolaria micans* showed higher growth and biomass accumulation. *C. micans* accumulates higher N, P, K, Zn, Cu and Fe contents in the shoot and root biomass while *A. indica* accumulates higher Ca in the root biomass. We conclude that *Crotolaria micans* was the most promising leguminous weed species in terms of growth performance, biomass production and nutrient accumulation and has better potential to be utilized as a green manure crop.

Key words: Biomass, Green manure, Legume, Macronutrient, Nutrient accumulation.

INTRODUCTION

Green manuring is a renewable resource and can be an essential substitute for improving soil quality and plant nutrition (White and Brown, 2010; Baba *et al*., 2019). Due to its increased sustainability in cropping systems through reducing soil erosion, improving soil physical properties and increasing soil organic matter and fertility level green manuring is regarded as a good management practice in all agricultural production systems (Tajeda *et al*., 2008). Leguminous green manure crops because of their symbiotic relationships with N_2-fixing bacteria result in the delivery of a significant amount of nutrients to the soil-plant system and make it potentially accessible in successive cultivations (Perin *et al*., 2003).

Leguminous species exhibit great diversity in their biomass yield and nutrient uptake, which must be related to the inherent traits of each species, the handling of crop leftovers and the current soil and climate conditions. Dry mass production stands out among the ideal features for species selection for green manure because it is associated with the ability to enhance nutrients through symbiosis with microbes, soil cover and nutrient recycling (Teodora *et al*. 2015; de Oliveiria Miranda *et al*., 2020). The choice of an appropriate species of legume has a great impact on the amount of biomass, N accumulation and rate of nutrient release into the available forms (Hirpa *et al*., 2009). Many species of leguminous plants exhibit an exceptional capacity to produce large amounts of biomass and accumulate high nutrient concentrations (Matos *et al*., 2008). The most productive green manure crops produced about 4-5 t ha^{-1} of dry biomass in 50-60 days (Irin and Biswas, 2021). Baba *et al*. (2019) stated that *Crotolaria* spp are a potential source of green manure as they produce large amounts of biomass, containing higher nitrogen content.

Understanding green manure legumes' biomass and nutrient content is important for optimizing their benefits and integrating them effectively into crop rotations. Moreover, knowledge of the nutrient content of green manure legumes can help farmers reduce their reliance on synthetic fertilizers and minimize the environmental impacts associated with their use. We can identify the best species for a given location by assessing the potential biomass of local leguminous species. Although many leguminous weeds are abundantly growing in the wild, their growth behavior, biomass and nutrient accumulation are not known. Therefore, the study was conducted to evaluate the growth, biomass production and nutrient accumulation of the three locally available leguminous weeds of Mizoram, India to assess their suitability as potential green manure crops.

[1]Department of Forestry, School of Earth Sciences and Natural Resources Management, Mizoram University, Aizawl-796 004, Mizoram, India.

Corresponding Author: Jyoti Jopir, Department of Forestry, School of Earth Sciences and Natural Resources Management, Mizoram University, Aizawl-796 004, Mizoram, India.
Email: jyotijopir10@gmail.com

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MATERIALS AND METHODS

The experiment was conducted under field conditions at the Horticulture Research farm of Mizoram University, Aizawl, India during the month of April- June of 2021 and 2022. The soil of the experimental site was acidic in nature with a pH of 4.82 with soil organic carbon content of 1.52%. The average monthly rainfall received during the cropping seasons in the years 2021 and 2022 was 195.3 mm and 252.1 mm respectively.

We used three leguminous weed species, *i.e.*, *Crotolaria micans* Link., Aeschynomene *indica* L. and *Calopogonium mucunoides* Desv. (Fig 1 a, b and c respectively) for the present study. The experiment was laid out in plots in Randomized Block design with four replications for each species. Raised beds of size 1.5 m × 1.5 m were prepared for each species. Pre-treated seeds of the selected legumes were sown in line spaced 30 × 10 cm during the first week of April. After 90 days of sowing, fresh biomass of shoot and root was recorded separately. Sub-samples from each plot were collected and kept in a hot air oven at 60 p C until a constant weight was obtained to determine the dry weight for the shoot and root biomass. To evaluate the growth performance, 10 individual plants were selected randomly from each plot and data were recorded.

The oven-dried samples were milled and passed through a 1 mm sieve for nutrient analysis. Nitrogen was determined after digesting the samples with H_2SO_4 by the micro Kjeldahl method (AOAC, 1995). Phosphorous contents were measured colorimetrically by digesting the plant samples with Diacid (3:1: Nitric acid: Perchloric acid) mixture (Koenig and Johnson, 1942). Potassium, Calcium, Magnesium and other micronutrients (Zn, Cu and Fe) contents were determined by atomic absorption spectrophotometer.

Averaged pooled data were subjected to analysis of variance and means were compared by least significant difference at 5% (Gomez and Gomez, 1984).

Table 1: Average per plant growth attributes of the leguminous weeds at 90 DAS (Average pool data of two years).

Growth parameters	*C. micans*	*C. mucunoides*	*A. indica*
Shoot length (cm)	87.54^a	58.50^b	46.25^b
Root length (cm)	28.41^a	24.29^a	25.77^a
Basal diameter (mm)	7.10^a	2.56^b	3.83^b
No. of primary branches	26.51^a	8.00^b	25.41^a

*Mean followed by the same alphabet in the column does not differ by LSD at 0.05 level.

RESULTS AND DISCUSSION

The study indicated that there were significant differences among the growth parameters of the species, except for the root length (Table 1). *Crotolaria micans* presented the highest shoot length (87.54 cm) followed by *Calopogonium mucunoides* (58.50 cm) and the least by *Aeschynomene indica* (46.25 cm). Duarte *et al*. (2013) studied different green manuring crops and found that *Crotolaria juncea* had a longer height (129.3 cm) than the other at its flowering stage. Similarly, Irin and Biswas, (2021); Romulo *et al*. (2013) reported that *C. juncea* had the longest height among the other crops.

There was no significant difference in the root length which ranged from 24.29 cm to 28.41 cm which was lower than the range recorded by Fageria *et al*. (2016) where the maximum root length varied from 27.40-35.47 cm in five tropical legume cover crops. Many environmental factors, including soil moisture content, temperature and the physical, chemical and biological characteristics of the soil, have also an impact on root growth (Fageria, 2009). Basal diameter and no. of primary branches ranged from 2.56-7.10 mm and 8.00-26.51 respectively (Table 1).

Fresh and dry biomass of the shoot and root

There was a significant difference in the fresh shoot and root biomass. The fresh shoot biomass ranged from 2.10-14.20 t ha^{-1} with *C. micans* producing significantly higher fresh shoot biomass followed by *C. mucunoides* and *A. indica* (Fig 2). The fresh root biomass produced was in the order of *C. micans* (1.61 t ha^{-1}) > *A. indica* (0.35 t ha^{-1}) > *C. mucunoides* (0.28 t ha^{-1}). *C. micans* represented higher biomass accumulation, which may be attributed to its fast and determinate growth habit which will increase the soil fertility and also its morphological characteristics as shown in Table 1. However, Vimala *et al*. (1999) showed that *C. mucunoides* after 3 months produced the highest fresh biomass (39 t ha^{-1}).

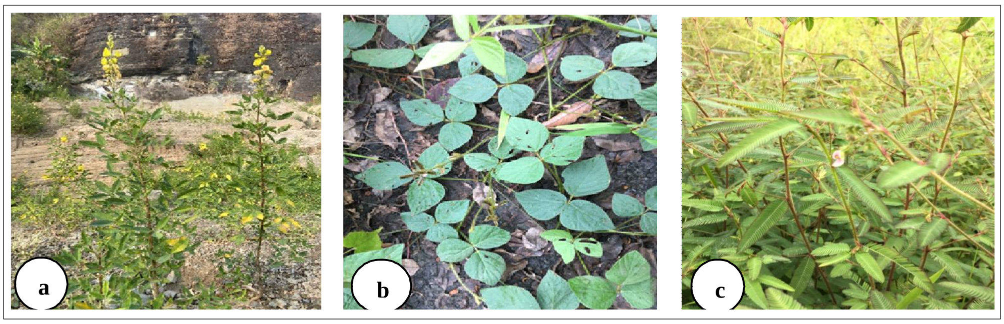


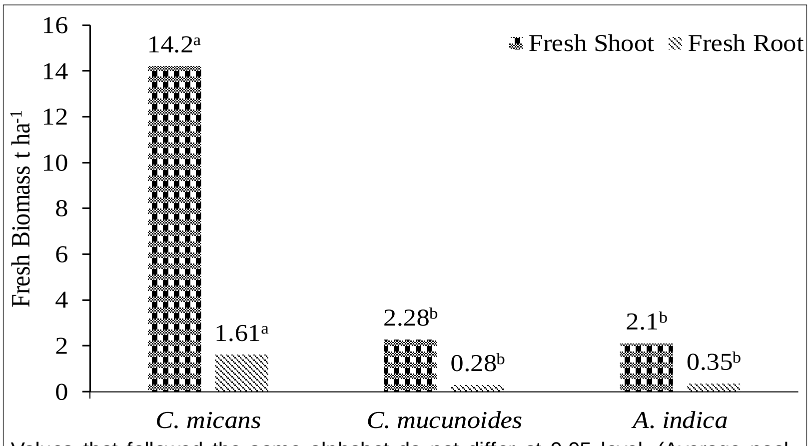
Fig 1: Image showing the three leguminous weed species where a) *Crotolaria micans,* b) *Calopogonium mucunoides* c) *Aeschynomene indica.*

The dry biomass for shoot and root ranged from 0.58 - 2.72 t ha^{-1} and 0.14-0.56 t ha^{-1} respectively (Fig 3). Irin and Biswas, 2021; Pereira *et al*. (2016) reported that *Crotolaria juncea* produced significantly higher fresh biomass (35 tons/ha and 45.76 Mg ha^{-1} respectively). Several other studies have supported the potentiality of Crotolaria spp for dry matter production (Torres *et al*., 2005; Teodora *et al*., 2011; Mattar *et al*., 2015)). The plant populations in normal conditions without any competition will increase the plant biomass (Feichtinger *et al*., 2004; Daudu *et al*., 2006). However, Pramanik *et al*. (2009); Chand *et al*. (2015) reported that Sesbania recorded significantly higher fresh shoot biomass compared to Crotolaria. *Sesbania aculeata* and *Crotaria juncea* produced 5.3-6.3 and 6.2-8.2 t ha^{-1} of dry biomass respectively (Hiermath and Patel, 1996). Similarly, Miah *et al*. (2015) reported fresh shoot and root biomass of 5 green manure crops ranged from 6.24 to 52.62 t ha^{-1} and 1.32-11.3 t ha^{-1} respectively; dry shoot and root biomass ranged from 0.86-6.3 t ha^{-1} and 0.20-1.59 t ha^{-1} respectively which was higher than our findings. However, a study by Chilagane *et al*. (2018) reported the highest dry biomass (15.13 t ha^{-1}) in velvet beans which was more than that of *C. juncea* (11.75 t ha^{-1}).

The differences in biomass among the studied species may also be attributed to the region's availability of light, temperature and climatic factors. Thomas and Palaniappan, (2012) commented on some leguminous green manure crops being sensitive to photoperiod including *Crotolaria juncea* and further observed that the vegetative growth period was restricted due to shorter growth period and low temperature.

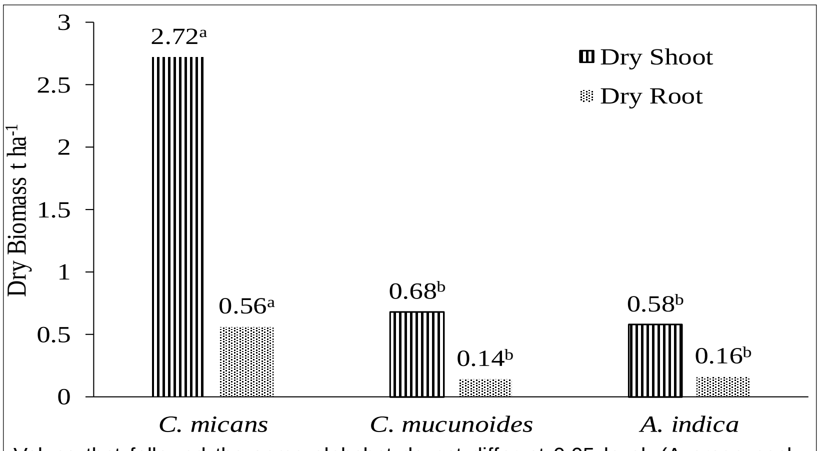
Nutrient content and accumulation

Nutrient contents in the shoot and root biomass was significantly different among the species (Table 2). *C. micans* exhibited the highest nitrogen content in the shoot (29.40 g kg^{-1}) and root (21.91 g kg^{-1}), followed by *A. indica* and *C. mucunoides*.



Values that followed the same alphabet do not differ at 0.05 level. (Average pool data of two years).

Fig 2: Fresh shoot and root biomass of three leguminous weed species.



Values that followed the same alphabet do not differ at 0.05 level. (Average pool data of two years).

Fig 3: Dry shoot and root biomass of three leguminous weed species.

Significantly higher P content for shoot and root was observed in *C.micans*, 5.24 g kg^{-1} and 4.38 g kg^{-1} respectively. The highest K content in the shoot was observed in *C. micans* (21.47 g kg^{-1}), while *C. mucunoides* exhibited the highest in the root (17.60 g kg^{-1}). Ca content in shoot biomass ranged from 0.52-0.69 g kg^{-1} with *A. indica* having the maximum whereas, Ca content in the root ranged from 0.03-0.22 g kg^{-1} with *C. mucunoides* having the highest. The highest N values found in *C. micans* can be attributed to the plant's high biological nitrogen fixation efficiency by the plant's root nodules. The P contents in the studied legume were higher than those studied by Duarte *et al*. (2013). Contents of micronutrients among the species were in order Fe > Zn > Cu (Table 2). Fageria *et al*. (2002); Fageria *et al*. (2016) also reported an order (Fe > Mn > Zn > Cu) of micronutrient concentration in crop plants. Duarte *et al*. (2013) also reported that in the aerial part of the studied green manure plants, the content of Fe was higher and Cu content was the lowest.

The leguminous species accumulated significantly different amounts of nutrients in their shoot and root biomass (Table 3). *C. micans* was statistically superior for the accumulation of N, P and K in both the shoot and root biomass. Furthermore, the highest dry biomass production of *C. micans* is an added plus in contributing the highest amount of nutrient accumulation among the studied legumes. *C. juncea* (126 kg ha^{-1}) recorded the highest total N values before the cultivation of eggplant (Castro *et al*., 2004). Pereira *et al.* (2016) accumulated about 377 kg ha^{-1} N at 92 days and Duarte *et al*. (2013) accumulated about 175.8 kg ha^{-1} N during the full flowering phase. In 55 days of growth, *C. juncea*, *S. aculeata* and *V. unguiculata*

Table 2: Nutrient contents in the shoot and root biomass of the leguminous weed species (Average pool data of two years).

Nutrients		Biomass fractions	*C. micans*	*C. mucunoides*	*A. indica*
N	g kg^{-1}	Shoot	29.40^a	13.18^c	21.50^b
		Root	21.91^a	10.33^c	15.15^b
P		Shoot	5.24^a	4.63^b	4.77^b
		Root	4.38^a	4.25^a	3.48^b
K		Shoot	21.47^a	11.70^c	15.27^b
		Root	11.07^b	17.60^a	11.23^b
Ca		Shoot	0.66^b	0.52^c	0.69^a
		Root	0.03^c	0.22^a	0.19^b
Zn	mg kg^{-1}	Shoot	26.23^b	27.55^b	40.67^a
		Root	57.95^c	84.47^a	63.78^b
Fe		Shoot	521.78^b	991.90^a	481.28^c
		Root	1634.93^c	1978.55^a	1851.13^b
Cu		Shoot	15.25^a	12.23^b	10.28^c
		Root	32.10^c	65.85^a	36.62^b

Values following the same alphabet in the column do not differ by LSD at 0.05 level; n= 3.

Table 3: Accumulation of nutrients in the shoot and root biomass of the leguminous weed species at 90 days after sowing (Average pool data of two years).

Nutrient		Biomass fraction	*C. micans*	*C. mucunoides*	*A. indica*
N	Kg ha^{-1}	Shoot	78.56^a	8.96^c	12.59^b
		Root	12.04^a	0.87^c	2.14^b
P		Shoot	14.51^a	3.17^b	2.79^b
		Root	2.34^a	0.50^b	0.49^b
K		Shoot	59.45^a	8.00^b	8.94^b
		Root	6.09^a	2.01^b	1.59^b
Ca		Shoot	18.33^a	3.53^c	4.02^b
		Root	0.17^c	0.25^b	0.27^a
Zn	g ha^{-1}	Shoot	72.65^a	18.84^c	23.81^b
		Root	10.49^a	7.51^b	5.11^c
Fe		Shoot	1445.02^a	679.31^b	281.73^c
		Root	900.06^a	229.46^c	261.84^b
Cu		Shoot	42.23^a	8.36^b	6.02^c
		Root	29.15^a	9.85^c	11.70^b

*Values following the same alphabet in the column do not differ by LSD at 0.05 level; n= 3.

respectively accumulated 103, 84 and 67 kg of N (Datt and Bhardwaj, 1995). Calcium accumulation in the shoot biomass ranged from 3.53 to 18.33 kg ha^{-1} with, *C. micans* having the highest and the least by *C. mucunoides*. However, *A. indica* accumulates higher amount of Ca in the root biomass (0.27 kg ha^{-1}). *C. micans* recorded higher accumulation of Zn, Fe and Cu (1445.02, 72.65 and 42.23 g ha^{-1} respectively) in the shoot biomass and (900.06, 10.49 and 29.15 g ha^{-1} respectively) in the root biomass (Table 3).

The varying nutrient accumulation in the shoot and root biomass of the leguminous weed species in this study and other studies may be attributed to genetic variations in the species, ages and cultivation practices of the crops.

CONCLUSION

It is concluded that *Crotolaria micans* was the most promising species in terms of growth performance, biomass production and nutrient accumulation after 90 days of sowing.

The high nutrient accumulation capacity, in a short period, makes *C. micans* potential species for use as a green manuring crop. However, a detailed investigation is required in terms of its decomposability, nutrient release, crop response and allelopathic impact through systematic on-station and off-farm trials in certain to its suitability to be recommended as a green manure crop.

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Conflict of interest: None.

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