**Revista Verde de Agroecologia e Desenvolvimento Sustentável**
V. 11, Nº 2, p. 11-14, 2016
Pombal, PB, Grupo Verde de Agroecologia e Abelhas
*http://www.gvaa.com.br/revista/index.php/RVADS*
DOI: http://dx.doi.org/10.18378/rvads.v11i2.3945

**ARTIGO CIENTÍFICO**

# Biomass and nutrient accumulation of leguminous green manure species in the Jaguaribe-Apodi region, Ceará, Brazil

## *Biomassa e acúmulo de nutrients por espécies de leguminosas utilizadas como adubo verde na região do Jaguaribe-Apodi, Ceará, Brasil*

*Natanael Santiago Pereira[1*], Ismail Soares[2], Fábio Rodrigues de Miranda[3]*

**Abstract:** The ability of leguminous green manure to incorporate significant amounts of nutrientes into the soil makes them excellent alternatives for the region agriculture systems. This study aimed to evaluate the potential use of six leguminous species (*Crotalaria juncea, Canavalia ensiformes, Cajanus cajan, Crotalaria spectabilis, Dolichos lab lab* and *Mucuna deeringiana*) as green manure in an area of the Jaguaribe-Apodi agricultural region, CE, Brazil. The experiments were carried out under field conditions in a randomized block design with five replications. Sampling of biomass of shoots was carried out 78 days after sowing on each plot. It was determined the total biomass and nutrients accumulation in the plants that grew in the plots (leguminous and weeds). We concluded that the use of *Crotalaria juncea* showed up as the most promising treatment in terms of biomass production and nutrient accumulation.

**Key words:** legume; nutrient cycling; plant residues.

**Resumo:** A habilidade de espécies de leguminosas utilizadas como adubos verdes em incorporar quantidades significativas de nutrientes no solo fazem destas excelentes alternativas para as regiões agrícolas. O objetivo deste trabalho foi avaliar o potencial de utilização de seis espécies leguminosas (*Crotalaria juncea*; *Canavalia ensiformes* - feijão-de-porco; *Cajanus cajan* - Guandu anão; *Crotalaria spectabilis*; *Dolichos lab lab* - Labe-labe; e *Mucuna deeringiana* - Mucuna anã) como adubo verde em uma área no Agropólo Jaguaribe-Apodi, CE, Brasil. Os experimentos foram desenvolvidos em condições de campo, em blocos casualizados com cinco repetições. Foram amostradas as partes aéreas das plantas aos 78 dias após a semeadura em cada parcela. Foram determinadas a biomassa e o acúmulo totais de nutrientes das plantas que cresceram na parcela (leguminosas e invasoras). Nas condições edafoclimáticas em que o trabalho foi realizado pode-se concluir que o tratamento com utilização de *Crotalaria juncea* apresentou-se como o mais promissor em termos de aporte de fitomassa e acúmulo de nutrientes.

**Palavras-chaves:** leguminosa; ciclagem de nutrientes; resíduos vegetais.

*Autor para correspondência
Recebido para publicação em 12/01/2016; aprovado em 20/03/2016
[1]Master in Agronomy/ Soil and Plant Nutrition. Agronomy Engineer of Instituto Federal de Educação, Ciência e Tenologia do Ceará, Rua Estevam Remígio, 1145. CEP: 62930-000 Limoeiro do Norte (CE), Brazil. E-mail: natanael@ifce.edu.br.
[2]Associate Professor of Department of Ciência do Solo, Universidade Federal do Ceará, Av. Mister Hull, 2977. CEP 60021-970 Fortaleza (CE). Brazil. E-mail: soaresufc@hotmail.com
[3]Researcher at Embrapa Agroindústria Tropical, Rua Dra. Sara Mesquita, 2270, Planalto do PICI. CEP 60511-110 Fortaleza (CE). Brazil. E-mail: fabio.miranda@embrapa.br

## INTRODUCTION

The Baixo Jaguaribe region in the state of Ceará, is one of the areas with the greatest potential for irrigated agriculture in the Brazilian Northeast. The agricultural systems in the region use large amounts of inputs, especially mineral fertilizers, which can represent a large proportion of production costs. Thus, the use of leguminous green manure can be a alternative for recycle and incorporate significant amounts of nutrients, particularly the nitrogen (N), through fixation of atmospheric N, increasing economic returns and decreases the negative environmental impact (LIM, 2012).

There is wide variation in the yield of biomass and nutrient accumulation by leguminous species, which must be related to the intrinsic characteristics of each specie, the management of crop residues and soil and climate conditions prevailing. Variations in biomass production and accumulation of nutrients by green manure legumes in different environmental conditions were reported by Odhiambo (2011) and Thomas and Palaniappan (2012).

By evaluating the potencial biomass of leguminous species, we can indicate the best species for local conditions. In this respect, Crotalaria genus has excelled in studies of potential of green manure (MATTAR et al., 2015). The capacity to nutrients accumulation can also be a good criterion in the selection of the species to be used as green manure. In Sete Lagoas, MG, Brazil, Favero et al. (2000) evaluated the potential of five leguminous species, which have accumulated between 109 and 222 kg $ha^{-1}$ of N.

Thus, the objective of this study was to evaluate the potential use of leguminous species as green manure in the Jaguaribe-Apodi region.

## MATERIAL AND METHODS

The experiment was done in the area of farm Frutacor Ltda, in Quixeré, CE, Brazil (coordinates: 5° 07'30 "S and 37 ° 57'15" W). Sample of the soil at the 0-20 cm layer, performed as Silva (2009), presented the following chemical characteristcs: pH ($H_2O$) = 7,0; organic matter (g $kg^{-1}$) = 18,8; available P (extracted by Mehlich-1 (mg $kg^{-1}$) = 48; $K^+$, $Ca^{2+}$, $Mg^{2+}$, $H^+$+$Al^{3+}$, base sum (BS), cation exchange capacity (CEC) ($cmol_c$ $kg^{-1}$) = 0,66; 7,9; 2,5; 1,48; 11,3 e 12,8, respectively, and base saturation (%) = 88.

We used six leguminous species, corresponding to treatments L1 – sunn hemp (*Crotolaria juncea*); L2 – jack bean (*Canavalia ensiformis*); L3 – dwarf pigeon pea (*Cajanus cajan*); L4 – showy crotalaria (*Crotalaria spectabilis*); L5 – lab-lab (*Dolichos lab lab*) and L6 - dwarf mucuna (*Mucuna deeringiana*). Treatments were arranged in randomized block design, with five replications, in plots of 13.0 x 14.4 m.

We performed the mechanical preparation of the area for seeding of legumes. No fertilizer was performed Sowing was performed manually on 02/10/2008, in rows spaced 0.50 m, at a depth of 2 to 3 cm and sowing densities of: 1.25, 0.50, 1.25, 5.00, 2.00 to 4.00 g $m^{-1}$ for treatments L1, L2, L3, L4, L5 and L6, respectively.

It was installed micro sprinkler system in the area to supplement rainwater. The precipitation in the experimental period was 53.6 mm (February), 294.4 (March) and 138.8 (April).

Sampling of biomass of shoots was carried out 78 days after sowing (04/28/2008), using a square frame with an area of 0.5 m² on each plot. Leguminous plants and weeds were cut at ground level and weighed to determine biomass fresh weight.

At each sampling, part the material was dried in an oven with forced ventilation of air at 65 °C for 72 h and the mass of the plant material was determined. Then it was milled for the determination of carbon and nutrients. Carbon contents were determined by the Walkley-Black method described by Yeomans and Bremner (1988). Nitrogen was determined after sulfuric digestion by micro Kjeldahl method, and the macronutrients (P, K, Ca, and Mg) were determined after mineralization nitro-perchloric mixture as described by Silva (2009). The amount of original nutrient was estimed through product of its tenor and dried mass.

Data were subjected to analysis of variance and means were compared by Tukey test at 5 % probability. The significance of the coefficients of correlation and determination were assessed by t test at 5 % probability.

## RESULTS E DISCUSSION

Treatment L1 (*Crotalaria juncea*) was not statistically different from L2 (*Canavalia ensiformes*) and L5 (lab-lab) for the production of fresh matter, however the L1 was superior to the others for dry matter production (Table 1). In fact, several studies have confirmed the potential of *Crotalaria. juncea* for dry matter production (CÁCERES; ALCARDE, 1995; PERIN, 2005; TORRES et al., 2005; TEODORO et al., 2011). According to Mattar et al. (2015), the Crotalaria genus stand out when studying green manure.

The dry mass yield of treatment L5 (*Dolichos lab lab*) was lower than the results presented by Faria (2004) for legumes in the Submédio São Francisco region of 10.64 and 12.69 Mg $ha^{-1}$ with the mowing season at 128 and 175 days after planting, respectively (full flowering). For the other legumes, in general, the results were higher than those presented by Faria (2004), with emphasis on *Crotalaria juncea*, for which he obtained a dry mass yield of 5.71 Mg $ha^{-1}$ (68 days after planting), while in this study it was 12.82 Mg $ha^{-1}$ (Table 1).

Some of these differences can be explained by the different cutting times. The availability of light and temperature in the Baixo Jaguaribe region may also have favored legumes in this work. Thomas and Palaniappan (2012) pointed to the sensitivity of some leguminous green manure to photoperiod, including *Crotalaria juncea*. The authors observed that the shorter growth period and low temperature restricted vegetative growth.

Cáceres and Alcarde (1995) also obtained biomass yields lower than those of the present experiment, except *Crotalaria spectabilis*, which they observed yields of 21.6 and 4.2 t $ha^{-1}$ of green and dry matter, respectively. Cavalcante et al. (2015) also observed higher values of fresh mass (26.5 t ha-1) and dry mass (6.0 t ha-1) for this leguminous specie in an experiment conducted in Araíraca, Agreste of Alagoas. That can be explained by the delay in germination observed in all plots with *Crotalaria spectabilis* in this work.

The weeds may have influenced the biomass production of legumes, mainly because they have been grown in the rainy season, when competition with them is more intense, but not necessarily affect the total biomass yield. Favero et al. (2000) found no influence of weeds on yield of shoot dry weight, demonstrating that the presence of weeds did not reduce the total biomass yield.

We observed differences of nutrient accumulation in shoot biomass of legumes (Table 2). Legumes have accumulated on average almost 200 kg ha$^{-1}$ N in shoots (Table 2).

**Table 1** - Fresh and dry mass, and percentage of dry matter in the biomass of legume treatments, at 92 days after planting.

| Treatment(1) (1) | Fresh mass (Mg ha$^{-1}$) | Dry mass (Mg ha$^{-1}$) | Dry matter seca seca (%) |
|---|---|---|---|
| L1 | 45.76 a | 12.82 a | 28.02 |
| L2 | 33.16 ab | 5.83 b | 17.61 |
| L3 | 23.80 b | 5.76 b | 24.15 |
| L4 | 20.90 b | 3.51 b | 16.88 |
| L5 | 28.54 ab | 4.80 b | 16.98 |
| L6 | 27.42 b | 4.83 b | 17.78 |
| Mean | 29.93 | 6.26 | 20.24 |
| C.V.(%) | 30.54 | 38.00 | 23.23 |

Means followed by the same letter in the column do not differ by Tukey test at 5 % probability. (1) L1 – sunn hemp (*Crotolaria juncea*); L2 – jack bean (*Canavalia ensiformis*); L3 – dwarf pigeon pea (*Cajanus cajan*); L4 – showy crotalaria (*Crotalaria spectabilis*); L5 – lab-lab (*Dolichos lab lab*) and L6 - dwarf mucuna (*Mucuna deeringiana*).

**Table 2 -** C/N ratio and nutrient accumulation (kg ha$^{-1}$) in biomass of legume treatments, at 92 days after planting.

| **Treatment (1)** | **C/N** | **N** | **P** | **K** | **Ca** | **Mg** |
|---|---|---|---|---|---|---|
| L1 | 14.97 ab | 377.67 a | 28.72 a | 184.46 a | 113.08 ab | 50.74 a |
| L2 | 11.92 b | 234.71 b | 16.10 abc | 139.48 a | 132.69 a | 19.87 b |
| L3 | 15.82 ab | 85.76 bc | 15.59 abc | 145.68 a | 34.90 b | 16.74 b |
| L4 | 19.41 a | 78.24 c | 8.87 c | 104.55 a | 37.31 b | 16.71 b |
| L5 | 17.39 a | 123.41 bc | 25.08 ab | 145.48 a | 48.41 ab | 15.93 b |
| L6 | 14.88 ab | 136.73 bc | 11.47 bc | 119.99 a | 67.66 ab | 15.78 b |
| Mean | 15.73 | 189.42 | 17.64 | 139.94 | 72.34 | 22.63 |
| C.V.(%) | 15.29 | 33.63 | 39.48 | 32.72 | 62.99 | 62.91 |

Means followed by the same letter in the column do not differ by Tukey test at 5 % probability. (1) L1 – sunn hemp (*Crotolaria juncea*); L2 – jack bean (*Canavalia ensiformis*); L3 – dwarf pigeon pea (*Cajanus cajan*); L4 – showy crotalaria (*Crotalaria spectabilis*); L5 – lab-lab (*Dolichos lab lab*) and L6 - dwarf mucuna (*Mucuna deeringiana*).

In general, the treatments produced high accumulations of N in biomass, which makes it interesting to use these species as a source of nitrogen in agroecosystems in the region studied. Treatment L2 presented the lowest C/N ratio, but it was significantly different only from treatments L4 and L5 (Table 2). These treatments still had low C/N ratio (<20), a parameter that can be decisive to speed mineralization of organic N in the soil.

However, it should be considered that the C/N ratio may be a characteristic quite variable within a farming system, having close relationship with the conditions for plant growth. Torres et al. (2005) found variations in C/N ratio of legumes used as cover crops in two growing seasons. That variation was explained by possible disfavoring of N fixation by legumes. According to Ribeiro Jr. and Ramos (2006), any factor that affects plant growth may influence the biological fixation of N.

In that sense, the successive planting of legumes may encourage the symbiotic fixation, increasing the inoculum potential of the soil, but also because of the influence of green manure in stimulating microflora and improving soil quality (BUZINARO et al., 2009).

Thus, smaller values of the C/N ratio should be associated with higher amounts of N in biomass, thereby suggesting potential for the rapid mineralization of residues of these species (RIBEIRO JUNIOR; RAMOS, 2006).

Overall, nutrients accumulated in biomass of legume species can be considered high and are comparable or superior to those found by Cáceres and Alcarde (1995), at 110 days after planting, except for N and Ca, for *Crotalaria spectabilis*, for which the same authors found amounts of 113.4 and 63 kg ha$^{-1}$, respectively. The accumulation of N in L1 (*Crotalaria juncea*) was superior to those presented by other authors such as Torres et al. (2005) (118.1 kg ha$^{-1}$), Odhiambo (2011) (302 kg ha$^{-1}$), Patro et al. (2011) (176.7 kg ha$^{-1}$), Lim et al. (2012) (130 kg ha$^{-1}$) and Cavalcante et al. (2015) (138.5 kg ha$^{-1}$), probably due to the high yield of dry mass obtained in this work. However, Teodoro et al. (2011) found accumulations of nutrients, in general, higher even for the N in *Crotalaria juncea* (514 kg ha$^{-1}$) but with a cycle of 163 days (flowering).

Treatment L1 (*C. juncea*) showed higher accumulation of nutrients, except Ca, for which treatment L2 (jack bean) showed higher accumulation (Table 2). In general, one can say that *C. juncea* stood out as the most promising legume in terms of supply of biomass and nutrients, while the residues of jack bean showed lower C/N ratio, but showed lower biomass production in relation to L1, despite the competitive capacity of the jack bean against weeds due to its allelopathic potential (FARIA, 2004).

The accumulation of P in *C. juncea* was similar to lab-lab (Table 2), although it has presented a dry mass production 2.7 times higher than the lab-lab. This can be explained by the high absorption capacity of P for this species.

There were no significant differences between treatments for the accumulation of K (Table 2), which may be explained by the high level of this nutrient in the soil.

The high accumulation of K presented by legumes can be very important when one wants to use those species associated with fruit trees, avoiding the loss of that nutrient through leaching, allowing its recycling.

In general, the characteristics evaluated showed that legume species showed a high accumulation of nutrients, demonstrating their potential for nutrient cycling in the agricultural system.

## CONCLUSIONS

In general, the characteristics evaluated showed that legume species showed a high accumulation of nutrients, demonstrating their potential for nutrient cycling in the agricultural system.

*Crotolaria juncea* was the most promising specie in terms of biomass production and nutrient accumulation.

## ACKNOWLEDGEMENTS

The authors thank the ETENE/FUNDECI/BNB for financial support, the agribusiness company Frutacor Ltda. for necessary support for the field work and the company Piraí Seeds, for the seeds assigned.

## REFERENCES

BUZINARO, T.N.; BARBOSA, J.C.; NAHAS, E. Atividade microbiana do solo em pomar de laranja em resposta ao cultivo de adubos verdes. Revista Brasileira de Fruticultura, 31:408-415, 2009.

CACERES, N.T.; ALCARDE, J.C. Adubação verde com leguminosas em rotação com cana-de-açúcar (*Saccharum* spp.). STAB. Açúcar, Álcool Subpr., 13:16-19, 1995.

CAVALCANTE, V. S., BARBOZA, J. T. V., COSTA, L. C., DOS SANTOS, V. R.; DOS SANTOS, M. J. N. Produção de adubos verdes e a utilização dos resíduos no cultivo da cebolinha. Revista Brasileira de Agroecologia, v. 10, n. 1, 2015.

FAVERO, C.; JUCKSCH, I.; COSTA, L.M.; ALVARENGA, R.C.; NEVES, J.C.L. Crescimento e acúmulo de nutrientes por plantas espontâneas e por leguminosas utilizadas para adubação verde. Revista Brasileira de Ciência do Solo, 24:171-177, 2000.

FARIA, C.M.B. (2004) Comportamento de leguminosas para adubação verde no Submédio São Francisco. Petrolina, Embrapa Semi-Árido, 22 p, 2004 (Boletim de Pesquisa e Desenvolvimento, 63)

LIM, T. J., KIM, K. I., PARK, J. M., LEE, S. E.; HONG, S. D. The use of green manure crops as a nitrogen source for lettuce and chinese cabbage production in greenhouse. Korean Journal of Environmental Agriculture, v. 31, n. 3, p. 212-216, 2012.

MATTAR, E. P. L., MAIA, G. F. N., JUNIOR, E. F. F., DE MORAES, M. D.,; ORTEGA, G. P. Desempenho de Crotalaria micans Link. em argissolo amarelo distrófico no acre ocidental, brasil. Revista Brasileira de Agroecologia, v. 10, n. 1, 2015.

ODHIAMBO, J. J. O. Potential use of green manure legume cover crops in smallholder maize production systems in Limpopo province, South Africa.African Journal of Agricultural Research, v. 6, n. 1, p. 107-112, 2011.

PATRO, H. K., KUMAR, A., SHUKLA, D. K., & MAHAPATRA, B. S. L. Total Productivity, nutrient uptake and economics of rice-wheat cropping system as influenced by Crotalaria juncea green manuring. Journal of Environmental Research And Development, v. 5, n. 3, 2011.

RIBEIRO JR., W.Q. & RAMOS, M.L.G. Fixação biológica de nitrogênio em espécies para adubação verde. In: CARVALHO, A.M. & AMABILE, R.F., eds. Cerrado: adubação verde. Planaltina, Embrapa Cerrados, 2006, p. 171-209.

SILVA, F.C. Manual de análises químicas do solo, plantas e fertilizantes. 2.ed. Brasília, Embrapa Comunicações para Transferência de Tecnologia, 2009, 627p.

TEODORO, R.B.; OLIVEIRA, F.L.; SILVA, D.M.N.; FÁVERO, C.; QUARESMA, M.A.L. Aspectos agronômicos de leguminosas para adubação verde no cerrado do alto vale do Jequitinhonha. Revista Brasileira de Ciência do Solo, 35:635-643, 2011.

THOMAS, L.; PALANIAPPAN, S. P. Influence of Sowing Time on Biomass Production and Seed Yield of Three Green Manure Crops. International Rice Research Notes, v. 22, n. 3, 2012.

TORRES, J.L.R.; PEREIRA, M.G.; ANDRIOLI, I.; POLIDORO, J.C.; FABIAN, A.J. Decomposição e liberação de nitrogênio de resíduos culturais de plantas de cobertura em um solo de cerrado. Revista Brasileira de Ciência do Solo, 29:609-618, 2005.

YEOMANS, J.C.; BREMER, J.M. A rapid and precise method for routine determination of organic carbon in soil. Soil Sci. Plant Anal., 19:1467-1476, 1988.