RGSA – Revista de Gestão Social e Ambiental
ISSN: 1981-982X
Data de submissão: 02/10/2023
Data de aceite: 02/01/2024
DOI: https://doi.org/10.24857/rgsa.v18n4-009
Organização: Comitê Científico Interinstitucional
Editora Chefe: Christian Luiz da Silva
Avaliação: Double Blind Review pelo SEER/OJS

PERFORMANCE OF COMMON BEAN CULTIVATED IN SUCCESSION TO COVER CROPS

Érica de Oliveira Araújo[1]
Diogo de Souza Freitas[2]
Jose Vanor Felini Catânio[3]
Luís Antônio Bento Viana Filho[4]
Emily Gomes Guimarães[5]

ABSTRACT

Purpose: The present research aims to evaluate the biomass production and nutrient uptake by different cover crops, as well as to verify the effects of straw on bean productivity.

Method: The experimental design was completely randomized, consisting of sowing beans on straw four cover crops (Crotalaria ochroleuca, Pigeon pea, Mucuna gray and Lab-lab) + control, with five replications.

Results and conclusion: The Pigeon pea species has great potential for dry matter production and ability to absorb and accumulate phosphorus in the leaves in full bloom. The straw of the species Crotalaria ochroleuca, Pigeon pea and Mucuna cinza contributed significantly to the productivity of common bean cultivated in succession, as well as represent an alternative to reduce the dependence on synthetic fertilizers and increase the sustainability of agricultural systems.

Implications of the research: The search for maintaining or increasing crop production through the adoption of conservation practices with emphasis on the cultivation of cover crop species is emphasized as an efficient strategy for nutrient cycling, improving soil health and increasing productivity with sustainability assumptions.

Originality/value: The results obtained in this study are relevant to the scientific community, contributing to the training of educators and development of students, especially in the area of agricultural and environmental sciences, serving as a scientific basis for the regional technological process.

Keywords: *Phaseolus vulgaris L.*, Fabaceas, Nutrient Cycling, Plant Residues, Productivity, Sustainability.

PERFORMACE DO FEIJOEIRO CULTIVADO EM SUCESSÃO A PLANTAS DE COBERTURA

RESUMO

Objetivo: A presente pesquisa visa avaliar a produção de biomassa e a absorção de nutrientes por diferentes plantas de cobertura, bem como constatar os efeitos da palhada sob a produtividade do feijoeiro.

[1] Instituto Federal de Educação, Ciência e Tecnologia de Rondônia, Colorado do Oeste, Rondônia, Brazil.
E-mail: erica.araujo@ifro.edu.br Orcid: https://orcid.org/0000-0003-1996-4849
[2] 2Instituto Federal de Educação, Ciência e Tecnologia de Rondônia, Colorado do Oeste, Rondônia, Brazil.
E-mail: desouzafreitasdiogo@gmail.com Orcid: https://orcid.org/0000-0002-2626-9564
[3] Instituto Federal de Educação, Ciência e Tecnologia de Rondônia, Rondônia, Brazil.
E-mail: vanor.catanio@ifro.edu.br Orcid: https://orcid.org/0000-0001-9400-5555
[4]Instituto Federal de Educação, Ciência e Tecnologia de Rondônia, Colorado do Oeste, Rondônia, Brazil.
E-mail: viana.antonio2018@gmail.com Orcid: https://orcid.org/0009-0007-2601-4362
[5]Instituto Federal de Educação, Ciência e Tecnologia de Rondônia, Colorado do Oeste, Rondônia, Brazil.
E-mail: emily.gomes@estudante.ifro.edu.br Orcid: https://orcid.org/0009-0003-0890-2834

Método: O delineamento experimental foi o inteiramente casualizado, constituídos pela semeadura do feijão sobre a palhada quatro espécies de cobertura (Crotalária ochroleuca, Feijão guandu, Mucuna cinza e Lab-lab) + testemunha, com cinco repetições.

Resultados e conclusão: A espécie feijão guandu apresenta grande potencial para produção de massa seca e capacidade em absorver e acumular fósforo nas folhas em pleno florescimento. A palhada das espécies Crotalaria ochroleuca, Feijão guandu e Mucuna cinza contribuíram significativamente na produtividade do feijoeiro cultivado em sucessão, bem como representam alternativa para reduzir a dependência de fertilizantes sintéticos e aumentar a sustentabilidade dos sistemas de agrícolas.

Implicações da pesquisa: A busca pela manutenção ou aumento da produção das culturas mediante a adoção de práticas conservacionistas com destaque ao cultivo de espécies de plantas de cobertura são enfatizadas como estratégia eficiente de ciclagem de nutrientes, melhoria da saúde do solo e aumento da produtividade com premissas para a sustentabilidade.

Originalidade/valor: Os resultados obtidos neste estudo são relevantes para a comunidade científica, contribuindo para a formação de educadores e desenvolvimento de educandos, especialmente na área de ciências agrárias e ambientais, servindo de base científica para o processo de tecnológico regional.

Palavras-chaves: *Phaseolus vulgaris L.*, Fabaceas, Ciclagem de Nutrientes, Resíduos Vegetais, Produtividade, Sustentabilidade.

RGSA adota a Licença de Atribuição CC BY do Creative Commons (https://creativecommons.org/licenses/by/4.0/).

1 INTRODUCTION

Bean (*Phaseolus vulgaris* L.) is a crop of great economic and social importance and the main source of vegetable protein in human nutrition in developing countries in tropical and subtropical regions (Araújo et al., 2021). In Brazil, bean production is one of the most representative farms, with an area of 2.7 million hectares and a production of more than 3 million tons (Conab, 2023). For the Norte region the estimated area planted with beans in the 2022/2023 crop was 92,600 hectares, with production of 90,200 tons of beans, being the state of Rondônia holder of planting only in 2ª crop (Conab, 2023).

Despite this, the average regional productivity of the crop is still unsatisfactory, since much of the production is carried out in agricultural systems with a low level of technology, and the improvement of alternative low cost technologies capable of improving the productivity indexes of the productive systems is necessary. Among the alternatives, the use of cover species, mainly legumes, deserves to be highlighted for presenting interesting agronomic characteristics, such as short cycle, productive potential and nitrogen fixation plant (N), promoting numerous benefits that can derive from its use, both economic and environmental (Dalchiavon et al., 2011; Rocha et al., 2011).

These species of legumes, despite having a lower C/N ratio, can be included in the plan of succession and crop rotation in direct sowing system or direct planting system, because they present advantages in the short term, such as the release of nutrients during decomposition (Souza et al., 2012), characterized as a promising alternative in nitrogen supplementation, besides promoting significant increase in crop productivity, as demonstrated by Araújo et al., 2021, Souza et al., 2012, and Torres et al., 2013.

Thus, the soil management systems that recommend the use of cover plants, in succession or rotation with crops, is an auspicious practice and has been gaining ground in the agricultural areas of Brazil, demonstrating great efficiency in relation to soil cover and

protection, increased productivity and improvement in physical, chemical and biological conditions (Santos et al., 2010; Zanatta et al., 2023, Torres et al., 2024). they are still scarce and necessary, with premises for the deepening of scientific and technological knowledge intended for agricultural production, with lower costs for the reduction in the use of chemical fertilizers.

In the light of the above, the present study aimed to evaluate the production of biomass and the absorption of nutrients by different cover plants, as well as to verify the effects of straw on the productivity of the bean plant.

2 THEORETICAL FRAME

Brazil ranks third in the world ranking for bean production, behind only Myanmar and India, in the country research with this legume is among the most advanced, since the common bean is cultivated by small, medium and large producers in different production systems and in practically all Brazilian regions. As the crop is short cycle, a strong advantage is the possibility of suitability of planting within a smaller window without the need to give up the cultivation of other grains in the same crop year, which favors three different planting seasons in Brazil,

Preparing the area for sowing the crop, mainly with plowing and grading, causes soil aggregates to be destroyed, leaving organic matter more exposed to microbial action, increasing essential nutrient losses, and maximizing the erosion process (Costa et al., 2022) and contributing to reducing production potential. Therefore, the need to achieve sustainability and increase crop productivity has led the scientific community to seek solutions aimed at soil conservation, maintaining fertility at adequate levels, and maximizing soil coverage.

Thus, the cultivation of cover plants in the off-crop is emphasized as a strategy to improve the dynamics of the systems, as their benefits go beyond the cover of the soil, extending to the physical, chemical and biological components of the soil, since these plants are capable of improving the organic matter contents, biological activity, the structure and aggregation of the soil, the availability and balance of nutrients, the infiltration and storage of water, the conditions of rooting of plants along the soil profile, as well as preventing erosion and increasing the productivity of crops (Araújo e Ferreira, 2023).

It should be noted that with the introduction of Fabaceae in succession or rotation systems, nitrogen (N) fixation and increased availability of the element in the soil, in addition to other nutrients, however, the decomposition of residues is accelerated in soil and climatic conditions, due to the precipitation and temperature conditions that occur in the region and the lower carbon/nitrogen (C/N) ratio of plants used for straw production (Silveira et al., 2021; Torres et al., 2021, Torres et al., 2022).

Leguminous species such as *Crotalaria Ochroleuca* with an annual cycle, a determined, shrub and erect growth habit, have a green mass production capacity of 20-30 t/ha, dry mass of 7-10 t/ha and nitrogen fixation potential of 133-200 kg/ha (Carvalho et al., 2022). The guandu bean (*Cajanus cajan*) also with an annual cycle, determined growth, shrub and erect, well known for its rusticity, has a production capacity of green mass of 15-30 t/ha and dry mass of 4-9 t/ha (Carvalho et al., 2022). The species Mucuna ash *(Mucuna cinereum)* and Lab-lab *(Dolichos lablab*) of annual cycle, show undetermined growth and climbing branches. While the dry mass production capacity of Mucuna ash is 7-8 t/ha and nitrogen fixation potential 180 to 220 kg/ha (Ambrosano et al., 2016), Lab-lab species has a dry mass production capacity of 3-9 t/ha and a nitrogen fixation potential of 80 to 160 kg/ha (Carvalho et al., 2022).

According to Araújo et al., (2022) leguminous species such as Lab-Lab and Pork Beans despite lower dry mass production were efficient to increase the intake of organic matter, organic carbon, nitrogen and phosphorus from the soil, promoting direct impact on the fertility of the surface layer of the soil (0-10 cm) in the early years of adoption; and that residues of these leguminous crops enabled the average contribution of 2,995 kg/ha ofN-total, 77 kg/ha of

ammonium and 56 kg/ha of nitrate in soil. In this context, the use of cover plants can mean a form of agriculture with low greenhouse gas emissions, and the pursuit of sustainable agricultural production is associated with the evolution of production systems, which should bring economic advantages to rural producers, maintaining or increasing production, without causing harm to the environment (Torres et al., 2018).

However, the bean plant when grown in succession or rotation systems on the residues of different plants of roofs may present different responses in relation to its development and production. Araújo et al., (2021) found positive effects of the straw of *Crotalaria ochroleuca and Mucuna ash* under the components of the production of the bean plant, and these cover plants are able to provide nutrient to the subsequent crop in order to favor its growth and development. Torres et al., (2013) recorded higher yields of beans when cultivated on millet residues, when compared to the values obtained for Crotalaria, pork beans and spontaneous vegetation. Torres et al., (2014) found that the productivity of the beans was significantly higher when cultivated on the millet and *Crotalaria spectabilis*, and the plant cultivated on these roofs presented more full and heavy grains.

3 METHOD

The experiment was conducted under field conditions in the period from October 2021 to May 2022, in the experimental area of the Federal Institute of Education, Science and Technology of Rondônia, Colorado Campus do Oeste, in the municipality of Colorado do Oeste, RO, whose geographical coordinates are 13°06'S and 60°29'W, with an average altitude of 407 meters. The climate according to the Köppen classification is of type Awa, tropical hot and humid with two well-defined seasons. Average temperature and rainfall data during the conduct of the experiment were obtained from the FieldClimate database (Figure 1).Because this is a continuous research, the chemical characterization of the soil was carried out on samples collected in the 0-10 cm and 10-20 cm depth layer (Table 1). The soil correction was carried out, thirty days before the first sowing of cover plants (agricultural year 2019), considering the average results of soil analysis in the layers of 0-10 cm, using filler type dolomitic limestone (PRNT 97%), with the aim of raising base saturation to 65%. From this correction, the experimental premises were for direct planting, without soil revolution, with permanent cover and sowing in the straw.

Table 1. Chemical attributes of the soil before installation of the experiment.

Layer (cm)	MO g/dm^{-3}	CO	pH $CaCl_2$	P mg/dm^{-3}	K	Ca	Mg	H+Al	Al	SB	CTC	V (%)
						—mmolc/dm^{-3}—						
0-10	11.4	4.62	4.9	4.	81.9	29	8	30	1.	40	70	57
10-20	5.3	3.08	5.0	1.	58.5	36	4.	25	1.	41	66	62

Source: Prepared by the authors (2023).

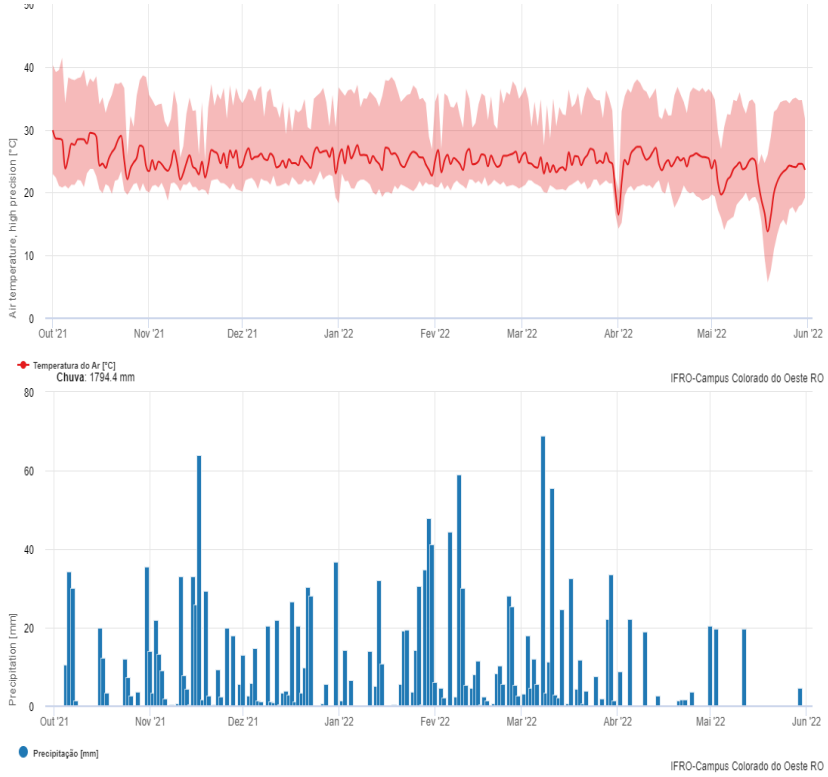


Figure 1. Monthly temperature (°C) and Precipitation (mm) recorded at the Federal Institute of Rondônia's weather station, Colorado West Campus, from October 2021 to May 2022.
Source: Fieldclimate (2022).

The experimental design used was entirely casualized. In the first experimental stage the treatments were constituted by planting four species of cover (Crotalária ochroleuca, Feijão guandu, Mucuna ash and Lab-lab); and in the second experimental stage the treatments were constituted by sowing the beans on the straw four species of cover (Crotalária ochroleuca, Feijão guandu, Mucuna ash and Lab-lab) + witnesses, with five repetitions.

In the first stage, the grooves for planting the cover plants were mechanically opened at a depth of 5 cm, according to the determined spacing, and the sowing carried out manually. The different seed expenditures adopted were based on technical recommendations for the different cover plants. Each experimental unit was composed of 8 lines of 5 meters in length, spaced 0.45 m between lines and 0.20 m between plants. The six centerlines were considered as a useful plot, excluding 0,5 m from each end of the plot.

On the occasion of the full flowering, the covering plants were dried using the herbicide glyphosate (1,920 g ha^{-1} of the i.a.) and then handled with manual brushing aid at a height of 5 cm in relation to the surface of the soil, aiming at the uniformization of the area. However, before desiccation, the production of dry mass by the different cover plants was assessed, using a table (0,50 m x 0,50 m) to demarcate the area of the plot, in which the sample was collected (close to the ground) and weighed, and taken into a forced air circulation oven at 65ºC, until it reached constant weight, determining the dry mass. The levels of macronutrients in the dry mass of the different cover plants were determined according to the methodology described in Embrapa (2009).

In the second stage, after 45 days of desiccation of the cover plants, on the straw was carried out mechanized sowing of the common bean, cultivar BRS Style (of commercial grain carioca, semi-erect plant architecture, habit of undetermined growth type II), in spacing of 0.50 m between rows, with plant population of 200 000 thousand/plants/hectare considering as

useful parcel two central lines, excluding 0.50 m of each end of the parcel. In sowing, the basic fertilizer was carried out on the planting line for the supply of 40 kg ha-1 of N and 60 kg ha-1 of K. All other cultural treatments were carried out as recommended for the bean plant.

On the occasion of full flowering (50% of flowering plants) it was sampled by removing the first fully expanded leaf from the upper leaflets (Malavolta et al., 1997). All the plant material collected was put up in paper bags and dried in an oven with forced circulation of air, at a temperature of 65ºC, for 72 hours, and afterwards ground and submitted to sulfuric digestion and nitro-perchloric digestion, using the methodology described in Embrapa (2009) for determining the levels of macronutrients in full bloom.

The production components, such as number of pods per plant, number of grains per pod, number of grains per plant, weight of one thousand grains and grain yields were obtained at the time of the physiological maturity of the crop, from the measurements of six plants of the useful area of the parcel. Productivity was determined by the weight of grain of the useful area in kilograms, with correction for 13% humidity, transforming the data to kg ha^{1}.

After all the analyzes, the data were submitted to the normality test and variance analysis to verify the effects and the comparisons of the means were made by the Tukey test at 5% probability, using the Sisvar statistical program.

4 RESULTS AND DISCUSSIONS

There was a significant difference ($p \leq 0.05$) between the cover plants as to the production of dry mass and accumulation of nutrients in full flowering, while the effects of the straw of different cover plants on the bean plant were evidenced by the number of grains per plant, grain productivity, nitrogen and calcium content in the leaves in full flowering.

The cultivation of guandu beans yielded the best results for dry mass production (17.23 t.ha^{-1}), differing statistically from Crotalaria ochroleuca (15.99 t.ha^{-1}), Mucuna ash (8.83 t.ha-1), and Lab-lab (7.29 t.ha-1), as shown in Figure 2. The production and subsequent increase in dry mass in the soil can cause significant changes in the maintenance and/or elevation of soil organic matter levels, and therefore in the chemical, physical and biological characteristics of the soil, as well as favoring the development and productivity of agricultural species in subsequent crops (Andrade Neto et al., 2008; Boer et al., 2008).

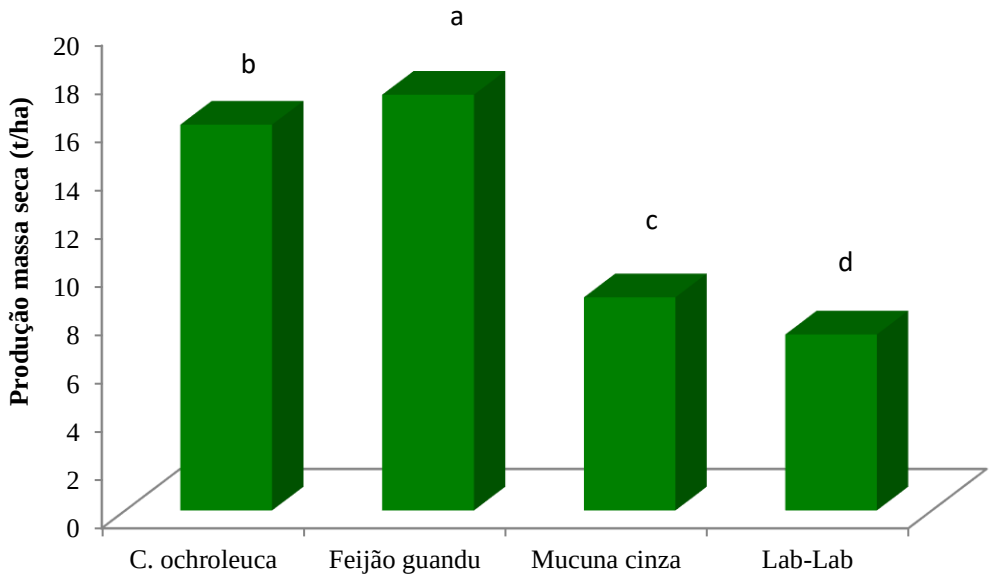


Figure 2. Production of dry dough by different roofing plants.
*Equal letters in the bar do not differ from each other by the Tukey test at 5% probability.
Source: Prepared by the authors (2023).

The high capacity of dry mass production by the species Feijão guandu correlates with the capacity to absorb and accumulate phosphorus in the leaves in full bloom; while the Lab-Lab species presented better capacity to accumulate calcium, differing statistically from the other cover plants (Figure 3). The Lab-Lab species is recognized as an excellent cover species because it has a high capacity to extract nutrients from the soil even with low intake of dry mass, and results similar to those found in the research were obtained by Araújo et al., (2021). It should be noted that although the amount of nitrogen in the dry mass at full bloom among the cover plants does not present any statistical difference ($p>0.05$), the average was 36.06 g/kg, which is sufficient to guarantee an effective nitrogen cycling and increase the sustainability of agricultural production. It should be noted that the release of nitrogen from the cultural residues is linked to the rate of decomposition of these residues, passing the N from the organic to inorganic form by the mineralization of these residues. Therefore, it is variable according to the species of cover plant

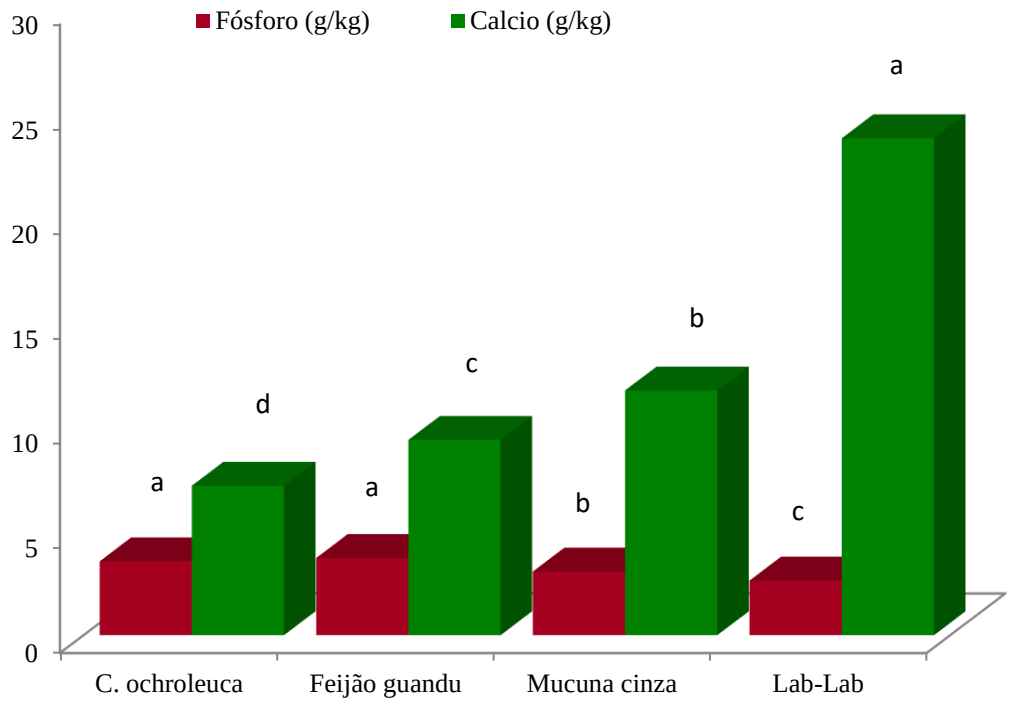


Figure 3. Phosphorus and calcium levels in the full flowering of cover plants.
*Equal letters in the bar do not differ from each other by the Tukey test at 5% probability.
Source: Prepared by the authors (2023).

For the production parameters of the bean crop, significant effects of the straw of Crotalaria ochroleuca, Feijão guandu and Mucuna ash on the production of grains per plant are observed, and therefore on the productivity of bean grains, not differing statistically among themselves (Figure 4A and 4B); while in relation to the control (crop managed under conventional planting) there was a statistical difference ($p \leq 0,05$). However, the straw of the above-mentioned cover plants without any addition of nutrients and even with rapid decomposition, due to the low C/N ratio, was able to provide Among the cultivation of beans, in order to favor their growth and development, since the average indices of productivity of the bean plant for second harvest in dry conditions were in the order of 2,165 kg/ha, a value considered superior to the regional and national average according to data from Conab (2023), with productivity increases of 139% in relation to the absence of cover plants (witness). Although the Lab-lab species shows less straw production, the grain productivity of the bean crop was about 86% higher when compared with the sample, it being evident that the correlation of these plants with the system of managing the soil results in gains in crop productivity.

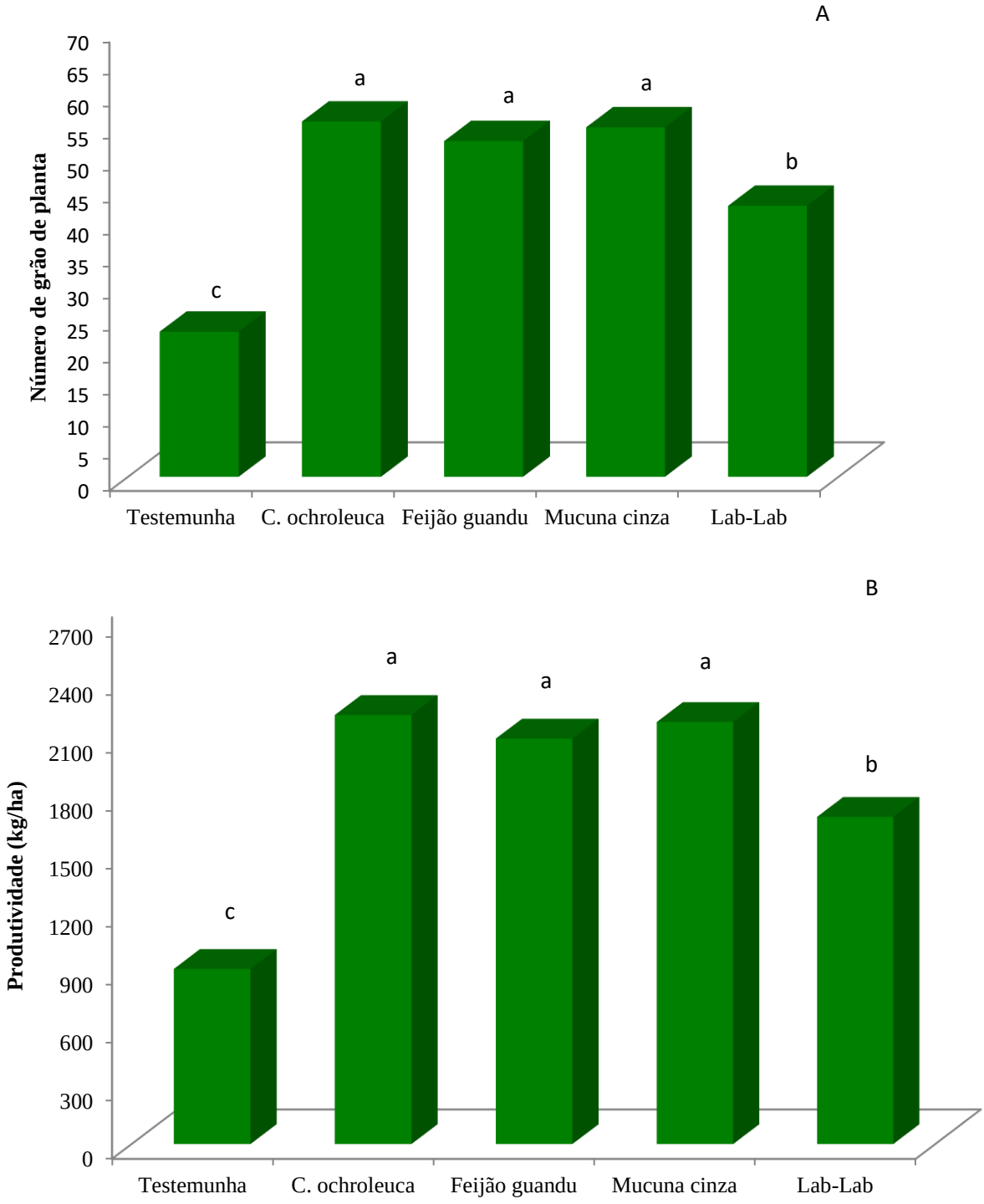


Figure 4. Number of grains per plant (A) and productivity of the bean plant (B) grown in the absence and presence of straw from cover plants.
*Equal letters in the bar do not differ from each other by the Tukey test at 5% probability.
Source: Prepared by the authors (2023).

The levels of N and Ca in the bean plant tissues in full blossoming did not differ statistically between the plant species covered, except for Ca content when cultivated in succession to the Lab-lab roofing plant, and there was significant difference when compared to the control (Figure 5). The average levels of N and Ca in the fully flowering bean plant

cultivated in succession to the different cover plants were 33,69 g/kg and 21,13 g/kg, respectively, being within the range considered appropriate by Malavolta et al. (2006), ranging from 30-50 g/kg of N to 15-20 g kg^{-1} of Ca.

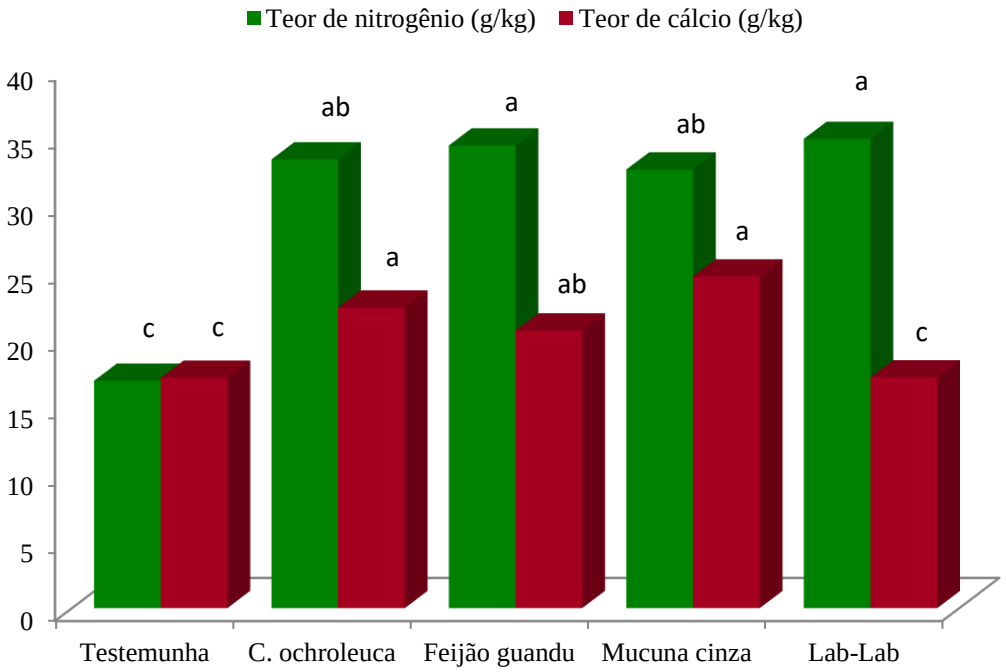


Figure 5. Nutrient levels in fully flowering bean plants cultivated in the absence and on the straw of different cover plants.
*Equal letters in the bar do not differ from each other by the Tukey test at 5% probability.
Source: Prepared by the authors (2023).

5 CONCLUSION

The guandu bean species has great potential for producing dry dough and capacity to absorb and accumulate phosphorus in the leaves in full bloom.

The straw of Crotalaria ochroleuca, Feijão guandu and Mucuna ash species contributed significantly to the productivity of the bean plant grown in succession, as well as representing an alternative to reduce the dependence on synthetic fertilizers and increase the sustainability of agricultural production systems.

ACKNOWLEDGEMENTS

The authors thank the Agrisus Foundation, the Federal Institute of Rondônia and the Department of Research, Innovation and Postgraduate Studies of the Colorado West Campus for making funds, bench fee and scientific initiation scholarship available to the second author by means of Notice No. 08/2022/PROPESP

REFERENCES

Ambrosano,E.J., Wutke, E.B., Salgado, J.C., Rossi, F., Dias, F.L.F., Tavares, S., Otsuk, I.P. (2016)Caracterização de cultivares de Mucuna quanto a produtividade de fitomassa,extração de nutrientes e seus efeitos nos atributos do solo. *Agroecologia*, v.11, n.2, 1-9.

Andrade Neto, R.C., Góes, G.B., Miranda, N.O., Filho, E.T.D., Filho, F.S.T.P. (2008) Adubação verde: uma alternativa sustentável para o Brasil. *Revista Verde*, v.3, n.1, p.16-20.

Araújo, E.O., Ferreira, M.H.V. (2023) Plantas de cobertura: aliadas do produtor na saúde do solo. 07 dez 2023. Disponível em:< https://www.agrorondonia.com.br/colunas/plantas-de-cobertura-aliadas-do-produtor-na-saude-do-solo>.Acesso em: 11 dez 2023.

Araújo, E.O., Macieski Neto, V., Venturim, D.J., Catanio, J.V.F., Freitas, D.S., Ribeiro, J.A.S. (2022) Cover crops and concentrations of carbon and nitrogen in Amazonian soil . *Australian Journal Crop Science*, n.16, v.11, p.1261-1269.

Araújo, E.O., Freitas, D.S., Catânio, J.V.F., Moreira, A.O., Ribeiro, J.A.S. (2021) Desempenho agronômico do feijoeiro cultivado sob a palhada de plantas de cobertura submetidas à adubação fosfatada. *Research, Society and Development*, v. 10, n. 14, p.1-11.

Boer, C.A., Assis, R.L., Silva, G.P., Braz, A.J.B.P., Barroso, A.L.L, Filho, A.C., Pires, F.R. (2008) Biomassa, decomposição e cobertura do solo ocasionada por resíduos culturais de três espécies vegetais na região centro-oeste do Brasil. *Revista Brasileira de Ciência do Solo*, v.32, n.2, p. 843-851.

Dalchiavon, F.C., Carvalho, M.P., Freddi, O.S., Andreotti, M., Montanari, R. (2011) Variabilidade espacial da produtividade do feijoeiro correlacionada com atributos químicos de um Latossolo Vermelho Distroférrico sob sistema de semeadura direta. *Bragantia*, v. 70, n. 4, p.908-916.

Carvalho, M.L., Vanolli, B.S., Schiebelbein, B.E., Borba, D.A., Luz, F.B., Cardoso, G.M., Bortolo, L.S.; Marostica, M.E.M., Souza, V.S. (2022) *Guia prático de plantas de cobertura.* Piracicaba:ESALQ-USP, 126p.

Costa, A.A., Carvalho, G.P., Lopes, P.S. (2022) Cultivo do feijão carioca em sucessão a plantas de cobertura submetido a doses de nitrogênio em solos arenosos no Cerrado. *Brazilian Journal of Development,* v.8, n.7, p.49181-49195.

Conab (2023) *Acompanhamento da Safra Brasileira de Grãos 2022/2023: Décimo Levantamento, Julho/2023*, 1. Ed, Brasília: Companhia Nacional de Abastecimento.

Empresa Brasileira de Pesquisa Agropecuária – Embrapa (2009) *Manual de análises químicas de solos, plantas e fertilizantes,* 2. Ed, Brasília: Embrapa Informação Tecnológica.

Malavolta, E. (2006) *Manual de nutrição mineral de plantas*. 1Ed, São Paulo: Editora Agronômica Ceres.

Malavolta, E., Vitti, G.C., Oliveira, S.A. (1997) *Avaliação do estado nutricional das plantas: princípios e aplicações.* Potafos.

Rocha, P.R., Araújo, G.A.A., Carneiro, J.E.S., Cecon, P.R., Lima P.C. (2011) Adubação molíbdica na cultura do feijão nos sistemas de plantio direto e convencional. *Revista Caatinga*, v. 24, n. 2, p. 9-17.

Santos, P.A., Silva, A.F., Carvalho, M.A.C., Caione, G. (2010) Adubos verdes e adubação nitrogenada em cobertura no cultivo do milho. *Revista Brasileira de Milho e Sorgo*, v. 9, n. 2, p. 123-134.

Silveira, B.S., Torres, J.L.R., Orioli Junior, V., Favaro, J.H.S., Costa, L. L., Charlo, H.C.O. (2021) Cover crops in the production of green and sweet corn. *Horticultura Brasileira*, v. 39, p. 94-101

Souza, L.C.D., Sá, M.E., Silva, M.P., Abrantes, F.L., Simidu, H.M.; Arruda, N., Valério Filho, W. V. (2012) Efeito da adubação verde e época de semeadura de cultivares de feijão sob sistema plantio direto, em região de cerrado. *Bioscience Journal*, v. 28, n. 5, p. 699-708.

Torres, J.L.R., Vieira, D.M.S., Orioli Junior, V., Daines, R., Pinto, V.B., Alves, C.P.M., Guimarães, C.C., Santana, G.M. (2024) Produção de milho e soja cultivados em sucessão e rotação com diferentes coberturas no cerrado. *Revista de Gestão Social e Ambiental*, v.18, n.2, p.1-15, e04458.

Torres, J.L.R., Leal Junior, A.L.B., Barreto, A.C., Carvalho, F.J., Assis, R.L., Lemes, E.M., Vieira, D.M.S. (2022) Mechanical and Biological Soil Decompaction for No-Tillage Maize Production. *Agronomy*, v.12, p.1-12.

Torres, J.L.R., Gomes, F.R.C., Barreto, A.C., Orioli Junior, V., França, G.D., Lemes, E.M. (2021) Nutrient cycling of different plant residues and fertilizer doses in broccoli cultivation. *Horticultura Brasileira*, v.39, p.11-19.

Torres, J.L.R., Assis, R.L., Loss, A. (2018) Evolução entre os sistemas de produção agropecuária no Cerrado: convencional, Barreirão, Santa Fé e Integração Lavoura-Pecuária. *Informe Agropecuário*, v.39, n.2, p.7-17.

Torres, J.L.R., Cunha, M.A., Pereira, M.G., Vieira, D.M.S. (2014) Cultivo de feijão e milho em sucessão a plantas de cobertura. *Revista Caatinga*, v. 27, n. 4, p. 117-125.

Torres, J.LR., Santana, M.J., Pizolato Neto, A., Pereira, M.G., Vieira, D.M.S. (2013) Produtividade de feijão sobre lâminas de irrigação e coberturas de solo. *Bioscience Journal*, v. 29, n. 4, p.833-841.

Zanatta, T. P., Rizzi, M., Schorr, L. P. B. (2022) Avaliação de ativador da microbiota dos solos sobre o desempenho agronômico e produtividade da soja. *Revista de Gestão Social e Ambiental*, v.16, n.3, p.1-16, e03051.