Opinion Article

Biological Nitrogen Fixation and Yield of Cowpea Intercropped with Pearl Millet or not, with or without Nitrogen Fertilization, During the Dry Season

Leandro Barbosa de Oliveira[1], Rodrigo Luiz Neves Barros[2] and Carlos Pimentel[3*]

[1]Instituto Federal do norte de Minas Gerais, Brazil

[2]Instituto Federal de Educacao, Ciencia e Tecnologia de Roraima, Rodovia Antonino Menezes da Silva, Amajari, RR, Brazil

[3]Department of Crop Science, Federal Rural University of Rio de Janeiro, Seropédica, RJ, Brazil

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***Corresponding author**
Carlos Pimentel, Department of Crop Science, Federal Rural University of Rio de Janeiro, Seropédica, RJ, Brazil

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Abstract

The research objective was to compare the potential biological nitrogen fixation (BNF) and yield of cowpea cultivated in a single crop or intercropped with pearl millet during the dry season. The experiment was conducted at the experimental field of the Crop Science Department of the Federal Rural University of Rio de Janeiro. It was done in a randomized block design with four replications and treatments. The nitrogen fertilization and cultivation system did not interfere with the cowpea's potential BNF and yield components, and thus, N fertilization is not required for cowpea production. However, the grain weight of cowpea, with or without nitrogen fertilization, was higher than for intercropped cowpea due to the higher plant population per area. Still, intercropped cultivation reduces the risk of total failure for harvest because two different crops are in the same location, especially for small farmers in marginal areas of agriculture.

Introduction

Cowpea is one of the most important food legume crops in the semiarid tropics (*Vigna unguiculata* L. Walp.). A drought-tolerant and warm-weather crop, cowpea is remarkably adaptable to the dry regions of the tropics, where other food legumes struggle to thrive [1]. This adaptability is a reassuring factor for farmers in these regions, where a large part of cowpea production takes place on farms ranging from 1 to 10 ha in size, generally in marginal areas for agriculture, with low water and nutrient contents in the soil, and limited resources for fertilization and other agronomic practices [2]. Cowpea cultivation can improve soil N content because it can do BNF with a range of bacteria of the gender *Rhizobium* inoculated or natives from the site without inoculation [1]. To reduce the risks of total failure of the culture and to improve the use of the land, some little farmers, without the possibility for mechanical cultivation, do the intercrop of cowpea with grass, such as pearl millet, which is also very tolerant to environmental stresses [3]. Therefore, cowpea and pearl millet intercrop is a standard agricultural cultivation system recommended for small farmers in semiarid marginal areas with water and nutrient deficits in the Americas, Africa, and Asia [2]. It is an interesting system that ensures low-cost vegetable protein production [3]. Cowpea obtain N from BNF and absorption from the soil, with a critical N rhizodeposition, because half of the total cowpea crop N is belowground at plant maturity [4]. Thus, it will improve soil N fertility and benefit the pearl millet intercropped. Another benefit of the intercrop system, with cowpea and pearl millet in Africa, is the reduced evapotranspiration due to improved canopy cover of soils. Pearl millet (*Pennisetum glaucum*), a staple cereal in the African Sahel, is characterized by tall and numerous tillers capable of producing a high leaf area per plant, which can be very useful in an intercropped system to increase canopy cover, reducing evapotranspiration [3].

In addition to reducing losses of evapotranspiration and erosion, the intercrop system of cowpea and pearl millet will improve soil fertility, firstly through the BNF of cowpea and secondly through crop residues. It will enhance organic matter and soil fertility and the opportunity to offer food to this poor population, leaving marginal areas for agriculture [2].

Material & Methods

The work was carried out in the experimental field of the Crop Science Department of the Federal Rural University of Rio de Janeiro (UFRRJ). The experiment was done during the dry season, in a clay soil whose chemical analysis revealed: pH in water 5.3; Ca, 1.5 cmol dm^{-3}; Mg, 0.5 cmol dm^{-3}; H + Al, 3.5 cmolc dm^{-3}; Al, 0.5%; P, 4.0 mg. L^{-1}; K, 6.0 mg. L^{-1}; organic matter, 0.9%; and base saturation (V), 37%. During the experiment, total precipitation, total evapotranspiration, and average maximum and minimum temperatures were 256 mm, 287 mm, 27.8°C, and 18.6°C, respectively.

The experimental design used in both experiments was a randomized block design with four replications. The blocks consisted of four treatments with cowpea cultivar EPACE 10 and pearl millet cultivar ENA 1: T1- single crop of cowpea without nitrogen fertilization (0.50 m between rows), T2- single crop of cowpea with 20 kg N ha^{-1} (0.50 m between rows), T3- cowpea intercropped with millet, with two rows of cowpea without nitrogen fertilization and one row of millet (1.50 m between pearl millet rows and 0.50 m between cowpea rows, and T4 - cowpea intercropped with pearl millet, with two rows of cowpea, with 20 kg N ha^{-1} at sowing and one row of pearl millet (1.50 m between millet rows and 0.50 m between cowpea rows: 1 PM x 2 C-0.50). The pearl millet crop in the consortium was grown without fertilization, and the cowpea crop was fertilized with phosphorus and potassium directly at the side of the planting furrow, according to the results of the soil analysis, following the recommendations for the crop [4].

At flowering, nodules' number and dry weight were assessed to determine BNF potential [1]. At grain maturity, at 112 DAS, the two middle rows of each plot were harvested, and the number of pods, grains per plant, and grain yield of cowpea in the treatments were assessed. A Tukey (0.5%) variance analysis was used to analyze the results statistically.

Results & Discussion

Regarding the potential for biological nitrogen fixation (BNF) in the different treatments, statistical differences were found between them for the number of nodules (NN) and nodule dry weight (NDW). The highest NN and NDW values were found in the single crop and intercropped systems, both without the addition of (20 kg N ha^{-1}) compared to the single and intercropped crops with 20 kg N. ha^{-1}, indicating a probable negative effect of N on nodulation, as pointed out by several authors [4]. However, there is no total inhibition of BNF potential, and the nodules formed fewer in number in the presence of N contribute to the supply of N, increasing its content in the plant and positively affecting legume yield.

Treatments	Cowpea single	Cowpea single with 20 kg de N ha^{-1}	Cowpea intercropped	Cowpea intercropped with 20 kg de N ha^{-1}
NN	40,2a	26,7b	38,5a	29,2b
NDW	0,021a	0,014b	0,020a	0,015b

Table 1: The biological fixation potential of cowpea at the flowering stage: number of nodules (NN) and nodule dry weight (NDW).
Means followed by the same letters in the same line are not significantly different by the Tukey test at P=0.05 probability level.

For the yield components, there was a significant difference in grain weight (GW) among the treatments (Table 2). However, the N fertilization did not increase the GW of cowpea in either system. In the single crop system, cowpea, fertilized with and without N addition, had a higher GW than those grown intercropped with millet. However, in the intercropped system, there are two crops to harvest, and the risk of crop failure is reduced in this system.

Treatments	NPP	NGP	GW
Cowpea single	7,9a	61,4a	1552,5a
Cowpea single with 20 kg de N ha^{-1}	7,9a	62,3a	1579,4a
Cowpea intercropped	7,8a	60,8a	947,2b
Cowpea intercropped with 20 kg de N ha^{-1}	7,8a	61,6a	963,7b

Table 2: Yield components: number of pods per plant (NPP), number of grains per plant (NGP), and grain weight in kg. ha^{-1} (GW).
Means followed by the same letters in the same column are not significantly different by the Tukey test at P=0.05 probability level.

This higher yield (GW) obtained in the cowpea single crop is mainly due to the more significant number of plants per experimental area compared to the intercropped system. Still, the farmer has two crops to harvest for food production in the last system, diminishing the risk of crop failure. In addition, N fertilization and the intercropped system did not affect some yield components of cowpea, such as the number of pods per plant as well as grains per plant (Table 2), which were similar among the treatments, confirming the results presented by Freire Filho et al. [4].

Conclusion

Nitrogen fertilization, with 20 kg of N ha^{-1}, at sowing reduces but does not inhibit the BNF potential of cowpea, either as a single crop or intercropped with pearl millet. Therefore, cowpea inoculated with *Rhizobium* strains did not need N fertilization to yield well in both crop systems. However, more studies are required to confirm this result.

Nitrogen fertilization and the intercropping system did not interfere with the yield components evaluated, such as the number of pods per plant and grains per plant of cowpea. However, in the single cropping system, cowpea, fertilized with 20 kg of N ha^{-1} or not, had a higher GW than those grown intercropped with pearl millet due to the higher plant number in the single crop system. Nevertheless, for a small farmer, having two crops in the same place reduces the risk of total loss of grain production.

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