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Productivity of two cowpea cultivars in tobacco agroecosystems of Pinar del Río, Cuba

Productividad de dos cultivares de frijol caupí en agroecosistemas tabacaleros de Pinar del Río, Cuba

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ABSTRACT

The objective of this research was to determine the productivity of INIFAT 93 and INIFAT 94 cultivars of cowpea (*Vigna unguiculata* (L.) Walp.) in tobacco agroecosystems in Pinar del Río. Between April and July 2019, field experiments were established in agricultural settings of Guane and San Juan y Martínez, characterized by a leached yellowish Ferralitic soil. Sowing was done manually at 0.60 m between rows and 0.15 m between plants. The evaluations were carried out at harvest time and growth variables (biomass), yield components and crop index were considered for each cultivar and agroecosystem. Higher biological productivity was achieved with INIFAT 94, although the differentiated response between cultivars, for biomass values, was more accentuated in San Juan and Martínez. Yield components were favored in INIFAT 94; while the lowest variability and highest efficiency in the conversion of economically useful biomass was obtained with INIFAT 93. The agricultural productivity of the INIFAT 94 cultivar exceeded that of INIFAT 93 by more than 25 % in the two agroecosystems, with values higher than 1.0 t/ha.

***Keywords*:** biomass; grain legume; yield; *Vigna unguiculata.*

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RESUMEN

El objetivo de la presente investigación fue determinar la productividad de los cultivares INIFAT 93 e INIFAT 94 de frijol caupí (*Vigna unguiculata* (L.) Walp.) en agroecosistemas tabacaleros de Pinar del Río. Durante el periodo abril – julio de 2019, se establecieron experimentos de campo en escenarios agrícolas de Guane y San Juan y Martínez, caracterizados por un suelo Ferralítico Amarillento lixiviado. La siembra se realizó de forma manual a una distancia de 0,60 m entre surcos y de 0,15 m entre plantas. Las evaluaciones se realizaron al momento de la cosecha y se consideraron variables de crecimiento (biomasa), componentes del rendimiento e índice de cosecha para cada cultivar y agroecosistema. Se alcanzó mayor productividad biológica con INIFAT 94, aunque la respuesta diferenciada entre los cultivares, para los valores de biomasa, fue más acentuada en San Juan y Martínez. Los componentes del rendimiento se favorecieron en INIFAT 94; mientras que, la menor variabilidad y mayor eficiencia en la conversión de biomasa económicamente útil se obtuvo con INIFAT 93. La productividad agrícola del cultivar INIFAT 94 excedió más del 25 % la de INIFAT 93 en los dos agroecosistemas, con valores superiores a 1,0 t/ha.

***Palabras clave**:* biomasa; leguminosa de grano; rendimiento; *Vigna unguiculata.*

INTRODUCTION

The cowpea (*Vigna unguiculata* (L.) Walp.) is a grain legume widely cultivated and consumed in tropical countries (Boukar et al., 2019; Farooqa et al., 2020) due to the content's protein, mineral, carbohydrate and other elements that give it nutritional importance (Hamid et al., 2016; De Paula et al., 2016), both for human food and animal consumption.

The production and harvested area of cowpea in the world reach values of 7.2 million tons in 12.5 million hectares, with an agricultural yield of less than 0.60 t/ha. In the Caribbean region, around 31.9 thousand tons are produced in 43.3 thousand cultivated hectares, for an agricultural yield of more than 0.70 t/ha (FAO, 2018; Martínez et al., 2020).

In Cuba, the agricultural yield of this crop ranges between 0.5 and 2.0 t/ha (Gómez, 2015; Hernández, Santana & Carrodeguas, 2019), depending on the yield potential of the cultivars used, the climatic conditions, crop nutrition and pest incidence, among other limiting factors for plant development.

It is stated that the cowpea has productive and agronomic potential under the climatic and edaphic conditions of Cuba (Quintero et al., 2010; Figueroa et al., 2014), which together with the recent affectations in the production volumes of common bean (*Phaseolus vulgaris* L.), favors the interest in the cultivation of this grain legume, since it constitutes an alternative for sowing in spring, without competing with other crops of agricultural importance.

This crop prevails in the eastern region of the country, but it is currently spreading to other areas as an acceptable option that is little used in social consumption and other destinations in the province. Knowing its response in local production agroecosystems can contribute to grain availability, due to the influence exerted by the genotype-environment interaction (Odeseye et al., 2018).

In this context, the studies that demonstrate the productive potential of cowpea in agroecosystems of Pinar del Río (Cuba) are limited, particularly in tobacco producing areas, where it can be used in alternating crops for the food production in its main economic line. For this reason, the present investigation aims to determine the productivity of two cowpea cultivars in tobacco agroecosystems of the province.

MATERIALS AND METHODS

The research used certified seeds from two commercial cowpea cultivars (Table 1), distributed in a completely randomized design with four replicas, in divided plots. The total area of the experiment in each agroecosystem was 250 m^2, with experimental units (subplots) of 28 m^2.

Table 1. Characteristics of the cowpea cultivars used.

Cultivar	Grain color	Growth habit	Economic cycle (days)	Potential yield (t/ha)
INIFAT 93	Red	Determined	65 – 70	1,0
INIFAT 94	Black	Determined	75 – 80	1,7

Source: Elaborated by the authors based on Díaz (1994); Fernández et al. (2014); López (2021).

The crop was established in spring (April – July 2019) in tobacco agroecosystems of Guane and San Juan y Martínez, Pinar del Río. In both cases, sowing was carried out manually at 0.60 m between furrows and 0.15 to 0.20 m between plants. Cultural practices were carried out as recommended for this crop in Cuba (Díaz, 1994; Figueroa et al., 2014). Edaphoclimatic conditions for agroecosystems are described below.

Guane: sowing was carried out on the farm "Los Criollos" of the Sábalo Popular Council, Guane Municipality (22° 10' N and 83° 57' W), Pinar del Río, Cuba. The soil was classified as leached Yellowish Ferralitic (Hernández et al., 2015), with pH values (KCl) = 6.34 and organic matter 1.42 %. Climatic conditions were characterized by a mean temperature of 23.3ºC, relative humidity of 75.9% and cumulative precipitation of 142.5 mm, according to data from the Meteorological Station No. 313 of Pinar del Río.

San Juan y Martínez: sowing was carried out in a tobacco agroecosystem of the Río Seco Popular Council, municipality of San Juan y Martínez, located at 22° 18′ 13" N and 83° 47′ 39" W. The soil was classified as leached Yellowish Ferralitic (Hernández et al., 2015), with pH values (H_2O) = 5.98 and organic matter 1.74 %. Climatic conditions during the test were characterized by average temperature of 27.1ºC and relative humidity of 75.6 %, with cumulative precipitation of 409.8 mm, according to data obtained at the Meteorological Station No. 314 of the provincial Meteorological Center.

Evaluations of the yield and its components were carried out at the time of harvest. Ten plants were randomly selected from the subplots of each cultivar and agroecosystem. In each plant, the following variables were analyzed: dry mass (g) of stems, pods and grains, number of pods (u), pod length (cm), grains per pod (u), grains mass per pod (g), mass of 100 grains (g) and crop index (%). The latter was calculated by the ratio of the dry mass of grains between the dry mass of the aerial part of the plant at harvest. To calculate the agricultural yield (t/ha), 6 m^2 of the center were harvested in each subplot, the plants were threshed, and the grains dried up to 14% humidity (Maqueira et al., 2017).

With the data obtained, the assumptions of normality and homogeneity of variances were verified, using the Kolmogorov-Smirnov and Levene tests, respectively (Gavilánez, 2021). Analysis of variance was applied for mean comparison, with a 95 % confidence level. Minitab® statistical software version 17.1.0 for Windows was used (Minitab, 2015).

RESULTS AND DISCUSSION

The agricultural yield reached values higher than 1.0 t/ha in the two agroecosystems with the cultivar INIFAT 94 and exceeded in all cases more than 25 % of what was obtained in INIFAT 93. However, no differences were found between cultivars when they were harvested in the edaphoclimatic conditions of Guane (Figure 1).

The possibility of promoting this crop as an alternative for the grain harvest is evident in view of the growing consumer demand and the need to substitute imports, with cultivars that exceed the average yield statistics of beans in 2020 (0.89 t/ha) in our country (ONEI, 2021). This reaffirms the cowpea as a legume with productive potential in climatic and edaphic conditions of Cuba (Quintero et al., 2010; Figueroa et al., 2014).

In correspondence with the results obtained, other authors report similar and higher values of agricultural yield in cowpea (Santos et al., 2016, Martínez et al., 2020). In Cuba, particularly, values between 0.84 and 1.72 t/ha stand out for results obtained with 12 cultivars in a Fluvisol soil from the eastern region of the country (Gómez, 2015).

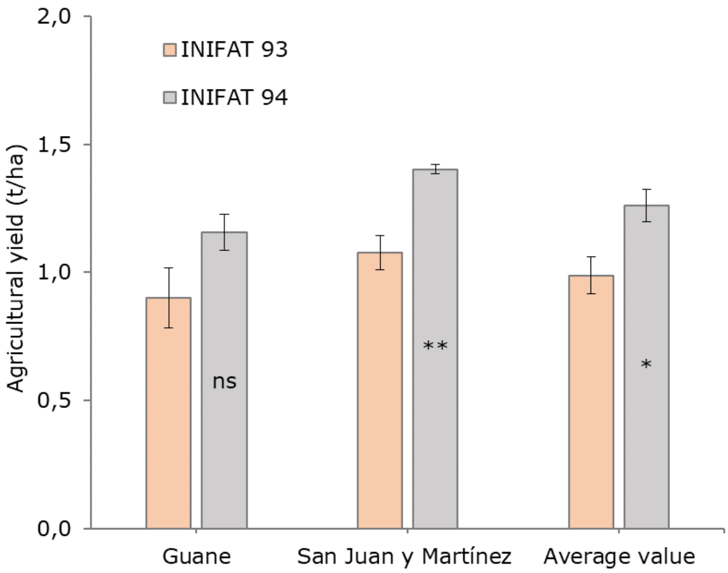

Figure 1. Agricultural yield of cultivars in the agroecosystems studied. **Legend:** ns= not significant, **significant for p≤0,01, *significant for p≤0,05.

Source: Elaborated by the authors

For the yield components (Table 2) variations were found between the cultivars studied that are related to grain production. A compensatory character is also appreciated between certain components of the same cultivar, an element related to the characteristics of the crop and the development conditions, since these influence the distribution of photoassimilates during the reproductive phase (Jonah, 2011; Cardona-Ayala et al., 2013). Significant differences were also found between cultivars in the components of pod length, pod mass, mass of grains per pod, and mass of 100 grains.

Table 2. Yield components in cowpea cultivars. **Legend:** VP-number of pods per plant; LV-pod length, GV- grains per pod, MV- mass per pod, MGV-grains mass per pod, M100G-mass of one hundred grains.

Cultivar	VP (u)	LV (cm)	GV (u)	MV (g)	MGV (g)	M100G (g)
Agroecosystem: Guane						
INIFAT 93	9,00	**19,66**	13,02	2,07	1,54	11,87
INIFAT 94	9,25	15,39	12,54	**2,67**	**1,98**	**15,83**
Sig.	*,952*	*,000*	*,910*	*,003*	*,000*	*,001*
Agroecosystem: San Juan y Martínez						
INIFAT 93	16,53	**19,80**	11,12	2,37	1,63	14,62
INIFAT 94	17,83	15,54	11,58	2,75	**2,08**	**17,92**
Sig.	*,410*	*,000*	*,279*	*,135*	*,004*	*,001*
Average values						
INIFAT 93	12,77	**19,73**	12,07	2,22	1,59	13,25
INIFAT 94	12,93	15,45	12,13	**2,70**	**2,03**	**16,72**
Sig.	*,952*	*,000*	*,910*	*,003*	*,000*	*,001*

Source: Elaborated by the authors

Total dry biomass production, at harvest time, was higher with INIFAT 94 in the two agroecosystems, which in turn expressed higher proportions of grain and stem masses, although these were unequal between cultivars in San Juan and Martínez. The dry mass of pods was similar in the two production conditions and reached proportions ≤21 % (Figure 2). In addition, the two cultivars reached higher vegetative and reproductive development in San Juan and Martínez, but the differentiated response between them was maintained in the two agroecosystems. This suggests that regardless of the prevailing production conditions, the INIFAT 94 cultivar has a higher biomass production capacity.

This result is of great importance because some studies carried out on cowpea corroborate that the dry mass of the aerial part is a component related to grain productivity (Santana et al., 2017).

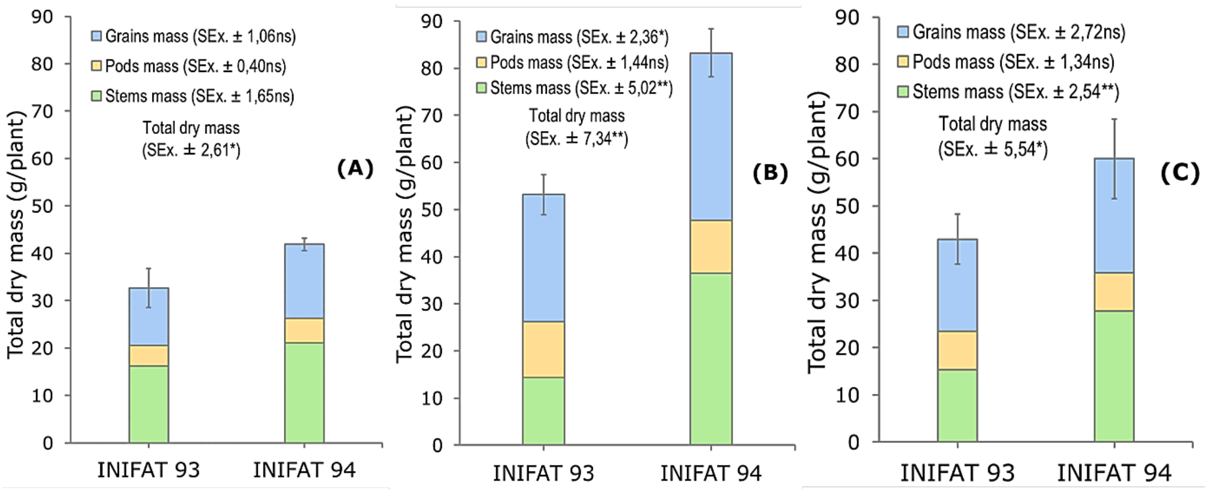

Figure 2. Biomass production in cowpea cultivars. **Legend:** A) Guane, B) San Juan y Martínez, C) Average values.

Source: Elaborated by the authors.

Dry biomass accumulation values obtained at San Juan y Martínez, in any cultivar, exceed what was reported for the crop (42 g/plant) under edaphoclimatic conditions of Villa Clara, Cuba (González, Álvarez & Lima, 2018). These authors state that changes in the environment can interfere with the production of dry biomass of a plant species, although there are factors inherent in the plant such as age, distribution of assimilates, variety, and water and nutritional content.

Dry biomass production is also very important because its incorporation into the soil recycles nutrients and fosters nutrition for the next crop. Some authors claim that it increases organic matter and the values of pH, nitrogen, phosphorus and potassium (García, 2017; Zayas-Infante, Boeckx & Vargas-Rodríguez, 2019).

It is estimated that the values obtained with INIFAT 94 in San Juan y Martínez exceeded 3.8 t/ha of dry mass, a result that suggests developing future trials to deepen the contribution of the studied cultivars to soil improvement, either by the contribution of dry biomass or as green manure, with the purpose of using the crop as an alternate alternative in tobacco agroecosystems with low fertility.

Crop indexes are also reported for cowpea under the edaphoclimatic conditions of agroecosystems, reaching values between 41.6 % and 52 % (Figure 3), with higher mean values in INIFAT 93, although it did significantly exceed INIFAT 94 in San Juan and Martínez.

These results are similar to those obtained for beans, which oscillate around 50 %, although factors such as the date and distance of sowing, the genetic characteristics of the cultivars and the climatic conditions prevailing in the development of the crop can have an impact (Romero et al., 2019; Anaya-López et al., 2022). However, the crop index is a little variable discussed in cowpea productivity studies despite its importance to assess the impact of genotype-environment interaction on crop development.

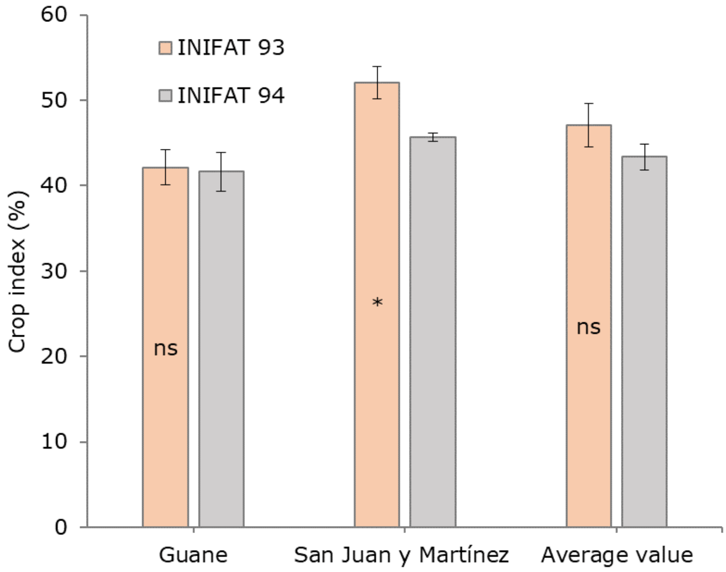

Figure 3. Crop index in cowpea cultivars for edaphoclimatic conditions of cultivation.
Legend: ns= not significant, *significant for p≤0,05.
Source: Elaborated by the authors

While total crop production in dry mass (biological productivity) is important, it is also necessary to ensure that a portion of this production is destined for economically useful biomass (agricultural productivity). In this sense, the INIFAT 93 cultivation was more efficient, although future trials should be developed to deepen the efficiency of biomass production in different spatial and temporal arrangements, as well as in relation to crop management.

CONCLUSIONS

With INIFAT 94, higher biological productivity is achieved in the two evaluated agroecosystems, although the differentiated response among cultivars for biomass values was more pronounced in San Juan and Martínez.

The yield components are promoted in INIFAT 94; while the lowest variability and efficiency in converting economically useful biomass is achieved with INIFAT 93.

The agricultural productivity of cultivar INIFAT 94 exceeds that of cultivar INIFAT 93 by more than 25 % in the two scenarios assessed, with values greater than 1.0 t/ha.

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AUTHORS' CONTRIBUTION

SBY, CDS, CLR and RSM: carried out the study and participated in the data processing. They participated in the design of the research study project and supervised the work.

All these authors contributed to the writing of the manuscript submitted to your journal for publication.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.