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Original Article

Evaluation of four black bean cultivars for yield increase in Sancti Spíritus

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ABSTRACT

The introduction of new cultivars of common bean (*Phaseolus vulgaris* L.) can be an efficient alternative to increase crop diversification and yield. The aim of this research was to evaluate the productivity of four new cultivars of common black bean, for certification and diversification in Sancti Spíritus province. The sowing of the cultivars ENAR-63, ENAR-64, ENAR-67, ENAR-68 and Bat-304 as control, was carried out from October 2018 to January 2019, in the edaphoclimatic conditions of the Cooperative of Credits and Services "José Regino Sosa", Sancti Spíritus, Cuba. Treatments were arranged in a randomized block design with five treatments and five replications. The following production indicators were observed at harvest: number of pods per plant; number of grains per pod; 100-seed mass (g); production per plant (g); yield (t ha^{-1}). The results indicated that the cultivars of the ENAR group increased the productive indicators and yield, compared to the commercial variety Bat-304. The cultivars ENAR-63 and ENAR-67 were superior to ENAR-64, ENAR-68 and Bat-304, because they achieved yield increases of 14, 27 and 126 %, respectively. The successes of this study demonstrated that these four cultivars constitute an alternative to diversify and increase the productive potential of black beans in Cuba.

Key words: diversity, beans, *Phaseolus vulgaris*, productivity, varieties

INTRODUCTION

Global food security is affected by climate change which, in turn, affects soil quality, crop productivity, human and animal health, as well as the environment [(1)]. There is a clear need for new cultivars/varieties for our producers to motivate and awaken in them the understanding of the imminent need for sustainable agriculture, which contributes to environmental quality, income generation and food security, to coincide with the increase in world population [(2)].

Bean production is important in the dietary consumption of Cubans and other developing countries [(3-6)], because it is a source of protein, vitamins and minerals for food in emerging countries and countries with low economies [(7,8)]. The use of new cultivars could be a rational and sustainable alternative to increase the productivity of common beans, which among its productive limitations are high temperatures, drought stress, pests, among others) [(9,10)].

The genetic improvement of this species can be exploited by the biological diversity offered by different varieties or cultivars [(4,11)]. These varieties/cultivars, which tolerate biotic and abiotic stresses and increase growth and productivity, should be identified and used by bean breeding programs [(8,12)], such as these cultivars related to the National Adaptability and Yield Assay (ENAR according its acronyms in Spanish) program, conducted at the National Institute of Agricultural Sciences (INCA) [(13,14)].

The common bean cultivation in Cuba is represented, officially, by 41 varieties of different colors, recognized in the Official Registry of Commercial Varieties, sufficient diversity to achieve the adaptability of the species to the different regions and agroecosystems of the country, to mitigate the adverse conditions, from the edaphic and climatological point of view [(13)].

On the other hand, agricultural practice indicates that producers should have more than one variety/cultivar of the crop, in order to have a varietal structure capable of responding to edaphoclimatic demands. In addition, biodiversity is important for the recycling of nutrients, the regulation of hydrological processes and the management of harmful organisms, among others. In fact, few varieties are currently marketed in the Sancti Spíritus province, with the most demanded varieties of black grains being CUL 156 and Bat-304, while those of red grains are Velazco largo and Delicias 364 [(15,16)].

Therefore, it is pertinent to test the hypothesis that the introduction and characterization of four new common bean cultivars of the ENAR group could be an efficient alternative to increase crop productivity and, at the same time, could be included in the varietal composition of the Ministry of Agriculture (MINAG) in the territory. In this sense, the main objective of this work was to evaluate the productivity of four new cultivars of common black bean, to increase the diversification and production of the grain in Sancti Spíritus province.

MATERIALS AND METHODS

Growing conditions and plant material

The research was developed between months of October 2018 to January 2019, in the farm "El Ateje" belonging to the Credit and Services Cooperative (CCS) "José Regino Sosa", Sancti Spíritus, Cuba. The climatic conditions were adequate for crop development, which were recorded by the Municipal Station of Hydraulic Resources of Sancti Spíritus, the average daily temperature was 24.2 ± 2.3 ºC, the relative humidity between 80.00 and 85.0 % and the accumulated rainfall during the development of the experiment was 203.1 mm. The soil was classified as Carbonate Sialitic Brown [(17)], called Cambisol [(18)], classified as agro-productive category II.

National Institute of Agricultural Sciences (INCA) provided the seeds of the four varieties ENAR 63, ENAR 64, ENAR 67 and ENAR 68, in its program called National Test of Adaptability and Yield (ENAR). Meanwhile, seeds of the Bat-304 variety were obtained from the Seed Enterprise of Sancti Spíritus, with 97 % germination. The varieties were planted at a distance of 0.50 m between rows and 0.10 m between plants to obtain approximately 200,000 plants ha^{-1} [(19)]. The cultivation tasks, such as mineral fertilization (one application at 50 kg ha^{-1} before planting 9-13-18) (N, P, K) and another with urea at the same dose, 35 days after emergence (R_5) [(20)], irrigation (sprinkling), pest control, cleaning (manual); among others, were carried out following the recommendations and instructions given in the technical instructions for the crop [(14)].

Experimental design and treatments

The experimental design used was a randomized block design with five treatments and five replicates. The treatments studied consisted of the five cultivars: ENAR 63, ENAR 64, ENAR 67, ENAR 68 and Bat-304 as a control. The plots were 15 m^2, consisting of three furrows 5 m long and 3 m wide. The effective area was 5 m^2.

Production parameters evaluated

The observations of the parameters evaluated corresponded to the descriptors recommended for the growth and development stages of the bean crop [(21)]. Sampling was carried out in the effective area and 50 random plants were taken per treatment. The production parameters determined were:

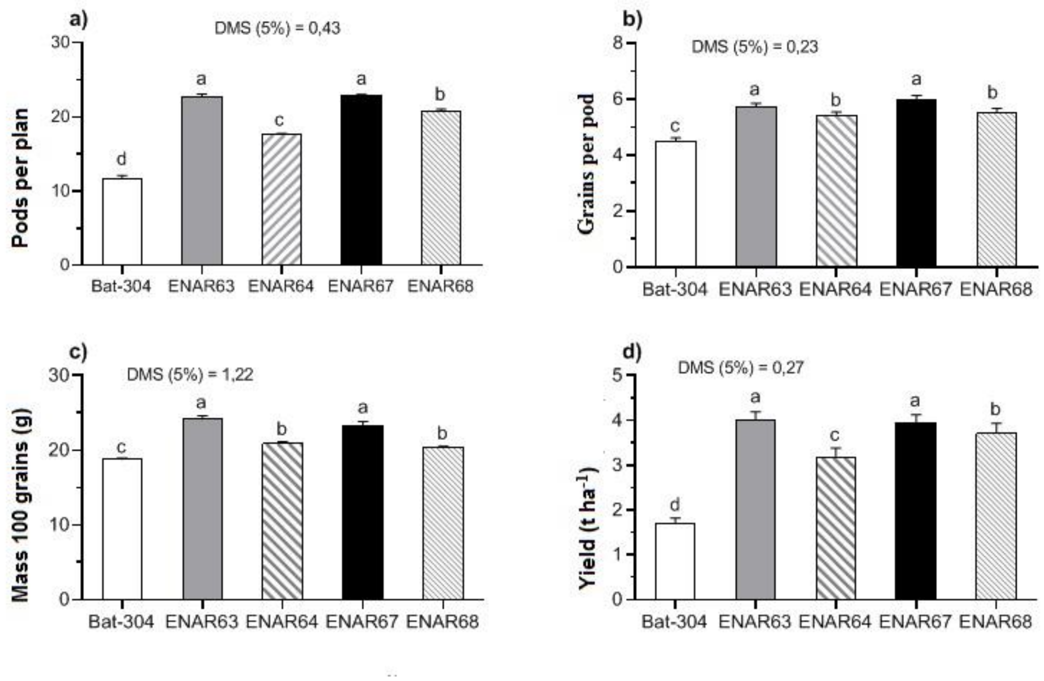
number of pods per plant (NP), number of grains per pod (NG), mass of 100 grains (g) (M100) and yield (t ha^{-1}) (YD).

Statistical analysis

The data obtained in treatments studied were analyzed assuming normality and homogeneity of variance with the Shapiro-Wilk and Fisher tests ($P<0.05$), respectively. Verified these assumptions, the data were subjected to a simple analysis of variance (ANOVA), in R software [22]. The mean values were compared using Tukey's test ($P<0.05$).

RESULTS AND DISCUSSION

The bean cultivars evaluated showed significant effects ($P<0.001$) on NP, NG, M100 and YD (Figure 1). NP was similar in the varieties ENAR-63 and ENAR-67 and were significantly higher by 96 % than the variety Bat-304 and the cultivars ENAR-68 and ENAR-64, but the latter, at the same time, outperformed the control treatment by 76 and 51 %, respectively (Figure 1a). ENAR-67 and ENAR-63 cultivars showed similar NG responses and were significantly superior by 13 % to ENAR-64 and ENAR-68 and 37 % compared to Bat-304 (Figure 1b).



Values symbolized by the means of five replicates ± standard deviation (SD)

Different letters in the treatments indicate significant differences according to Tukey's test ($P<0.05$)

LSD: Least significant differences

Figure 1. Production indicators evaluated in the treatments: (a) number of pods per plant, (b) beans per pod, (c) average mass of 100 beans and (d) yield, obtained in the common bean cultivars studied in Sancti Spíritus, Cuba

The highest M100 was obtained in cultivars ENAR-63 and ENAR-67, compared to ENAR-64, ENAR-68 and the control treatment (Bat-304), because they achieved average increases of 18 and 38 %, respectively. The YD was increased by all the varieties of the ENAR group, in relation to the Bat-304 cultivar, with ENAR-63 and ENAR-67 standing out, which showed similar effects and yields of 126 %, compared to the control treatment. However, RD was 27 and 14 % higher in ENAR-64 and ENAR-68, compared to cultivarBat-304.

A high significant correlation ($P<0.001$) was observed among the evaluated variables (Table 1), this indicates that the cultivars increased common bean productivity, especially because of the strong correlation between YD with M100 ($P<0.001$, $r = 0.98$**), NP ($P<0.001$, $r = 0.95$**) and NG ($P<0.001$, $r = 0.93$**).

Table 1. Correlation between the variables evaluated in the different cultivars studied

	NP	NG	M100	YD
NP	1	**	**	**
GP	0,90	1	**	**
M100	0,96	0,95	1	**
YD	0,95	0,93	0,98	1

NP, number of pods; GP, grains per pod; M100, mass of 100 grains; and YD, total yield

In this study, it was evidenced that these cultivars of the ENAR group showed a high productive potential, superior to the Bat-304 variety (Figure 1). These effects could be influenced by a greater adaptability to the environment, observed in the increase of the productive parameters NP, NG and M100 and YD (Figure 1) and by the high correlation obtained between these evaluated variables (Table 1). The average monthly rainfall of the experiment favored the development of early stages, such as germination and vegetative development stages. The December rainfall was lower, but favored a balance for the maintenance of flowering, fruiting and grain filling, complemented by the December rains [(23)].

This study represents the first report in Cuba, obtained with this group of ENAR cultivars of black bean, so it is an unprecedented result for this group of cultivars. On the other hand, the results achieved by the cultivar (Bat-304) agree with yields reported in other Cuban agroecosystems [(15,24-26)].

In the present study the bean cultivars of the ENAR group showed high yields, especially ENAR-63 and ENAR-67, which reached average yields close to 4 t ha^{-1}, this indicates that they exceeded the national average by approximately 3 t ha^{-1} and by more than 1.5 t ha^{-1} the commercial cultivar Bat-304. The beneficial effects of ENAR cultivars on yield increase could be due to significant fluctuations in monthly average temperatures, which were very favorable for the different phenological stages of the crop, such as flowering, fruiting and grain filling [(23)]. These results indicate that ENAR cultivars should be proposed for the diversification and increase of crop productivity in Sancti Spíritus province, because about 37 % of bean production is obtained in brown carbonate sialitic soils. Positive results in bean productivity with other varieties and cultivars were previously reported in other Cuban agroecosystems [(16,19)].

Finally, results confirm the proposed hypothesis that the cultivars of the ENAR group increased crop yields, which were superior to the commercial cultivar. Therefore, this study demonstrated the productive potential of these cultivars, which benefit the grain producers of the territory and should be included among the commercial varieties of the Ministry of Agriculture (MINAG).

The results of this research suggest the continuation of similar studies in other agroecosystems and managed in the different planting seasons established for the crop, under other production systems (organic or low chemical inputs).

CONCLUSIONS

- The results obtained indicated that the cultivars of the ENAR group increased the productive indicators and yield, compared to the commercial variety.
- The cultivars ENAR-63 and ENAR-67 were more promising than the cultivars ENAR-64 and ENAR-68 and increased yield by 126 % compared to Bat-304.
- The findings of this study showed that these new varieties constitute a productive potential for grain production in the province of Sancti Spíritus, Cuba.

ACKNOWLEDGMENTS

We thank the National Institute of Agricultural Sciences (INCA), for providing the cultivars unselfishly; the Local Agricultural Innovation Project (PIAL), in Sancti Spíritus, for the support provided and the Credit and Service Cooperative (CCS) "José Regino Sosa", for the help and services rendered.

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