Cultivos Tropicales, 2019, vol. 40, no. 4, e01
ISSN impreso: 0258-5936
ISSN digital: 1819-4087

octubre-diciembre
Ministerio de Educación Superior. Cuba
Instituto Nacional de Ciencias Agrícolas

http://ediciones.inca.edu.cu

Original Article

Comparison of six varieties of beans in yield and their components, in Chaltura, Imbabura, Ecuador

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ABSTRACT

In the northern Ecuador, the beans (*Phaseolus vulgaris* L.) productivity is low due to varieties little adapted to local conditions. The objective of this study was to evaluate six pure bean varieties collected in the Ecuador's Andes mountains and compare to the Rosado bolón variety, which is highly used by local farmers. Was evaluated the plant vigor, grain colour, flower colour, presence of pests, 100-grain weight, seed moisture, number of pods per plant, number of seeds per pod, number of grains per plant, number of leaves per plant and plant height. A single-plot design was used. The results showed that the grain yield was correlated with the varieties Toro rojo, Rosado bolón and Paragachi. Number of grains per pod and number of pods per plant were highly correlated with yield. Finally, was observed the presence of Bean common mosaic virus (BCMV), while the insect that had the greatest presence was the Trip (*Caliothrips phaseoli* (Hood)).

Key word: Seed quality, purity, pests

INTRODUCTION

Beans (*Phaseolus vulgaris L.*) is a legume highly consumed by the Ecuadorian population, included among the 22 most commercialized agricultural products in the country, mainly by people with low incomes. It is characterized by being a very nutritious food with a high content of amino acids, carbohydrates and rich in calories. It is consumed in soups and combined with other foods such as flours, rice and tubers, its nutritional value is compared with red meat [(1)].

There are several varieties of this legume in the country, it is characterized by having a high content of proteins and amino acids, from 20 to 46 % in dry grain, in addition to carbohydrates, minerals and fibers, which determines its value and importance in the feeding. A large part of the producers own small farms of up to 5 ha and use recycled seeds, which explains the low yields and low profitability of their crop [(2)].

In 2014, average global bean yields were 0.83 t ha^{-1}, while productivity levels above the world average were reported in the United States, China, Myanmar, Tanzania and Brazil; however, in countries like Mexico and India they were inferior, according to [(3)]. In Ecuador, dry bean yields of between 0.3 and 2.2 t ha^{-1} are reported according to the National Institute of Statistics and Census. Agricultural Statistics-ESAG, ESPAC in 2017 [(4)].

Another important characteristic of this species is that it fixes nitrogen to the soil and can be used in rotation with other crops more extractors of this nutrient. They are classified into several groups according to their type of growth: shrubby determined growth plants (Type I), shrubby Indeterminate growth plants (Type II) which do not end in a floral bud but stop growing between four to five months of sowing and do not require tutors, Indeterminate prostrate (Type III) that is more branched than type II but can be grown without tutors, only with the use of wood or wire supports, and finally the Indeterminate climber (Type IV), which does requires tutors or support [(5,6)]. They are also classified by the color of the grain: black, white, red, pink, berries, and by their shape: round, elongated [(7)]. They are also differentiated by the duration of the vegetative cycle, being classified into long, medium and short cycles and by their behavior against pests [(8)].

Taking into account that in this region of Los Andes, in the period of 3000 to 8000 years a. C. appeared the first sedentary human societies, capable of producing their food that began to adapt a wide variety of plants in different areas and the domestication of plant and animal species that contributed to "The Neolithic Revolution" that marked an important point in

history of man, because agriculture became the basis of the economy [9]. Other authors point out that multiple domestications in time and space have been key determinants in the structure of genetic diversity present in current crops. Among the documented examples of multiple domestication in different species on the American continent, is beans (Phaseolus sp.) [10].

That is why the objectives that were traced in this research, in addition to evaluating agronomic behavior, was the search for native genetic variability that facilitates improved adaptation to the environment, resistance to pathogens and performance.

MATERIALS AND METODOS

The work began with the collection of 12 local bean varieties (*Phaseolus vulgaris* L.) carried out on farms of producers in the provinces of Carchi and Imbabura in northern Ecuador, during the months of August and September of 2013, which showed high yields and low presence of pests, under conditions of low input culture. From them, the six varieties with the best behavior were selected in the aforementioned parameters, to be evaluated in the conditions of the Chaltura Parish, Imbabura Province, using the Rosado Bolón variety as a witness because it is the most used by the producers in the area.

The students of the seventh semester of the Genetic subject of the Agricultural Engineering career of the Faculty of Agricultural and Environmental Sciences (FICAYA) of the Technical University of the North (UTN) participated as part of the research project "Creation of a bank of germplasm in the Experimental Station La Pradera, Ibarra, Ecuador. The planting of the six selected varieties was carried out on April 25th, 2014, at the "La pradera" farm of the UTN, Chaltura parish in the Antonio Ante municipality, Imbabura province. The study area has a dry mesothermal equatorial climate with an average annual temperature that ranges between 12 and 18 °C. The soil is classified as: Inceptisol, it is characterized by a high content of organic matter, greater than 1.5 %, with a sandy texture and pH 7.0. The area has a 5 % slope and an altitude of 1920 meters above sea level, with an average annual rainfall of 750 mm [11,12].

A simple plot design was used, with double rows of 5 m in length and 0.50 m between rows for an area of 12 m^2 and a planting density of 100 plants per plot. The emergency percentage of the plants was evaluated ten days after planting and the weight of 100 grains in grams, the

percentage of moisture, the number of pods and grains per plant, the number of grains per pod and the number were measured of leaves per plant, at 120 days after sowing and the height of the plants at 30 days. Cultural attention was carried out according to the technical instructions in force [13] except for the phytosanitary control that was only carried out during the 30 days after the emergence of the plant.

The harvest was carried out on August 29th, 2014. Once the manual harvest was carried out, 100 grains were weighed and the humidity percentage was determined in the FICAYA Physical, Chemical and Microbiological Analysis Laboratory, in the UTN in 2014, to proceed with storage without risk of germination percentage affectation, a test that was subsequently carried out.

For the statistical analysis, the data of each variable were submitted to analysis of variance (ADEVA) and depending on the significance of the Duncan Multiple Ranges test at 5 and 1 %, the statistical package SPSS 20.0 [8] was used.

RESULTS AND DISCUSSION

The emergence of the plants observed was greater than 85 % in all varieties. According to the visual evaluation of the vigor of the plants, carried out 20 days after planting (Table 1), the TOA variety was the one that presented the best behavior, standing out over the rest of the varieties evaluated, however in the weight of 100 seeds stood out the control Rosado Bolón with 61.34 g, the percentage of humidity varied between 9 and 12 %; as for the color of the grain there was similarity between Toro Rojo and Rosado Bolón, with colors that varied between Red Spotted and Purple Spotted; Paragachi and TOA presented red Jasper grains, while those of Capulí, were Red Brown and those of Black Andean Afro, which corresponds to the INIAP Variety Catalog (2010) [13]. Regarding the color of the flower, no notable differences were observed, predominantly pink.

In the behavior against diseases, the varieties Capulí, Rosado Bolón and Paragachi stood out, in which only low presence of the common Mosaic virus (Bean common mosaic virus-BCMV) was observed, coinciding with the results described in the Catalog of varieties of INIAP bean [13].

Table 1. Morpho-agronomic characterization of six bean varieties collected in the second half of 2014

Nu.	Variety	Vigor of plants	Weight 100 grains (g)	% humidity	Grain color	Flower color
1	Toro Rojo	B	50.00	11.78	Rojo Moteado	Pink
2	Rosado Bolón	B	61.34	10.21	Morado Moteado	Creamywhite
3	Paragachi	B	58.68	10.41	Rojo Jaspeado	Pink
4	TOA	MB	54.04	10.8	Rojo Jaspeado	Pink
5	Capulí	B	56.03	9.63	Rojo Pardo	Pink
6	Afro Andino (Matahambre)	B	17.19	8.99	Negro	Creamywhite

The results of the ADEVA and the Duncan multiple range test showed that the Toro Rojo variety was superior for its yields by area, to those obtained by the witness Rosado Bolón and the Paragachi variety, which showed no significant differences between them (Table 2). These results exceeded those obtained in similar tests in the Boyacá Valley, Colombia, [14].

Regarding the number of pods per plant, significant differences were observed in Table 2, among the varieties evaluated, the Toro Rojo variety was superior, surpassing the Rosado Bolón control and the Paragachi variety, results that coincide with other studies [15].

In relation to the behavior of the varieties in the number of grains per pod component, the results showed significant differences between them, as observed in the Duncan Multiple Ranges test (Table 2), the Red Bull variety was the one that reached higher values , which is explained by being a variety adapted to low input culture conditions. In other works reported by CIAT, similar behaviors have been observed in varieties of Mesoamerican and Andean origins [15] and in relation to the variable number of grains per plant it is observed in the own (Table 2) the Toro Rojo variety was the most outstanding, far exceeding the rest of the varieties evaluated.

Table 2. Comparison of performance and its main components in the trials studied

Nu	Variety	Yield (t ha^{-1})	Nu. de pods/plants	Nu. Grains/pod	Nu. of grain/plant
1	Toro Rojo	2. 3 a	72.71 a	7.71 a	562.29 a
2	Rosado Bolón	1. 6 b	62.29 b	5.14 b	319.29 b
3	Paragachi	1. 4 b	54.57 b	5.29 b	286.00 b
4	TOA	0. 6 c	26.00 c	4.86 b	125.71 c
5	Capulí	0. 5 c	25.29 c	4.86 b	115.57 c
6	Afro Andino	0. 3 d	30.71 c	5.86 b	175.71 c
	X	1. 1	45.26	5.62	264.10
	CV (%)	23.35	18.05	15.92	23.00

Means with equal letters do not differ significantly for Duncan p <0.05

To determine the relationship between the leaf area and the yield, the number of leaves per plant was counted and the behavior between varieties and the correlation of this character with the total yield was evaluated. The results allowed us to observe highly significant differences between the varieties (Table 3), with the Toro Rojo and TOA standing out, in the case of the Toro Rojo variety, correspondence was observed with the results obtained in the yield per plant character, which coincides with the results de Ríos, Viteri and Delgado (2014) in studies conducted in Colombia [(8)].

One of the first characteristics that was evaluated in the experiment was the height of the plants 30 days after planting, with the aim of studying the possibility of using it as a selection criterion in the early stages of their development, the varieties most Highlights were TOA and Toro Rojo, which showed no statistical differences with Capulí and Paragachi, but with Afro Andino and the witness Rosado Bolón, which allows us to recommend the use of this character as an early indicator of selection, but only for shrub varieties (Table 3).

Table 3. Comparison of performance and two of its secondary components in the trials studied

Nu.	Variety	Nu. of leaves/plant	Height of plant (cm)
1	Toro Rojo	47.14 a	24.71 a
2	Rosado Bolón	32.43 b	20.43 b
3	Paragachi	33.86 b	22.00 ab
4	TOA	43.57 a	25.00 a
5	Capulí	35.86 b	23.86 ab
6	Afro Andino	33.57 b	20.57 b
	X	37.74	22.76
	CV(%)	16.94	14.26

Means with equal letters do not differ significantly for Duncan p <0.05

The results of the correlation analysis between the six evaluated characters indicated the existence of highly significant associations between the characters: number of grains/plant and number of pods/plant with yield/plant, which coincides with that reported by other researchers in varieties of Cowpea evaluated in Colombia [16]. In addition, there was a positive and significant correlation between the characters number of grains/pod and yield/plant, other important correlations were those found between the characters number of pods/plant and number of grains/pod with character number of grains/plant.

The number and size of the grain are yield components, since they are relatively stable characteristics and very little affected by the environment, similar results were obtained in studies of genotype-environment interaction conducted in Cawpea [16]. Likewise, the result of negative correlations between the characters Height of the plant and Weight / plant (Table 4) must be taken into account.

Table 4. Phenotypic correlations between the six characters evaluated in the bean experiment, in the first half of 2015

Characters	Weight/planta	Grains/plant	Pods/plant	Grains/Pod	Height/Plant (cm)
Weigth/plant					
Grains/plant	0.95**				
Pods/plant	0'91**	0.89**			
Grains/pod	0.62*	0.76**	0.42**		
Height/ Plant IM	-0.48**	-0.26 ns	-0.35 ns	0.31*	
Nu. leaves at 30 days	0.23 ns	0.27 ns	0.11 ns	0.23 ns	0.15ns

The insects that had the greatest presence in the plantation were in order of importance: the Trips (*Caliothrips phaseoli* Hood, Lorito verde (Empoasca kraemeri Ross) and the Black cutworm (*Agrotis* sp and *Spodoptera* sp. Smith) although in no case the damages caused they affected yields on a considerable scale as can be seen in Figure 1, which is corroborated by the Agricultural Handbook of Beans [13].

Figure 1. Toro Rojo varieties, which was the most prominent in the characters related to grain yield and the Rosado Bolón control

CONCLUSIONS

- The varieties that showed the best behavior against the Common Mosaic Virus were Capulí, Bolón Rosado and Paragachi. Trips presence was observed but without affectations that allowed comparing the varietal behavior.
- The Toro Rojo variety stood out in the study for its results in yield and number of pods/plant, in addition, in number of grains/plant and number of grains/pod.
- Regarding the most significant associations, the following were observed among the characters: number of grains/plant, number of pods/plant and number of grains/pod with yield.
- According to the visual evaluation of the vigor of the plants, the TOA variety was the one that showed the best behavior, standing out over the rest of the varieties evaluated and weighing 100 seeds, the control Rosado Bolón stood out.

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