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Bush snap bean genotypes under conventional and organic cultivation

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ABSTRACT

Snap bean is a species widely cultivated in Goiás, in which cultivars of indeterminate growth are used in a staking system. Considering the high cost of staking and the unavailability of a workforce, there has been a demand for bush cultivars, but little is available on the market. In this sense, the present study was developed to evaluate, in 2016, under the conventional and organic cultivation systems, in Anápolis-GO, the behavior of 20 bush snap bean genotypes. The experimental design was randomized blocks, with 20 treatments and three replications. There was a significant interaction between genotypes and cultivation systems for vigor, average pod mass, number of pods per plant, and pod yield, evidencing that the types of cultivation, organic and conventional, interfered with the response of these variables. Although the Commodore Improved cultivar has excelled in pod yield in the conventional system, all genotypes were suitable for organic production. Hab 39, Improved Gold Wax, Kentucky Wonder Bush, Provider, Stringless Green, and Tendergreen genotypes are unsuitable for the conventional production system.

Keywords: *Phaseolus vulgaris* L., Production system, Organic agriculture.

Genótipos de feijão-vagem arbustivos sob cultivo convencional e orgânico

RESUMO

O feijão-vagem é uma espécie largamente cultivada em Goiás, em que se utiliza cultivares de crescimento indeterminado em sistema tutorado. Considerando-se o alto custo de tutoramento e indisponibilidade de mão de obra, tem havido demanda por cultivares arbustivas, pouco disponíveis no mercado. Neste sentido desenvolveu-se o presente trabalho, com o objetivo de avaliar, em 2016, sob os sistemas de cultivo convencional e orgânico, em Anápolis-GO, o comportamento de 20 genótipos de feijão-vagem arbustivos. O delineamento experimental foi de blocos casualizados, com 20 tratamentos e três repetições. Houve interação significativa entre os genótipos e os sistemas de cultivo, para vigor, massa média de vagem, número de vagem por planta e produtividade, demonstrando que tipos de cultivo, orgânico e convencional, interferiu na resposta dessas variáveis. Embora a cultivar Commodore Improved tenha se sobressaído em produtividade no sistema convencional, todos os genótipos mostraram-se apropriados à produção orgânica. Os genótipos Hab 39, Improved Gold Wax, Kentucky Wonder Bush, Provider, Stringless Green e Tendergreen não são apropriados ao sistema convencional de produção.

Palavras-chave: *Phaseolus vulgaris* L., Sistema de produção, Agricultura orgânica.

1. Introduction

Snap bean belongs to the same species as the common bean (*Phaseolus vulgaris* L.), but its immature pods have a low fiber content, which allows its consumption as a vegetable, one of the main vegetables grown in the world, whose production reaches, annually, 6.5 million tons. It is an essential source of fiber, vitamins B1 and B2, A, and C, phosphorus, potassium, and proteins (Peixoto and Cardoso, 2016).

This vegetable has great economic and social importance in Brazil, cultivated throughout the year, mainly by small properties, employing family labor. In Goiás, in 2019, the sales volume of snap beans was 3,145.74 t, with the following municipalities as the main suppliers: Leopoldo de Bulhões (1,694.67 t), Goianápolis (378.64 t), Anápolis (304 .15 t), and Abadia de Goiás (230.80 t) (CEASA, 2019).

The snap bean cultivars can be classified, according to the growth habit, as indeterminate (staked) or determinate (bush). Most cultivars on the market are of indeterminate habit, typically used in succession to other vegetables such as tomato and cucumber, taking advantage of staking and fertilizer residues from previous crops. The determined cultivars have been gaining interest from producers because they have advantages such as shorter cycles, no staking required, and the harvesting is concentrated, which makes it possible to carry out a single harvest, uprooting the plants in the field for later separation of the pods, or even planting large irrigated areas and mechanized harvesting (Filgueira, 2013, Peixoto and Cardoso, 2016, Vaz et al., 2017).

According to Néri et al. (2020), although the introduction of bush cultivars in Brazil is recent, their demand has grown since the 1980s, and the availability of appropriate cultivars is of fundamental importance, both for organic and conventional cultivation. One issue that permeates agricultural production debates is the focus on sustainability, emphasizing organic and agroecological production systems. In addition, the search for healthy food also increases the demand for food from these systems, requiring cultivars developed according to agroecological principles, using germplasm adapted to local conditions (Andrade et al., 2017).

The evaluation of snap beans in different production systems is essential to compare and identify the advantages of one system over the other, mainly in terms of yield and product quality. Because they have specific characteristics, different production systems influence crops differently (Gomes et al., 2017). In this sense, Néri et al. (2020) evaluated, in Anápolis, regarding seed production, 20 bush snap bean genotypes in conventional and organic systems, with most genotypes being more productive in the organic system. Portal et al. (2018), studying 20 bean genotypes of indeterminate growth, in the same location, of both systems, also obtained better productive performance in the organic system.

Bush snap bean cultivation has aroused the interest of small producers in Brazil due to its shorter cycle, lower demand for labor, and reduced production cost, which requires the availability of appropriate cultivars for different cropping systems. This study aimed to evaluate the behavior of 20 bush snap bean genotypes under conventional and organic cultivation systems in Anápolis-GO.

2. Material and Methods

Two experiments were carried out from April 12 to June 22, 2016, one under conventional cultivation and the other under organic cultivation. They were conducted in the field, in different areas, at EMATER - Anápolis Experimental Station (GO), in the vegetable and fruit growing sector, in Latossolo Vermelho, according to Santos et al. (2018), and according to the Köppen classification, at 16°19'48" S, 48°58'23" W, and altitude of 1,032 m.

The treatments consisted of 20 bush bean genotypes, consisting of 18 cultivars, of which 15 were North American (Commodore Improved, Contender, Delinel, Espada Bush, Festina, Improved Golden Wax, Jade, Kentucky Wonder Bush, Provider, Royal Burgundy, Slenderwash, Stringless Green, Strike, Tendergreen, and Tendergreen Improved), two Brazilian (Napoli and Turmalina), one Japanese (Amarelo Japonês) and two lines from the International Center for Tropical Agriculture - CIAT (Hab 1 and Hab 39).

The experimental design used for both experiments was randomized blocks with three replications. The plot consisted of four lines 3 meters long, spaced 0.50 meters and 0.10 meters between plants. Two rows were considered for the evaluations (3 m²). The water needs of the crop were met through sprinkler irrigation, performed twice a week to replace evapotranspiration. The experiment under conventional cultivation was carried out in an area whose soil analysis results were pH(CaCl2) = 5.6, Available-P (Mehlich^{-1} extractor) = 13.6 mg dm^{-3}, Available-K = 141.0 mg dm^{-3}, Ca + Mg = 3.7 cmolc dm^{-3}, Al = 0.0 cmolc dm^{-3}, and organic matter = 15.0 g dm^{-3}. Sowing fertilization was carried out with 1 t ha^{-1} of the NPK formulation 02-20-18. The topdressing fertilization was conducted 20 days after sowing, with 0.3 t ha-1 of ammonium sulfate.

Weed control was carried out by applying the active ingredient fluazifop-p-butyl herbicide. To control Diabrotica speciosa and Bemisia tabaci, azadirachtin, pyriproxyfen, and acetamiprid were used according to the recommendations of manufacturers. The experiment under organic cultivation was carried out in an area that

has been organically managed since 2000, according to the criteria for organic production (MAPA, 2021; Brasil, 2007; Brasil, 2003).

Soil analysis results were pH (CaCl2) = 5.2; Available-P (Mehlich^{-1} extractor) = 6.4 mg dm^{-3}, Available-K = 107.0 mg dm^{-3}, Ca + Mg = 2.89 cmolc dm^{-3}, Al = 0.0 cmolc dm^{-3}, and organic matter = 30.0 g dm^{-3}. The organic compound analysis results were pH (water) = 6.69, K = 8 g kg^{-1}, N = 14 g kg^{-1}, P = 22 g kg^{-1}, and organic matter=200 g kg^{-1}. The organic compost was produced at the Experimental Station of Anápolis from green corn straw and pure poultry manure. Fertilization at sowing was carried out with 10 t ha^{-1} of organic compost and 0.6 t ha^{-1} of Yoorin thermophosphate. The topdressing fertilization was carried out 20 days after sowing, with 4 t ha^{-1} of organic compost.

Cultural and phytosanitary treatments allowed for organic cultivation were carried out. The weeds were controlled by manual weeding, leaving strips between plots as ground cover. Diabrotica speciosa and Bemisia tabaci were controlled by spraying with Neem oil associated with biofertilizer, according to the recommendations of the manufacturer. The variables studied in both experiments were: 1) yield of green pods (at the stage considered suitable for commercialization), obtained by the sum of the mass of three harvests in each plot, expressed in tons per hectare; 2) average mass of pods, obtained by the division of the total mass of pods by the total number of pods in each plot, expressed in grams; 3) number of pods per plant, obtained by the division of the total number of pods by the number of plants in the plot; and 4) plant vigor, evaluated in the flowering phase, using a scale of notes from 1 to 5, where 1 is low vigor, and 5 is high vigor (Portal et al., 2018). Data were subjected to analysis of variance for each experiment, followed by the joint analysis. The means were grouped by the Scott-Knott clustering algorithm at 5% probability using the SISVAR® software (Ferreira, 2011).

3. Results and Discussion

Significant differences were verified among snap bean genotypes, cultivations systems, and the genotype x system interaction for plant vigor and average pod mass. Regarding the number of pods per plant, there was a significant influence from the genotypes and genotype x system interaction. For yield, there were significant differences for genotypes, cultivations systems, and genotype x system interaction (Table 1).

Regarding plant vigor, there was a greater distinction between the genotypes in the conventional system, with the formation of three groups; in the organic system, the genotypes constituted only two groups. Amarelo Japonês, Commodore Improved, Jade, Royal Burgundy, and Tendergreen Improved cultivars were the most vigorous in the conventional system, while in the organic system, Amarelo Japonês, Festina, Kentucky Wonder Bush, Royal Burgundy, Stringless Green, and Tendergreen cultivars and Hab 1 and Hab 39 genotypes were the most vigorous. The Contender, Hab 1, Hab 39, Kentucky Wonder Bush, Provider, Stringless Green, and Tendergreen genotypes showed higher vigor in the organic system, while the others were equal in both systems (Table 2).

It was observed that the more vigorous plants tend to close the row spacing more quickly, thus contributing to reducing the need to control invasive plants. There was no difference among the genotypes in the conventional system for the average pod mass, with an average of 5.10 grams. In the organic system, the genotypes Amarelo Japonês, Contender, Espada Bush, Festina, Hab 1, Hab 39, Kentucky Wonder Bush, Stringless Green, Tendergreen, Tendergreen Improved, and Turmalina obtained the highest average pod mass (Table 3).

Table 1. Analysis of variance for plant vigor, average pod mass (APM), number of pods per plant (NPP), and pod yield (PDY) of 20 bush snap bean genotypes under conventional and organic cultivation systems Anápolis-GO, 2016

Sources of variation	Mean squared error			
	Vigor	APM (g)	NPP	PDY (t ha^{-1})
Block (system)	2.05**	5.87**	4.90^{ns}	6.27^{ns}
Genotypes	0.86**	2.40**	120.12**	40.11**
System	5.42**	143.44**	1.82^{ns}	282.96**
Genotype * system	0.77**	1.35*	58.15**	38.90**
Residue	0.21	0.64	23.65	11.62
Average	3.93	6.22	15.35	10.43
CV(%)	12.21	12.84	31.67	32.68

*significant ($0.01 \leq \rho \leq 0.05$), **highly significant ($\rho \leq 0.01$), ^{ns} not significant ($\rho \geq 0.05$), CV=Coefficient of variation.

Table 2. Plant vigor, at flowering, of 20 bush snap bean genotypes under conventional and organic cultivation systems. Anápolis-GO, 2016.

Genotypes	Vigor	
	Conventional	Organic
Amarelo Japonês	4.17 to A	4.33 to A
Commodore Improved	4.66 to A	4.00 b A
Contender	2.83 c B	3.67 b A
Delinel	3.67 b A	3.83 b A
Espada Bush	3.83 b A	3.50 b A
Festina	3.67 b A	4.17 to A
Hab 1	3.67 b	4.67 to A
Hab 39	3.00 c B	4.17 to A
Improved Golden Wax	3.00 c A	3.33 b A
Jade	4.50 to A	3.67 b A
Kentucky Wonder Bush	3.00 c B	4.67 to A
Napoli	3.50 c A	3.67 b A
Provider	2.83 c B	3.67 b A
Royal Burgundy	4.33 to A	5.00 to A
Slenderwash	3.17 c A	3.50 b A
Strike	3.33 c A	3.50 b A
Stringless Green	3.17 c B	4.50 to A
Tendergreen	3.00 c B	4.33 to A
Tendergreen Improved	4.17 to A	3.67 b A
Turmalina	3.50 c A	3.50 b A
Cultivation systems		
Conventional	40.39 a	3.54 b
Organic	40.05 a	3.95 a

Means followed by the same lowercase letter in the column and uppercase letter in the line belong to the same group by the Scott-Knott test at the 5% error probability level.

The Contender, Espada Bush, Hab 1, Hab 39, Kentucky Wonder Bush, Tendergreen, and Improved Tendergreen genotypes have higher average pod mass when cultivated under an organic system. Cultivation systems did not influence the other genotypes. Gomes et al. (2017) also found a higher average pod mass in an organic production system compared to the conventional system. There was a difference between genotypes in terms of the number of pods per plant within each system. Commodore Improved, Espada Bush, Festina, Jade, Slenderwash, and Tendergreen Improved have the highest means in the conventional system. The other genotypes were equal. Delinel, Espada Bush, Festina, Improved Golden Wax, Napoli, Slenderwash, and Tendergreen Improved stood out in the organic system.

There was also an interaction between genotypes and cultivation systems, corroborating the result obtained by Gomes et al. (2017). Espada Bush, Festina, Slenderwash, and Improved Tendergreen cultivars had the highest number of pods per plant in both cultivation systems. The Provider, Stringless Green, and Tendergreen genotypes stood out with the highest number of pods per plant in organic cultivation, and Commodore Improved, Festina, and Jade in the conventional system (Table 3). The averages were higher than those of Gomes et al. (2017) in both conventional and organic systems.

In the conventional system, the cultivars were distributed into four distinct groups, with the most productive being Commodore Improved, followed by Festina, Jade, and Tendergreen Improved. In the organic system, the genotypes were equal, although there was an amplitude from 8.09 to 15.18 t ha^{-1}. The cultivar Commodore Improved was more productive in the conventional system. The Improved Golden Wax, Kentucky Wonder Bush, Provider, Stringless Green, and Tendergreen cultivars and the Hab 39 lines were more productive in the organic system, while the others were equal in systems.

Vaz et al. (2017) studied 29 bush snap bean genotypes, from different countries of origin, under conventional cultivation, in Ipameri-GO, of which 19 are from the same study, and recorded the cultivars Contender, Jade, and Provider as the most productive (18 t ha^{-1}). Brunner et al. (2014) analyzed eight bush snap bean genotypes, in an organic system, in Puerto Rico and found that the cultivars Provider, Contender, Festina, and Jade were among the most productive, with a range from 10.90 to 14.60 t ha^{-1}. Andrade et al. (2017) evaluated 25 bush snap bean accessions under organic cultivation in Londrina-PR; they found yields between 5.14 and 9.72 in the September-December season and between 7.02 and 11.07 t ha^{-1} in April-June.

Table 3. Average pod mass (APM), number of pods per plant (NPP), and pod yield (PDY), of 20 bush snap bean genotypes under conventional (Conv) and organic (Org) cultivation systems. Anápolis-GO, 2016.

Genotypes	APM (g)		NPP		PDY (t ha^{-1})	
	Con	Org	Conv	Org	Conv	Org
Japonês Amarelo	5.16	7.53 a A	16.49	13.66 b	10.71	13.54 a
Commodore Improved	5.21	6.63 b A	28.56	16.10 b	21.38	11.38 a
Contender	4.78	8.30 a A	13.63	11.57 b	8.38	8.28 a
Delinel	5.46	7.03 b A	13.54	17.37 a	7.81	12.25 a
Espada Bush	4.77	7.53 a A	18.55	20.80 a	9.60	10.13 a
Festina	4.96	7.43 a A	28.08	19.77 a	14.93	15.18 a
Hab 1	5.30	8.47 a A	13.62	12.47 b	8.84	14.92 a
Hab 39	5.30	9.07 a A	11.39	12.97 b	4.17	14.33 a
Improved Golden	4.33	6.47 b A	16.19	21.13 a	6.17	12.98 a
Jade	5.00	6.63 b A	22.83	14.23 b	13.90	11.44 a
Kentucky Wonder	5.21	8.50 a A	8.07	13.93 b	4.88	11.37 a
Napoli	6.53	6.73 b A	13.56	17.70 a	10.69	12.81 a
Provider	4.82	6.47 b A	6.76	15.00 b	3.32	10.12 a
Royal Burgundy	5.37	6.17 b A	15.59	14.57 b	9.67	9.99 a
Slenderwash	4.67	6.17 b A	21.37	17.37 a	10.05	11.30 a
Strike	4.43	5.53 b A	15.76	15.73 b	8.00	10.55 a
Stringless Green	5.38	7.63 a A	4.22	13.60 b	1.87	11.50 a
Tendergreen	4.69	7.87 a A	3.16	14.77 b	1.71	14.62 a
Tendergreen Improved	4.67	7.33 a A	21.55	19.20 a	13.03	13.81 a
Turmalina	6.45	8.67 a A	12.13	7.63 b A	8.38	8.09 a
Cultivation systems						
Conventional	5.10 b		15.31 a		8.88 b	
Organic	7.30 a		15.61 a		12.00 a	

Means followed by the same lowercase letter in the column and uppercase letter in the line belong to the same group by the Scott-Knott test at the 5% error probability level.

Néri et al. (2020) obtained results for seed production in snap bean genotypes in organic and conventional systems, evaluating the identical genotypes used in this study, observed that the Amarelo Japonês, Hab 1, and Tendergreen Improved genotypes had good productive performance in both cultivation systems. In conventional cultivation, Commodore Improved, Festina, and Jade stood out, and in the organic system, Delinel, Hab 39, Improved Gold Wash, Royal Burgundy, Slenderwash, and Tendergreen. The genotypes Hab 39, Improved Golden Wax, and Tendergreen, evaluated in the organic system, and the Commodore Improved in the conventional system, were more productive in pod weight and seed weight. The genotypes produced similar or higher yields than those reported by other studies with snap bean grown in conventional and organic systems.

Conclusions

Except for the Commodore Improved cultivar, which was more productive in the conventional system, the genotypes were suitable for organic production. Amarelo Japonês, Contender, Delinel, Espada Bush, Festina, Hab 1, Jade, Napoli, Royal Burgundy, Slenderwash, Strike, and Tendergreen Improved performed well in both systems. Hab 39, Improved Gold Wax, Kentucky Wonder Bush, Provider, Stringless Green, and Tendergreen are unsuitable for conventional production systems.

Authors' Contribution

Valdivina Lúcia Vidal: Conception and design, data acquisition, data analysis and interpretation, and writing. Aracelle Assunção: data analysis, interpretation and writing. Marcos Coelho: data acquisition. Raimunda Nascimento Sales: data acquisition. Nei Peixoto: preparation, conception, design, writing, and paper´s review.

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