Investigation note

Biostimulant application increases yield components of Bill Z Pinto beans in southern Sonora

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Abstract

Taking into consideration the importance of beans for human nutrition, and the contribution of local production to the regional food security in the south of the state of Sonora, a trial was established during the spring-summer 2020 cultivation cycle in the Block 2110 of the Yaqui Valley. The experiment aimed to evaluate the effect of the application of three commercial biostimulants in the yield components of bean, variety Pinto Bill Z. Four treatments with four repetitions were established: T1 (FloraStart®); T2 (Austar®); T3 (mixture of Tricel-20® + Aminocel 500®, 1:1 ratio) and T4 (control, without biostimulant application) in a completely randomized experimental design. The treatments were applied only once during the flowering phenophase R6. The variables evaluated were number of pods per plant, pod length, number of grains per pod, grain mass per pod and per plant, and grain yield. The use of biostimulants increased the number of pods per plant in the evaluated variety. The pod length and the number of grains per pod did not show significant variation with respect to control. The T1 was the one that most contributed to the increase in the number of pods per plant, to the individual grain mass and, consequently, to the grain yield (5.4 t ha^{-1}), with an increase of 2.3 t ha^{-1} with respect to the control, which demonstrates the feasibility of their application to increase the production of Bill Z Pinto beans in southern Sonora.

Key words: *Phaseolus vulgaris* L., foliar nutrition, pods per plant.

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Temperature is one of the abiotic factors that limit bean production in Mexico, mainly during flowering and fruit set (López-Salinas *et al*., 2015). Seventy percent of the beans grown in Mexico are grown under rainfed conditions, so productivity is highly vulnerable to high temperatures, another factor such as drought that occurs in regions where there are real possibilities for their development and production (Montesillo-Cedillo, 2017). At the national level, bean consumption increases every year, and more than 140 thousand tonnes have to be imported from the United States and Argentina (CEDRSSA, 2020), 1.3 million tonnes are needed to meet the national demand and less than half are produced (Romero-Félix *et al*., 2019).

In Sonora, beans are produced under irrigation conditions, but considering that it is a semidesert region and the limiting condition is water, it is urgent to have efficient irrigation systems and tolerant and productive varieties that generate profitable production (López-Salinas *et al*., 2015). Approximately 10 000 ha of beans are sown in the state and of these, more than 90% correspond to southern Sonora, particularly in the Yaqui and Mayo Valleys (SIAP, 2021). In the Yaqui Valley, beans are sown in two cycles: spring-summer (S-S) and autumn-winter (A-W), with a larger area in the A-W cycle (Padilla *et al*., 2009). The climatic conditions and water requirements in both cycles are completely different, so controlling at least one of them through an efficient irrigation system and mitigating the possible impact of environmental conditions with the use of foliar biostimulants would have great economic importance.

Given these limiting situations of bean production in southern Sonora, there is a need to apply economically viable production alternatives to mitigate imported production volumes and increase regional food sovereignty through the establishment of promising crops. The objective of this trial was to evaluate the effect of three foliar-applied biostimulants on the yield components of Pinto beans Bill Z in the S-S cycle in the Yaqui Valley, Sonora, Mexico.

Location of the experimental site

The experiment was carried out in the S-S cycle from March-June 2020 in an open-field experimental condition in the Yaqui Valley, Sonora, on a plot located in Block 2110, with an area of 28 ha. Characteristics of the soil used. The type of soil was clayey, the previous crop was corn, and the preparation of the land was a double pass of harrow, tracing of beds 1.6 m apart and, at the same time, the irrigation tape was installed at 10 cm deep; subsequently, pre-sowing irrigation was applied from March 07 to 15, 2020. Commercial variety used and cultivation work. The variety Bill Z was used and sown in a mechanized way in wet soil from March 19 to 25, 2020, considered a late date according to INIFAP. Eighteen seeds per linear meter were deposited at 6 cm depth to have an average population of 17 plants per linear meter.

The separation between rows was 60 cm (Padilla *et al*., 2009) and the established seed density was 80 kg ha^{-1}, with a germination percentage of 98%. Fertilization, in all treatments, was applied based on urea (46 kg ha^{-1}) in the first supplemental irrigation plus 30 L ha^{-1} of phosphoric acid (Arellano *et al*., 2015). Ten supplemental irrigations were applied with a water volume of 150 m^3 ha^{-1} using a drip irrigation system.

Treatments and experimental design

Four treatments were established with an area of seven ha each. The treatments were: T1, 250 g ha^{-1} of FloraStart® (w/w: 12.6% K_2O, 10% Mo, 9.5% P_2O_5, 8% Bo, 5% free amino acids); T2, 250 ml ha^{-1} of Austar® (250 g L^{-1} paclobutrazol); T3, a mixture of 2 kg ha^{-1} of Tricel-20® (20-20-20, 3% free amino acids, 2% organic extracts and 1% chelated microelements) and 200 g ha^{-1} of Aminocel 500® (50% free amino acids, 10% N, 10% K, 8% P_2O_5) at a 1:1 ratio; T4, control, where no developmental stimulant was applied. Treatments were applied only once in the flowering phenophase, 35 days after emergence. These were distributed by a completely randomized experimental arrangement with four repetitions.

Variables evaluated

Number of pods per plant ($P\ P^{-1}$): the number of pods per plant was counted in a total of 100 plants per treatment. Pod length (PL): it was measured with a 3 m millimeter tape of the Truper brand, with a measurement error of 0.00001 in a total of 100 plants per treatment. Number of grains per pod ($\#G\ P^{-1}$). The grains were counted in a total of 1000 pods taken at random in each treatment. Grain mass per pod ($GM\ P^{-1}$): the grains of the pods taken to evaluate the number of grains per pod were weighed in an analytical balance (Sumilab) with a measurement error of 0.000001 g. Grain mass per plant ($GM\ L^{-1}$): it was determined with the use of the analytical balance used for the variable $GM\ P^{-1}$ and a sample size of 100 plants per treatment was used.

Grain yield

It was calculated in kg ha^{-1}, at 14% moisture in a total of 4 repetitions per treatment (each repetition consisted of 11 plants per linear meter). In order to avoid the edge effect and neighboring variants, they were taken randomly in the central part of each treatment.

Statistical processing

Once the data were taken, compliance of the theoretical assumptions of homogeneity of variance was verified (Kolmogorov, 1933). Subsequently, the respective analyses of variance of simple classification based on a linear model of fixed effects were performed (Fisher, 1937). When there were significant differences between treatments, Tukey's multiple comparison of means test (Tukey, 1960) was used for significance levels of 1%. The statistical indicators coefficient of variation (CV) and coefficient of determination (R^2) were determined without adjustment to elucidate in what percentage the established treatments explained the total variability existing in the variables evaluated. The professional statistical package Statistica version 12 was used for all analyses.

Number of pods per plant

This variable (Table 1) showed highly significant differences between the treatments (p= 0.0002). The treatment where T1 was applied had the highest number of pods per plant. In decreasing order, averages of treatments T2, T3 and T4 were obtained, with reductions of 8.4%, 13.8% and 34%

compared to T1, respectively. The results confirm that by using any of these developmental stimulants, at least an average increase in the number of pods of 18%, compared to the control, would be obtained. The variability of PP response was explained in 96% by the effect of the stimulants applied (R^2= 0.96); however, the (%) variability was high due to the dispersion that existed in treatment T4 with respect to the mean.

Table 1. Average of yield components in the cultivation of beans variety Pinto Bill Z in the Yaqui Valley, Sonora. Cycle S-S 2020.

Treatments	P P^{-1}	PL	# G P^{-1}	GM P^{-1}	GM L^{-1}
T1	25.22 ±1.1 a	11.13 ±1	4.8 ±0.3	1.53 ±0.02	38.1 ±2.1 a
T2	23.10 ±1.3 b	10.88 ±1.2	4.6 ±0.2	1.22 ±0.01	27.8 ±1.8 b
T3	21.72 ±1.3 c	11.74 ±1.8	4.5 ±0.1	1.28 ±0.04	27.3 ±2.5 b
T4	16.42 ±4.2 d	11.29 ±2.4	4.6 ±0.3	1.23 ±0.02	21 ±6.2 c
SE_x	0.53	0.01	0.01	0.04	0.34
CV	26.44	1.57	1.16	1.73	25.32
R^2	0.96	0.54	0.49	0.52	0.95

P P^{-1}= number of pods per plant; PL= pod length; #G P^{-1}= number of grains per pod; GM P^{-1}= grain mass per pod; GM L^{-1}= grain mass per plant. Different letters in the means of the treatments show significant differences by Tukey for p= 0.001. SE_x= standard error of the mean of the treatments; CV= coefficient of variation; R^2= unadjusted coefficient of determination.

Number of pods per plant, pod length and number of grains per pod

The number of pods per plant showed highly significant differences between treatments. In this variable, although it had a high percentage of variability (CV= 26.44), the effect of the treatments contributed 96% to the total variability found (R^2= 0.96). Pod length (with an overall mean of 11.2 cm) and the number of grains per pod (with an average of 4.6) showed no significant differences between treatments (p= 0.0532 and p= 0.0632, respectively) (Table 1). The number of grains per pod also showed no significant differences between treatments, although the tendency was to increase in T1. The results obtained indicate that the biostimulants applied do not cause variation in pod length or in the number of grains. These two characteristics present considerable genetic stability (López-Salinas *et al*., 2015) for beans of the commercial variety Pinto Bill Z.

Grain mass per pod and per plant

Grain mass per plant had significant differences in the present study (p= 0.0424), finding the highest value of the indicator when T1 was applied (1.53 g per pod). Treatments T2, T3 and T4 were statistically equal to one other (Table 1). Grain mass is a variable that demonstrates the rate of mobilization of carbohydrates and proteins from the leaves to the grain in beans, so a good nutritional status and an adequate water state favors that the substances produced arrive from the source (the leaves) to the sink (the fruits). The uneven distribution of the substances produced towards the pods demonstrates the existence of stress conditions (Prieto-Cornejo *et al*., 2019).

Grain mass per plant showed highly significant differences between treatments (*p*= 0.0016). In this variable, the variability found was explained in 95.4% by the effect of the established treatments. The effect of the use of developmental biostimulants shows the decrease in the variability of the mass of the grains, as observed in the standard deviation found in T4 (±6.2 g) where no developmental stimulant was applied.

Grain yield

There were significant differences between the means of all treatments (*p*= 0.0002). The highest grain yield was obtained in T1 with an average of 5.41 t ha^{-1} (Figure 1), higher by 1.7 t ha^{-1} with respect to T2 and T3, these two with significant differences only between them (*p*= 0.0472). The increase in yield in the treatments where biostimulants were applied demonstrates the feasibility of their use in bean cultivation as an alternative to mitigate the adverse effect of high temperatures during reproductive phenophases (Boote *et al*., 2018).

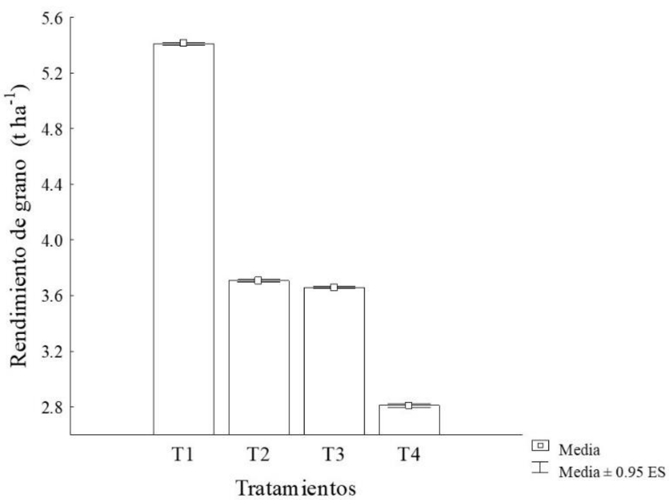

Figure 1. Grain yield of beans variety Pinto Bill Z in the Yaqui Valley, Sonora. Cycle S-S 2020. Rectangular bars indicate differences standard error of the means of each treatment (ES).

These yields are considered high for a SS cycle in this region and in others in Mexico, especially managed with traditional irrigation or gravity irrigation, this due to the considerable variation in temperatures for bean cultivation (Acosta *et al*., 2018).

Conclusions

The use of biostimulants in the present trial increased the number of pods per plant and the weight of the grains in beans of the variety Pinto Bill Z. The highest grain yield was obtained due to the application of FloraStart®, with an average increase of 2.3 t ha^{-1} with respect to the control. The application of this biostimulant contributes to raising bean productivity in southern Sonora and mitigating the effect of adverse conditions such as high temperatures.

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