# Cost-benefit of seed treatment and applications for the management of foliar diseases in common bean

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## ABSTRACT

The fungal diseases anthracnosis and angular leaf spot are the main pathology constraints of common bean production in Santa Catarina state. These diseases can be transmitted via seeds and have the potential of cause total losses of a bean crop. The objective of this work was to provide practical information regarding seed treatment, sequence and number of foliar applications on SCS205 Riqueza common bean during the second season. We evaluated yield and economic return of the different proposals for a minimum necessary of chemical use in an integrated disease management for a better fit of cost-benefit. Herein we show that seed treatment and two fungicides applications as preventive control for diseases ensure yield and economic return for the grower.
**Keywords:** Chemical control; interval and timing; fungicides; growth regulator.

## INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is cultivated over the central and western regions of Santa Catarina state (Brazil) over two seasons. The first season is established during springtime, sowed in October-December and harvested in January-March, and the second season is sown during the summer, between January and March and harvested in May-July. It was accounted a sowed area of 58.3 thousand ha in 2018/2019 season, with productivity of 1.796 kg $ha^{-1}$ and production of 104.7 thousand ton (Conab, 2019). The two most important diseases of common beans are the anthracnosis, caused by the phytopathogenic fungi *Colletotrichum lindemuthianum*, and angular leaf spot, also caused by a fungi, *Phaeoisariopsis griseola*. These diseases can be transmitted via seeds and have the potential of cause total losses of a bean crop.

These diseases can be managed through adoption of integrated disease management, which consists with timely application of a combination of strategies and tactics included in cultural practices, genetic resistance and chemical fungicides, which can be used in the seeds treatment and foliar application (Pandey et al. 2016). The active ingredients azoxystrobin, trifloxystrobin and pyraclostrobin belong to the chemical group of the strobilurins. Because of high risk of pathogen resistance for their very specific mode of action, strobilurins are usually offered mixed with other chemical groups such as triazoles. Acibenzolar-S-methyl is an analogue to salicylic acid, of the benzothiadiazole group, and activates latent plant disease resistance through the acquired systemic resistance via.

Seed treatment with fungicides protects the crops in the early phases from pathogenic fungi present in the soil and transmitted via seeds. Additionally, sequential foliar spray of fungicides applied in the appropriate timing in a planned system based on crop development stage is a management intervention needed to keep diseases below economic damage. The objective of this work is to provide practical information regarding seed treatment, sequence and number of foliar applications on common bean during second season. We evaluated yield and economic return of the different proposals for a minimum necessary of chemical use in an integrated disease management for a better fit of cost-benefit.

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## MATERIAL AND METHODS

The experiment was conducted on a second season bean crop in 2018, in the experimental field of Epagri, in Chapecó, SC. Seedbed preparation consisted in herbicide dissection before basic seeds of SCS205 Riqueza (Kavalco et al. 2017) was sown using a tractor-propelled sowing machine. The experiment was established with 12 proposals with 4 replications each (Table 1), arranged as a randomized block design. Two-hundred and forty seeds were placed in each plot, which was 4 m long (4 rows spaced 0.45 m apart). The plots were spaced 1 m between them to avoid product drift. Except proposals 1 and 3 (Table 1), all the seeds sown in the other plots received a fungicide and insecticide treatment, using carbendazim + thiram, 45 + 105 g ai 100 kg-1 (Bayer CropScience) and imidacloprid 140 g ai 100 kg-1 (Bayer CropScience). Phytosanitary products included in this experiment are currently contemplated in the list of registered products for bean production provided by the Ministry of Agriculture, Livestock and Food Supply (Brazil). The proposals included seed treatment of and foliar applications of azoxystrobin + difeconazole, 100 + 62.5 g ai $ha^{-1}$ (Syngenta Crop Protection), trifloxystrobin + prothioconazole, 75 + 87.5 g ai $ha^{-1}$ (Bayer CropScience), pyraclostrobin + metconazole, 65 + 40 g ai $ha^{-1}$ (Basf, Schwarzheide), thiophanate-methyl + chlorothalonil, 360 + 900 g ai $ha^{-1}$ (Iharabras) and acibenzolar-S-methyl 25 g ai $ha^{-1}$ (Syngenta Crop Protection) (Table 1). Harvesting was performed when pods were fully matured, manually pulling up the plants of the two main rows of the plots. Grain were mechanically separated from gross plant debris. Grain humidity of each parcel was adjusted to 13%. Then, dockage and pick were estimated for each parcel according with Pynenburg et al. (2011). Briefly, dockage, which is defined as any material or seed below the standard quality intermixed with the grain sample, was removed using a 0.35 cm x 1.9 cm oblong steel sieve. Pick was estimated as the percentage of discoloured grain in a random sample of 100 grains, after dockage was removed. Net yield already converted to kg $ha^{-1}$ was calculated using formula 1 described below, where pick was removed twice considering the grading factor and the cost of removing the unmarketable grain: Average market price practiced by bean processors for the 2018 second season was 96.675 BRL per 60 kg sack (Conab, 2019). This information was used to calculate the gross return, with the formula 2:

$$\text{(1)}\quad Net\ yield\ (kg/ha) = \left[\left(adjusted\ harvested\ weight\ to\ 13\%\ (g) - dockage\ (g)\right) - \left(\left(\frac{pick(\%)}{100}\right)\cdot 2\right)\right]\cdot 10/3.6$$

$$\text{(2)}\quad Gross\ return\ (BRL) = [Net\ yield\ (kg/ha)/60]\cdot 96.675$$

The cost of each management proposal was calculated for each parcel considering the retail price of chemical products used in this work and the application cost of foliar spray. The cost of each product was calculated for the dosage recommended in their prescription applied in each proposal per hectare. The application cost of foliar sprays was estimated considering a simulated price for machinery and labour supply for intervention per hectare (12 BRL). No cost of intervention was attributed to Control (Table 1). Then, the economic return for each parcel was calculated subtracting treatment cost (cost of chemical product demanded per ha + cost of intervention for foliar spray) from gross return. Statistical analysis was performed using ANOVA Duncan's test at $p \leq 0.05$, after checking normality and homogeneity. Statistical analysis was carried using Agricolae package (version 1.2-4, 2016) of the R.

Table 1. Proposals for foliar common bean diseases, with employment of different chemicals, number of interventions and application timing and the cost of fungicide interventions in a second season crop

| Proposal | Description | Seed treatment | Phenological stage of foliar application V3 | V4 | R5 | R7 | Cost of interventions (BRL) |
|---|---|---|---|---|---|---|---|
| 1 | Control | - | - | - | - | - | 0 |
| 2 | ST | F | - | - | - | - | 13.69 |
| 3 | 2 FA | - | - | A | - | D | 228.50 |
| 4 | ST + 1 FA | F | - | - | A | - | 131.19 |
| 5 | ST + 2 FA | F | - | A | - | D | 242.19 |
| 6 | ST + 2 FA | F | - | D | - | A | 242.19 |
| 7 | ST + 3 FA | F | A | - | D | A | 359.69 |
| 8 | ST + 2 FA | F | - | B | - | D | 240.49 |
| 9 | ST + 2 FA | F | - | C | - | D | 177.79 |
| 10 | ST + 2 FA | F | E | - | - | E | 177.79 |
| 11 | ST + 2 FA | F | E | - | A | - | 204.79 |
| 12 | ST + 3 FA | F | E | - | A | E | 278.39 |

Note: ST = Seed treatment; FA = Foliar application. Description of vegetative (V) and reproductive (R) phenological stages of common bean plant: V3 = 3rd trifoliolate leaf unfolded; V4 = 4th trifoliolate unfolded; R5 = one pod with fully developed seeds; R7 = one pod at mature colour. Fungicides: A) azoxystrobin + difenoconazole, B) trifloxystrobin + prothioconazole, C) pyraclostrobin + metconazole, D) thiophanate-methyl + chlorothalonil, E) acibenzolar-S-methyl, F) carbendazim + thiram. Cost of intervention in Brazilian Real (BRL), considering the cost of chemical product demanded by ha following the dosage recommended in their prescription + a simulated cost of intervention for foliar spray (12 BRL).

## RESULTS AND DISCUSSION

We prompted to analyse whether the employment of seed treatment and foliar spray would entail benefit for the producer. In our experiment, we presented suggestions of number of foliar applications and various application timings with different chemical products. Although it was not registered high levels of anthracnosis and angular leaf spot during this crop season, our results show that it is worth performing seed treatment and two preventive applications of fungicides on the bean crop cultivation. The proposals that contained two fungicide sprays resulted in improved net yield and net economic return (Table 2), also a higher seed mass retained in the seed (Fig. 1), which could be explained by the retention of bigger grains. Better cost-benefit of acibenzolar-S-methyl was obtained when this active ingredient was combined with a fungicide (Table 2). In fact, the actual recommendation of its use is in a management program along traditional fungicides.

Table 2. Mean of yield and economic parameters of the evaluated treatments applied for management of foliar diseases on common bean (cv. SCS205 Riqueza) during a second season in Chapecó, SC

| Proposal | Net yield (kg ha$^{-1}$) | | Net economic return (BRL ha$^{-1}$) | |
|---|---|---|---|---|
| 1 | 1927.69 ± 51.49 | b | 3105.99 ± 82.97 | bc |
| 2 | 2047.01 ± 271.45 | b | 3056.08 ± 437.38 | bc |
| 3 | 1915.67 ± 149.31 | b | 2858.12 ± 240.58 | c |
| 4 | 2193.52 ± 25.36 | ab | 3403.11 ± 40.87 | abc |
| 5 | 2401.58 ± 45.30 | a | 3627.36 ± 72.99 | ab |
| 6 | 2477.79 ± 114.18 | a | 3750.14 ± 183.98 | a |
| 7 | 2284.12 ± 117.82 | ab | 3320.60 ± 189.84 | abc |
| 8 | 1919.11 ± 133.07 | b | 2851.67 ± 214.41 | c |
| 9 | 2184.79 ± 133.41 | ab | 3342.45 ± 214.96 | abc |
| 10 | 2005.43 ± 89.12 | b | 3053.45 ± 143.59 | bc |
| 11 | 2257.43 ± 107.61 | ab | 3432.48 ± 153.90 | abc |
| 12 | 2219.80 ± 40.80 | ab | 3298.26 ± 65.74 | abc |

Note: Proposals are described in Table 1. Mean ± Standard error followed by same letters are not different by Duncan's test ($p < 0,50$). Means are a result of yield and economical return calculation of each plot ($n = 4$).

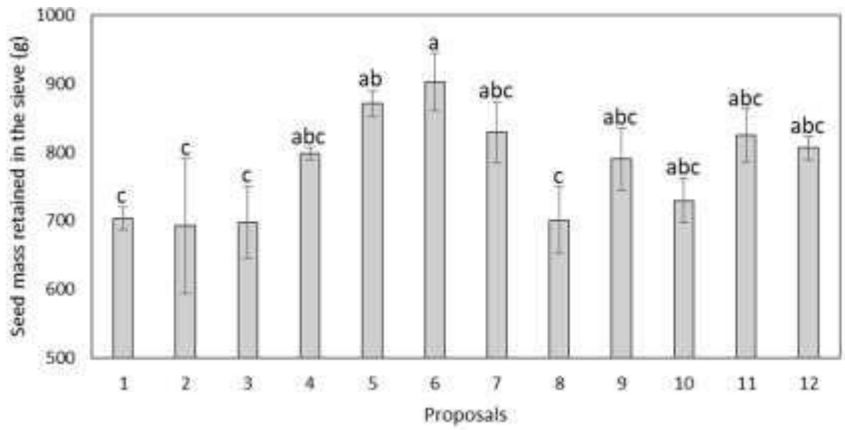


Figure 1. Seed mass retained in the 3.5 mash sieve. Error bars represent standard error. Letters are not different by Duncan's test (p < 0,50).

Our results are in accordance with the recommendations of other research groups, that reported a superior performance of common bean production regarding plant health, crop maturity and yield when they combined seed treatment and foliar spray, and verified that sequential fungicide treatments were superior to single fungicide treatment (Pynenburg et al. 2011, Gillard et al. 2012). It is important for the growers of Santa Catarina to integrate disease management tools considering the use of disease-resistant crop varieties, appropriate hygienic practices such as crop rotation and soil management, along with the adoption of seed treatment and foliar spray with fungicides. Adequate disease management can result in a production grater in quantity and quality, hence in a more appropriate economic return.

## CONCLUSION

Seed treatment and two fungicides applications as preventive control for diseases ensure yield and economic return for the grower.

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