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Article

Bioinsecticides for the control of *Zabrotes subfasciatus* Boheman and seed quality in beans

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Abstract

Beans are the second most important crop in Mexico for human consumption. During storage, there have been losses of more than 35% due to the attack of weevils, for which chemical control represents the most common method. Great efforts have been made in the search for methods of natural control. This study aimed to evaluate, in three varieties of beans (Negro, Peruano and Flor de Mayo), the effect of the use of plant powders (*Eucalyptus globulus* and *Tagetes erecta*) with two drying methods (natural and freeze-drying) on the mortality of bean weevil (*Zabrotes subfasciatus*) and seed quality. Mortality was assessed at 24, 48, 72 and 96 h. There were statistical differences between varieties and plant powders, but not for doses and drying methods. The highest cumulative mortality was observed with eucalyptus with 71.41%; in contrast, marigold reached 52.93%. The seed treated with powders reached 87% germination, while the control had 88%.

Keywords:

Eucalyptus globulus, *Tagetes erecta*, *Zabrotes subfasciatus*, plant powders, seed quality.

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Introduction

As of July 31, in the autumn-winter 2022-2023 cycle, 203 375 ha were harvested, which represented an advance of 99.9% of sowings, in which 244 664 t have been obtained. Sinaloa has generated 92 535 t, 37.8% of the total for the cycle; Nayarit 69 246 t, 28.3%; Chiapas 27 125, 11.1%; Veracruz 18 826, 7.7%, and the rest of the states 36 933 t, 22.7% of the total (SIAP, 2023).

A consumption of 1 013 t and a final inventory of 83 000 t are calculated to supply 1.0 months (SIAP, 2023). Prices show differentiated behaviors. In July 2023, the average rural price of pinto beans was $12.63 pesos kg^{-1}, similar to that paid the previous month and 33.1% lower than that paid in the same month of 2022. The reference price for wholesale beans was $25.29 pesos kg^{-1}, 1.2% lower than that registered in the previous month and 11.9% higher than in July 2022. On the other hand, the price paid by the consumer was $41.30 pesos kg^{-1}, 3.6% more than that observed last June and 19.4% higher in annual comparison (SIAP, 2023).

Adverse weather conditions, mainly drought in important producing regions, affected global bean production during 2019; in contrast, in 2020, it managed to recover to 27.5 million tonnes, a volume obtained in 34.8 million hectares cultivated with this legume, according to FAO information. The main producing and consuming countries, India, Myanmar, and Brazil, continue to boost global bean production.

With a world consumption of around 25 million tons, per capita consumption has shown a stable trend in the last five years and stands at 2.46 kg per person per year. It is around 12.7 kg in Brazil, 4 kg in India, 2.8 kg in Myanmar, 1.8 kg in the United States of America, and 7.8 kg in Mexico, according to FAO estimates. Approximately 16% of the world's production is traded on the international market.

In Mexico, beans are the third most important crop by area planted, with 7.9% of the total in the agricultural year; on the other hand, they ranked tenth in terms of the value of national agricultural production, with a share of 2.4% in 2020. In the 2021 agricultural year, 1 176 million tons were obtained in a harvested area of 1.6 million hectares, 87.2% of rainfed and 12.8% of irrigation, which meant an increase of 11.3% compared to the production of the 2020 agricultural year.

Greater rainfall in the main rainfed regions mainly favored the recovery of average yields per unit of area, so national production grew for the second consecutive year after the strong impact of the drought recorded in 2019. Seventy-three point two percent of the production was obtained in the spring-summer cycle and 26.8% in the autumn-winter (A-W) cycle. The Negro, Pinto and Azufrado/ Peruano bean varieties are the ones with the highest participation in national production. Five states participated together with 68.2% of the national production: Zacatecas (29.9%), Sinaloa (13%), Durango (10.5%), Chihuahua (8.9%) and Nayarit (6%).

The average yield was 1.76 t ha^{-1} under irrigation conditions and 590 kg ha^{-1} under rainfed conditions. On the other hand, the consumption of beans in Mexico during the commercial cycle from Oct. 2020 to Sep. 2021 is estimated at 1 061 million tons. Nine percent of this volume was supplied with imported beans, mainly from the United States of America. During the first eleven months of 2021, Mexico imported 177.5 thousand tons of beans and exported 37.2 thousand tons (FAO, 2022).

The conservation and protection of this grain during storage is a food, social and economic need. More than two decades ago, it was estimated that 5-10% of the world's food grain production was lost due to warehouse insects, which, at that time, could help feed 130 million people annually (FAO, 1999). For Central America and Mexico, postharvest losses have been estimated to reach up to 35% of stored beans (Nava-Pérez *et al*., 2010).

The species that causes the most damage to stored beans is the Mexican bean weevil [*Zabrotes subfasciatus* (Boheman)], order Coleoptera, family Chrysomelidae, subfamily Bruchinae (De Franca, 2012). The deterioration of bean grain as a result of the attack of these insects occurs when the larvae feed on the seeds, causing damage to the cotyledons. The grains are covered

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with eggs and present perforations that correspond to the feeding chambers of the insects, which causes significant weight loss.

There are several technical and management alternatives that have been implemented to reduce postharvest losses, mainly during bean grain storage (López-Monzón *et al*., 2016). The increase in imports and decrease in exports is a consequence of the fact that the country's weather conditions have not favored domestic production, coupled with the exchange rate and the fact that the legume is free of tariffs for countries with which Mexico does not have a trade agreement, several nations have managed to increase their participation in the national market, which is reflected in the volume acquired from the foreign market (SIAP, 2023).

This research aimed to evaluate, in three varieties of beans (Negro, Peruano and Flor de Mayo), the effect of plant powders (*Eucalyptus globulus* and *Tagetes erecta*) with two drying methods (natural and freeze-drying) on the control of the bean weevil and seed quality.

Materials and methods

The work was carried out in the Seed Health Laboratory of the Technological Institute of Roque; 244 stems of marigold plants, *Tagetes erecta*, were collected randomly from a crop in the municipalities of Comonfort and Valle de Santiago, Guanajuato, Mexico, in November 2019. For the freeze-drying method, the leaves and flowers of the plants were placed in 50 ml Falcon tubes in an ultra-low freezer (Thermo Scientific®, Model 931, Series TSE) at -80 ±1 °C for three weeks, then placed in a freeze-dryer (Scientz® -18N) at a pressure of 15 kPa and a final temperature of 22 ±2 °C.

For the method of natural drying at room temperature, the leaves and flowers of the plants were placed in negro plastic bags and the material was placed for 48 h at room temperature until the material had a crispy consistency to the touch. Both materials -freeze-dried and naturally dried- were ground, one in a Krups® mill and a UDY® cyclone mill, model Ciclone SDMPUCM; for storage, they were placed in airtight containers.

For the reproduction of the weevil *Zabrotes subfasciatus* Boheman, 500 unsexed adults were placed per 700 g of Mayocoba beans in 1 000 ml plastic containers covered with organza fabric in a bioclimatic chamber (VWR S/P, Sheldon MFG, Inc., Model 3025T) at a temperature of 28 ±2 °C and a photoperiod of 12:12. Four weeks later, the F2 generation was obtained, from which 10 adult weevils were taken and placed in a 256 ml plastic container with a lid, which contained 100 g of seed of each variety of beans (Flor de Mayo, Peruano and Negro beans) owned by the germplasm bank of INIFAP, Celaya; likewise, they were produced under the same technological package of bean production; the doses of the corresponding plant powder were added to them (Table 1) and they were stirred manually for 30 s for homogenization (Cerna *et al*., 2010).

Table 1. Plant powders and concentration of eucalyptus and marigolds.

Plant powder	Dose	Drying method
Eucalyptus	0.5 g	Freeze-drying
	1 g	Natural
Marigold	0.5 g	Freeze-drying
	1 g	Natural

To quantify weevil mortality (M), the method described by Mazzonetto (2002) was used; the counts were carried out over a period of 24, 48, 72 and 96 h. The correction of mortality was made using the formula described by Abbott (1925). MC= mortality between treatment-mortality in the control100-mortality in the control × 100. Where: MC= is corrected mortality.

Physiological seed quality: for physiological quality tests, 50 seeds were taken from each previously stored bioassay; of these, 25 seeds were used for the standard germination test and 25 for sand bed. The standard germination test was used to record the germination percentage (GP); the sand

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bed test for the emergence percentage (EP), emergence speed (ES), and seed vigor index II (VIII). The methodology described by ISTA (2005) was used for the counts.

Experimental design: the experimental design used was completely randomized with a four-factor factorial arrangement in four replications. The traits evaluated for weevil mortality were mortality at 24, 48, 72 and 96 h, cumulative mortality at 48, 72 and 96 h. Regarding seed quality, the traits evaluated were germination percentage (GP); emergence percentage (EP); emergence speed (ES); and vigor index II (IVII). The data recorded for each of the variables studied were subjected to analysis of variance (Anova) with a comparison of means of LSD (## 0.05). The Sas statistical package version 9.3 (Sas Institute, 2011) was used for the analyses.

Results and discussion

Table 2 presents the mean squares for *Z. subfasciatus* mortality per day and cumulative mortality at 24, 48, 72 and 96 h of exposure; significant differences in mortality per day and cumulative mortality at all exposure times due to the effect of the varieties were examined; on the other hand, for the drying methods (freeze-drying and natural), they have a significant effect on the survival of the weevil under study at 24, 72 and 96 h, while differences were observed in cumulative mortality at 48 and 96 h of exposure. Plant powders have a significant effect on daily and cumulative mortality of *Z. subfasciatus* at all exposure times evaluated.

Table 2. Mean squares of the variables for mortality of weevils *Zabrotes subfasciatus* at 24, 48, 72 and 96 h in Negro, Flor de Mayo and Peruano beans with two drying methods and two doses of plant powders in 2019.

Source of variation	Mortality (h)				Cumulative mortality (h)		
	24	48	72	96	48	72	96
Variety	121.11**	3. 51*	4.07*	49.38**	83.65**	50.18**	12.74*
Drying method	2.8*	0.46^{ns}	8.24*	3.25*	3.32*	0.22^{ns}	1.17*
Plant powders	100.55**	80.71**	90.32**	54.22**	218.03**	313.38**	377.99**
Dose	0.01^{ns}	7.4*	0.01^{ns}	0.56^{ns}	1.75*	0.21^{ns}	0.72^{ns}
Var x DM	1.16*	0.04^{ns}	0.37^{ns}	0.13^{ns}	0.71^{ns}	1.83*	1.76*
Var x PP	45.98**	7.07*	7.55*	12.9*	42.71**	16.72**	6.14*
Var x dose	0.2^{ns}	1.15^{ns}	1.99*	0.26^{ns}	0.01^{ns}	0.99^{ns}	0.34^{ns}
DM x PP	1.85*	2.63*	2.24*	8.24*	0.83^{ns}	0.07^{ns}	1.36*
DM x dose	3.9*	0.02^{ns}	0.43^{ns}	5.31*	0.88^{ns}	1.39*	0.01^{ns}
PP x dose	0.03^{ns}	1.89*	0.47^{ns}	0.24^{ns}	0.47^{ns}	0.39^{ns}	1.38*
Var x DM x PP	0.5^{ns}	5.22*	0.19^{ns}	0.06^{ns}	3.02*	1.75*	2.1*
Var x PP x dose	1.08*	0.32^{ns}	0.68^{ns}	1.07^{ns}	0.68 ns	1.48*	0.34^{ns}
DM x PP x dose	0.98*	0.45^{ns}	1.77*	1.85*	0.86^{ns}	0.39^{ns}	0.45^{ns}
Var x DM x PP x dose	0.46^{ns}	0.45^{ns}	1.54*	0.04^{ns}	0.4^{ns}	0.23^{ns}	0.29^{ns}
Error	1.11	2.43	2.05	2.14	2.19	1.84	1.62
CV	39.77	50.43	46.07	57.68	35.16	24.69	20.18

**, *= statistical significance at 0.01 and 0.05 respectively; ^{ns}= not significant.

In the interaction of drying method by plant powder, there were significant differences, except for the cumulative mortality at 48 and 72 h. The interaction of variety by dose shows no differences, except for percentage of mortality at 96 h; the interaction of drying method by dose showed significant differences at 24 h in the percentage of mortality and at 96 h of exposure, it was significant for both

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percentages; the effect of plant powders by dose only presented significant differences in mortality at 48 h and in cumulative mortality at 96 h.

In the interaction of the three variables under study, variety by drying method by plant powder, significant differences were perceived in mortality at 48 h and in cumulative mortality at 48, 72 and 96 h, while for the interaction of variety by plant powder by dose, it only showed significant differences in mortality at 24 h and in cumulative mortality at 72 h.

Table 3 shows the mean squares for the variables of germination percentage (GP), emergence percentage (EP), emergence speed (ES), and vigor index II (IVII), where there were highly significant differences in each of the variables evaluated for variety; significant differences were also analyzed in emergence percentage and vigor index for drying methods; however, for plant powders, significant differences were observed for germination percentage, emergence percentage, emergence speed, and vigor index II; for the effect of the dose, there were only differences in germination percentage.

Table 3. Mean squares of germination percentage, emergence percentage, emergence speed and vigor index II (IV II) evaluated in Negro, Flor de Mayo and Peruano beans with two drying methods, two plant powders and two doses in 2019.

Source of variation	GP	EP	ES	IV II
Variety	7 542.98**	1 756.31**	171.8**	41 792.38**
Drying method	0.39 ns	189.7*	0.12 ns	6 929.17*
Plant powders	178.27*	448.66*	13.27*	3 610.4*
Dose	498.77*	7.32 ns	0.18 ns	43.32 ns
Var x DM	455.41*	843.19*	2.67*	4 169.58*
Var x PP	537.86*	723.4*	21.58*	1 162.14*
Var x dose	342.26*	46.29 ns	0.29 ns	452.29 ns
DM x PP	154.98*	1069.19*	6.44*	966.62*
DM x dose	37.78 ns	77.2*	2.77*	467.06 ns
PP x dose	278.88*	408.71*	0.1 ns	2 103.41*
Var x DM x PP	96.95 ns	343.72*	4.23*	1 384.52*
Var x PP x dose	160.89 ns	142.53*	0.52 ns	1 378.14*
DM x PP x dose	13.62 ns	401.55*	4.72*	1 784.14*
Var x DM x PP x dose	160.58 ns	321.17*	1.57 ns	1 198.52*
Error	259.85	137.02	3.8	1 347.73
CV	21.02	15.7	14.5	24.54

GP= germination percentage; EP= emergence percentage; ES= emergence speed; IVII= vigor index II; **, *= statistical significance at 0.01 and 0.05 probability; ns= not significant.

In the interactions where varieties with drying methods and plant powders participate, there were significant differences for all study variables. Regarding the interaction of varieties by dose, there were only differences in germination percentage; in the interaction of drying method by plant powders, significant differences were observed in each of the variables; for drying methods by dose, there were only significant differences in emergence percentage and vigor index II; in the interaction of plant powder by dose, there are significant differences in the variables, except for emergence speed, which does not show differences; in the interactions of variety by drying method by plant powder and drying method by plant powder by dose, significant differences were observed in the variables, excluding germination, which was not significant; for the interactions of variety by plant powder by dose and variety by drying method by plant powder by dose, significant differences were observed only for emergence percentage and vigor index II.

Table 4 shows significant differences between the varieties, where the Negro bean reached its highest mortality percentage at 24 h with 19.57% while the Flor de Mayo and Peruano varieties

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only reached 2.48% on average, which represents 88% more mortality. Flor de Mayo and Peruano registered the highest percentage of mortality at 72 h with 9.55% and 10.19%, respectively.

Table 4. Comparison of means of LSD (α= 0.5) for mortality by count and per day at 24, 48, 72 and 96 h and cumulative mortality at 48, 72 and 96 h, Roque, Celaya, Guanajuato, in 2019.

Variety	Mortality by count (h)				Cumulative mortality (h)		
	24	48	72	96	48	72	96
Flor de Mayo	2.63b	8.02a	9.55a	9.17a	11.33b	23.41b	34.9b
Peruano	2.35b	8.14a	10.19a	9.3a	11.33b	23.7b	36.34b
Negro	19.57a	11.06a	7.23a	1.36b	32.33a	44.12a	47.11a
				Method			
Freeze-drying	7.28a	9.36a	10.65a	5.16a	18.42a	29.31a	38.18a
Natural	5.8a	8.68a	7.68b	6.68a	15.9a	30.19a	40.46a
				Mortality per day			
Without no powders	0.78c	2.59c	1.9b	1.29b	3.38c	6.84c	9.36c
Eucalyptus	15.58a	18.42a	16.72a	7.79a	38.18a	59.4a	71.41a
Marigold	7.39b	9.36b	12.53a	10.72a	18.95b	35.98b	52.93b
				Dose			
0.5 g	6.47a	10.45a	9.17a	6.2a	18.07a	30.19a	40.2a
1 g	6.57a	7.68a	9.04a	5.6a	16.22a	29.31a	38.43a

For cumulative mortality, the Negro bean variety reached 40% mortality at 72 h and 47.11% at 96 h, while the Flor de Mayo and Peruano varieties were statistically grouped equally and at 96 h, they had barely reached 34.9% and 36.34%, respectively. These results may be due to the antibiosis effect conferred by the amount of a protein called arcelin in the cotyledons, as reported by Harmsen *et al*. (1987); Miranda *et al*. (2002), which has been responsible for the resistance effect to the attack of *Zabrotes subfasciatus*. For their part, Guzmán *et al*. (1995) indicated that the protective effect in beans is given by the lectin content, which, in their study, was higher in the Flor de Mayo variety.

In the comparison of means by drying methods for daily and cumulative mortality, it is observed that there are no differences between drying methods for the variables evaluated, except for mortality at 72 h, where higher mortality values are observed for freeze-drying with 10.65% compared to the natural method that only registered 7.68%.

Concerning the cumulative mortality at 96 h, only the natural method had reached 40% at that exposure time. In this regard, Paez *et al*. (1990); Lagunes (1994) established, as a criterion, that plant powder treatments that show mortality greater than 40% are promising; in this study, it was highlighted that freeze-dried powders did not achieve this threshold on average, so powders prepared under the natural drying method should be preferred in addition to the fact that they present a more affordable option for farmers.

On the other hand, in the means obtained by plant powder for mortality per day and cumulative mortality, it was observed that the highest values were recorded for eucalyptus, which, at 48 h of exposure, had almost achieved 40% mortality, at 72 h of exposure it registered 59.4% and by 96 h it had reached 71.41% of accumulated mortality; in contrast, marigolds only reached 52.93% cumulative mortality at 96 h of exposure, which represents 25.87% more survival of *Z. subfasciatus* in the application of marigolds.

These results are consistent with those obtained by Nava *et al*. (2010), who used aqueous extract of eucalyptus to control *Acanthoscelides obtectus* with 61.57% and 74.44% at 3 and 6 days of

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application, respectively, compared to this study in which eucalyptus showed 71.41% of cumulative mortality at 96 h. Likewise, this study coincides with the one carried out by Issa *et al*. (2011) with garlic extracts in *Sitophilus* at 96 h of exposure, in which they observed that, as the extract is in contact with the weevil for prolonged periods, its mortality increases.

For the doses in mortality per day and cumulative mortality, they are shown in Table 2, where no significant differences were found in exposure times; therefore, it is advisable to use the lowest dose of 0.5 g, which represents a proportion of 5 k of plant powder for each tonne of seed, thus reducing costs and having the same effects as with the use of the highest dose of 1 g. In this regard, Shaaya *et al*. (1997) mention that the use of high doses of plant oils can cause severe detriments in germination, which make them unsuitable for the control of seed storage pests. Paul *et al*. (2009) states that the mortality of *Z. subfasciatus* varies by up to 20% at 24 and 48 h of exposure depending on the dose of plant powder used.

In this regard, Ortega-Nieblas *et al*. (2014) point out that higher doses of oregano essential oil increased mortality in *Z. subfasciatus* and decreased exposure time to achieve 100% mortality. For his part, Lagunes (1994) pointed out that, at present, plant powders represent an alternative for the control of these pest insects. Additionally, it is necessary to consider what Isman (2006) warned, who indicated that the main benefit of natural pesticides may be that obtained under low-tech agriculture schemes and in developing countries that cannot afford the purchase of synthetic pesticides, but also in organic agriculture.

Table 5 showed that seed quality behaves differently between varieties. The GP is higher in Negro beans with 93.72%, Peruano beans and Flor de Mayo did not reach 90% germination percentage (GP). The ISTA (2005) indicated that the minimum GP in seeds was 85%; nevertheless, González (1995) pointed out that seeds treated with plant powders that did not exceed 90% germination cannot be marketed as seeds.

Table 5. Comparison of means of LSD (α= 0.5) for the variables of emergence percentage, emergence speed, vigor index II and gemination percentage by plant powder. Roque, Celaya, Guanajuato, 2019.

Variety	GP	EP	ES	IVII
Flor de Mayo	79.44c	90.13a	15.28a	127.74b
Peruano	88.91b	88.17a	11.5c	183.15a
Negro	93.72a	83.34b	13.37b	137.85b
		Method		
Freeze-drying	87.53a	87.92a	13.35a	156.5a
Natural	87.58a	86.6a	13.41a	142.65b
		Powder		
Without powder	88.68a	88.71a	13.91a	153.64ab
Eucalyptus	87.49a	87.49ab	13.38ab	155.48a
Marigold	86.48a	85.29b	12.86b	139.62b
		Dose		
0.5 g	86.49a	87.39a	13.35a	149.03a
1 g	88.61a	87.13a	13.42a	150.13a

GP= germination percentage; EP= emergence percentage; ES= emergence speed; IVII= vigor index II.

The lower germination rate in the case of Flor de Mayo (79.44) may be due to the fact that this variety has greater adherence of the testa to the cotyledons, so imbibition is slow (Powell *et al*., 2005); therefore, the percentage of germination decreases and is delayed. Agronomic and nutrition management was in accordance with INIFAP's technological package. The Flor de Mayo and Peruano varieties were statistically the same for the EP, with 89.15% on average, which represented 6.51% more than what was observed in Negro beans, for which 83.34% was recorded.

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The delay in EP observed in Negro beans may be due to the fact that this variety contains a higher amount of flavonoids that restrict seed germination (Debeaujon *et al*., 2000). For ES, it was again observed that the three varieties under study behaved differently. In this case, the Flor de Mayo variety showed 15.28, the Negro 13.37 and the Peruano 11.5; it could be observed that there was a difference of 24.7% between the highest and lowest ESs.

The differences between the evaluated seed quality parameters can be attributed to the characteristics of each genotype, such as the testa, color, and size of the seed (Rangel *et al*., 2011). For the vigor index (IVII), it was noted that, of the two statistical groups, Peruano beans registered 183.15 and the Peruano and Flor de Mayo varieties showed 137.85 and 127.74, respectively. Therefore, Peruano beans registered 27.49% more than the average of the other two varieties under study.

The results obtained in the IVII are consistent with what was indicated by Gholami *et al*. (2009), who indicated that the advantage of the larger size of a seed is that it produces seedlings with a higher growth rate than those analyzed with small seeds, such as the Peruano beans. For the drying methods, in the seed quality variables, only significant differences were observed in the IVII; in this case, it was found that the seed treated with freeze-dried plant powders was the most vigorous with 156.5, which represents 8.8% more than the powders dried naturally.

It should be noted that the GP recorded for both drying methods exceeded 85%, which is the value set by the ISTA; however, González (1995) pointed out that seeds treated with plant powders that do not exceed 90% germination cannot be marketed as seeds. As for the powders, in EP, the control, which showed 88.71%, and the marigolds in a second statistical group, which had 85.29%, showed significant differences. The same behavior was shown for the ES, a variable that was 13.91 for the control and 12.86 for the marigold. For IVII, the highest value was observed in treatments with eucalyptus plant powder and in a second statistical group was marigold with 139.62.

The results showed that, for the four quality variables evaluated, the values recorded in the application of marigolds are the lowest. These results are consistent with those reported by Santos *et al*. (2015); when evaluating aqueous, hydroethanolic, and ethanolic extracts of *Tagetes erecta* and *Tagetes patula* applied to *Lactuca sativa* seeds in three concentrations, in the results they perceived that, at a higher concentration of *Tagetes* extracts, the seeds decreased the GP to 0% compared to a control that registered 98%; derived from these results, they indicated that the species of the genus *Tagetes* contain various compounds capable of directly interfering in the germination and growth of seedlings of other species.

In this regard, Hernández *et al*. (2006) reported that seeds treated with different plant oils decreased germination, there was a reduction of up to 50% in seedling height, and the fresh and dry weight of seedling decreased by 35 to 45%. It is important to note that, according to international standards, seeds treated with plant powders that show values of less than 90% germination could not be marketed as seed (González, 1995). Nonetheless, for low-tech agriculture or for subsistence farmers, germination values above 70% are acceptable. In the present study, no treatment reached 90% GP.

Conclusions

The drying method and the dose of the plant powders used did not influence the mortality results, so it is advisable to use the powders dried naturally and the dose of 0.5 g to reduce costs. When eucalyptus plant powder was applied to bean seed, 71.41% of accumulated mortality of *Zabrotes subfasciatus* was reached at 96 h of exposure; in contrast, only 52.93% was recorded with marigolds. Therefore, the effect of eucalyptus is 25.87% more effective compared to marigold, across bean varieties. In the average seed of the varieties in this study, with plant powders, it showed 87% GP on average; therefore, it is suitable for sowing in non-technified agriculture or traditional agriculture.

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Bibliography

1 Abbott, W. S. 1925. A method for computing the effectiveness of an insecticide. Journal Economic Entomology. 18(2):265-267.

2 Cerna, Ch. E.; Landeros, F. J.; Ochoa, F. Y. M.; Guevara, A. L.; Badi, Z. M. and Olalde, P. V. 2010. Evaluación de aceites y extractos vegetales para el control de *Sitophilus zeamais* y su efecto en la calidad de semilla de maíz. Revista FCA UNCuyo. 42(1):135-145.

3 Debeaujon, I.; Leon-Kloosterziel, K. M. and Koornneef, M. 2000. Influence of the testa on seed dormancy, germination and longevity in *Arabidopsis*. Plant Pthysiology. 122(2):403-414.

4 De Franca, S. M.; Vargas-Oliveira, A. B.; Esteves-Filho, A. B. and Moura-Oliveira, C. 2012. Toxicity and repellency of essential oils to *Zabrotes subfasciatus* (Boheman) (Coleoptera, Chrysomelidae, Bruchinae) in *Phaseolus vulgaris* L. Acta Amazónica. 42(3):381-386.

5 FAO. 2022. Organización de las Naciones Unidas para la Agricultura y la Alimentación. Alimentación Panorama alimentario frijol. https://sursureste.org.mx/wp-content/uploads/2023/01/Panorama-Agroalimentario-Frijol-2022.pdf. 227 p.

6 FAO. 1999. Organización de las Naciones Unidas para la Agricultura y la Alimentación. Alimentación, nutrición y agricultura. 2ª. Ed. Roma, Italia, Dirección de Información de la FAO. 56 p.

7 Gholami, A.; Sharafi, S.; Ghasemi, S.; and Sharafi, A. 2009. Pinto bean seed reserve utilization and seedling growth as affected by seed size, salinity and drought stress. Journal of Food, Agriculture and Environment. 7(2):411-414.

8 González, H. R. 1995. El maíz y su conservación. Ed. Trillas. México. DF. 399 p.

9 Guzmán, M. S. H.; Marín, J. A.; Castellanos, J. Z. and González-Mejia, E. 1996. Relationship between physical and chemical characteristics and susceptibility to *Zabrotes subfasciatus* (Boh.) (Coleoptera:Bruchidae) and *Acanthoscelides obtectus* (Say) in common bean (*Phaseolus vulgaris* L.) varieties. J. Stores Prod. Res. 32(1):53-58.

10 Harmsen, R.; Bliss, F. A.; Cardona, C.; Posso, C. E. y Orborn, T. C. 1987. Transfering genes for arcelin protein from wild to cultivated beans: implications for bruchid resistance. Annual Report (USA). Bean Improvement Cooperative. 31(1):54-55.

11 Hernández, C. G.; Facio, P. E; Guerrero, R. E. y Vázquez, M. B. 2006. Control de *Sitophilus zeamais* Motschulsky por productos naturales en semillas de maíz. Entomología Mexicana. 1003-1005 pp.

12 Isman, M. B. 2006. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu. Rev. Entomol. 51(1):45-66.

13 Issa, U. S.; Afun, J. V. K.; Mochiah, M. B.; Owusu-Akyaw, M. and Braimah, H. 2011. Effect of some local botanical materials for the oppressions of weevil populations. International Journal of Plant, Animal and Environmental Sciences. 1(3):270-275.

14 ISTA. 2005. International Seed Testing Association. International rules for seed testing. Zurich, Switzerland. 243 p.

15 Lagunes, T. A. 1994. Extractos de polvos vegetales y polvos minerales para el combate de plagas del maíz y del frijol en la agricultura de subsistencia. Colegio de Postgraduados. Montecillo, Texcoco, Estado de México, México. 35 p.

16 López-Monzón, C. E.; Tobar-Tomas, W. V. y Ventura-Gómez, A. L. 2016. Controles alternativos para el gorgojo del frijol *Acanthoscelides obtectus* (Say) (Coleptera:Bruchidae). Ciencia, Tecnología y Salud. 3(2):149-156.

17 Mazzonetto, F. 2002. Efecto de genótipos de feijoeiro e de pós de origen vegetal sobre *Zabrotes subfasciatus* (Boh.) e *Acanthoscelides obtectus* (Say) (Col.: Bruchidae).

DOI: https://doi.org/10.29312/remexca.v16i1.3086

Piracicaba. Tesis Doutorado, Escola Superior de Agricultura 'Luiz de Queiroz'. Universidad de Sao Paulo. 134 p.

18 Miranda, J. E.; Toscano, L. C. y Fernandes, M. G. 2002. Evaluación de resistencia de diferentes genotipos de *Phaseolus vulgaris* a *Zabrotes subfasciatus* (Boh.) (Coleoptera: Bruchidae). Sanidad Vegetal, Plagas. 28(4):571-576.

19 Nava, P. E.; Gastélum, H. P.; Camacho, B. J. E.; Valdez, T. B.; Bernal, R. B. y Herrera, F. E. 2010. Utilización de extractos de plantas para el control de gorgojo pardo *Acanthoscelides obtectus* (Say.) en frijol almacenado. Universidad Autónoma Indígena de México. El Fuerte, Sinaloa. 37-43 pp.

20 Ortega-Nieblas, M. M.; Robles-Burgueño, M. R.; Acedo-Félix, E.; González-León, A.; Morales-Trejo, A. y Vázquez-Moreno, L. 2011. Composición química y actividad antimicrobiana del aceite esencial de orégano (*Lippia palmeri* S. Wats). Revista Fitotecnia Mexicana. 34(1):11-17.

21 Paul, U. V.; Lossini, J. S.; Edwards, P. J. and Hilbeck, A. 2009. Effectiveness of produsts from four locally grown plants for the management of *Acanthoscelides obtectus* (Say) and *Zabrotes subfasciatus* (Boheman) (Coleoptera: *Bruchidae*) in stored beans under laboratory and farm conditions in Northern Tanzania. J. Stores Prod. Res. 45(1):97-107.

22 Páez, A.; Lagunes, A. y Carrillo, J. L.; Rodríguez, J. C. 1990. Polvos vegetales y materiales inertes para el combate del gorgojo *Sitophilus zeamais* (Coleoptera: *Curculionidae*) en maíz almacenado. Agrociencia. 3(1):35-46.

23 Powell, A. A.; Corbineau, F.; Franca-Neto, J.; Lechappe, J.; Mesterhazy, A.; Pritchard, H. W. and Tarp, G. 2005. Towards the future in seed production, evaluation and improvement. Seed Science and Technology. 33(2):265-281.

24 Rangel-Lucio, J. A.; Juárez-Goiz, J. M.; García-Moya, E.; Fernández-Andrés, M. D.; Rodríguez-Hernández, C. y Alvarado-Bárcenas, E. 2011. Oleorresina de jícama y calidad de semilla de frijol infestada con *Acanthoscelides obtectus* Say. Agron. Mesoam. 22(1):109-16.

25 SAS Institute Inc. 2011. Institute INC. Statistical Analysis Systems Institute. Sas/Stat user's guide, version 9.1th Ed. Cary (NC). 5 136 p.

26 Santos, P. C.; Santos, V. H. M.; Mecina, G. F.; Andrade, A. R.; Fegueiredo, P. A.; Moraes, V. M. O.; Silva, L. P. and Silva, M. G. 2015. Phytotoxicity of *Tagetes erecta* L. and *Tagetes patula* L. on plant germination growth. South African Journal of Botany. 100:114-121.

27 Shaaya, S. K.; Kostjukovski, M.; Eilberg, J. and Sukprakarn, C. 1997. Plant oils as fumigants and contact insecticides for the control of stored-product insects. Journal of Stored Products Research. 33(1):7-15.

28 SIAP. 2023. Cierre de la producción agrícola por cultivo. Anuario estadístico de la producción agrícola. https://www.gob.mx/cms/uploads/attachment/file/856677/Frijol-Agosto.pdf.

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