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Research Note

Encrusting offers protection against phytotoxic chemicals and maintains the physiological quality of sunflower (*Helianthus annuus*) seeds

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Summary

Precision planting of sunflower seeds is hampered by the large variability in size and shape. Seed encrusting, the application of layers of adhesive and inert material, has the potential to solve this problem. However, these layers could reduce the physiological quality of the seeds. The aim of this study was to evaluate the effect of encrusting on the germination and seedling growth of sunflower seeds, after encrusting and during storage. The treatments applied were: encrusted with talc, encrusted with carbonate, encrusted with talc + insecticide + fungicide, treated with insecticide, treated with fungicide and treated with insecticide + fungicide. Encrusting improves radicle emergence, without negatively affecting seedling percentage and growth rate. The dry weight of seedlings was significantly higher in encrusted seeds. The germination percentage was stable for eight months in control, encrusted and treated seeds, with significant reduction after that time. We verified an adverse effect of insecticide + fungicide upon germination, but it seems that encrusting blocked the negative effect of pesticides on sunflower germination.

Experimental and discussion

Seed coating includes numerous techniques and formulations that are beneficial to seeds (FIS, 1999). It allows the application of pesticides, nutrients, growth regulators, water or oxygen provider products and inoculation with microorganisms. It also increases the size and weight of seeds to facilitate precision planting (Taylor and Harman, 1990). The process involves the gradual accumulation of layers of adhesive and inert material on the seed (Scott, 1989). ISTA (2010) makes a distinction between pelleted and encrusted seeds: both result in a change in size and weight, encrusted seeds have the same shape as the original seeds while pelleted seeds become spherical. Treated seeds are those to which pesticides, dyes or other additives have been applied, without changing their form.

Seeds of sunflower (*Helianthus annuus* L.) have wide variability in size and shape. The use of mechanical feeders in seed drillers, like those mainly used in Argentina, requires a very precise fit between the size of the holes and thickness of the metering plate and the seeds, making it necessary to have plates with different characteristics for each seed lot (Maroni *et al.*, 2004). For these reasons, small sunflower seeds are usually discarded. The encrusting technique has the potential to solve this problem because it reduces the variation in size (Halmer *et al.,* 2005) and increases the accuracy of sowing (Allen *et al.*, 1983).

Despite these benefits, the encrusting process can reduce the physiological quality of the seed (Finch-Savage, 1995; McDonald, 1998). Encrusted pepper (*Capsicum annuum* L.) and lettuce (*Lactuca sativa* L.) seeds have shown a radicle emergence percentage similar to that of non-encrusted seeds, but a significantly lower radicle emergence rate (Sachs *et al.,* 1982; Silva *et al.,* 2002). On the other hand, Coraspe *et al.* (1993) found no significant differences in radicle emergence percentage or rate between encrusted and non-encrusted lettuce seeds. Similarly, no significant differences in seedling emergence rate and germination percentage were observed between encrusted and non-encrusted seeds of carrot (Medeiros *et al.,* 2006) or maize (*Zea mays* L.) (Da Conceição and Duarte Vieira, 2008). Silva and Nakagawa (1998) found a similar behaviour in lettuce seeds encrusted with fine sand or a mixture of carbonate and sand, but a significant reduction in germination percentage with carbonate encrusting. Moreover, the dry weight of these seedlings showed no significant differences compared with the control. Arsego *et al.* (2006) found that the germination percentage of rice seeds (*Oryza sativa* L.) was significantly lower when the fungicides fludioxinil and metalaxyl were combined with coating. Allen *et al.* (1983) detected that encrusted sunflower seeds had significantly higher seedling emergence rate than non-encrusted ones.

Oliveira *et al.* (2003) for pepper and Furtado de Mendonça *et al.* (2007) for sweet corn detected significant reductions in germination percentage of encrusted seeds during storage. In addition, the former authors found a significant reduction in seedling vigour of seeds treated with fungicide. In contrast, Medeiros *et al*. (2006) detected no significant differences in the emergence percentage of carrot seedlings between encrusted and non-encrusted seeds evaluated during storage.

The objective of the present study was to evaluate the effect of encrusting on the percentage and rate of germination of sunflower seeds, after encrusting and during storage.

The treatments applied were: encrusted with talc, encrusted with carbonate, encrusted with talc + insecticide + fungicide, treated with insecticide, treated with fungicide, treated with insecticide + fungicide and control. Treated seeds are considered as non-encrusted seeds. Treatments were carried out by placing seed samples of 200 g of the PAN 7031 hybrid in an experimental machine (Cimbria Heyde type) and sequentially adding the encrusting or coating materials. For encrusted seeds calcium carbonate or talc (inert agents) in a dose of 500 g kg^{-1} seeds and Equate® (adhesive polymer, diluted in water to 8%) in a proportion of 200 ml kg^{-1} were used. For the insecticide and fungicide treatments, the active ingredient tiametoxan 35% (6 ml kg^{-1} seeds) and metalaxyl 35% (3 ml kg^{-1} seeds) were used, respectively. The encrusting products (carbonate + Equate®) were not able to be pasted to the seed surface previously treated with the first slurry. This did not occur when talc was used as filler. So, carbonate was not used in the complete encrusting treatment applied. Once encrusted, seeds maintained their original shape.

The moisture content of the seeds was determined on dry weight basis (ISTA, 2010) and was 9% for control seeds (prior to application treatments). Immediately after treatment the moisture content was 11% for seeds treated with insecticide, fungicide or insecticide + fungicide, 14% for talc-encrusted seeds, and 15% for carbonate--encrusted seeds and talc + insecticide + fungicide-encrusted seeds. After a 24-hour stabilising period in a laboratory environment, seeds were sampled for all the germination and seedling vigour assessments. After a further 24 hours (total of 48 hours stabilisation), the moisture content of the remaining seeds had stabilised at 8% for all treatments. These were then stored in kraft-paper bags at 25°C and 60% relative humidity for the monitoring of germination during storage at three, five, eight and ten months post-treatment.

Radicle emergence (physiological germination) was examined by placing three replications of 50 seeds of each treatment in 9 cm-diameter Petri dishes on two pieces of Whatman N°1 filter paper moistened with 2.5 ml of distilled water. Afterwards, the Petri dishes were wrapped with plastic wrap and placed in a chamber at continuous 25°C (ISTA, 2010) with 12 hours of alternating light/dark. The numbers of seeds with emerged radicles (> 2 mm) were counted at 24, 26, 28, 30, 32, 34, 37, 40, 43, 45, 47 and 49 hours from sowing. The time required for the emergence of 50% of radicles (G50) was calculated according to Ranal and García de Santana formula (2006), expressed in hours for 50% of maximum emergence (1). The final percentage of seeds with emerged radicle (ER) resulting from the relationship between the total number of seeds sown and those which indeed showed root emergence.

(1)
$$G50 = \frac{\left[\left(ER/2\right) - R_1\right] \times \left(H_2 - H_1\right)}{R_2 - R_1} + H_1$$

Where ER is final percentage of seeds with radicle emerged, H_1 is the number of hours from the start of radicle emergence, H_2 is the number of hours to the end of radicle emergence, R_1 is the number of radicles emerged at H_1 and R_2 is the number of radicles emerged at H_2.

To assess seedling emergence (technological germination), eight replications of 50 seeds were sown between paper (ISTA, 2010). Incubation conditions were 25°C and 12 hours alternating light/dark. The time for 50% seedling emergence (GS50) was calculated using the same formula as for G50 in which time of emergence was expressed in days. The number of normal seedlings was counted at four, seven and ten days after sowing. The speed of seedling emergence index (SSEI) was calculated according to Maguire's formula (Maguire, 1962) in which the time interval for emergence was expressed in days (i.e., normal seedlings day^{-1}). Germination percentage (GP) was calculated through the discrimination between normal, abnormal seedlings, dead and fresh seeds on the tenth day from the time when germination boxes were placed in the germination chamber (ISTA, 2010). To determine seedling dry weight (SDW), all normal seedlings from day-10 of the germination test were dried according to Murcia *et al.* (2006).

Radicle emergence was studied by means of a complete randomised design (CRD), whereas seedling emergence was studied by means of a complete randomised block design (CRBD) considering each day of sowing as a block. Values of germination percentage were arcsine-transformed before statistical analysis to ensure homogeneity of variance. Analysis of variance (ANOVA) was performed and comparison of the means was carried out to detect differences by means of the DGC- (Di Rienzo, Guzmán and Casanoves) test ($P < 0.05$). The statistical software INFOSTAT (Di Rienzo *et al.*, 2008) was used.

Radicle emergence speed of encrusted seeds was significantly increased compared with non-encrusted seeds (table 1). Such behaviour was not consistent with that found by Sachs *et al.* (1982) and Silva *et al.* (2002). In addition, these results did not agree with the results reported by Coraspe *et al.* (1993). The final percentage of seeds with emerged radicle showed statistically higher values in encrusted seeds (table 1). These results were not consistent with those of Sachs *et al.* (1982), Corapse *et al.* (1993) or Silva *et al.* (2002). Differences in morphology and size between vegetables and sunflower seeds could explain these different effects. However, the performance of sunflower encrusted seed germination, from the point of view of radicle emergence, represents a comparative advantage of this technology. Possible reasons for this behaviour may be related to water absorption of sunflower encrusted seeds. The encrusted layers, which form an additional structure that makes water flow between the seeds and the external environment, could bring about changes in the dynamics of water absorption of seeds with a direct impact on their ability to germinate.

With regards to the seedling emergence rate and germination percentage, no differences were found between encrusted and non-encrusted seeds (table 1), in agreement with results reported by Medeiros *et al.* (2006) and Da Conceição and Duarte Vieira (2008). However, the response varied from those of Silva and Nakagawa (1998) using carbonate encrusting, nor did they agree with the results of Allen *et al.* (1983), who found significant increases in seedling emergence rate of encrusted sunflower seeds.

The dry weight of seedlings was significantly higher in encrusted seeds. The higher growth of seedlings coming from encrusted seeds expressed a trend that was inconsistent with the statements made by Silva and Nakagawa (1998).

The insecticide + fungicide combination was the only treatment with significant lower values in germination percentage and seedling emergence rate (SSEI) (table 1). These results are in agreement with the reduction found by Arsego *et al.* (2006) in rice for the fludioxinil and metalaxyl coating combination. The phytotoxic effects resulting from the combination of pesticides should be examined in detail and the effects of adjusting the dosage of products evaluated when developing encrusting technology. On the other hand, the interaction with the germination substrate used should be also examined. This would make it possible to identify whether the response observed is magnified by the use of paper substrate. However, no differences were found between seedling emergence rate and germination percentage of seeds treated with insecticides or fungicides alone and encrusted and non-encrusted seeds. This finding agrees with the results by Arsego *et al.* (2006) in treatments combining coating with carboxin plus thiram.

The germination percentage was stable in control, encrusted and treated seeds for eight months, with significant reduction after that time (figure 1). This response is consistent with that found by Medeiros *et al.* (2006). Moreover, that response does not match up with that found by Furtado de Mendonça *et al.* (2007), who detected significant reductions in the germination percentage of encrusted seeds during storage. The insecticide + fungicide

Table 1. Comparison of mean time required for the emergence of 50% of radicles (G50), final percentage of seeds with emerged radicle (ER), time required for the emergence of 50% of seedlings (GS50), speed of seedling emergence index (SSEI), germination percentage (GP) and seedling dry weight (SDW) of sunflower encrusted and non-encrusted seeds.

Treatment		Radicle emergence		Seedling emergence			
		G50 (hours)	ER (%)	GS50 (days)	SSEI	GP (%)	SDW (mg $seedling^{-1}$)
Non-encrusted seeds	Control	36.4 ± 1.20 A*	81 B	5.9 ± 0.24 A	5.9 ± 0.23 A	86 A	25.2 ± 0.24 B
	Insecticide	36.6 ± 1.88 A	83 B	6.0 ± 0.29 A	5.8 ± 0.35 A	85 A	25.6 ± 1.06 B
	Fungicide	39.2 ± 0.76 A	85 B	6.0 ± 0.24 A	5.8 ± 0.25 A	85 A	26.8 ± 1.15 A
	Insecticide + Fungicide	37.8 ± 1.09 A	78 B	5.9 ± 0.16 A	5.5 ± 0.25 B	82 B	25.3 ± 0.94 B
Encrusted seeds	Carbonate	30.4 ± 0.53 B	100 A	5.8 ± 0.18 A	6.2 ± 0.35 A	89 A	27.2 ± 2.16 A
	Talc	32.6 ± 1.29 B	94 A	5.8 ± 0.03 A	6.0 ± 0.28 A	87 A	27.0 ± 1.51 A
	Talc + Insecticide + Fungicide	29.9 ± 0.87 B	98 A	5.9 ± 0.14 A	5.9 ± 0.19 A	87 A	26.7 ± 1.03 A
C.V.** (%)		4.2	9	3.5	4.5	4	4.8

* Different letters in each column indicate significant differences ($P < 0.05$). Values are mean ± SD. **C.V. = coefficient of variation.

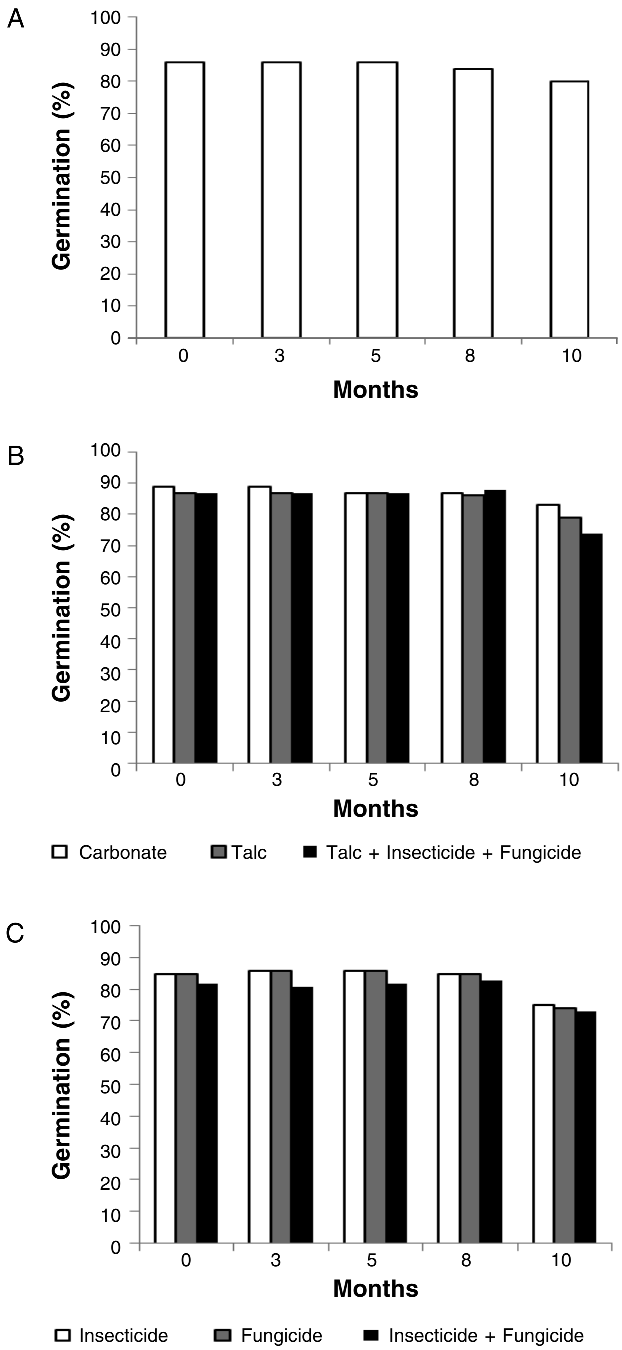

Figure 1. Germination during storage of control (A), sunflower encrusted seeds (B) and non-encrusted (C) seeds.

treatment showed significant lower germination percentages throughout the storage period (figure 1). A decrease in quality due to pesticide treatments has been mentioned only by Oliveira *et al.* (2003).

In conclusion, encrusting improves radicle emergence and seedling size, without negatively affecting seedling percentage and growth rate. Encrusting maintains the physiological quality of sunflower seeds during storage. A negative effect on germination was verified with pesticide combinations without encrusting, both at the beginning of the treatment and during storage. Furthermore, it seems that encrusting might have blocked the negative effect of pesticides on sunflower germination.

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