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Research article

Capacity of Albit® Plant Growth Stimulator for Mitigating Side-effects of Pesticides on Soil Microbial Respiration

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Abstract

Microorganisms give an early and integrated measure of soil functioning. In particular, soil microbial respiration is recommended for monitoring soil quality. The present study aims to determine the capacity of Albit® (poly-β-hydroxybutyrate, PHB) to reduce the detrimental effects of pesticides on soil microbial respiration. The effects of three conventional pesticides (deltamethrin, dithianon, and difenoconazole) on basal respiration (BR) and substrate-induced respiration (SIR) were assessed in the presence and absence of Albit®. The studied pesticides caused negative impacts on soil functioning, reducing BR and SIR. Applications of Albit® increased BR and SIR, and both BR and SIR were kept similar to the control when pesticides were applied with Albit®. PHB, an active ingredient of Albit®, is known to increase beneficial microflora in the rhizosphere due to its regulatory activity on indigenous microorganisms. Thus, more studies should be carried out under different edaphoclimatic conditions to study the benefits of Albit® applications along with pesticides in order to mitigate their side effects on soil microbial functioning.

1. Introduction

The use of pesticides for crop protection has become an integral part of traditional agriculture. Soil is the ultimate sink for pesticides because less than 1 % of the total applied pesticides generally gets to the target pests [1]. Side effects of pesticides on soil functioning have been reported for decades [2], [3]. In particular, changes in microorganism activity and biodiversity in response to pesticides are of great concern [4]-[6].

Microorganisms give an early and integrated measure of soil functioning, which cannot be obtained with physical/chemical measures and/or analyses of the diversity of higher organisms [7], [8]. Soil microbial respiration is recommended for monitoring soil quality. Specifically, basal respiration (BR) and substrate-induced respiration (SIR) are recommended. These methods measure the constant mass of CO₂ released without and with substrate addition, respectively [9]. Both indicators are complementary and they are commonly used to assess the detrimental effects of pesticides on soil quality (e.g. [10]).

Albit® (poly-β-hydroxybutyrate or poly-beta-hydroxybutyric acid, PHB) is a plant growth stimulator of biological origin (www.albit.com). It is known to improve seed germination and plant growth, and induce early flowering [11], [12]. Additionally, some positive side-effects of Albit® have been described in the literature. For instance, Pusenkova, *et al.* [13] found that Albit® decreased the abundance of pathogenic species in the rhizosphere of sugar beet, while increasing beneficial microflora. Early studies demonstrated that the accumulation and degradation of PHB is a strategy by which bacteria can improve establishment, proliferation, and survival in competitive settings such as the soil and rhizosphere [14]. Specifically, PHB functions as a carbon and/or energy source and is degraded under conditions of stress and starvation [15], [16].

Taking into account the beneficial effect of PHB on soil microflora, the present study aims to determine the capacity of Albit® to reduce the detrimental effects of pesticides on soil microbial respiration. Specifically, the present study focuses on an insecticide, deltamethrin, and two fungicides, dithianon and difenoconazole, that have been associated with detrimental effects on soil microorganisms [4], [17]-[20].

2. Materials and methods

The experiment was carried out at the experimental station of the Russian Research Institute of Floriculture and Subtropical Crops in 2012-2013. The experimental plot was of northern exposure, located on a slope of 8-12 %; the elevation was 250 m above sea level. The soil was classified as Eutric Cambisol [21]. Soil organic matter content on the plot was in the range of 0.74-1.35 % and soil pH (in water extract) was in the range of 6.5-7.2.

In order to assess the effect of pesticides in the presence and absence of Albit® on the soil functioning, three pesticides, conventionally used in peach plantations, were assessed. For each pesticide, there were

three treatments: application of pesticide, application of pesticide with Albit®, and a control. For the first treatment, plots were treated with Delan® (BASF, Germany), Score® (Switzerland, USA), and Decis® (Bayer, Germany) (only one pesticide in each plot). The dose of each pesticide application (dose of the product, based on recommended application rates) and the hydrothermal conditions under which they were applied are detailed in Table 1. In the second treatment, Albit® (250 mL ha⁻¹) was applied without pesticides. In the third treatment, the same pesticides were applied with Albit® (250 mL ha⁻¹). Finally, a control treatment only received water at volumes equal to the other treatments. All treatments were performed during spring (mid-April) but only those related to application of Decis® or Score® were repeated during summer (beginning of June).

Table 1: Pesticide descriptions and hydrothermal regime of soil in peach plantations after application of the respective pesticides.

Pesticide	Active ingredient	Dose per ha	Soil moisture, % / soil temperature,			
			Day 1	Day 7	Day 14	Day 21
Spring season						
Decis	Deltamethrin	0.5 kg	19 / 15	19 / 16	18 / 16	-
Delan	Dithianon	0.7 L	17 / 14	17 / 15	19 / 15	-
Score	Difenoconazole	0.2 L	19 / 17	19 / 18	19 / 19	-
Summer season						
Decis	Deltamethrin	0.5 kg	17 / 23	16 / 22	15 / 23	16 / 23
Score	Difenoconazole	0.2 L	15 / 21	16 / 22	-	-

A peach plantation was divided into 9 experimental plots (100 m² each) in the same agrolandscape. In each plot, two soil samples were collected from the arable soil horizon (0-20 cm) of the peach trees, at day 1, 7, 14 during spring, and until day 21 after the application of Decis® during summer. Soils were dried and sieved for analyses of BR and SIR according to ISO-16072 [22]. For BR, the incubation time was 24 hours. The evolved CO₂ was trapped by 0.1 M NaOH solution in a closed container, followed by back titration with standard HCl solution. For SIR, 0.5 % glucose solution was added and the incubation time was 6 hours, with the rest of the procedure the same as for BR.

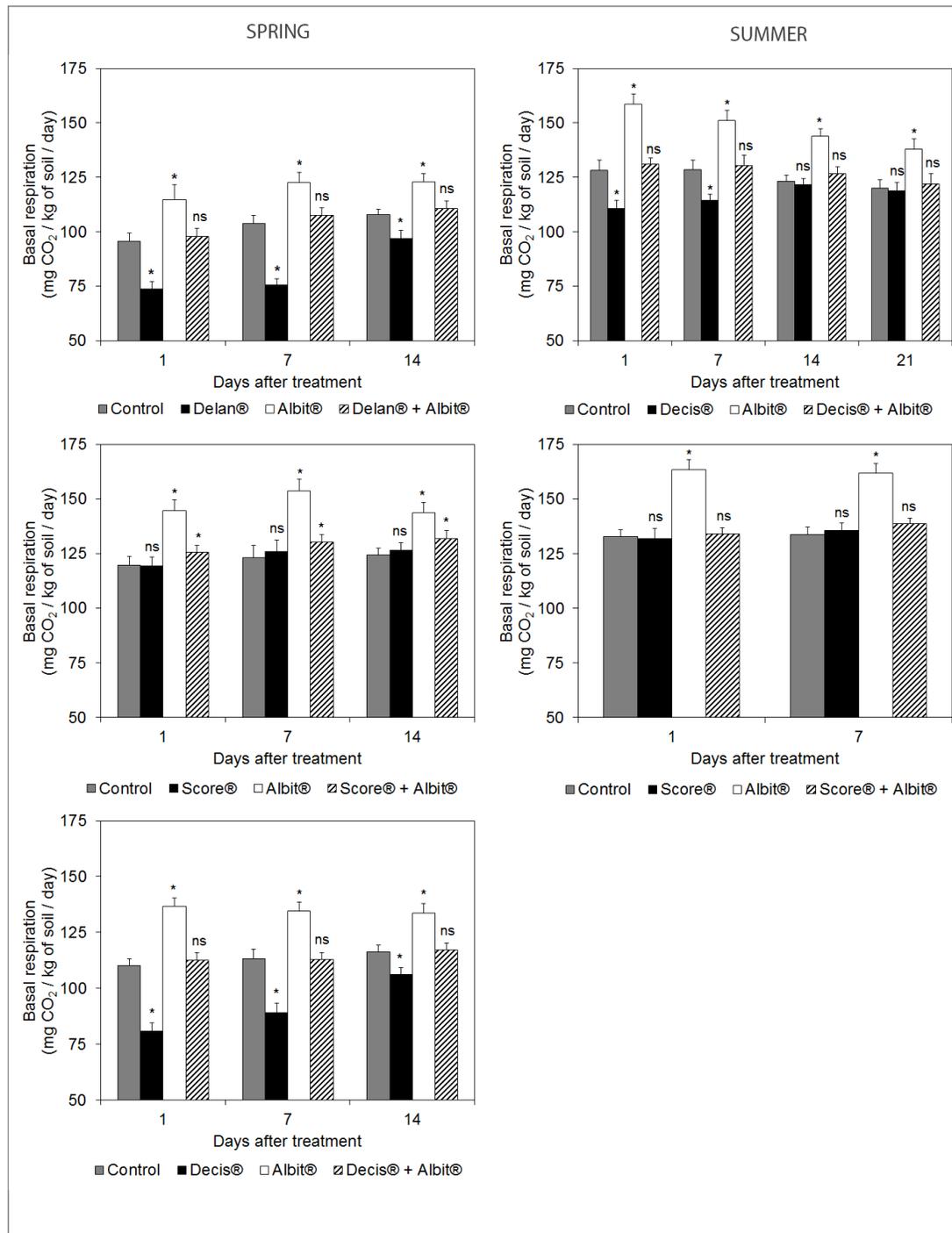
For pesticides and pesticides with Albit treatments, BR and SIR were compared with the control through ANOVA analysis and Tukey's test (p<0.05). All these results were processed using the Statistica 6.0 program.

3. Results and Discussion

3.1. Effects of pesticides on soil microbial respiration

Application of Decis® or Delan® significantly reduced BR, while the effect of Score® was not significant (Figure 1). On the other hand, SIR was significantly reduced by application of each of the studied pesticides (Figure 2), suggesting that SIR is a more sensitive indicator to exposure to pesticides, in comparison to BR. Our results agree with [23], who concluded that the glucose responsive part of the microflora, determined by SIR, is more sensitive to pollution, in comparison to other microbial indicators.

Figure 1: Basal respiration ($\text{mg CO}_2 / \text{kg of soil / day}$) in peach plantations after the application of the treatments. ns= not significant difference with the control ($p > 0.05$).



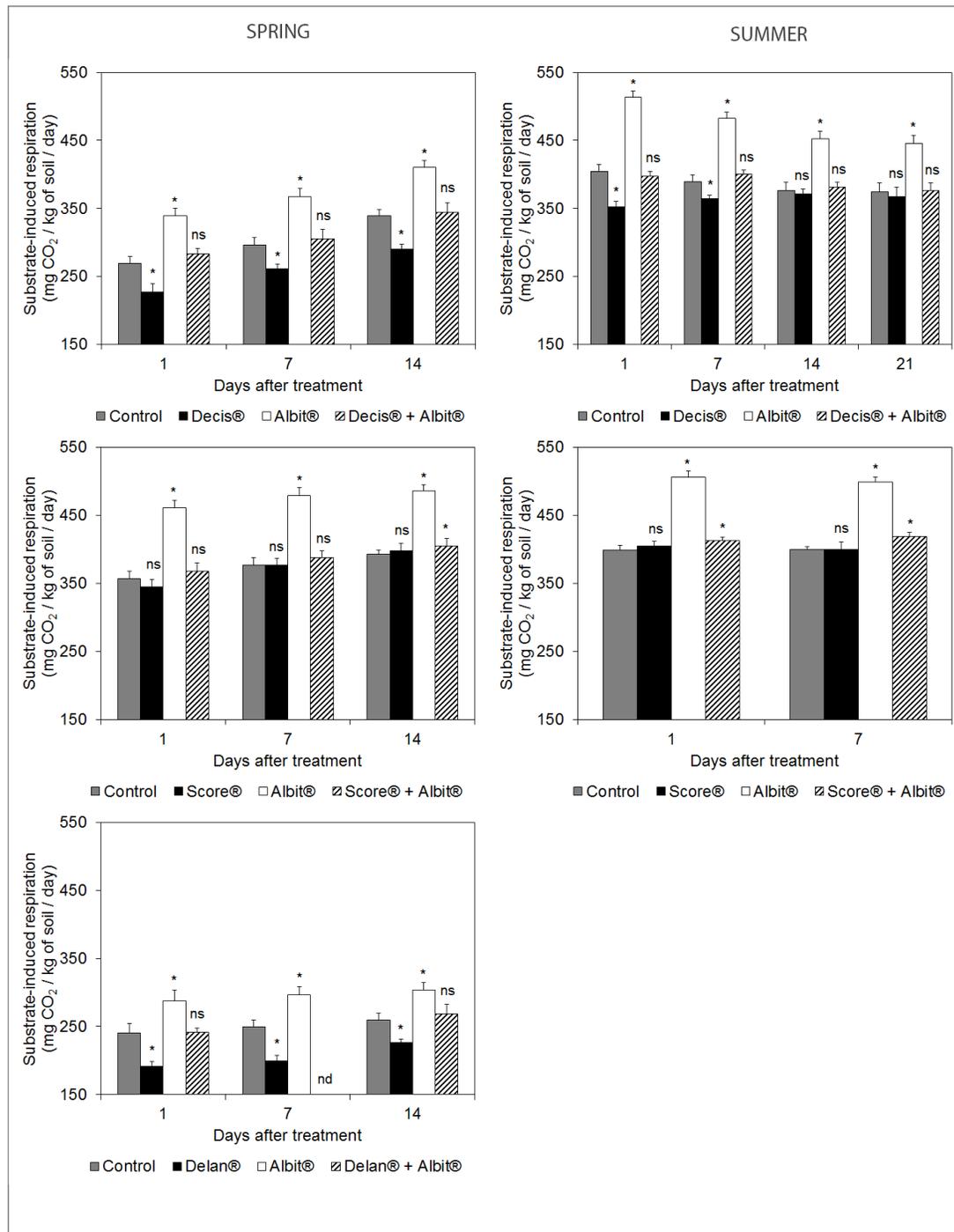
Generally, the effects of the pesticides persisted up to 21 days (Figure 1 and Figure 2) and there was no recovery, except for one case that showed a recovery of BR at day 21 after summer application of Decis® (Figure 1). In contrast to the rest of the cases, SIR was significantly higher at day 14 after the spring application of Delan®, in comparison to the control (Figure 2). This behavior suggests there was a shift in the microbial community. Species sensitive to Delan were replaced by species that showed a higher tolerance to this pesticide, similar

to the results reported by Lane *et al.* [24] and Cycoń and Piotrowska-Seget [5] for application of glyphosate and imidacloprid, respectively.

3.2. Capacity of Albit® to mitigate effects of pesticides

As shown in Figure 1 and Figure 2, BR and SIR did not decrease when application of pesticides was accompanied by Albit® (black columns), in contrast to application of the pesticides alone (gray columns).

Figure 2: Substrate-induced respiration (mg CO₂ / kg of soil / day) in peach plantations after the application of the treatments. ns= not significant difference with the control (p>0.05).



Moreover, applications of Albit® alone (without pesticides) increased BR and SIR. These results suggest that Albit® has the capacity to reduce or mask the negative impacts of pesticides on microbial respiration. Moreover, it is remarkable that pesticides both with and without Albit® were effective in the fight against the target organisms of pesticides: *Taphrina deformans*, *Clasterosporium carpophilum* and *Monilia cinerea*.

The only detrimental effect of the pesticides with Albit® was a reduction in BR one day after application of Decis® + Albit® (Figure 1). However, there was a recovery of this effect by the 7th day. In contrast, the recovery of BR for the application of Decis® in the absence of Albit® was not reached during the studied period. Therefore, Albit® is also able to speed up recovery after pesticide application.

3.3. Possible mechanism of action of Albit® in mitigating effects of pesticides

The mechanism of action of Albit® in mitigating the effects of pesticides seems to be indirect. As mentioned above, PHB, an active ingredient of Albit®, functions as a carbon and/or energy source and is degraded under conditions of stress and starvation [14]-[16]. Additionally, a recent study suggests that PHB acts as an oxidative damage protector [25]. Thus, Albit® increases beneficial microflora in the rhizosphere due to its regulatory activity on indigenous microorganisms. Future studies with soil microbial composition analysis would help to understand the multiple effects associated with the combined application of pesticides and Albit®.

4. Conclusion

The studied pesticides caused negative impacts on soil functioning, reducing BR and SIR. Applications of Albit® increased BR and SIR, while both BR and SIR were kept similar to the control when pesticides were applied together with Albit®. PHB, an active ingredient of Albit®, is known to increase beneficial microflora in the rhizosphere due to its regulatory activity on indigenous microorganisms. Thus, more studies should be carried out under different edaphoclimatic conditions to study the benefits of Albit® applications along with pesticides in order to mitigate their side effects on soil microbial functioning.

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