

SCIENTIFIC COMMUNICATION

MANAGEMENT OF ROOT ROT IN AVOCADO TREES

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ABSTRACT - Root rot (*Phytophthora cinnamomi* Rands) is one of the most restrictive factors to avocado growing in main producing regions worldwide. In Brazil, scientific reports on the effectiveness of control methods are scarce. The objective of this study was to evaluate the efficiency of gypsum applications and dolomitic limestone to the soil and potassium phosphite sprays in controlling this disease in ‘Hass’ avocado, grown without irrigation. The application of dolomitic limestone or gypsum alone is not effective to recover plants affected by root rot. The application of potassium phosphite, combined or not with dolomitic lime or gypsum enables the partial recovery ‘Hass’ avocado plants affected by the disease.

Index terms: *Phytophthora cinnamomi*, limestone, gypsum, potassium phosphite, sanitary visual condition.

MANEJO DA PODRIDÃO RADICULAR EM ABACATEIROS

RESUMO – A podridão radicular (*Phytophthora cinnamomi* Rands) é um dos fatores mais restritivos ao cultivo do abacateiro nas principais regiões produtoras do mundo. No Brasil, relatos científicos sobre a eficiência de métodos de controle são escassos. O objetivo deste trabalho foi avaliar a eficiência de aplicações de gesso e calcário dolomítico ao solo e pulverizações de fosfito de potássio no controle desta doença em abacateiros ‘Hass’, cultivados sem irrigação. A aplicação de calcário dolomítico ou gesso de forma isolada não é eficaz na recuperação de plantas afetadas pela podridão radicular. Pulverizações foliares de fosfito de potássio, combinadas ou não com calcário dolomítico ou gesso ao solo, possibilitam a recuperação parcial de plantas de abacateiro ‘Hass’ afetadas pela doença.

Termos para indexação: *Phytophthora cinnamomi*, calcário, gesso, fosfito de potássio, aspecto visual sanitário.

Damage caused by root rot (*Phytophthora cinnamomi* Rands) to avocado trees (*Persea americana* Miller) includes wilting, leaf loss, reduced size of fruits that also are more easily exposed to sunburn, and death of roots and branches, with negative impact on production and orchard longevity (BEZUIDENHOUT et al., 1987; BEDENDO, 2011). Management of root rot includes preventive culture, chemical, and biological measures, like (i) the use of healthy seedlings that are transplanted to deep, well-drained soils; (ii) appropriate irrigation and fertilization practices and the use of gypsum or limestone soil amendments; (iii)

application of potassium phosphite, phosphorous acid, metalaxyl, and aluminum fosetyl; and (iv) the incorporation of organic matter to the soil, which favors the colonization of antagonist microorganisms (AKINSANMI et al., 2013; STASIKOWSKI et al., 2014; GROVES et al., 2015).

Gypsum, limestone, and potassium phosphite may be applied to treat the disease in adult avocado trees. Both gypsum and limestone induce chemical and physical changes in soils, with favorable impacts on root development. Calcium (Ca) has shown to suppress *P. cinnamomi*, while gypsum reduces number and size of *Phytophthora* spp. zoosporangia

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(MESSENGER et al., 2000; SERRANO et al., 2012). Phosphites act systemically and may be sprayed on leaves, on the soil, or even injected into the trunks (SCOTT et al., 2015) during root growth periods, when these compounds are transported to active root growth sites, where their protective role is enhanced (MENGE et al., 1999). Akinsanmi and Drenth (2013) observed that application of phosphites on leaves was more effective and less toxic compared with injections on the trunk when treating macadamia plants infected by *P. cinnamomi*. Also, Leal et al. (2014) observed that applications of the fungicides metalaxyl + mancozeb, mancozeb + phosetyl-Al and potassium phosphite reduced *P. cinnamomi* population and severity of root rot by 42% and 50%, respectively, also increasing seedling height by 66% and improving dry weight of avocado tree roots.

In this context, the objective of this study was to evaluate the influence of limestone, gypsum, and potassium phosphite applications on the recovery of 'Hass' avocado trees affected by root rot. The experiment was carried out in a 7-year-old non-irrigated commercial orchard located in the municipality of Limeira, state of São Paulo (SP), Brazil using a 7 m × 4 m spacing. The climate in the region is classified as Cwa, with mean rainfall of 1,300 mm concentrated between October and March, with dry winters between April and September. The experiment was conducted according to a randomized block design with four replications, three plants per replication, and seven treatments, as follows: (T1) non-treated control; (T2) 135 kg ha⁻¹ year⁻¹ Ca applied to the soil as gypsum in October, January, and March; (T3) 135 kg ha⁻¹ year⁻¹ Ca applied to the soil as dolomitic limestone in the same months as T2; (T4) 4 ml L⁻¹ potassium phosphite (30% P₂O₅ and 20% K₂O) foliar-sprayed in October, November, December, January, and February; (T5) combined applications of T2 and T4 and (T6) combined applications of T3 and T4. An additional treatment, (T7) was introduced in the second year of the trial to evaluate a cultural practice recently used by local avocado growers consisting of spraying the trunk and main branches with 4 ml L⁻¹ potassium phosphite in October 2011, November 2011, and March 2012. In all foliar-applied treatments, a spray volume of 1,500 L ha⁻¹ was utilized. The treatments were applied on plants initially selected with advanced canopy wilting symptoms attributed to root rot.

Tree health condition was assessed before and after 129, 218, 379, 518, and 574 days from the first treatment application (from October 2010 thru March 2012). Since T7 was firstly applied in October 2011, this treatment was only evaluated in two dates (518

and 574 days after first treatment application). Tree health rate was evaluated by visual canopy rating using a 0-10-score scale specifically conceived for avocado trees, as follows: (0) healthy plant with shiny and dark-green leaves; (1) canopy with shiny, dark green leaves, with first wilt symptoms; (2) canopy with shiny, dark green leaves, showing moderate wilt symptoms; (3) initial leaf chlorosis, moderate to severe canopy wilt, but with no defoliation; (4) leaf chlorosis, moderate to severe canopy wilt, incipient defoliation; (5) moderate defoliation and sunburnt fruit; (6) severe defoliation, with no dead shoot tips yet; (7) dead tips on a few shoots; canopy with up to 50% of dead branches; (9) canopy with more than 50% of dead branches and (10) dead plant (BEZUIDENHOUT et al., 1987).

After the evaluation of plant health condition, root system density was determined and the presence of *Phytophthora* spp. in the soil was quantified. Soil samples were collected at four points distant 0.5 m from the trunk of two trees per replication, under the crown projected area, using a stainless steel probe with 0.07 m in diameter that was drilled into the soil to a depth of 20 cm. Roots were then separated from soil samples using a 3-mm mesh sieve and they were then washed in tap water, patted dry, weighed and left to dry in a stove at 70°C until constant weight. The presence of *Phytophthora* spp. was quantified on 1-gram soil samples in the Laboratório de Fungos Patogênicos da USP/ESALQ according to the method described by Tsao and Guy (1977). *Phytophthora* spp. colony forming units (CFUs) were counted after a 72 h incubation period.

Tree health rating scores were submitted to a non-parametric analysis of variance by using the Friedman's test, and means were compared by the Tukey-Kramer's test. Original CFU counts were log₁₀-transformed to stabilize data variance. A significance level of 5% was considered for all statistical analyses.

Before treatments were applied, the experimental trees had similar health condition, with scores varying between 6.67 and 7.08, indicating leaf loss and shoot tip death. After 129 and 218 days from the beginning of applications, mean tree health scores rated between 6.00 and 6.58, and between 5.75 and 6.50, respectively, with no significant differences between treatments (Figure 1). On day 379 from the first application, the plants sprayed with potassium phosphite and treated with soil-applied gypsum (T5) had a mean tree health score 24% lower than those of plants treated with soil gypsum (T2) and dolomitic lime (T3) applications, confirming a better effect of T5 treatment on mitigating root rot symptoms. On

day 508 after the first application, 'Hass' avocados treated with potassium phosphite combined with gypsum (T5) or dolomitic limestone (T6) soil applications had scores that were 21% to 23% lower than those recorded on plants treated with soil-applied gypsum (T2) or dolomitic limestone (T3). Later on day 574, the trees sprayed with potassium phosphite combined with soil-applied dolomitic (T5) had lower health rating scores compared with the control trees (T1) and with those treated with soil applications of gypsum (T2) and limestone (T3) (Figure 1). The application of potassium phosphite on trunks and branches (T7) reduced scores after 200 days from the first application of this treatment, which coincided with day 564 after the first application of the formerly applied treatments. Considering that significant recovery of tree health condition was only recorded after 379 (T5) and 518 (T6) days after the first applications, the application of potassium phosphite to the tree trunks and main branches seems to be a feasible control strategy against 'Hass' avocado root rot.

The highest root density was observed in plants sprayed with potassium phosphite and applied with dolomitic limestone applications to the soil (T6), compared with those treated with dolomitic limestone (T3), potassium phosphite (T4), and the control plants (T1). Soil applications of dolomitic limestone (T3) or foliar-applied potassium phosphite (T4) did not affect the root density of 'Hass' avocado trees. Nevertheless, there seems to be a synergic action between these treatments, as indicated by higher root density recorded on plants applied with dolomitic limestone to the soil and foliar-sprayed potassium phosphite (T6). The number of *Phytophthora* spp. CFUs was not affected by the treatments (Table 1).

'Hass' avocado trees showed significant better health condition after 379 and 574 days from first treatment application. Despite being present in the soil of all the treatments, the number of *Phytophthora* spp. CFUs in the soil was not significantly influenced by any of the applied treatments.

Soil applications of dolomitic limestone and gypsum combined with foliar sprayings of trees with potassium phosphite induced higher root densities and a better tree health recovery, being more tolerant to the presence of the pathogen in the soil.

Previous research has demonstrated that the effects of gypsum and limestone soil applications during root development of avocado trees are a consequence of changes on soil chemical and physical properties induced by both compounds as they enhance soil infiltration and internal drainage, and to increase soil suppressiveness on

the growth of *P. cinnamomi* (MESSENGER et al., 2000; SERRANO et al., 2012). The recovery of plants affected by diseases caused by pathogens of the genera *Phytophthora*, *Colletotrichum*, and *Fusicladium* after application of potassium phosphite was reported for other fruit species, such as cocoa, apple, and pecan (ARAÚJO et al., 2010; McMAHON et al., 2010; BOCK et al., 2013).

The obtained results indicate that soil applications of either dolomitic limestone or gypsum are not effective for recovering avocado plants affected by root rot. Yet, whether separately or in combination with these two compounds, the use of potassium phosphite promotes the partial recovery of 'Hass' avocado trees affected by the disease.

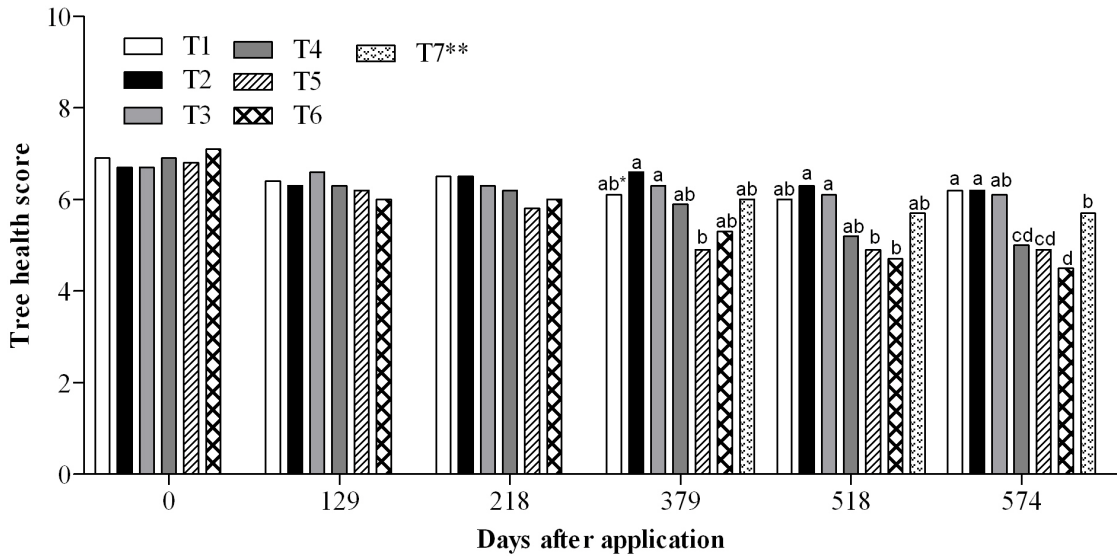


FIGURE 1 - Evolution of tree health scores of non-irrigated ‘Hass’ avocados during the experimental period in Limeira, SP, Brazil, 2010-2012. T1: non-treated control; T2: soil-applied gypsum; T3: soil-applied dolomitic limestone; T4: foliar-sprayed potassium phosphite; T5: T2+T4; T6: T3+T4; T7: potassium phosphite sprayed on the trunk and main branches. *On each date values in columns followed by different letters indicate significant differences (Tukey-Kramer, $p < 0.05$). **First applied in October 2011.

TABLE 1 - ‘Hass’ avocado root density and *Phytophthora* spp. colony forming units (CFUs) in the upper 20cm soil layer in the different treatments, Limeira, SP, Brazil, June 2012.

Treatment	Root density* g L ⁻¹	<i>Phytophthora</i> spp. CFUs ** (N°. g ⁻¹ solo)
T1: Control	0.11 c	433.33 a
T2: Soil-applied gypsum on soil	1.24 ab	435.00 a
T3: Soil-applied dolomitic limestone on soil	0.28 bc	313,05 a
T4: Foliar-sprayed potassium phosphite spray	0.30 bc	400.00 a
T5: T2 + T4	1.48 ab	733. 63 a
T6: T3 + T4	5.23 a	466.67 a
T7: Potassium phosphite sprayed on trunk and main branches	0.80 abc	676.60 a
VC (%)	30.62	52.00
p-value (Friedman)	0.0281	0.5399

*Data were analyzed using the Friedman non-parametric test. **Original data were \log_{10} -transformed to stabilize the variance. Values followed by different letters in one column indicate significant differences (Tukey-Kramer, $p < 0.05$).

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