

## Potential use of fresh mulch to curb potato late blight epidemics in Brazil

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### ABSTRACT

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Field experiments were conducted during spring 2014 and fall and spring 2015 to determine the effect of fresh mulch on the development of *Phytophthora infestans* epidemics, in Lapa Municipality, Parana State, southern Brazil. The used cultivars were 'Agata', susceptible, and 'BRS Ana', moderately susceptible. The main treatment consisted in manually applying a 10cm-thick layer of fresh mulch when potato sprouts were emerging. Fresh mulch was prepared with plants available at that time of the year. For the spring experiments, fresh mulch was a mixture of oats, rye grass and wild radish (60 t/ha) and for the fall experiment, semi-ripe elephant grass (90 t/ha). Plots consisted of six 10m-long rows, spaced at 0.8m, containing 28 plants per row. Experimental design was in completely randomized blocks with

four replicates. Natural inoculum was adopted. Percentage of leaf area was weekly estimated until the end of the plant cycle and the area under the disease progress curve (AUDPC) was calculated. Application of fresh mulch significantly reduced AUDPC by 32.1%, 12.4% and 23.1%, compared to control in all seasons, for 'BRS Ana' and by 26.1%, 2.8% and 12.0% for 'Agata'. Application of fresh mulch showed to be a promising practice for the integrated management of late blight and for the protection of yields, especially in periods more favorable to the development of the disease. More detailed studies should be conducted on the plant type and amount of fresh mulch to be used, as well as on the possibility of reducing concentrations or increasing intervals between fungicide sprays.

**Keywords:** *Solanum tuberosum*, *Phytophthora infestans*, alternative disease control.

### RESUMO

Nazareno, N.R.X. de; Finckh, M.R.; Canalli, L.B.S.; Yada, I.F.U.; Kawakami, J. Uso potencial de cobertura verde para retardar a epidemia de requeima da batata no Brasil. *Summa Phytopathologica*, v.46, n.3, p.191-197, 2020.

Experimentos de campo foram executados durante a primavera de 2014 e outono e primavera de 2015 para determinar o efeito de cobertura verde no desenvolvimento da epidemia de *Phytophthora infestans*, no município da Lapa, Estado do Paraná, região Sul do Brasil. As cultivares usadas foram 'Agata', suscetível, e 'BRS Ana', moderadamente suscetível. O principal tratamento consistiu da aplicação manual de uma camada de aproximadamente 10 cm de espessura, com material vegetal recém-colhido (cobertura verde), quando os brotos de batata estavam emergindo. O material para a cobertura verde era o disponível para a época do ano. Para os experimentos de primavera, foi utilizada uma mistura de aveia, centeio e nabiça (60 t/ha) e para os de outono, capim elefante em final de ciclo (90 t/ha). As parcelas consistiram de seis linhas de 10 m, espaçadas de 0,8 m, 28 plantas por linha. O delineamento experimental

foi de parcelas pareadas em blocos casualizados, com quatro repetições. Confiou-se em inoculação natural. A porcentagem da área foliar foi estimada semanalmente até o final do ciclo das plantas e a área sob a curva de progresso da doença (AUDPC) foi calculada. A aplicação de cobertura verde reduziu significativamente a AUDPC em 32,1, 12,4 e 23,1%, comparando-se ao controle, em todas as safras para 'BRS Ana', e em 26,1, 2,8 e 12,0% para 'Agata'. O uso de cobertura verde mostrou-se uma prática promissora para entrar no manejo integrado da requeima e proteger a produtividade, especialmente nos períodos mais favoráveis ao desenvolvimento da doença. Mais estudos detalhados devem ser continuados sobre o tipo de plantas, quantidade de cobertura verde a ser usada e a possibilidade de redução da dose ou aumento do intervalo de pulverizações com fungicidas.

**Palavras-chave:** *Solanum tuberosum*, *Phytophthora infestans*, controle alternativo de doenças.

Potato late blight (PLB), caused by *Phytophthora infestans* [Mont.] de Bary, is the most destructive foliar disease affecting potatoes in Southern Brazil (Nazareno & Jaccoud Filho (11); Souza-Dias & Imauti (17)). Under favorable climate conditions without chemical control, commercial yield can be reduced to zero when strong epidemics occur

(Souza-Dias & Imauti (17); Stevenson et al. (19); Turkensteen (23)). In the south of Paraná State, PLB epidemics may develop as early as 25 to 35 days after planting and may lead plants to death within two to three weeks (Nazareno & Jaccoud Filho (11)).

Organic farming has increased state and nationwide (MAPA (10)).

Although copper-based fungicides can be employed, which are not as effective as regular fungicides, no effective measures for reducing PLB are available to organic farmers. Recently, debates on food production and human well-being have increased, and the organic production system, as a sustainable practice, has become an important option (Bennett (1)). Copper-based fungicides may harm the environment and may be banned in different countries in the near future (Tamm et al. (21)). There is intense search for possible alternatives or ways to reduce the amount of employed copper (e.g., EU-project CO-FREE – Innovative strategies for copper-free low input and organic farming systems – <https://www.wur.nl/en/show/cofree.htm> (14)); however, no effective alternative products are currently available to organic farmers, who need to find alternatives to minimize losses due to this disease (Finckh et al. (7); Nechwatal & Zellner (12)).

The use of mulch based on freshly cut green material has recently been shown to reliably reduce overall PLB by approximately 30% under temperate climate conditions in Germany (Finckh & Bruns (5); Finckh et al. (6); Finckh et al. (8)). Changes in the microclimate and reductions in the mechanical plant damage may play an important role (Finckh et al. (8)). Similarly, Nyankanga & Olanya (13) reported lower PLB severity in leaves with the use of oat straw in the USA. Dvorák et al. (4) studied the influence of straw mulch, black textile mulch, in comparison to conventional potato cultivation, on canopy microclimate variation, PLB intensity and yield during two growing seasons in Czech Republic. They concluded that straw mulch significantly reduced the favorable weather conduciveness of PLB and haulm infection, and increased the yield in comparison with conventional cultivation. Black textile mulch had an effect similar to that of straw mulch and less tuber infection due to the physical barrier to sporangia and/or zoospores carried to tubers. In contrast, in earlier experiments, Döring et al. (3) found no effect of straw mulch on PLB or yield. Polyethylene mulching, under greenhouse conditions, can also reduce late blight of tomatoes when integrated with chemical sprays (Shtienberg et al. (20)). However, the use of polyethylene on potatoes is impractical and not ecologically sound.

The effect of mulching on other plant diseases is rarely reported. Dalla Pria et al. (2) compared black polyethylene cover prior to transplanting pak choi and white polyethylene cover suspended over pak choi plants after transplanting. They observed that there was a significant reduction in *Alternaria* sp. when white polyethylene cover was used.

The agronomic benefits of mulching are well known and, depending on the used materials, may include buffering of the soil temperature in the root zone, retention of moisture, prevention of soil erosion and weed suppression (Dvorák et al. (4); Teasdale & Mohler (22)).

Even though a large number of chemical, physical and biological variables and their interactions are involved when the soil is covered with plant material, the objective of this study was solely to determine the effects of fresh mulch on PLB epidemic in potatoes under subtropical southern Brazilian conditions. If fresh plant mulch can significantly curb PLB, this field practice can be implemented for small organic farmers and be incorporated with other control measures against this disease.

## MATERIAL AND METHODS

Two sets of field experiments in spring 2014 and 2015, and one set in fall 2015, were conducted to study the effect of fresh mulch on the development of late blight epidemics at Iapar Experimental Station in Lapa, Paraná State, Brazil (Altitude: 910 m.a.s.l.; Latitude: 25°47'S;

Longitude: 49°46'W). The soil type was Dystric Cambisol (Alumic) + Dystric Leptosol, depending on the experiment. Weather data (maximum and minimum air temperature, and rainfall) were recorded daily by a weather station 50 m away from the experimental plots.

Planting/harvesting dates were September 05/December 17, 2014, February 27/May 06, 2015, and September 05/December 14, 2015 (spring, fall and spring seasons, respectively). Late blight occurred without the need for artificial inoculation and no fungicides were applied. To prevent *Diabrotica speciosa* (Germer) leaf damage from interfering in PLB epidemic, the commercial insecticide Chlorpyrifos (480 g.L<sup>-1</sup>) was applied at the equivalent level of 1 L.ha<sup>-1</sup> every two weeks or when new infestations occurred.

Prior to planting, the soil was plowed and furrows were mechanically made, 0.8 m apart. Dry chicken manure was applied as base fertilizer in spring 2014 and fall 2015, while mixed compost was applied in spring 2015, at a rate of 5 t/ha and 8 t/ha, respectively. The compost was a mixture of plant material and bovine excrement ready to use and available in the experimental station. There was no supplementary nitrogen top dressing. The cultivar 'Agata', very susceptible, the most planted germplasm in Brazil, and 'BRS Ana', a moderately susceptible cultivar, were used in each season in two separate experiments. Plots were six-row wide and 10m long, including 28 seed tubers per row. Spacing between rows was 0.8 m. A randomized complete block design with four replicates was used, adopting two treatments: with (W) and without (WO) mulching. Hilling was done manually when plants were emerging in all plots and again when plants were about 30-cm tall in plots without mulch but not in the mulched plots. When sprouts just appeared and after the first hilling, mulched plots were hand covered with a 10cm-thick layer, equivalent to 90 t/ha semi-ripe mowed elephant grass in the fall or to 60 t/ha plant fresh material (predominantly oats with ryegrass and wild radish), in the spring seasons (Figure 1). When haulms were completely dry, the four central plot rows were harvested.

Late blight was visually assessed, at 7-day intervals, until the end of the epidemic in each quadrat of the plot to obtain averages. Disease diagram, key 3.1.1, proposed by James (10), was used as visual reference to disease severity. With the estimated disease data, the area under the disease progress curve (AUDPC) was calculated for each plot (Shaner & Finney (16)). Means were compared with a two-sided t-test (Steel & Torrie (18)) and analyses were run using SAS GLM procedures (SAS (15)).

## RESULTS AND DISCUSSION

Climate conditions were favorable to PLB development in all seasons (Figure 2). In spring 2015, there was excessive rain due to an "El Niño" event, resulting in massive damage and failure of the crop. The onset of PLB in both cultivars started on November 10, 2014, April 9, and October 29, 2015, i.e., 62, 42 and 58 days after planting in spring 2014, fall 2015, and spring 2015 growing seasons, respectively. Severity of 100% was reached 35, 20 and 26 days after the onset of PLB in 'Agata', and after 49, 20 and 35 days in 'BRS Ana' for the respective epidemics (Table 1). This difference between cultivars in spring seasons was due to different resistance levels, as reported before in organic management (Virmond et al. (24)). In fall 2015, the temperatures were lowest and slowly decreased as the season progressed (Figure 2B), resulting in the most conducive climate conditions and in earlier and shorter epidemics for both cultivars (Table 1). Generally, under southern Brazilian conditions, the fall season is more prone to



**Figure 1.** Harvesting fresh plant material in early spring (A), and mulch layer sampling (B) for hand spreading on potato plots at Lapa Experimental Station, Paraná State, southern Brazil.

PLB development, since air temperature decreases and relative humidity increases during the growing period. This explains why PLB started nearly 20 days earlier in fall 2015, compared to the two studied spring seasons. In addition, 100% severity values for both cultivars were reached at the same time in fall 2015, in contrast to spring 2014 and 2015, when the death of the resistant cultivar ‘BRS Ana’ due to PLB was approximately 14 and 9 days later, respectively, than that of ‘Agata’ (Figure 3). Differences in the epidemics were smaller in spring 2015 due to excessive rain. The AUDPC for the spring seasons was higher than that for the fall season because the overall epidemics lasted longer in spring (Figure 2B; Table 1).

In both spring seasons, the AUDPC for both potato cultivars was significantly lower in mulched plots, compared to non-mulched plots.

**Table 1.** Time length in days from the planting date to the onset of potato late blight (PLB) epidemics in two cultivars and three growing seasons at Lapa Experimental Station, Paraná State, Brazil.

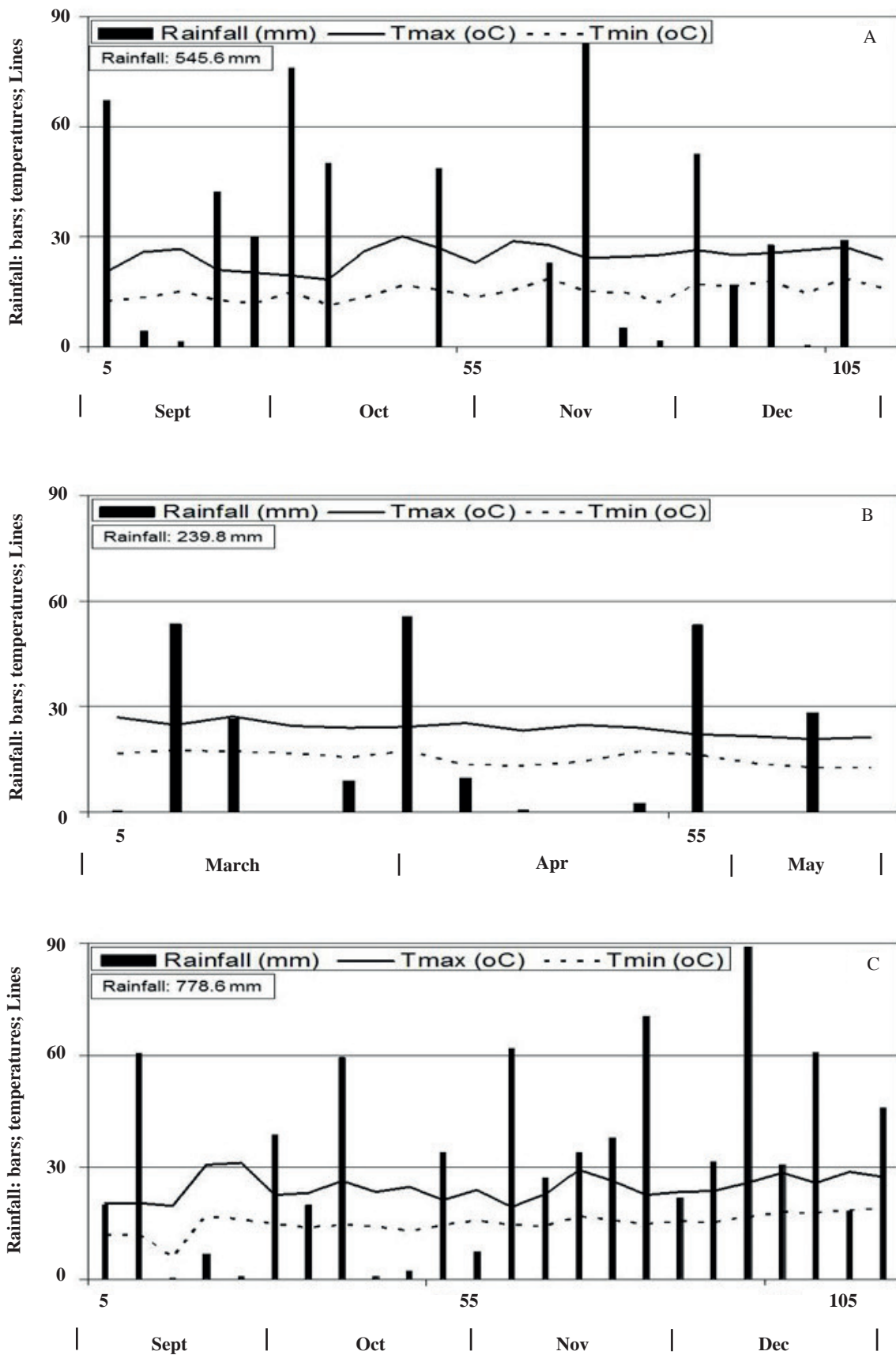
Observed variable	Cultivar	spring 2014	fall 2015	spring 2015
Days from planting date to PLB onset	Agata	62	42	58
	BRS Ana	62	42	58
Days to reach 100% severity	Agata	35	20	26
	BRS Ana	49	20	35

Fresh mulch reduced the AUDPC for ‘BRS Ana’ by 32.1%, 12.4% and 23.1% in spring 2014, fall 2015 and spring 2015 growing seasons, respectively. Similarly, reductions for ‘Agata’ were 26.1%, 2.8% and 12.0%. Considering the airborne nature of *P. infestans* dispersal and its aggressiveness in the potato canopy, these results are very impressive. In the fall season, which is more favorable to PLB epidemic development, the difference was only significant for ‘BRS Ana’ but not for the susceptible cultivar ‘Agata’ (Table 2). These results confirm the effects of mulch reported by Dvorák et al. (4), Finckh et al. (8) and Nyankanga & Olanya (13), which are reported for the first time in Brazil. All inocula used for the experiments were from outside the area. The causes of the observed positive effect of fresh mulch, reducing the AUDPC, may be diverse in nature: physical aspects, such as buffering soil temperature and protecting root systems from water stress and favoring nutrient uptake; chemical aspects, such as beneficial leachates from the fresh mulch material, inducing resistance mechanisms, and biological aspects, such as selecting beneficial microorganisms in the root zone. Further studies should be considered to better understand the complex of this observed phenomenon.

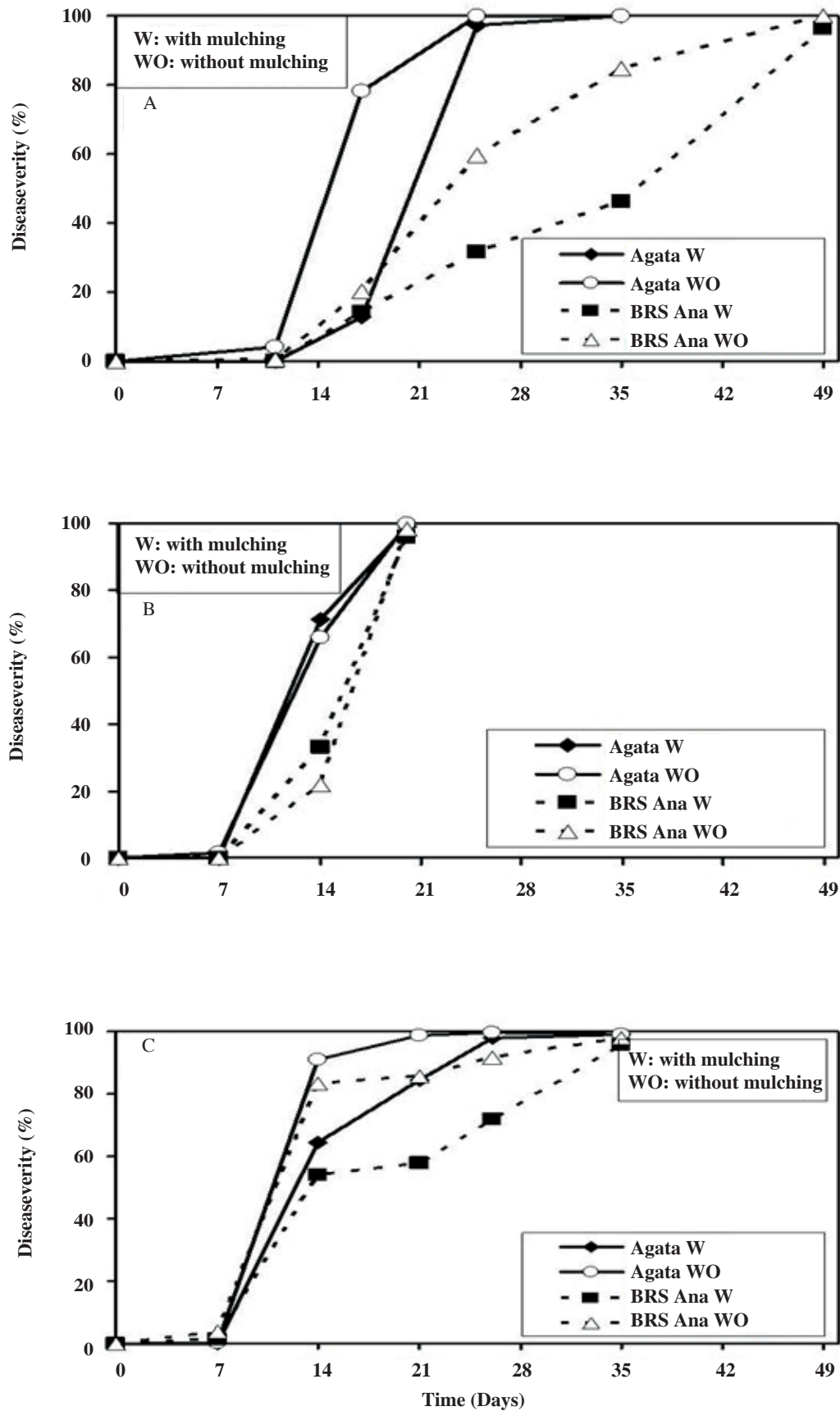
In spring 2014, when the season could be successfully completed, yields were considerably higher for mulched treatments, compared to non-mulched treatments. The differences were statistically significant for the most resistant cultivar ‘BRS Ana’ but not for ‘Agata’ (Table 3). The yield recorded for ‘BRS Ana’ in the treatments without mulch (1.5 t/ha) was smaller than that recorded by Virmond et al. (24) for potato crop in organic management: 3.3 t/ha. On the other hand, the yield obtained for ‘Agata’ (7.1 t/ha) was higher than that recorded by those same authors (Virmond et al. (24)): 1.8 t/ha. The lower AUDPC observed in mulched plots (Table 2) may have resulted in the higher yield in spring 2014 for cultivar ‘BRS Ana’ (Table 3). In fall 2015, the rapid epidemic resulted in no commercial yield (Table 3). Yield in spring 2015 was very poor because of excessive rainfall as a consequence of the Pacific “El Niño” effect on southern Brazil. Thus, yield data for this period cannot be related to late blight severity. In this unexpectedly wet season, mulching also impeded early plant growth. Similar effects were reported for temperate regions (Finckh et al. (6)). Yield effects in those German experiments with fresh mulch varied depending on the weather and the mulch material. Under drought conditions, mulch always benefitted the potatoes. However, when water was not limited, legume rich mulch materials could support adequate potato yields (Finckh et al. (8)). Yield levels in Germany were considerably higher than those reported here, ranging between 19 and 35 t/ha.

In conclusion, the use of fresh mulch, under the conditions of the present study, has shown to be an alternative to help manage PLB and protect yields, along with resistant cultivars and healthy seed tubers, especially during the warmer spring season. The percentage of reduction in the AUDPC was very significant. Fresh mulch helped protect potatoes from water stress during dry periods. In addition, soil erosion due to the typically heavy tropical rain events could also be prevented (personal





**Figure 2.** Maximum and minimum temperatures (°C) and rainfall (mm) for spring 2014 (A), fall 2015 (B) and spring 2015 (C) at Lapa



**Figure 3.** Potato Late Blight (PLB) progress curves for cultivars ‘Agata’ and ‘BRS Ana’, in the presence and absence of fresh mulch, in spring 2014 (A), fall 2015 (B) and spring 2015 (C) at Lapa Experimental Station, Paraná State, southern Brazil.

**Table 2.** Effect of fresh mulch on the area under the disease (potato late blight) progress curve (AUDPC) in different cultivars, for three growing seasons, at Lapa Experimental Station, Paraná State, Brazil.

Cultivar	Treatment	spring 2014	fall 2015	spring 2015
BRS Ana	Mulching	1504.2 a <sup>1</sup>	498.8 a	1670.5 a
	No mulching	2216.4 b	569.5 b	2171.2 b
AUDPC reduction (%)		32.1	12.4	23.1
<i>LSD</i> ( $P \leq 0.05$ )		230.9	46.6	104.2
<i>CV</i> (%)		16.7	12.0	7.2
Agata	Mulching	1466.9 a	822.1 a	2089.9 a
	No mulching	1983.9 b	845.5 a	2375.9 b
AUDPC reduction (%)		26.1	2.8	12.0
<i>LSD</i> ( $P \leq 0.05$ )		117.1	57.2	116.0
<i>CV</i> (%)		9.4	9.5	5.7

<sup>1</sup>: Means followed by the same letter in the columns within a cultivar do not differ at  $P > 0.05$ , according to t-test.

**Table 3.** Effect of fresh mulch on total potato yield (t/ha) in different cultivars, for three growing seasons, at Lapa Experimental Station, Paraná State, Brazil.

Cultivar	Treatment	spring 2014 <sup>1</sup>	fall 2015	spring 2015
BRS Ana	With mulch	4.3 a <sup>2</sup>	1.3 a	0.4 a
	Without mulch	1.5 b	1.8 a	0.3 a
<i>T</i> <sub>test</sub> ( $P \leq 0.05$ )		6.8**	1.1ns	0.7ns
<i>CV</i> (%)		14.4	53.5	34.4
Agata	With mulch	9.6 a	1.4 a	0.6 a
	Without mulch	7.1 a	1.6 a	0.9 a
<i>T</i> <sub>test</sub> ( $P \leq 0.05$ )		1.6ns	0.3ns	0.9ns
<i>CV</i> (%)		27.3	45.9	22.0

<sup>1</sup>: Means followed by the same letter in the columns within a cultivar do not differ at  $P > 0.05$ , according to t-test.

Experimental Station, Paraná State, southern Brazil. Planting/harvesting dates: A – September 5/December 17, 2014; B – February 27/May 6, 2015; C – September 5/December 14, 2015.

observation). However, if PLB pressure is too high and epidemics start as early as in fall 2015, reduction in the disease pressure through mulching will not suffice. Mulching is especially interesting for small farmers in southern Brazil, where the required amount of green material can be found nearby and serve as no-cost fertilizer. Since a significant effect on curbing PLB epidemic was observed in most cases, further studies with the aim of reducing copper fungicides per spray or increasing intervals between applications, together with the use of resistant cultivars, are needed. More detailed studies on the amount and the type of fresh mulch to be used are also needed. It is hypothesized that the use of fresh mulch and tolerant cultivars may reduce the required amount of copper to control late blight.

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