# Potato clones resistance to early and late blight

**César Augusto Brasil Pereira Pinto*; Cláudio Aparecido de Faria and Eduardo de Souza Lambert**
Universidade Federal de Lavras (UFLA), Departamento de Biologia, Caixa Postal 37, CEP 37200-000, Lavras, MG, Brazil. (*Corresponding Author: E-mail: cesarbrasil@ufla.br)

## ABSTRACT

It is extremely important to obtain potato (*Solanum tuberosum* L.) genotypes resistant to early and late blight caused by the fungi *Phytophthora infestans* and *Alternaria solani*, respectively, to adopt integrated pest management to control these diseases. Potato clones previously selected for resistance to early blight by the potato breeding program at the Federal University of Lavras were assessed in three locations in the south of Minas Gerais state, under different cultivation conditions: one experiment involved 192 clones, inoculated with *Alternaria solani*, another assessed 291 clones in the presence of natural infection by *Phytophthora infestans*, and the other assessed 192 non-infected clones. The clones more resistant to *Alternaria solani* tended to have a longer plant cycle. Clones with good levels of resistance to both diseases were identified as having tuber yields superior to the controls, both in the presence and absence of early blight. These clones presented tuber specific weight similar or superior to the control cultivars.

**KEY WORDS**: *Solanum tuberosum* L, *Alternaria solani*, *Phytophthora infestans*.

## INTRODUCTION

Early and late blight are the most important fungal potato (*Solanum tuberosum* L.) diseases in Brazil (Reifschneider, 1987). Early blight, caused by *Alternaria solani* (Ellis and Martin) Sorauer is especially problematic under high humidity and temperatures, while late blight, caused by *Phytphthora infestans* (Mont.) de Bary is favored by high humidity and temperatures of around 12°C. Some crop management practices such as crop rotation using non-host plants and balanced chemical fertilizer applications can minimize the effects of these diseases. However, chemical control continues to be the most used method since most of the cultivars used commercially are highly susceptible to both the pathogens (Fry, 1994). The high cost and the indiscriminated use of chemical products by farmers have raised crop production costs in Brazil and, most importantly, increased the danger of using products harmful to the environment and man.

Due to these problems, obtaining materials resistant to early and late blight is one of the main objectives of potato breeding programs. Obtaining resistant cultivars commercially competitive and adapted to our edafoclimatic conditions is the most practical control strategy that is at the same time economic and ecologically safe. Several sources of resistance to both pathogens have been found in wild species and clones (Ross, 1986). Rate-reducing infection or horizontal resistance was identified by several authors studying resistance to *P. infestans* and *A. solani* (Black, 1970; Holley et al., 1985; Martins, 1995; Christ and Haynes, 2001). Specific resistance to certain *Phytophthora infestans* races, such as the resistance genes found in *Solanum demissum* (Ross, 1986), were found in several materials, however, their use has not been recommended because of their great variability and consequent breakage in resistance. Although they have been widely studied, cultivars resistant to *Phytophthora infestans* are few and cases of short-lived resistance are not uncommon (Fry, 1994). Therefore, further studies on the identification of materials with longer-lasting resistance are constantly needed. It has already been demonstrated (Martins and Pinto, 1996) that the general combining ability of early blight is more important than its specific combining ability, indicating that it is possible to identify parents capable of generating resistant clones. On the other hand, the main difficulty in obtaining resistant materials is the strong correlation observed between resistance and long plant vegetative cycle (Douglas and Pavek, 1972; Johanson and Thurston, 1990; Boiteux et al., 1995). Johanson and Thurston (1990) have warned that if growth cycle is the only difference between resistant and susceptible materials, then the resistance observed might not be considered a true genetic resistance. The identification of early or medium maturity genotypes with good resistance levels suggests the existence of some resistance mechanisms that act regardless of the

physiological maturity of the tissues, indicating the viability of practicing selection (Douglas and Pavek, 1972; Boiteux et al., 1995). The objective of this study was to assess potato clones for resistance to *Alternaria solani*, resistance to natural *Phytophthora infestans* infection and for agronomic behavior.

## MATERIAL AND METHODS

Three experiments were carried out in three locations in Southern Minas Gerais to assess, under different conditions, the agronomic performance of potato clones that had been previously selected by Martins and Pinto (1996) for resistance to early blight. One hundred and ninety-two clones were assessed in the first two experiments. The first was conducted in the winter season (May to September 1997) in Lavras, MG, in the presence of early blight. *Alternaria solani* was inoculated twice (at 40 and 50 days after planting) using the methodology described by Martins (1995). Another experiment was carried out in the winter season (June to September 1997) in Alfenas, MG, in the absence of the disease, that is, with rigorous phytosanitary control. The Bintje, Achat, Delta and Aracy cultivars were used as controls in both experiments.

Resistance to *Phytophthora infestans* was assessed by testing 291 clones in the wet season (November 1996 to March 1997) in Maria da Fé, MG, under natural infection and without applying any fungicide to the plants. The Bintje, Achat and Aracy cultivars were used as controls in this experiment.

Plots with five plants were used in the three experiments, spaced at 0.30 x 0.80 m, in a simple lattice design. Three 10 x 10 lattices were used in Maria da Fé, while in Lavras and Alfenas a 14 x 14 lattice was used. Fertilization was based on 3.0 t/ha of the commercial formula 4-14-8 (N, $P_2O_5$, $K_2O$) in the planting drill and 300 kg/ha of ammonia sulfate in side dressing. Plants were earthed up 30 or 40 days after planting. The other crop treatments were those normally used in commercial fields, except in the experiments in Lavras and Maria da Fé, where fungicides were not used. The scores for diseases were given independently by four assessors, 60 and 75 days after planting (DAP) for late blight and at 60, 70 80 and 90 DAP for early blight, using the diagram presented by Reifschneider (1987). The scores were given according to the percentage of the area with lesioned tissue, on a scale varying from 0 (absence of symptoms) to 5 (partially dead plants). Methodology by Shaner and Finney (1977) was used to estimate the area under the disease-progress curve (AUDPC).

## RESULTS AND DISCUSSION

There were significant differences among treatment means for both reactions to late blight assessments (60 and 75 DAP) . Table 1 shows the means for the

**Table 1.** Means of the ten most resistant clones to late blight (*Phytophthora infestans*) and the controls for the mean scores of four assessors at 60 and 75 days after planting (DAP) in three experiments. Maria da Fé, 1997 [1/].

| Lattice 1 | | | Lattice 2 | | | Lattice 3 | | |
|---|---|---|---|---|---|---|---|---|
| Clones | 60 DAP | 75 DAP | Clones | 60 DAP | 75 DAP | Clones | 60 DAP | 75 DAP |
| PRM – 146 | 1.27 a | 1.00 a | PRM – 475 | 1.25 a | 1.00 a | PRM – 178 | 0.99 a | 1.53 a |
| PRM – 43 | 0.98 a | 1.52 a | PRM – 461 | 1.50 a | 1.03 a | PRM – 170 | 0.97 a | 2.03 a |
| PRM – 41 | 1.03 a | 1.92 a | PRM – 374 | 1.13 a | 1.53 a | PRM – 156 | 1.41 a | 2.03 a |
| PRM – 160 | 1.13 a | 2.02 a | PRM – 468 | 1.12 a | 1.54 a | PRM – 153 | 1.52 a | 2.08 a |
| PRM – 60 | 1.14 a | 2.50 b | PRM – 420 | 1.39 a | 1.49 a | PRM – 236 | 1.67 a | 2.42 a |
| PRM – 79 | 1.72 a | 2.48 b | PRM – 516 | 1.12 a | 2.05 a | PRM – 234 | 1.10 a | 3.00 b |
| PRM – 68 | 1.28 a | 2.92 b | PRM – 458 | 1.23 a | 1.98 a | PRM – 176 | 1.05 a | 3.08 b |
| PRM – 59 | 1.23 a | 2.98 b | PRM – 365 | 1.26 a | 2.01 a | PRM – 226 | 1.16 a | 3.03 b |
| PRM – 51 | 1.28 a | 3.02 b | PRM – 441 | 1.98 b | 1.43 a | PRM – 155 | 1.24 a | 3.03 b |
| PRM – 135 | 1.77 a | 3.10 b | PRM – 469 | 1.61 b | 1.99 a | PRM – 167 | 1.52 a | 3.00 b |
| Aracy | 3.59 d | 4.48 c | Aracy | 3.50 d | 3.98 c | Aracy | 3.99 d | 4.50 c |
| Achat | 4.36 e | 4.96 c | Achat | 3.99 e | 4.97 d | Achat | 4.09 d | 5.00 d |
| Bintje | 4.98 e | 4.94 c | Bintje | 4.99 f | 4.92 d | Bintje | 4.80 e | 4.94 d |
| General Mean | 3.60 | 4.46 | General Mean | 2.96 | 5.88 | General Mean | 3.16 | 4.38 |
| CV (%) | 9.85 | 10.46 | CV (%) | 10.91 | 13.34 | CV (%) | 11.46 | 8.86 |
| $h^2$ | 0.95 | 0.87 | $h^2$ | 0.96 | 0.90 | $h^2$ | 0.93 | 0.89 |

[1/] Means followed by the same letter in the column do not differ by the Scott and Knott test ($p<0.05$).

clones whose genotypes were more resistant to the pathogen than those of the controls. Disease score means at 60 DAP were lower than the means at 75 DAP, indicating that the disease index increased considerably between assessments due to the environmental conditions (ideal temperature and moisture) which were suitable for late blight development. For a successful selection of means, the clones identified as resistant by one assessor must also be assessed as resistant by the other assessors in both field assessments. To ascertain whether this was true, a joint analysis of variance was performed between the four assessors at 60 DAP (Table 2). Although there were differences among the four assessors, indicating different criteria to quantify the disease, interaction among the scores of the assessors and the clones was not detected, showing that the means of the four assessors gave a high degree of reliability to the selection of the most resistant clones.

Whether the behavior of a certain clone was constant throughout the plant cycle, that is, whether a clone identified as resistant in the assessment at 60 DAP maintained its performance in the subsequent assessment, is of extreme importance. Thus, a joint analysis was performed considering the effects of the assessments at 60 and 75 DAP (Table 3). Assessment x clones interaction was significant indicating resistance instability during the cycle, that is, clones identified as more resistant at 60 DAP behaved differently at 75 DAP. However, it is questionable which assessment would give a greater degree of reliability to the selection of more resistant clones. James (1974) quoted the assessment model of the disease considering the critical point of the lesioned leaf area from which yield is reduced. Tuber development stops when 75% of the leaf area is damaged in the late blight-potato system. A critical point is the moment in the crop cycle when this percentage of lesions occurs. Parlevliet (1979) suggested the assessment of the disease severity at the peak of development of the epidemic, assuming that the action of resistance components is cumulative and they act together. Most of the clones showed the same level of resistance in both assessments despite the changes in positions in the clone resistance classification . Table 1 shows some clones which had an outstanding performance due to their high resistance level in both assessments. Since the percentage of damaged leaf tissue was extremely low, there may be specific resistance to the races present in the area. Tuber yield and the other traits were not assessed in this experiment because the yield was low and some plots were lost due to the presence of late blight.

**Table 2.** Summary of the joint analysis of variance of three assessors for resistance to late blight (*Phytophthora infestans*) at 60 DAP. Maria da Fé, 1996/97.

| SV | DF | MS | | |
|---|---|---|---|---|
| | | Lattice 1 | Lattice 2 | Lattice 3 |
| Assessors | 3 | 7.8265 [1/] | 23.0747 [1/] | 3.2700 [1/] |
| Clones | 99 | 10.4226 [1/] | 11.4085 [1/] | 8.2692 [1/] |
| Assessors x Clones | 297 | 0.2030 [ns] | 0.2755 [ns] | 0.1969 [ns] |
| Pooled error | 324 | 0.2187 | 0.2232 | 0.2794 |
| Means | | 3.60 | 2.93 | 3.16 |
| CV (%) | | 12.97 | 15.93 | 16.70 |

[ns]: not significant; [1/] significant values at the 1% level of probability by the F test.

**Table 3.** Summary of the joint analysis of variance among the assessments of resistance to late blight (*Phytophthora infestans*) at 60 and 75 DAP. Maria da Fé, 1996/97.

| SV | DF | MS | | |
|---|---|---|---|---|
| | | Lattice 1 | Lattice 2 | Lattice 3 |
| Assessments | 1 | 73.1028 [1/] | 84.4937 [1/] | 147.6210 |
| Clones | 99 | 4.0574 [1/] | 5.1721 [1/] | 3.1327 |
| Assessments x Clones | 99 | 0.2691 [1/] | 0.3754 [1/] | 0.3735 |
| Pooled error | 162 | 0.1720 | 0.1864 | 0.1410 |
| Means | | 4.033 | 3.4231 | 3.7725 |
| CV (%) | | 10.29 | 12.61 | 9.95 |

[ns]: not significant; [1/] significant values at the 1% level of probability by the F test.

There were also significant differences for reaction to early blight among the treatment means in all the assessments. A joint analysis among the four assessors at 70 and 80 DAP was carried out for this disease (Table 4). These assessments were chosen because greater variability in damaged leaf area was detected among the plots. Furthermore, the disease level detected was still low in the assessment at 60 DAP, whereas at 90 DAP the disease level detected in the field was much higher and most of the plots presented signs of senescence. The assessors and clones effects were significant by the F test, showing the difference of criteria among the assessors and clone behavior. However, the assessors x clones interaction was not significant, showing that the resistant or susceptible clones were identified by all the assessors and that the mean gave a high degree of reliability to the selection of the most resistant clone.

A joint analysis was further carried out considering the effects of the assessments at 60, 70 80 and 90 DAP on the clone behavior (Table 5). The high significance observed for the interaction effect indicated that the behavior of certain clones was unstable and demonstrated that potentially more resistant materials should not be selected based on a single assessment.

Several studies have shown that resistance assessment from a single assessment does not permit a reliable classification of the resistance to early blight in epidemiological terms (Boiteux et al., 1995; Holley et al., 1983). Boiteux and Reifschneider (1993) considered that reduced rate infection-type resistance does not completely inhibit the dissemination of the pathogen and that the means obtained at a given moment in the epidemiological cycle may not reflect the real level of resistance of the genotype, which may be underestimated. The disease progress curve obtained by plotting the disease severity against time is considered the best representation of an epidemic cycle (Bergamin Filho, 1995). The curve represents the set of interactions between the host pathogen and environmental effects during the epidemy. The area under the disease-progress curve (AUDPC) is considered one of the main criteria to be used in comparative epidemiological studies, and there was high correlation between AUDPC and the progress rate of the disease or infection. The AUDPC was calculated using the percentage of infected leaf area data from the scores obtained in the field in each one of the assessments during the epidemiological cycle. The result of the analysis of variance for AUDPC was significant for clones, indicating that clones

**Table 4.** Summary of the joint analyses of variance for scores of early blight (*Alternaria solani*) from four assessors at 70 DAP and 80 DAP. Lavras, 1997.

| SV | DF | MS | |
|---|---|---|---|
| | | 70 DAP | 80 DAP |
| Assessors | 3 | 2.9546 [1/] | 2.4395 [1/] |
| Clones | 195 | 4.8876 [1/] | 4.8110 [1/] |
| Assessors x Clones | 585 | 0.2154 [ns] | 0.1548 [ns] |
| Pooled error | 676 | 0.1763 | 0.1689 |
| General Mean | | 3.73 | 4.84 |
| CV (%) | | 12.45 | 8.49 |

[ns]: not significant; [1/] significant values at the 1% level of probability by the F test.

**Table 5.** Summary of the joint analysis of variance among the assessment periods for resistance to early blight (*Alternaria solani*) at 60, 70 80 and 90 DAP. Lavras, 1997.

| SV | DF | MS |
|---|---|---|
| Assessments | 3 | 1234.8488[1/] |
| Clones | 195 | 2.4964[1/] |
| Assessments x Clones | 585 | 0.2399[1/] |
| Pooled error | 676 | 0.0771 |
| General Mean | | 3.88 |
| CV (%) | | 7.16 |

[ns]: not significant; [1/] significant values at the 1% level of probability by the F test.

resistant to early blight exist. Table 6 shows the means for the most resistant clones and the controls for AUDPC for early blight. Clones are selected based on this trait since the mean is the best representative of pathogen x host x environment interactions, and of the problems with selection based on a single field assessment. The broad sense heritability for AUDPC was relatively high (0.89) and superior to other values in the literature (Christ and Haynes, 2001). Thus resistant clones identified in this study have great potential for use as a source of resistance to the disease and for being released as cultivars, as long as they present desirable agronomic traits.

There are results in the literature showing a correlation between resistance and long plant vegetative cycle. Some researchers even suggest that resistance to early blight is not a true genetic resistance. Table 7 shows the correlation coefficients for resistance to early blight and the clone plant cycle. Negative and highly significant values were observed for the correlation in all the assessments, indicating that the most resistant clones tended to have a longer plant vegetative cycle. The smallest significant correlation value was that for the assessment at 60 DAP, since the epidemic level was relatively low at this time and the most susceptible clones received lower scores. There was a tendency for more resistant clones to be late, however, this was not always true. In this study, for example, it was observed that 13 out of the 50 more resistant clones had a cycle of less than 95 DAP. This data reinforces other researchers' idea of concentrating the breeder´s efforts on selecting clones with intermediary maturity with a resistance level similar to that of late materials.

Other interesting data found in this study concerns tuber production, which is of real interest to commercial potato production. Nine out of the 50 most susceptible clones had yield superior to 500 g/plant and plant cycle less than 90 DAP. This result suggests that these clones may present an earlier tuberization phase so that the peak of the epidemic does not greatly affect yield. The early start of tuberization is not mentioned in the literature as a resistance mechanism to early blight, however, this characteristic may deserve greater attention from researchers. If the clone is productive under a high level of symptoms at the peak of the epidemic, its commercial value will be the same as a more resistant clone.

The correlation between tuber yield per plant and resistance at 80 DAP was –0.24, indicating a slight tendency for more resistant clones to be also more productive. To best illustrate this tendency, more susceptible and resistant clones to AUDPC were taken and their yield means were 335.08 g/plant and 551.35 g/plant, respectively.

Whether the clones resistant to late blight were also resistant to early blight was also investigated. The coefficient of correlation of the disease scores was only 0.0965 for late blight at 60 DAP and early blight at 70 DAP, indicating that resistance to one disease has no relation to resistance to the other. Christ and Haynes (2001) also found low coefficient of correlation values between the two diseases, suggesting that different genes are involved in the resistance to the pathogens

**Table 6.** Means of the twenty most resistant clones to early blight (*Alternaria solani*) and the controls for the area under the disease-progress curve (AUDPC), total tuber yield per plant, percentage of large tubers and tuber specific gravity. Lavras, 1997 [1/].

| Clones [2/] | AUDPC | Tuber Yield (g/plant) | Percentage of large tubers | Tuber specific gravity |
|---|---|---|---|---|
| PRM – 68 | 74.35 a | 450 c | 41 b | 1.0663 b |
| PRM – 466 | 124.61 a | 518 b | 46 b | 1.0648 b |
| PRM – 227 | 156.18 a | 233 c | 76 a | 1.0550 d |
| PRM – 277 | 216.35 a | 340 c | 82 a | 1.0554 d |
| PRM – 51 | 318.47 a | 589 b | 60 a | 1.0710 a |
| Aracy (R) | 342.87 a | 508 b | 30 c | 1.0613 c |
| PRM - 63 | 353.19 a | 829 a | 27 c | 1.0645 b |
| PRM - 465 | 364.13 a | 503 b | 45 b | 1.0643 b |
| PRM - 530 | 427.06 a | 342 c | 73 a | 1.0602 c |
| PRM - 177 | 429.57 a | 648 a | 63 a | 1.0636 c |
| PRM - 467 | 482.50 a | 1059 a | 54 a | 1.0622 c |
| PRM - 178 | 513.34 b | 718 a | 33 b | 1.0643 b |
| PRM - 261 | 518.32 b | 408 c | 60 a | 1.0671 b |
| PRM - 511 | 522.29 b | 176 c | 40 b | 1.0632 c |
| PRM - 471 | 530.69 b | 836 a | 76 a | 1.0591 c |
| PRM - 486 | 537.87 b | 312 c | 40 b | 1.0604 c |
| PRM - 516 | 551.46 b | 407 c | 4 d | 1.0570 d |
| PRM - 102 | 609.11 b | 755 a | 34 b | 1.0677 b |
| PRM - 264 | 610.66 b | 395 c | 41 b | 1.0617 c |
| PRM - 67 | 612.12 b | 653 a | 61 a | 1.0623 c |
| PRM - 477 | 616.24 b | 764 a | 43 b | 1.0699 a |
| Delta (MR) | 1022.04 c | 201 c | 21 c | 1.0639 b |
| Achat (S) | 1904.86 f | 295 c | 33 b | 1.0495 d |
| Bintje (S) | 1951.88 f | 258 c | 7 d | 1.0563 d |
| General Mean | 1154.53 | 440 | 25 | 1.0639 |
| CV (%) | 16.37 | 28.25 | 53.18 | 0.30 |
| $h^2$ | 0.89 | 0.72 | 0.78 | 0.82 |

[1/] Means followed by the same letter in the column do not differ by the Scott and Knot test ($p<0.05$); [2/] S: susceptible; MR: moderately resistant and R: resistant.

**Table 7.** Correlations between plant vegetative cycle in days after planting (DAP) or days after emergence (DAE) and resistance to early blight (*Alternaria solani*) assessed at 60, 70, 80 and 90 days after planting. Lavras, 1997.

| Evaluations | Vegetative Cycle (DAP) | Vegetative Cycle (DAE) |
|---|---|---|
| 60 DAP | - 0.4106 [1/] | - 0.3756 [1/] |
| 70 DAP | - 0.5581 [1/] | - 0.5228 [1/] |
| 80 DAP | - 0.6593 [1/] | - 0.6209 [1/] |
| 90 DAP | - 0.6345 [1/] | - 0.5722 [1/] |

[1/] significant values at the 1% level of probability by the t test.

in the clones studied. However, clones presented good levels of resistance to both late blight and early blight such as PRM 51, PRM 68, 178 and PRM 516.

Reaction to disease assessment carried out in a single location may be questioned, especially under tropical conditions since differences are expected under environmentally distinct conditions, mainly in the presence of several pathogen races. No significant genotype by environmental interaction was reported under the US conditions for reaction to late blight, thus the classification of the resistant materials remained practically the same in eight locations (Haynes et al., 1998). The clones x years interaction presented low magnitude for early blight (Christ and Haynes, 2001). In both studies the AUDPC resistance assessment methodology was used. It is expected that the results obtained here are true under other conditions.

Significant differences were detected among clones for all the agronomic traits assessed in Lavras in the presence of early blight, showing the great variability and possibility of selecting superior clones. The relationship between the coefficient of genetic variation and the coefficient of environmental variation presented values greater than 1.0, except for mean weight of large tubers mean and commercial tuber weight mean, which is a very favorable situation for selection. The estimates of heritability were relatively high (Table 6). General means for total tuber production and percentage of large tuber were low (Table 6), showing the drastic effect of early blight on the crop. These results were due to the shortening of the plant cycle, which was only 89.3. It is known that in the final stages of the crop there is a great translocation of photoassimilates to the tubers that contributes decisively to their growth. In the presence of early blight, total tuber production per plant varied from 49g to 1,059 g. The susceptible controls (Achat and Bintje) presented means of 295 g and 258 g per plant, respectively, showing their fragility in the presence of this disease. The Aracy cultivar (resistance standard) presented a mean of 508 g per plant. The specific weight of the tubers also seemed to have been affected by early blight with a mean value of only 1.0639.

Similar to the experiment in Lavras, significant differences were detected in Alfenas among clones for all the traits. On the other hand, the experimental accuracy was much better than that obtained in Lavras, except for tuber specific weight, that presented a similar CV (Table 8). This greater experimental accuracy was due, among other factors, to the rigorous phytosanitary control that prevented the occurrence of diseases in the foliage and permitted greater uniformity among the plots. The ratio between the coefficient of genetic variation and the coefficient of environmental variation was greater than 1.0. These values were also superior to those found in the experiment at Lavras and showed, once again, a favorable condition for clone selection. The estimates of the broad sense heritabilities were also superior to those at Lavras. In the absence of early and late blight total tuber yield per plant was 97% superior to that obtained in Lavras. These increases were due mainly to the increase in the number and mean weight of large tubers (data not presented). On the other hand, tuber specific weight presented lower means than those found at Lavras. These results were not expected since the phytosanitary control and absence of foliage diseases did not shorten the plant cycle, as it had done in Lavras. However, it is known that tuber specific weight is affected by a series of other environmental factors such as soil type, fertilization and climatic conditions that may have contributed to the lower means observed in Alfenas. The total tuber production varied from 105 g to 1,714 g per plant. About 68% of the production was of large tubers (> 45mm transversal diameter) that have a better market price and give better appearance to the product.

Results also showed that only 25% of the Lavras production was of large tubers (Table 6). Table 8 shows the means for the clones that excelled for tuber yield, percentage of large tubers and tuber specific gravity. Several clones produced over 1,000 grams per plant, showing their productive potential under favorable cultivation conditions.

Clones that presented good resistance levels to both diseases were identified. They also had tuber yields superior to the controls, both in the presence and

absence of the diseases. These clones further presented tuber specific weight similar or superior to those of the controls.

**Table 8.** Means of thirty more productive clones and controls for total tuber yield per plant, percentage of large tubers and tuber specific gravity in the absence of early blight and late blight. Alfenas, 1997 [1/].

| Clones | Tuber Yield (g/plant) | Percentage of large tubers | Tuber specific gravity |
|---|---|---|---|
| PRM – 505 | 1714 a | 71 b | 1.0534 c |
| PRM – 170 | 1512 a | 88 a | 1.0566 c |
| PRM – 467 | 1417 a | 42 c | 1.0516 d |
| PRM – 435 | 1417 a | 35 c | 1.0591 c |
| PRM – 504 | 1400 a | 84 a | 1.0570 c |
| PRM – 41 | 1382 a | 88 a | 1.0678 a |
| PRM – 466 | 1352 a | 65 b | 1.0577 c |
| PRM – 444 | 1308 a | 84 a | 1.0538 c |
| PRM – 432 | 1282 a | 81 a | 1.0620 b |
| PRM – 146 | 1278 a | 64 b | 1.0622 b |
| PRM – 477 | 1271 a | 49 c | 1.0658 a |
| PRM – 135 | 1270 a | 93 a | 1.0624 b |
| PRM – 223 | 1252 a | 78 a | 1.0665 a |
| PRM – 177 | 1249 a | 95 a | 1.0575 c |
| PRM – 178 | 1248 a | 68 b | 1.0614 b |
| PRM – 510 | 1238 a | 27 d | 1.0571 c |
| PRM – 149 | 1236 a | 54 c | 1.0585 c |
| PRM – 517 | 1236 a | 69 b | 1.0612 b |
| PRM – 274 | 1236 a | 88 a | 1.0491 d |
| PRM – 102 | 1229 a | 90 a | 1.0611 b |
| PRM – 54 | 1218 a | 88 a | 1.0650 b |
| PRM – 124 | 1200 a | 89 a | 1.0643 b |
| PRM – 365 | 1199 a | 65 b | 1.0594 c |
| PRM – 448 | 1194 a | 79 a | 1.0618 b |
| PRM – 212 | 1177 a | 96 a | 1.0586 c |
| PRM – 509 | 1171 a | 52 c | 1.0581 c |
| PRM – 246 | 1167 a | 77 a | 1.0621 b |
| PRM – 269 | 1158 a | 63 b | 1.0634 b |
| PRM – 521 | 1158 a | 86 a | 1.0686 a |
| PRM – 222 | 1148 a | 85 a | 1.0587 c |
| Achat | 635 c | 72 b | 1.0543 c |
| Bintje | 679 c | 57 c | 1.0587 c |
| Delta | 539 d | 54 c | 1.0602 b |
| Aracy | 413 d | 45 c | 1.0581 c |
| General Mean | 867 | 67 | 1.0591 |
| CV(%) | 18.58 | 15.29 | 0.34 |
| $h^2$ | 0.77 | 0.85 | 0.83 |

[1/] Means followed by the same letter in the column do not differ by the Scott and Knot test ($p<0.05$).

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## RESUMO

**Resistência de clones de batata à requeima e à pinta preta**

A obtenção de genótipos de batata (*Solanum tuberosum* L.) resistentes à requeima e à pinta preta, doenças causadas pelos fungos *Phytophthora infestans e Alternaria solani,* respectivamente, é de extrema importância para a adoção das práticas de manejo integrado para o controle destas doenças. Este trabalho teve como objetivo avaliar clones de batata previamente selecionados pelo programa de melhoramento da batata da Universidade Federal de Lavras para resistência à pinta preta. Foram realizadas três avaliações em três localidades do sul de Minas, sob diferentes condições de cultivo: um ensaio envolvendo 192 clones, com inoculação de *A. solani,* outro na presença de infecção natural por *P. infestans*, avaliando-se 291 clones e um último na ausência destas doenças, envolvendo também 192 clones. Houve tendência dos clones mais resistentes à *Alternaria* terem ciclo vegetativo mais longo. Foram identificados clones que apresentaram bons níveis de resistência a ambas as doenças, além de possuírem produtividades de tubérculos superiores às testemunhas, tanto em presença quanto na ausência da pinta preta. Esses clones apresentaram peso específico de tubérculos semelhantes ou superiores aos das testemunhas.

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