JOÃO PAULO ASCARI

TAXONOMIC AND PATHOGENIC DIVERSITY OF THE BLAST PATHOGEN POPULATIONS INFECTING WHEAT AND GRASSES IN MINAS GERAIS

Tese apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduação em Fitopatologia, para obtenção do título de *Doctor Scientiae*.

Orientador: Emerson Medeiros Del Ponte

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APROVADA: 19 de agosto de 2021.

Assentimento:

João Paulo

João Paulo Ascari
Autor

Emerson Medeiros Del Ponte
Orientador

Aos meus pais, Valdir and Gilvania,
A minha irmã, Daianny,
Aos meus sobrinhos (a), Anthony, Giovanna e Angela
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ABSTRACT

ASCARI, João Paulo, D.Sc., Universidade Federal de Viçosa, August, 2021. **Taxonomic and pathogenic diversity of the blast pathogen populations infecting wheat and grasses in Minas Gerais.** Adviser: Emerson Medeiros Del Ponte.

The blast disease of Poaceae is caused by a large species complex, among which *P. oryzae* is composed of several host-specialized lineages. The *Pyricularia oryzae Triticum* pathotype (PoT) causes the blast disease in wheat, but is also capable of infecting other grasses, which may serve as an inoculum reservoir for epidemics in wheat. In Brazil, severe wheat blast epidemics are most common in the Cerrado region. The dominant hypothesis is that signal grass (*Urochloa* sp.) and other gramineous plants harbor the wheat blast pathogen, thus serving as a major reservoir of inoculum for epidemics in wheat. A two-year survey of the *Pyricularia* blast pathogens was conducted in both wheat and non-wheat areas as well as prior (February) and during (May) the wheat growing season in Minas Gerais. A total of 1,368 plant samples representative of 31 Poaceae species, including wheat, were collected and inspected for the presence of blast symptoms. During the isolations, 932 isolates were obtained, being one fourth obtained from gramineous plants. A subset of 572 isolates was selected for identification at the species level based on portions of the CH7-BAC9 gene sequences. Most of the isolates (n = 494) were *P. oryzae*, within which 68% were PoT and 32% non-PoT based on two PCR assays targeting (MoT3 and C17 PCR assays). The PoT lineage was found predominantly (97%) in wheat and rarely in the other hosts, even nearby wheat fields (2.1%), as well as at longer distances from wheat regions (0.1%). The blast pathogen population isolated from signal grass grouped in different clades from PoT, and therefore referred to *Urochloa* lineage (PoU). A series of cross-inoculation greenhouse experiments was conducted using wheat (cv. BRS Guamirim and BR 18-Terena) and signal grass (cv. Marandu) as host and 14 PoT and six PoU isolates as pathogen factor. In the first leaf-inoculation experiment, results showed a significant interaction between host and pathogen; PoT was strongly/weakly aggressive towards wheat/signal grass and PoU was strongly/weakly aggressive towards signal grass/wheat. In inoculated wheat heads, PoT was more aggressive (>91% infected spikelets) than PoU (52% infected spikelets). In a third experiment, four signal grass cultivars (Marandu, Basilisk, Piatã, and Xaraés) were inoculated with the same set of 20 isolates. Similarly, signal grass cultivars were generally more susceptible to PoU than PoT. Severity induced by PoU was twice (7.7% severity) as high as PoT (3.8%) and so was the number of conidia/leaf produced by PoU (47,500) and PoT (23,200). Two groups of signal grass cultivars were formed, the most susceptible composed of Marandu and Basilisk and the least susceptible composed of Piatã and Xaraés. Results of our study confirm the host-specialization and the shaping of the blast populations according to the host. We further suggest that grasses in general, especially signal grass, may not play a major role as an inoculum reservoir for PoT, as it harbors mainly the PoU population. However, due to the large extent of pasture-growing regions and cross-infection ability in wheat, signal grass may harbor amounts of PoT inoculum that are sufficient for initiating leaf and head blast epidemics in wheat blast in Minas Gerais state.

Keywords: *Pyricularia oryzae. Magnaporthe oryzae.* Wheat blast. Alternative hosts. Epidemiology.

RESUMO

ASCARI, João Paulo, D.Sc., Universidade Federal de Viçosa, agosto de 2021. **Diversidade taxonômica e patogenicidade de populações do agente causal da brusone do trigo e gramas em Minas Gerais**. Orientador: Emerson Medeiros Del Ponte.

A brusone das *Poaceae* é causada por um complexo de espécies, dentre as quais, *Pyricularia oryzae* é a mais importante*,* uma espécie constituída por diversas linhagens filogenéticas com especialização pelo hospedeiro primário. O patótipo *Triticum* de *P. oryzae* (PoT), é especializado em causar brusone em trigo, porém, também infecta outras gramíneas, que podem servir como fontes de inóculo para epidemias de brusone em trigo. No Brasil, as severas epidemias de brusone são mais comuns na região do Cerrado. A hipótese dominante é que a braquiária e as outras gramíneas são hospedeiras do patógeno da brusone do trigo, servindo como principal fonte de inóculo para as epidemias de brusone que ocorrem no trigo. Foi realizado um levantamento de espécies de *Pyricularia* sp. durante dois anos, considerando campos de trigo e áreas naturais, amostradas antes (fevereiro) e durante (maio) a safra de trigo em Minas Gerais. Um total de 1.368 amostras de plantas, representando 31 espécies de Poaceae, incluindo o trigo, foram coletadas e inspecionadas quanto à presença de sintomas típicos de brusone. Após o término dos isolamentos, um total de 932 isolados foram obtidos, dos quais 1/4 dos isolados foram obtidos de gramas. Um subconjunto de 572 isolados foram selecionados para identificação a nível de espécie, baseando-se em sequências parciais de um gene anônimo amplificadas pelo primer CH7-BAC9. A maioria dos isolados (n = 494) foram identificados como *P. oryzae*, dos quais 68% foram PoT e 32% outras linhagens baseados nos dois genes amplificados por primers específicos (MoT3 e C17) através de reações de PCR. A linhagem PoT foi encontrada predominantemente infectando o trigo (97%), raramente em outras gramíneas, mesmo naquelas próximas aos campos de trigo (2,1%). PoT foi ainda menos frequente nas gramas coletadas longe das regiões de trigo (0,1%). A população do patógeno causador de brusone em braquiária foi filogeneticamente diferente da linhagem *Triticum*. Portanto, propomos um novo grupo para incluir essa população, a linhagem da braquiária - PoU. Foram conduzidos uma série de experimentos de inoculação cruzada em casa de vegetação, onde as plantas hospedeiras (fator 1): trigo (cv. BRS Guamirim e BR 18-Terena) e braquiária (cv. Marandu), foram pulverizadas com diferentes isolados de *P. oryzae* (fator 2): PoT (14) e PoU (6). No primeiro experimento, inoculação em folhas, os resultados demonstraram que ocorreu interação significativa entre hospedeiro e patógeno; PoT apresentou forte e fraca agressividade em trigo e braquiária, já PoU foi muito e pouco agressivo em braquiária e trigo, respectivamente. No segundo experimento, foi realizada a inoculação das espigas de trigo, PoT (>91% de espiguetas infectadas) foi mais agressivo que PoU (52%). No terceiro experimento, quatro cultivares de braquiária (Marandu, Basilisk, Piatã, and Xaraés) foram inoculadas com os mesmos 20 isolados de *P. oryzae*. Os resultados de agressividade foram similares aos observados no primeiro experimento, onde a braquiária foi mais suscetível a PoU do que PoT. A severidade foliar de brusone foi duas vezes maior em PoU (7,7%) do que em PoT (3,8%). O mesmo padrão ocorreu para número de conídios por folha produzidos por PoU (47.000) e PoT (23.200). Formou-se dois grupos de cultivares de braquiária, um mais suscetível composto por Marandu e Basilisk, e outro menos suscetível formado por Piatã e Xaraés. Nossos resultados confirmaram que o patógeno da brusone apresentou especialização patogênica e formou grupos de agressividade conforme o hospedeiro primário. Também sugerimos que as gramíneas, em especial a braquiária, podem não ser a principal fonte de inóculo de PoT, já que obtivemos principalmente populações de PoU. Entretanto, devido às vastas áreas cobertas com braquiária e também pela habilidade do PoU em causar doença no trigo, a braquiária pode produzir quantidades suficientes de PoT para iniciar uma epidemia de brusone na folha ou na espiga do trigo em Minas Gerais.

Palavras-chave: *Pyricularia oryzae. Magnaporthe oryzae.* Hospedeiros alternativos. Epidemiologia.

SUMMARY

1. INTRODUCTION

1.1. Geographical distribution of wheat blast

The ascomycete fungus *Pyricularia oryzae*, considered the worldwide most scientific/economic important fungus (Dean et al. 2012), is the cause of diseases known as rice blast (Rossman et al. 1990; Valent and Chumley 1991), gray leaf spot in perennial ryegrass (Farman 2002) and wheat blast (Igarashi et al. 1986a; Couch and Kohn 2002). These diseases are known to be caused by different host-specialized forms of the fungus known as pathotypes: *P. oryzae Oryzae* pathotype (PoO; rice blast), *Lolium* pathotype (PoL; gray leaf spot) and *Triticum* pathotype (PoT; wheat blast). In wheat, the disease is a current threat to production in at least three continents: South America, Asia, and Africa (Yesmin et al. 2020). First reported in 1985 in the state of Paraná, Brazil (Igarashi et al. 1986a), wheat blast further spread to all major Brazilian wheat-producing regions (Goulart et al. 1990; Prabhu et al. 1992; Lima 2004; Ceresini et al. 2018), and also to neighboring countries including Paraguay, Bolivia, and Argentina (Barea and Toledo 1996; Viedma 2005; Cabrera and Gutierrez 2007; Alberione et al. 2008; Perelló et al. 2015; Saharan et al. 2016; Pieck et al. 2017; Yasuhara-Bell et al. 2018b; Ceresini et al. 2019, Tosa 2021). International concern was significantly raised during the last five years after the arrival of the wheat blast in South Asian countries, such as Bangladesh (Islam et al. 2016; Callaway 2016). Even being one of Bangladesh's neighbor countries and having conductive weather conditions to wheat blast occurrence, no formal scientific reports confirmed the wheat blast introduction in India (Islam et al. 2020, Singh et al. 2021). More recently, the wheat blast pathogen arrived in Africa: Zambia (Tembo 2019; Tembo et al. 2020) (Figure 1).

Figure 1. Global distribution of fungal strains of the wheat blast pathogen (*Pyricularia oryzae*). Source of geographical information: Brazil (This dissertation), Bolivia (Barea and Toledo 1996), Paraguay (Viedma 2005; Pieck et al. 2017), Uruguay (Saharan et al. 2016; Yasuhara-Bell et al. 2018b), Argentina (Perelló et al. 2015), United States (Farman et al. 2017), Bangladesh (Islam et al. 2016), and Zambia (Tembo et al. 2020, 2021; Croll 2021). Adapted from *Pyblaster*, the wheat blast tracker website: (https://pyblastr.netlify.app/).

1.2. Economical and scientific importance

Wheat blast epidemics occur more frequently in the tropics where significant yield losses have been associated more often with wheat head blast rather than the leaf blast (Pagani et al. 2014; Cruz and Valent 2017). Leaf blast epidemics sporadically occurs in Brazilian wheat fields, but in epidemics seasons, the warm and wet weather during the early season might favor infection and inoculum build-up on young leaves of wheat, or even in other grass weeds nearby wheat fields (Cruz et al. 2015a; Gongora-Canul et al. 2020). The first report of yield losses due to blast was estimated at around 27% in Brazil (Goulart et al. 1990), but up to 100% have been also reported in the country (Goulart and Paiva 2000; Pagani et al. 2014; Santana et al. 2016, 2020), which was the case of the first major epidemics in Bangladesh where several fields have been destroyed (Islam et al. 2016).

The enhanced attention given to wheat blast has contributed new knowledge from both basic and applied research that emerged during the last 10 years. This is evident based on the increase in the yearly number of original articles and reviews published after the major epidemics reported in the Cerrado, Brazil, and disease's introduction into both Asia and Africa (Figure 2A). (Rajiv 2017; Sadat and Choi 2017; Cruz and Valent 2017; Mottaleb et al. 2018, 2019; Ceresini et al. 2018, 2019; Islam et al. 2019, 2020; Kamoun et al. 2019; Tembo 2019; Yesmin et al. 2020; Mbinda and Masaki 2021, Singh et al. 2021, Tosa 2021). While some aspects have been given more attention, such as the taxonomy and population genetics (Couch and Kohn 2002; Tanaka et al. 2009; Luo and Zhang 2013; Maciel et al. 2014; Murata et al. 2014; Klaubauf et al. 2014; Gladieux et al. 2015, 2018; Castroagudín et al. 2016; Valent et al. 2019), chemical control (Kim et al. 2003; Cruz et al. 2011, 2019; Pagani et al. 2014; Rocha et al. 2014; Castroagudín et al. 2015; Oliveira et al. 2015; Dorigan et al. 2019; D'Ávila et al. 2021; Ascari et al. 2021) and host genetic resistance (Cruz et al. 2016b; Anh et al. 2018; Rocha et al. 2019; Cruppe et al. 2020; Inoue et al. 2021; Dianese et al. 2021; Asuke et al. 2021), wheat blast epidemiology, in general, remains relatively poorly studied (Urashima et al. 2007; Cruz et al. 2015a; Gomes et al. 2018, 2019; Pizolotto et al. 2019; Kovaleski et al. 2020; Gongora-Canul et al. 2020; Mills et al. 2020, 2021) (Figure 2B).

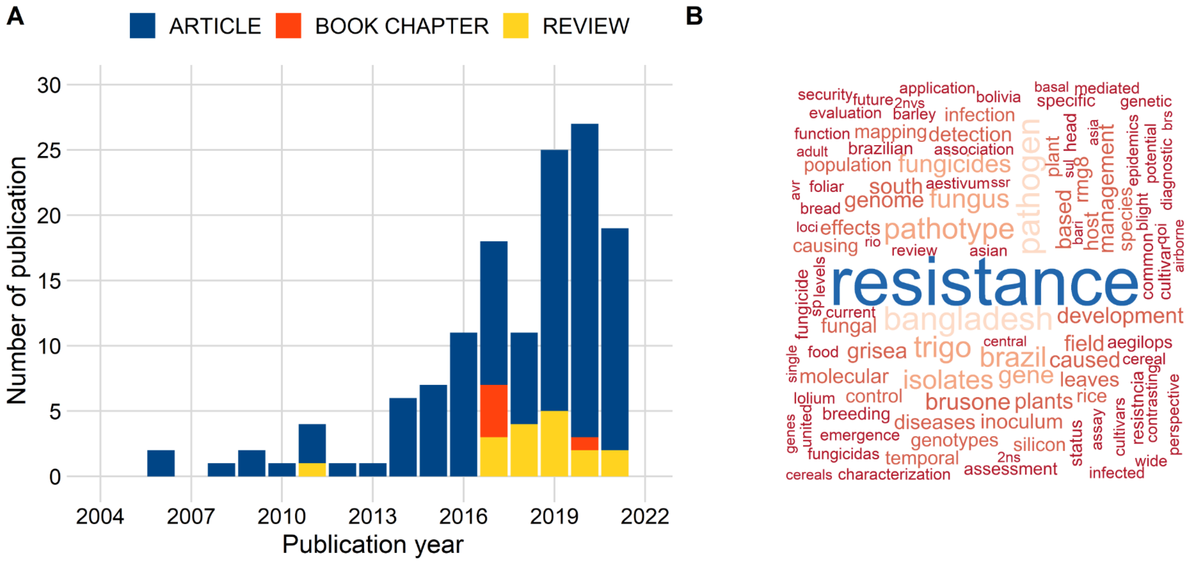


Figure 2. (A) Number of publications per year (colored by publication type) retrieved from the SCOPUS database on June 21, 2021 using the keyword “wheat blast” in the title, abstract and keywords of the publication. (B) Word cloud map for terms (at least two occurrences and excluding the name of the pathogen and of the disease) in the title of these publications.

1.3. Taxonomy and genetic diversity

The identity of the wheat blast pathogen has undergone a few corrections since its first denomination as *Pyricularia* sp. (Igarashi et al. 1986b). Because of the similar morphology between *P. grisea* and *P. oryzae,* the wheat blast pathogen had been referred to as *P. grisea* for some time in the past (Yaegashi and Udagawa 1978; Rossman et al. 1990). Further evidence based on pathogenicity tests, mating type ability, and genetic diversity, suggested the existence of host-specialized populations, meaning that they were much more aggressive towards one Poaceae species than others (Kato et al. 2000). Phylogenetic data supported the existence of two separate species with long-time reproductive isolation and associated with different hosts: 1) *P. grisea* that is commonly associated with *Digitaria* spp., and 2) *P. oryzae* that causes blast on rice, wheat and several grass species (Couch and Kohn 2002; Couch et al. 2005) (Figure 3). The name *P. grisea* (or *M. grisea)*, to refer to the wheat blast pathogen, remained in use for some time afterwards (Bruno and Urashima 2001;

Urashima et al. 2004, 2007, 2009; Couch et al. 2005; Silva and Prabhu 2005; Alves and Fernandes 2006; Hau et al. 2007; Yoshida et al. 2009; Chuma et al. 2009; Cruz et al. 2015a).

According to the International Code of Nomenclature for algae, fungi and plant, the name of the anamorph (*Pyricularia*) should be used over the teleomorph (*Magnaporthe*) (Luo and Zhang 2013; Murata et al. 2014; Klaubauf et al. 2014), but both genus names continue to be used, depending on the research group (Perelló et al. 2015; D'Ávila et al. 2016, 2021; Farman et al. 2017; Yasuhara-Bell et al. 2018b; Dorigan et al. 2019; Asuke et al. 2019; Tembo et al. 2020; Qi et al. 2021). A proposition of a new name for the species that cause wheat blast was recently made, based on phylogenetic and pathogenic data (Castroagudín et al. 2016). The authors of the study proposed a split of the *P. oryzae* into two species: *P. oryzae* that infects rice and *P. graminis-tritici* that infects wheat and grasses (Ceresini et al. 2019). The molecular evidence was based on ten different genes, mainly supported by 15 polymorphisms sites in the locus MPG1 (hydrophobin gene) and aggressiveness difference across rice, wheat, oats, and signal grass (Castroagudín et al. 2016). However, this proposition was considered premature by a group of scientists, which are supportive of the hypothesis that *P. oryzae* is a single species composed of subpopulations delimited by host specialization with significant gene flow and admixture in the genome (Gladieux et al. 2018; Valent et al. 2019) (Figure 3).

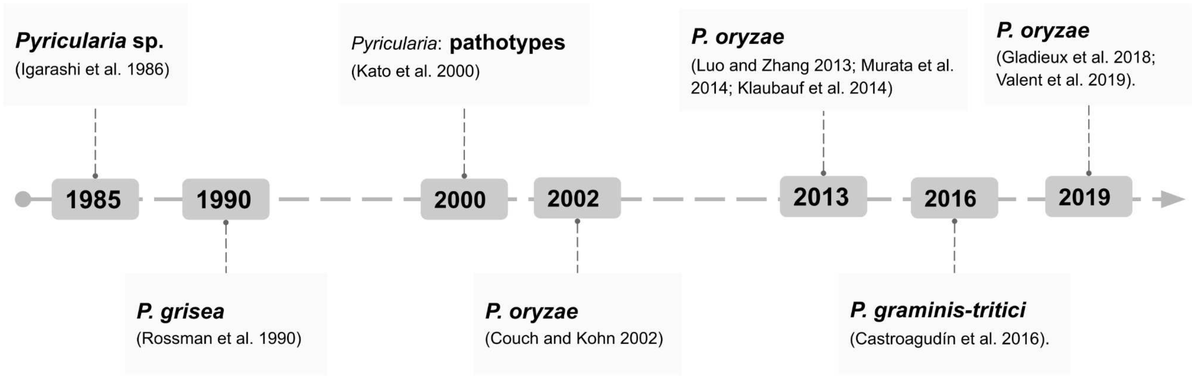


Figure 3. Important events in the wheat blast fungus taxonomy.

These sub-populations, also known as pathotypes (Ou 1980) or lineages (phylogenetically distinct group) (Talbot et al. 1993b), are often specialized on one particular host. Some lineages exhibited fairly strict host-specificity with almost no evidence of cross-infection in nature (Latorre et al. 2020). These include those found on *Oryza (P. oryzae Oryzae*, PoO)*, Setaria* (PoS)*,* and *Eleusine* (PoE). Others such as those infecting *Triticum* (PoT) and *Lolium* (PoL) should be more accurately defined as host-specialized because, although they are mostly found in association with their eponymous hosts, they can be found infecting other Poaceae species (Urashima et al. 1993, 2017; Kato et al. 2000; Tosa et al. 2004, 2016; Tosa and Chuma 2014; Farman et al. 2017; Cruz and Valent 2017; Gladieux et al. 2018).

In Brazil, wheat blast populations were genetically similar across several wheat-producing states in Brazil (Júnior et al. 2016). Therefore, crossing wheat isolates with some grasses lineages *in vitro*, resulted in high-fertile reproductive structures producing mature ascospores (Urashima et al. 1993). Gene flow among blast pathogens populations could be favored by shared hosts (Urashima et al. 1993; Kato et al. 2000) or even mixed infections (Lorenset et al. 2021). Population structure analysis suggested a mixed reproductive system across Brazilian blast also pointing to high lineage diversity structured according to the host of origin (Tanaka et al. 2009; Maciel et al. 2014).

Many events have been driving the gain or loss of related-virulence and avirulence genes involved in pathogenicity. For example, mixed infections in shared hosts favors gene flow through sexual recombination or non-meiotic parasexual processes, (Talbot et al. 1993a, b; Soanes et al. 2002; Inoue et al. 2017; Monsur and Kusaba 2018; Zheng et al. 2018; Gómez Luciano et al. 2019; Asuke et al. 2019), mutations in avirulence genes through selecting frequently occurs (Orbach et al. 2000), or through the moving of a Pot3 transposon across pathogenicity related-genes (Kang et al. 2001). Pathogenic effector proteins have been under evolutive selection across blast populations (Sweigard et al. 1995; Farman and Leong 1998; Jones and Dangl 2006; Avila-Adame 2014; Tosa et al. 2016; Wang and Valent 2017; Inoue et al. 2017, 2021; Gladieux et al. 2018; Langner et al. 2018; Gómez Luciano et al. 2019), which might explain the ability to infect a new host or the variable levels of aggressiveness across different hosts (Kato et al. 2000; Tosa et al. 2004; Castroagudín et al. 2016; Perelló et al. 2017; Urashima et al. 2017; Reges et al. 2018, 2019; Qi et al. 2021).

Long-term reproductive isolation is the main mechanism driving a new *P. oryzae* specialized population. As a heterothallic fungus, the fungus needs two mating types for sexual reproduction: MAT1-1 and MAT1-2 (Urashima et al. 1993; Kato et al. 2000; D'Ávila et al. 2016). Although studies reported that MAT1-1 predominated in the wheat blast population from Brazil (Urashima et al. 1993; Maciel et al. 2014; Moreira et al. 2015), sexual compatibility of wheat blast was reproduced in controlled conditions via crossing wheat isolates with isolates from *Eleusine coracana, Setaria italica,* and *Urochloa plantaginea* (Urashima et al. 1993; Bruno and Urashima 2001).

Some blast populations exhibited high probability of sexual reproduction between each other such as those from wheat (MAT1-1) and *U. plantaginea* (MAT1-2) (Urashima et al. 1993), nevertheless, MAT1-2 exhibited a low frequency in Brazilian blast population (Urashima et al. 2017). Therefore, pathogenicity and genetic analysis indicated that crossing may occur in natural conditions within wheat and between wheat and grass weeds blast infecting populations (Kato et al. 2000). However, the sexual structure has not been seen in nature (Urashima et al. 1993). In addition, population biology of blast populations infecting grass weeds across natural and commercial areas is poorly understood in Brazil, as well as epidemiological importance of conidia and ascospores (Maciel et al. 2014).

1.4. Genetic markers

Genetic markers were developed to study the evolutionary history and genetic diversity of the blast pathogen. Molecular tools allow the identification and differentiation across blast species and lineages. Some loci are frequently included in genetic/phylogenetic analysis of inter-species studies, such as actin (ACT), beta-tubulin (βT-1), and calmodulin (CAL) (Couch and Kohn 2002), largest subunit of RNA polymerase II gene (RPB1), translation elongation factor 1-alpha gene (TEF1), DNA replication licensing factor gene (MCM7), internal transcribed spacer of the rRNA genes (ITS), 18S rRNA gene (SSU) and 28S rRNA gene (LSU) (Zhang et al. 2011; Klaubauf et al. 2014), hydrophobin (MPG1), nitrogen regulatory protein (NUT1) (Couch et al. 2005). Other loci are used in genetics study at intra-species level, such as CH7-BAC7 (hypothetical protein), CH7-BAC9 (fragment of the MGG_02337 gene corresponding to a short retinol dehydrogenase chain) (Couch et al. 2005), and the transposons Pot3 (Farman 2002). Whole genome based-analyses are more precise and informative (Farman et al. 2017; Pieck et al. 2017), but the cost of sequencing is still high for some researchers groups.

Avoiding the extra cost with sequencing of genes (partial or complete) or whole genome, molecular markers were constructed to be specific and to fastly detect the wheat blast pathogens through Polymerase Chain Reaction (PCR). MoT3 was the first specific molecular marker used to identify the *Triticum* pathotype, which was constructed using a genome-based approach to detect unique molecular markers in PoT, producing positive PCR reactions. However, this primer could lead to a very low rate of false positives/negatives (Pieck et al. 2017). The specificity of the MoT3 was even contested for not separating across wheat and rice isolates from Bangladesh (Gupta et al. 2019). However, the author of the original purpose included some rice and wheat isolates from Bangladesh friendly sent by Gupta et al., re-confirming MoT3 specificity to differentiate wheat blast across non-*Triticum* pathogens (Yasuhara-Bell et al. 2019). More recently, a new specific marker to wheat blast pathogen was developed, the primer C17, designed to detect specifically polymorphism sites in the wheat genome. Until now, there is no error reported in its specificity to the *Triticum* pathogen. The intrinsic problem in markers such as MoT3 and C17, considering that the wheat blast population has high genetic variability, is the loss of specificity due to changes in the target site at the fungus genome.

1.5. Infection process

During the early phase of infection, the fungus forms a germ tube followed by an appressorium and penetration peg development, further invading and developing in the host' cells (Ebbole 2007). When the two septated pyriform conidia arrives on the leaf surface, it sticks tightly on the cuticle through an adhesive mucilage composed by glycerol released by an apical opening (Ebbole 2007; Wilson and Talbot 2009). Six hours after the conidia sticks on the leaf, the germination process begins (Cruz et al. 2016c), producing a hypha filament that is protected by extracellular substances also responsible to adhere the conidia on the cuticle surface (Ebbole 2007). The appressorium differentiates around 12 hours later (Cruz et al. 2016c) through glycerol transfer from conidia and germ tube. A melanin layer is deposited in the cell wall to support a turgor pressure up to 8 MPa (Boddy 2016; Fernandez and Orth 2018). Conidia and germ tube undergo autophagy from 36 to 72 hours later (Cruz et al. 2016c). Physical pressure imposed on the appressorium bases forming the penetration peg, puncturing the leaf cuticle. Leaf parenchyma cells are invaded and colonized through bulbous invasive hyphae. Hyphae move across cells through plasmodesmata (Ebbole 2007; Wilson and Talbot 2009; Boddy 2016; Fernandez and Orth 2018). In compatible infection, visible symptoms on leaf and heads began from 72 to 120 hours (Wilson and Talbot 2009; Cruz et al. 2015b, 2016c) if plant's innate immune system recognized the pathogen, non compatible infection occurs through hypersensitive reactions (Jeon et al. 2007; Fernandez and Orth 2018). Conidia are produced in sympodial conidiophores on the surface of necrotic lesions and sporulation began over 120 hours later (Cruz et al. 2016c).

1.6. Disease cycle and epidemiology

The ability of the wheat blast pathogen to infect several cereal crops, forage and grasses (Tosa and Chuma 2014) increases the concern with epidemics since these alternative hosts, especially invasive grasses, may occupy large geographical areas such as signal grass (*Urochloa* spp) particularly in Brazil (Jank et al. 2014). Several other grass weeds might play an important role on wheat blast epidemiology, whenever hosting the wheat blast pathogen, such as *Panicum maximum, P. miliaceum, E. coranana, Avena sativa, Lolium perenne*, *Stenotaphrum secundatum, Rhynchelytrum roseum* (Urashima et al. 1993, 2017; Oh et al. 2002; Tosa et al. 2004, 2006; Couch et al. 2005; Hirata et al. 2007; Tosa and Chuma 2014; Farman et al. 2017; Cruz and Valent 2017; Pak et al. 2021, Singh et al. 2021). A greater importance has been given to *U. brizantha*, which covers around 90 million hectares in Brazil, including surrounding and farway areas from wheat fields. *U. brizantha* was suggested as the major reservoir for the wheat blast pathogen and responsible to provide initial inoculum for triggering wheat blast epidemics in Brazil (Maciel et al. 2014; Castroagudín et al. 2016; Ceresini et al. 2019).

Senescent plant tissues may also serve as substrate for blast inoculum survival during the off-season for at least five months in wheat-infected residues (Pizolotto et al. 2019) and 18 months in rice-infected residues (Raveloson et al. 2018). The fungus may survive in stems, leaves and heads (Kovaleski et al. 2020). The magnitude of spore production in infected segments of wheat plant tissues was dependent on temperature and light, having highest amounts of conidia produced from 24°C to 27°C (Kovaleski et al. 2020), constant blue and red light, but also transition across white light and darkness (Leach 1962, 1980; Lee et al. 2006). Spores produced on alternative hosts or crops residual can escape the canopy and disperse through wind across fields distanced at least 1 km from the inoculum source (Urashima et al. 2007). Temperature varying between 25°C and 28°C, relative humidity of 76% to 100%, and light rain (< 5 mm) favored spore release from the source leading to increased amount of conidia in the air (Leach 1980; Danelli et al. 2019). Heavy rain and large raindrops seem to wash off conidia, thus reducing the amount of spores in air (Silva and Prabhu 2005; Danelli et al. 2019). As to long distance dispersal, infected/infested seeds or grains are the most probable source of inoculum (Tanaka et al. 2009). If infected seeds are sown, the pathogen may be transmitted to young plants, and foliar epidemics may further develop from seed borne inoculum (Gomes et al. 2018).

As to infection and colonization of the plant, the fungus develops more efficiently at the following weather-related conditions: temperature between 25°C and 30°C, >10 hours' duration of leaf wetness, and 24 to 48 hours of relative humidity >90%. These conditions seem to be similar regardless of the blast disease (lineage): wheat blast (PoT), gray leaf spot (PoL), or rice blast (PoO) (Uddin et al. 2003;

Cardoso et al. 2008; Debnath et al. 2019; Mills et al. 2020; Silva et al. 2021a). Severe blast epidemics in South American countries coincided with El Niño phenomena's years, which increased both rain and temperature. Similar situation could occur in Asian (Kohli et al. 2011; Islam et al. 2019, Singh et al. 2021). Greater amounts of conidia production, over half a million per gram of basal leaves, was reported in early infection on wheat leaves at artificial conditions, with the highest amounts observed during the heading stage, suggesting a contribution of inoculum from basal leaves to head infections (Cruz et al. 2015a).

Both within-canopy or external sources of airborne inoculum contribute to secondary infections on wheat (Gongora-Canul et al. 2020). Once the heads are infected, the pathogen may be transmitted to grains and then start a new cycle if used as seeds (Gomes et al. 2018). However, the grains positioned above the infection-site, if produced, are deformed with a low weight, and thus inappropriate to be used as seed (Goulart and Paiva 2000; Goulart et al. 2007).

Species other than *P. oryzae* may also infect wheat in artificial conditions, such as *P. grisea, P. pennisetigena and P. zingibericola.* However, these species have not yet been associated with economic losses in cultivated crops, instead they are frequently found infecting grass weeds such as *C. echinatus, Urochloa* spp., *P. maximum,* and *Digitaria* spp., and *Chloris distichophylla* (Reges et al. 2016; Sharma et al. 2021; Cazal-Martínez et al. 2021). Artificial cross-inoculation studies conducted in signal grass, barley, wheat and rice showed that these other *Pyricularia* species are capable of sporulating on leaves but, in general, they were a much weaker pathogen (Reges et al. 2016; Qi et al. 2019; Chung et al. 2020).

Temporal and spatial aspects of wheat blast epidemics have been studied more recently. In the field, epidemics have been represented by either the Gompertz or the logistic models, which are suggestive of polycyclic epidemics (Gongora-Canul et al. 2020;Gomes et al. 2019; Mills et al. 2021). In the controlled environment, a logistic model best fitted the growth of symptoms in point-inoculated spikes (Mills et al. 2021). Early infections (10 days after anthesis) were more damaging to grains fillin (Rios et al. 2016) and seed germination than late infection (Silva et al. 2021b), therefore, initial inoculum negatively affected wheat yield and physiological vigor of seeds (Gomes et al. 2017).

Climate conditions during the heading stage, such as frequent rainfall and warmer weather, contribute to increase initial inoculum and infection rate, driving to severe epidemics in mismanaged conditions (Mills et al. 2021). A study on the vertical gradients (within canopy) suggested a movement of inoculum from basal infected leaves to up leaves and to heads (Gongora-Canul et al. 2020; Mills et al. 2021). As an airborne pathogen, these conidia could be transported to neighboring plants or more distant fields through the wind (Urashima et al. 2007).

1.7. Wheat blast management

The integration of several tactics from cultural, genetic and chemical control methods is currently the best strategy for managing wheat blast (Ceresini et al. 2018, 2019; Mbinda and Masaki 2021). Climate is known to be a major driver of the occurrence and intensity of wheat blast outbreaks. Therefore, wheat grown in the tropics of Brazil (e.g. Minas Gerais, Mato Grosso do Sul, and Goiás) are at a greater risk than wheat crops in the subtropical regions. Shifts in sowing dates may be useful as an escape measure. For example, if not change the seeding window of the other crops, a two-month delay in the sowing date for crops grown in the Triangulo Mineiro, MG (from March to May) led to reduction in disease intensity and increase in yield than in the earlier plantings. This was likely due to the occurrence of cooler environmental conditions during the crop's susceptible period (Coelho et al. 2016). Another cultural practice is to avoid crop rotation with barley, oats, and rye, or, if feasible, the elimination of signal grass, goosegrass, and ryegrass via chemical control (Ceresini et al. 2019, Singh et al. 2021). As the blast pathogen can be seed-transmitted, using certified seeds is an important measure to avoid pathogen introduction into disease-free areas (Gomes et al. 2018; Martinez et al. 2021).

Fertilization may also affect the epidemics. A balanced plant nutrition is required to avoid excess of certain amino acids in plant cells, which is used by the pathogen. The effect of nitrogen on wheat blast is not entirely clear, but studies suggested a positive association between nitrogen rate and wheat blast intensity (Huber and Thompson 2007; Silva et al. 2019). The pathogen seems to be able to manipulate the plant system to obtain the required nutrients, thus causing physiological changes. On the other hand, several studies suggested that fertilization with silicon (Si), zinc (Zn), calcium (Ca), and magnesium (Mg) potentiated host resistance, reducing wheat blast intensity and protecting yield (Xavier Filha et al. 2011; Debona et al. 2012, 2016, 2017; Rios et al. 2017; Rodrigues et al. 2017; Aucique-Pérez et al. 2017, 2020; Moreira et al. 2020; Surovy et al. 2020).

Host genetic resistance is an important tool to integrate into disease management, but the progress in breeding for blast resistance has been challenged by a disease-conducive environment, especially in the tropics, as well as high variability in the fungal pathogen population (Coelho et al. 2016; Rocha et al. 2019; Gupta et al. 2021; Duan et al. 2021). Few wheat cultivars have been classified as resistant, or moderately resistant, to wheat blast, and in general most of them behave as moderately or fully susceptible to blast especially under disease-inductive weather conditions (Prestes et al. 2007; Cruz et al. 2012; Gomes et al. 2019; Comissão Brasileira de Pesquisa de Trigo e Triticale 2020; Cruppe et al. 2020; Goddard et al. 2020; Dianese et al. 2021; Roy et al. 2021, Singh et al. 2021).

Genetic resistance to head blast conferred by 2NS translocation segment is the most frequent source of resistance found in commercial wheat genotypes. The 2NS segment that originates from the old wheat relative *Aegilops ventricosa* is largely used in breeding programs in both South America (Cruz et al. 2016b). Wheat cultivars carrying the 2NS segment exhibited reduced head blast severity, up to 72.3% lower than NON-2NS cultivars (Cruz et al. 2012; Cardozo Téllez et al. 2019; Cruppe et al. 2020). The 2NS segment was effective against both old (1988) and contemporary (2014) isolates of the wheat blast pathogen. However, some lines carrying 2NS exhibited the same disease resistance level in lines without the 2NS, suggesting that the 2NS translocation does not confer a consistent resistance to wheat blast under certain climate conditions (Cruz et al. 2016b; Roy et al. 2021). In addition, leaf blast resistance has shown an inconsistent relationship with head blast resistance, indicating that leaf resistance may not be a good predictor of head blast resistance (Roy et al. 2021). Specific environmental conditions such as temperature directly affect the expression of genetic resistance, and in other cases, races of the pathogen contribute to overcoming the resistance (Maciel et al. 2014; Cruz et al. 2016b). Breeding efforts are challenged by the high genetic diversity of the populations, reinforcing the need to unveil both the genetic variability of the regional blast pathogen population (Rocha et al. 2019; Asuke et al. 2021) or a pandemic population recently reported in Asian wheat fields (Tembo et al. 2020, 2021; Croll 2021; Roy et al. 2021).

Several other resistance genes, such as *Rmg*1, *Rmg*2, *Rmg*3, *Rmg*4, *Rmg*5, *Rmg*6, *Rmg*7, *Rmg*8, and *Rmg*GR119 have been related to wheat blast resistance, mainly resistance to head infections. Air temperatures greater than 26°C and the genetic variability of the blast population observed in more aggressive *Triticum* lineage races had been the most important factors negatively affecting the genes' effectiveness. Therefore, durable and effective resistance is yet to be sourced and incorporated into commercial materials (Takabayashi et al. 2002; Hau et al. 2007; Zhan et al. 2008; Nga et al. 2009; Tagle et al. 2015; Anh et al. 2015, 2018; Cruz et al. 2016b; Wang et al. 2018; Asuke et al. 2019, 2021; Horo et al. 2020; Jiang et al. 2020; Inoue et al. 2021; Dianese et al. 2021). The efficiency of the photosynthetic apparatus affected the blast resistance response on one wheat commercial line moderately resistant and another one susceptible. This means that negative effects on photosynthesis could damage the performance of the cultivars under field conditions (Oliveira et al. 2021a, 2021b).

Although all these control tactics are useful to minimize the risk of damaging epidemics, chemical control with fungicides is the last resort to manage the disease more effectively (Ceresini et al. 2018, 2019; Cruz et al. 2019; Ascari et al. 2021). Several chemicals have been evaluated for the control of the disease since the first blast epidemics in Brazil (Goulart and Paiva 1993; Santana et al. 2013). These studies have shown that two to three sequential applications of fungicides may be required for an adequate disease control, yet with relatively modest levels of control being achieved (Santana et al. 2013). Currently, fifty-three commercial fungicides have been registered for wheat blast control in Brazil (AGROFIT 2021). These include Quinone outside Inhibitor (QoI) and DeMethylation Inhibitor (DMI) marketed solely or mixed together, but also multi-site mode of action fungicides such as mancozeb.

Despite the importance of wheat blast, the number of studies on chemical control of wheat blast is relatively small and the results inconsistent, despite the importance of wheat blast. Successful control with efficacy levels as high as 90% has been achieved when combining the use of QoI + DMI premix and less susceptible cultivar (Rios et al. 2016). However, control levels as low as 45% efficacy have been reported in susceptible cultivars grown at very favorable environments for blast outbreaks in the Brazilian Cerrado (Pagani et al. 2014). In Bangladesh, 19 commercial fungicides had their efficacy evaluated on a susceptible cultivar, and the blast control levels ranged from 43% to 96% (Roy et al. 2020). In 23 trials conducted in Brazil and Bolivia (Cruz et al. 2019), the authors reported various levels of efficacy for QoI, DMI, and multi-site fungicides depending on disease pressure. Relatively high control efficacy (58 to 68%) for picoxystrobin + cyproconazole, trifloxystrobin + tebuconazole, azoxystrobin + cyproconazole and pyraclostrobin + epoxiconazole applied twice across six field trials conducted in Bolivia from 2014 to 2015 were recorded. Average yield responses obtained from applying those premixes in that study were extremely high, in the magnitude of 1,834 kg/ha (Cruz et al. 2019).

Several questions remained from the aforementioned authors, including those related to differences between regions, years and profitability of fungicide applications. A recent study in Brazil summarized wheat blast index and yield data from nine years of using fungicides to control wheat blast. The trials were conducted in several locations and during nine years in Brazil by members of Cooperative Trials of Wheat (http://www.ensaioscooperativos.net/). The meta-analysis study showed no evidence of decline in fungicide efficacy over nine years (2012-2020) for any of the six fungicides evaluated (Ascari et al. 2021). However, in vitro studies detected Brazilian blast population carrying mutation points that confer resistance to strobilurins and triazoles fungicides (Castroagudín et al. 2015; Dorigan et al. 2019; D’ Ávila et al. 2020; Poloni et al. 2021). The efficacy of control of chemicals varied depending of the region, as wheat blast control and yield return were larger in subtropical climate than tropical conditions, differing by at least 18 percent points (40.6 to 58.9%) and 150.7 kg/ha (227.4 to 378.1 kg/ha), respectively. The best management strategy was spraying combinations of siti-specific and multi-site fungicides, with efficacy over 50%, such as mancozeb, trifloxystrobin + prothioconazole, tebuconazole, azoxystrobin + tebuconazole, and trifloxystrobin + prothioconazole (Ascari et al. 2021).

Managing the disease with chemical control by spraying fungicide of QoI + DMI delayed the epidemic in several wheat cultivars with different resistance levels. In low disease pressure and in less conductive climate conditions, just genetic resistant cultivar could perform well. However, under high inoculum pressure, fungicide spray and resistant cultivars becomes essential to controlling or slowing down disease progress over time (Urashima and Kato 1994; Pagani et al. 2014; Rios et al. 2016, 2017; Gomes et al. 2019).

Biological control is an environmental-friendly measure that may act synergistically with chemical and genetic control. Some biological control agents that have been used more frequently include *Streptomyces* spp. and *Bacillus subtilis*. These interact with *P. oryzae* producing secondary metabolites that affect hyphal growth, conidiogenesis process, causing morphological deformation, affect the conidial germination, and appressorium formation. Although promising, more studies testing the biological agents are needed at field conditions (Liao et al. 2016; He et al. 2019; Newitt et al. 2019; Chakraborty et al. 2020a, b).

1.8. Wheat blast pathogen population from Minas Gerais state

Comprehensive studies on the taxonomic diversity and population structure of wheat blast population have been conducted in Brazil in recent years (Maciel et al. 2014; Castroagudín et al. 2015, 2016; Castroagudin et al. 2017). Although covering seven states, the several hundreds of isolates studied thus far have been obtained mainly from wheat and grasses/weeds grown at the surroundings of wheat crops. Virtually none have been collected from natural landscapes away from wheat fields. Moreover, Minas Gerais state was not well represented in those studies. For example, the number of isolates from MG studied so far in six studies totalled 36, all from wheat and one isolate from *Digitaria* spp. (Castroagudín et al. 2015, 2016; Maciel et al. 2014; Rocha et al. 2019; Gomes et al. 2019; Reges et al. 2016). To our knowledge, no blast isolates from *Urochloa* spp. in Minas Gerais have been studied so far. Therefore, the genetic diversity and spatial distribution of the regionally-adapted blast populations across wheat and other grass hosts grown in Minas Gerais state is largely unknown.

In this dissertation, a large collection of isolates from wheat and grasses, both nearby and away from wheat areas were obtained during multi-year and multi-location surveys conducted across the state of Minas Gerais. The surveys spanned from western to the central-southernmost regions of the state. Several Poaceae were targeted during the visits, but mainly signal-grass (*Urochloa* spp.), grown in grass landscapes farther away from wheat regions.

Two main hypotheses were tested in this work: 1) the wheat-infecting lineage (known as PoT pathotype) is associated with blast on signal grass and other grass weeds that grow at the surroundings of wheat fields, but not at larger distances from the wheat fields, where other lineages can be found as dominant; 2) a different lineage, specialized to cause blast in signal grass and not in wheat, is less aggressive towards wheat. To test these hypotheses, molecular tools were used to identify the isolates at the both the species and lineage level - in particular the PoT using PCR assays; and pathogenicity assays were conducted to test the ability of the isolates from differents hosts to infect the original (isolated from) and the alternative host.

The general objective of this work was to characterize the taxonomic diversity and pathogenicity of host-specialized populations of *Pyricularia oryzae* causing blast disease on wheat and grass grown nearby or distant from wheat fields in Minas Gerais state. Specifically, the objectives were to 1) to determine the distribution of *Pyricularia oryzae*, in particular the PoT lineage, in wheat and forage or weed plants, sampled across the wheat commercial fields and natural landscapes of Minas Gerais state; 2) to assess the ability of the PoT and *Urochloa* lineages for cross-infecting, colonizing and producing spores on wheat and signal grass cultivars.

2. MATERIAL AND METHODS

2.1. Study area, sampling procedures and host identification

Field surveys were conducted in the wheat-growing regions and natural landscapes of Minas Gerais state during the 2018 and 2019 growing seasons. In 2018, blast incidence was mainly associated with wheat heads. The weather in that year was drier than in the 2019 season, in which there was a devastating early leaf and head blast epidemic in tropical areas of Brazil. The sampling target and strategy varied according to the timing of sampling and whether a wheat or non-wheat area. The pre-season summer (February) samplings targeted grass weed hosts which were collected randomly by conveniently visiting the natural landscapes along roadsides. Sampling sites were spaced at least 50 km between each other (Figure 4). The sample of grass weeds was composed of five to ten leaves, which were placed in paper bags.

The within-season fall (May) samplings focused on collecting: a) blast-symptomatic leaves and heads in wheat fields and b) blast-symptomatic leaves of grass weeds infesting or nearby wheat areas. Within a wheat field, we randomly defined five to 10 (depending on field size) 50-m transects distant 200 m apart from each other. At least one clustered (five to ten leaves or five heads) sample was collected at each transect, similar to previous studies (Maciel et al. 2014; Castroagudín et al. 2015). All samples were kept in paper bags and placed at room temperature (23°C ±4°C) to dry for one week before being stored at 10°C. Weed species were identified morphologically based on the literature (Crispim and Branco 2002; Lorenzi 2014). The wheat varieties could not be identified.

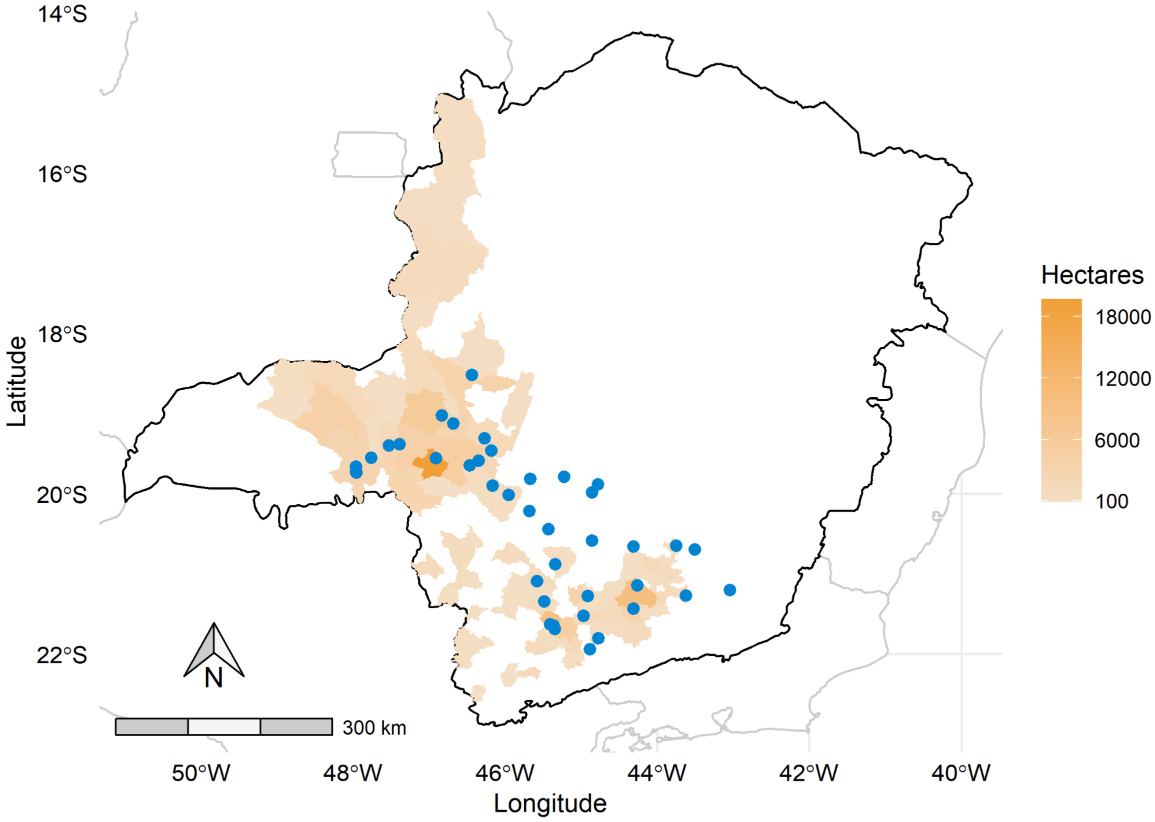


Figure 4. Map depicting wheat area planted per municipality (color gradient) and the location (blue dot) of the sampling sites where blast-symptomatic Poaceae (wheat and grasses) were found in Minas Gerais state Source: (IBGE 2017).

2.2. Symptom characterization

Natural landscapes, wheat commercial fields, and individual plants in the field were photographed using a smartphone camera (72 dpi resolution). In the laboratory, photographs of the symptoms, on leaves or heads (in the case of wheat), were obtained using a smartphone camera and a digital magnifying miniscope (10X, 96 dpi resolution). Landscape and plant symptoms characteristics were briefly described.

2.3. Culturing, purification and storage

Wheat heads (one per sample) and leaves (five per sample) of wheat or grass weeds, were cut into small pieces and placed within a 9 cm-plastic dish filled with moistened filter paper (Figure 5A), and incubated during 24 hours at 25°C ±5 under 12 hours photoperiod (light/darkness) to induce fungus sporulation (Urashima et al. 2017). Under the stereomicroscope light, conidiophores and associated sparkling crystal-clear spore mass on leaf and head-rachis could be visualized (Figure 5B, C). A sterilized sealed Pasteur pipette was scraped over the sporulation and loaded with conidia, which was streaked across the agar-water dishes supplemented with chloramphenicol and streptomycin at 100 µg/ml each. Plates were incubated at 25±5°C for 24 hours (12/12 h fluorescent light/darkness) (Farman et al. 2017; Gupta et al. 2020).

A unique displaced 2-septated pyriform conidia (Murata et al. 2014; Klaubauf et al. 2014) with visible germ tubes (Figure 5D) was individually transferred to an oatmeal agar (OA) dish (30g oats, 20g agar, 1L distilled water), where pieces of sterilized filter paper (10mm x 0.4mm) were placed nearly the conidia on the OA culture (Figure 5E, F). The dishes were incubated at the same conditions above described for seven days until fungus mycelium fully covered the filter paper. Blasted paper pieces were transferred to a new sterilized plastic dish filled with blue silica and left to dry at room temperature (25°C±5) for five days. Dried paper pieces were transferred to a 2 ml-microtube half-filled with new and sterile blue silica-gel (Figure 5G) and stored in a -10°C freezer (Farman 2002; Farman et al. 2017; Gupta et al. 2020). Isolates were stored in duplicates as a backup of the entire collection.

2.4. Growth of *Pyricularia* spp. and DNA extraction

A single filter paper of each isolate was put to grow on a potato-dextrose-agar (PDA) dish and incubated at 25±5°C under photoperiod 12/12 h (fluorescent light/darkness). A 6 mm-mycelial block from a 5 days-old colony was transferred to a 50 mL falcon tube filled with 20 mL of liquid-medium (6 g casamino-acids, 6 g yeast extract, and 10 g sucrose per 1 liter). The tubes were shaken for 7 days at 150 rpm under room temperature (23-26°C) and ambient light.

The mycelium was recovered through two layers of cheesecloth and let to dry at sterely-ambient temperature for three hours, and freeze-dried within a 2 mL microtubes for 24 hours (Farman et al. 2017; Urashima et al. 2017) using a CoolSafe Freeze Dryers (SCANVAC).

The mycelium ball was manually crushed into the microtube wall until it formed a powder, which was resuspended with 1 mL lysis buffer (100 mM Tris-HCl, pH8; 0.5 M NaCl, 10 mM EDTA; 1 % SDS) and heated 65°C for 30 minutes. Adding 700 µl phenol:chloroform:isoamyl-alcohol (25:24:1) and heated 65°C for 30 minutes. Subsequently, centrifuged at 14000 rpm for 15 minutes, and carefully transferred 0.8 µl of aqueous phase to a new identified microtube, where was added 450µl of cool isopropanol and centrifuged at 14000 rpm for 10 minutes to form the pellet of DNA. Supernatant was carefully discarded. The DNA was washed by 1 mL of 70% pure ethanol by centrifuging for 5 minutes at 14000 rpm. Newly formed DNA-pellet was dried at room temperature for 60 minutes. The DNA was resuspended with 100 µl TE + 2 µl RNAse A (1 µg/ml) and stored at 4°C overnight before being placed in the -20°C freezer (Farman et al. 2017). The DNA concentration was estimated using a spectrophotometer NanoDrop 2000 (Thermo Scientific™). DNA-concentration was adjusted to 100ng/µl by adding TE.

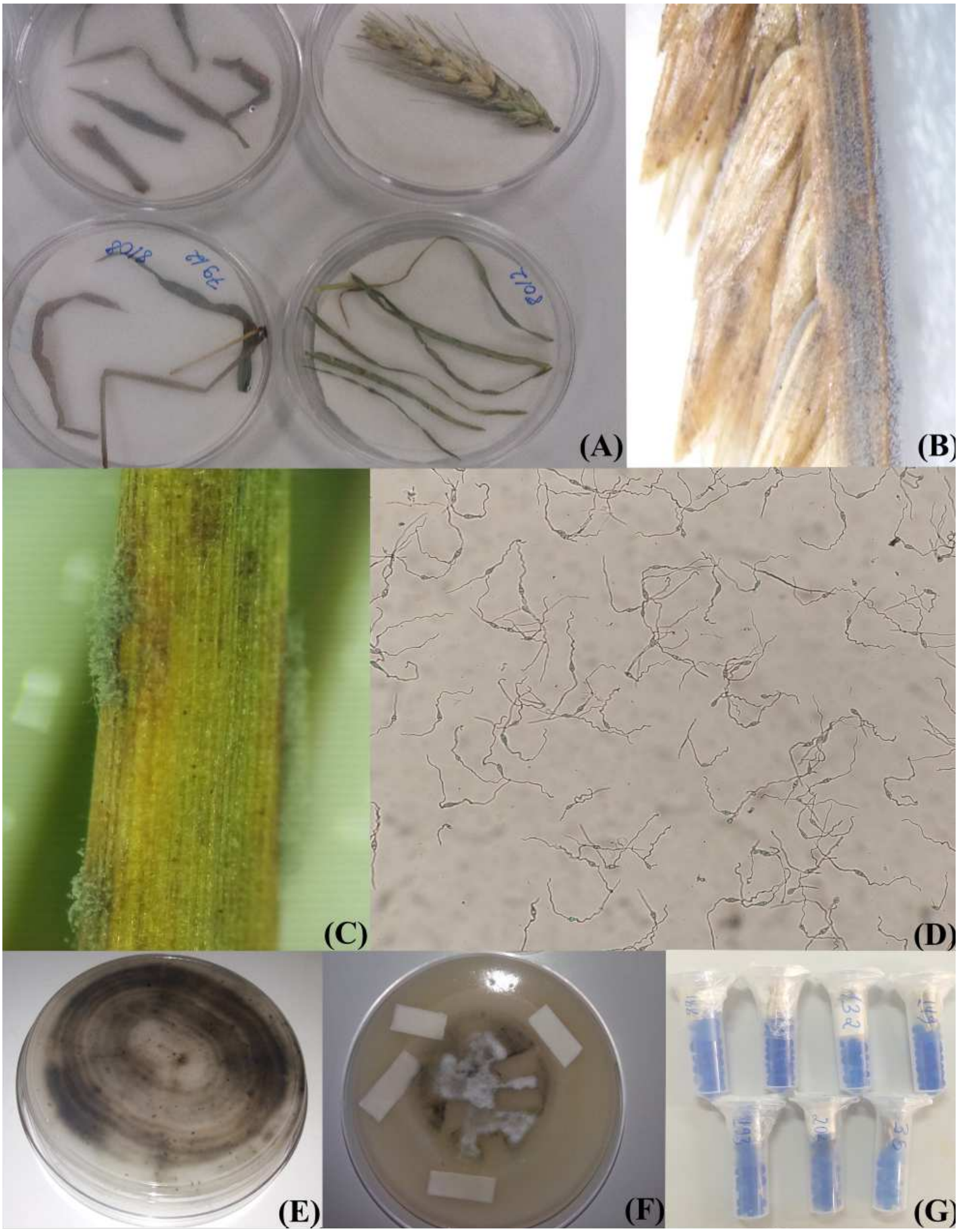


Figure 5. Procedures for obtaining a monoconidial collection of *Pyricularia* spp. isolates from grass weeds (leaf) and wheat (leaf and head). A) Incubation of samples in a humidity chamber; crystal-clear spore mass on B) wheat-neck and C) leaf; D) germinated 2-septated pyriform conidia; E) 8-days-old colony morphology at oatmeal

agar media; F) filter paper plus fungus mycelium ready to storage; G) *Pyricularia* spp. colonized filter paper stored in 2 ml-microtubes with silica-gel.

2.5. Polymerase Chain Reaction (PCR) assays

PCR reaction was performed to amplify the CH7-BAC9 locus. Positive reaction allows to discriminate *P. oryzae* (Po) from non-*P.oryzae* (non-Po) (Couch et al. 2005).The PCR assays were performed with 1µl of genomic DNA (100ng/µl) using the GoTaq® Colorless Master Mix, according to the manufacturer's specifications (Promega). Reactions were carried out at a thermal cycler MyGene™ (Model MG96G). From the entire collection, 572 isolates representing Minas Gerais regions, cities, hosts, and distance from wheat fields (Supplementary Table S1) were screened by using the primer CH7-BAC9 (Table 1). The amplification conditions were as follows: initial denaturation at 95° for 8 min, followed by 35 cycles of 95°C for 15 sec, 55°C for 20 sec, 72°C for 60 sec, and a final extension at 72°C for 5 min (Couch *et al.*, 2005).

To confirm the specificity of CH7-BAC9 primer for discriminating *P. oryzae* against non-*P. oryzae*, genomic DNA corresponding to positive and negative reactions had the hydrophobin (MPG1) locus sequenced. The sequence of this gene was used in phylogeny analysis to identify *Pyricularia* spp. at species level (Couch et al. 2005). PCR assays were performed with 1µl of genomic DNA (100ng/µl) using the same GoTaq® Mix and thermal cycler. A subcollection of 22 *Pyricularia* spp. isolates (Table 2), 14 from this study and eight from (Bruno and Urashima 2001; Islam et al. 2016; Castroagudín et al. 2016; Pieck et al. 2017), representing the host range and distance from wheat areas was selected and submitted to PCR assay using the MPG1 primer (Table 1). Amplification conditions for MPG1 were as follows: initial denaturation at 95° for 8 min, followed by 35 cycles of 95°C for 15 sec, 55°C for 20 sec, 72°C for 60 sec, and a final extension at 72°C for 5 min (Couch et al. 2005). PCR products were sequenced.

Table 1. Primers utilized in Polymerase chain reaction (PCR) to identify *P. oryzae* and discriminate *Triticum* against non-*Triticum* lineages.

Primer	Forward	Reverse	Reference
MPG1 (368 bp)	AGAAGGTCGTCTCTTGCTGC	TTCACTCAACGCTGATCGC	(Couch et al. 2005)
CH7-BAC9 (296 bp)	TGTAAGAAGCTCGGTGACTGAT	AGTGTTGCTTGAACGGCTAA	(Couch et al. 2005)
MoT3 (361 bp)	GTCGTCATCAACGTGACCAG	ACTTGACCCAAGCCTCGAAT	(Pieck et al. 2017)
C17 (500 bp)	GAGGAAGATCAAGTAAGTGG	GGTAGATGTCATGATTTCAC	(Thierry et al. 2020)

P. oryzae Triticum lineage (PoT) was determined for the non-PoT by using specific primers. Genomic DNA corresponding to all CH7-BAC9 positive reactions were included into MoT3 (amplify a fragment of the MGG_02337 gene corresponding to a short retinol dehydrogenase chain) (Pieck *et al.*, 2017) and C17 (Thierry et al. 2020) PCR assays (Table 1). Reactions of C17 (+) and MoT3 (+) are suggestive of PoT, instead C17 (-) and MoT3 (+ or -) indicate non-PoT. The assays used the same GoTaq® Mix and thermal cycler. Cyclical conditions to MoT3 as follows: initial denaturation at 95°C for 8 min, followed by 35 cycles of 95°C for 15 sec, 55°C for 20 sec, 72°C for 60 sec, and a final extension at 72°C for 5 min. While the C17 cycling conditions were: initial denaturation at 94°C for 2 min, 35 cycles of 95°C for 10 sec, 54°C for 30 sec, 72°C for 30 sec, and a final extension at 72°C for 5 min. PCR products were separated by electrophoresis in a 1%-agarose gel. DNA fragment size was labeled by 1 Kb Ladder (Cellco®). Electrophoresis was runned for 100 min at 80 Volts, 100 mA, and 80 watts. Gel was visualized under ultraviolet (UV) light and photographed.

2.6. Sequencing

PCR products of both MPG1 (14) and CH7-BAC9 (59) loci were purified and sequenced by Dr. Mark Farman at University of Kentucky using a Roche 454 GS FLX machine. Forward and reverse sequences were obtained for each strain. The consensus sequence was assembled using the software SeqAssem (Hepperle 2021).

2.7. Phylogenetic analysis

Reference sequences of *P. oryzae*, *P. pennisetigena,* and *P. grisea* were downloaded from GenBank and included into phylogenetic analysis (Table 2). Alignment of sequences was manually performed through the program MegaX (Kumar et al. 2018), as well as performing the Maximum Parsimony (MP) and Maximum Likelihood (ML) trees with ten thousand bootstrap replicates. The best phylogenetic model applied at ML and Bayesian Inference (BI) was the GTR+G (MPG1) and GTR+I (CH7-BAC9) models, which was determined through mrModelTest2 (Posada and Crandall 2001). Bayesian analysis was carried out on the program MrBayes 3.2 (Ronquist et al. 2012), running on ten million generations and burning 25% of trees. Trees were visualized and edited using FigTree v1.4.4 (Rambaut 2018). Phylogenetic relationship of *P. oryzae* and non-*P.oryzae* was reconstructed in a MP tree. Respectives MP and ML bootstrap support, and Bayesian posterior probabilities (BPP) BPP>95% were labeled on branches.

Table 2. Isolates of *Pyricularia* spp. with MPG1 and CH7-BAC9 genes sequenced, and reference/source of the sequences downloaded from GenBank.

Species	**Isolate**	**Host isolated from**	**Locus**	**Reference/Source**
P. oryzae	UFVPY23	*Rhynchelytrum roseum*	MPG1/ CH7-BAC9	This work
P. oryzae	UFVPY49	*R. roseum*	MPG1/ CH7-BAC9	This work
P. oryzae	UFVPY56	*Eleusine indica*	MPG1/ CH7-BAC9	This work
P. oryzae	UFVPY112	*Urochloa brizantha*	MPG1/ CH7-BAC9	This work
P. oryzae	UFVPY1	*Panicum maximum*	MPG1	This work
P. oryzae	UFVPY20	*P. maximum*	MPG1	This work
P. oryzae	UFVPY21	*U. brizantha*	MPG1	This work
P. oryzae	UFVPY22	*E. indica*	MPG1/ CH7-BAC9	This work
P. oryzae	UFVPY52	*U. brizantha*	MPG1	This work
P. oryzae	UFVPY111	*Digitaria insularis*	MPG1	This work
P. oryzae	UFVPY115	*P. maximum*	MPG1	This work
P. pennisetigena	UFVPY100	*Cenchrus echinatus*	MPG1	This work
P. pennisetigena	UFVPY114	*C. echinatus*	MPG1	This work
P. grisea	UFVPY131	*Digitaria sanguinalis*	MPG1	This work
P. oryzae	UFVPY110	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY121	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY673	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY203	*U. brizantha*	CH7-BAC9	This work

P. oryzae	UFVPY232	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY198	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UVFPY108	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY674	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY545	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY244	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY576	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY675	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY581	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY742	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY577	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY676	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY197	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY677	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY653	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY654	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY166	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY200	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY655	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY174	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY201	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY120	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY672	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY175	*U. brizantha*	CH7-BAC9	This work

P. oryzae	UFVPY679	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY118	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY758	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY109	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY202	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY171	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY204	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY205	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY206	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY207	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY208	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY119	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY209	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY215	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY88	*U. brizantha*	CH7-BAC9	This work
P. oryzae	UFVPY159	*Cynodon plectostachyus*	CH7-BAC9	This work
P. oryzae	UFVPY178	*E. indica*	CH7-BAC9	This work
P. oryzae	**UFVPY92**	***U. brizantha* - PoU4**	CH7-BAC9	This work
P. oryzae	B2	*T. aestivum*	CH7-BAC9	(Pieck et al. 2017)
P. oryzae	Br116	*T. aestivum*	CH7-BAC9	(Inoue et al. 2017)
P. oryzae	**Bm8309**	***U. mutica* - PoU1**	CH7-BAC9	Rahnama et al. 2021
P. oryzae	**Br35**	***U. plantaginea* - PoU3**	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Cd88217	*C. dactylon*	CH7-BAC9	Rahnama et al. 2021

P. oryzae	P3	*T. durum*	CH7-BAC9	(Pieck et al. 2017)
P. oryzae	Br7	*T. aestivum*	CH7-BAC9	(Pieck et al. 2017)
P. oryzae	U168	*Luziola peruvianum*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Bm8946	*U. mutica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	U171	*L. peruvianum*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	ATCC64557	*Lolium multiflorum*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Bm88324	*U. mutica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Br58	*Avena sativa*	CH7-BAC9	(Inoue et al. 2017)
P. oryzae	CHRF	*L. perenne*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	CHW	*L. perenne*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	LpKY97	*L. perenne*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	GG11	*L. perenne*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	HO	*L. perenne*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	PGPA	*L. perenne*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	P28	*Bromus tectorum*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	PY5010	*T. aestivum*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	P25	*Urochloa spp.*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	TP2	*L. perenne*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Po221	*L. multiflorum*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	PgKY	*L. perenne*	CH7-BAC9	(Islam et al. 2016)
P. oryzae	U217	*Stenotaphrum secundatum*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Lh88405	*Leersia hexandra*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Pg1204	*S. secundatum*	CH7-BAC9	Rahnama et al. 2021

P. oryzae	Pg1054	*S. secundatum*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	U233	*S. secundatum*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	FH	*L. perenne*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	Ec88443	*Echinochloa colona*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Lc8401	*Leptochloa chinensis*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	U237	*L. multiflorum*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	PY5003	*T. aestivum*	CH7-BAC9	(Islam et al. 2016)
P. oryzae	Ei88365	*E. indica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Ei8927	*E. indica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Ei9411	*E. indica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Ei9604	*E. indica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	G17	*E. curvula*	CH7-BAC9	(Couch et al. 2005)
P. oryzae	G22	*E. coracana*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	AR4	*E. curvula*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	CD156	*E. indica*	CH7-BAC9	(Farman 2002)
P. oryzae	MG03	*E. coracana*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	MG04	*E. coracana*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	MG12	*E. coracana*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	PH42	*E. coracana*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	Br62	*E. indica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	U169	*Eleusine spp.*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	U229	*E. indica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	B51	*E. indica*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	JP29	*E. coracana*	CH7-BAC9	Rahnama et al. 2021

P. oryzae	Guy11	*Oryza sativa*	CH7-BAC9	(Chiapello et al. 2015)
P. oryzae	IA1	*O. sativa*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	IB49	*O. sativa*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	IC17	*O. sativa*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	FR13	*O. sativa*	CH7-BAC9	(Chiapello et al. 2015)
P. oryzae	IE1K	*O. sativa*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	INA168	*O. sativa*	CH7-BAC9	(Yoshida et al. 2016)
P. oryzae	Lh8401	*L. hexandra*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	BP1	*Setaria faberi*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	**Bd8401**	***U. distachya*** **- PoU2**	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	Lh8844	*L. hexandra*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	MBSD02	*O. sativa*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	MG05	*S. italica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	MG08	*S. italica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	ML33	*O. sativa*	CH7-BAC9	(Gladieux et al. 2018)
P. oryzae	P131	*O. sativa*	CH7-BAC9	(Zhong et al. 2016)
P. oryzae	Pr8202	*P. repens*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Pr88165	*P. repens*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	SSID116	*O. sativa*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Sv9610	*S. viridis*	CH7-BAC9	(Zhong et al. 2016)
P. oryzae	TH0012rn	*Hordeum vulgare*	CH7-BAC9	(Chiapello et al. 2015)
P. oryzae	TH0016	*H. vulgare*	CH7-BAC9	(Chiapello et al. 2015)
P. oryzae	TH3	*O. sativa*	CH7-BAC9	(Yoshida et al. 2016)
P. oryzae	U107	*O. sativa*	CH7-BAC9	Rahnama et al. 2021

P. oryzae	U232	*S. italica*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	U75	*O. sativa*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	Y34	*O. sativa*	CH7-BAC9	Rahnama et al. 2021
P. oryzae	B2	*T. aestivum*	MPG1/ CH7-BAC9	(Pieck et al. 2017)
P. oryzae	Br35	*U. plantaginea*	MPG1/ CH7-BAC9	(Bruno and Urashima 2001)
P. oryzae	PY5003	*T. aestivum*	MPG1	(Islam et al. 2016)
P. oryzae	12.0.009i	*U. brizantha*	MPG1	(Castroagudín et al. 2016)
P. graminis-tritici	12.0.038i	*U. brizantha*	MPG1/ CH7-BAC9	(Castroagudín et al. 2016)
P. oryzae	12.1.009	*T. aestivum*	MPG1/ CH7-BAC9	(Castroagudín et al. 2016)
P. oryzae	12.1.020i	*T. aestivum*	MPG1/ CH7-BAC9	(Castroagudín et al. 2016)
P. oryzae	12.1.209	*T. aestivum*	CH7-BAC9	(Castroagudín et al. 2016)
P. oryzae	12.0.038i	*U. brizantha*	CH7-BAC9	(Castroagudín et al. 2016)
P. pennisetigena	12.0.100	*C. echinatus*	MPG1	(Castroagudín et al. 2016)
P. grisea	12.0.082	*D. sanguinalis*	MPG1	(Castroagudín et al. 2016)

Bold isolates represent *P. oryzae Urochloa* lineages (PoU1, PoU2, PoU3, and PoU4).

2.8. Inoculum production

Cross-inoculation experiments were analysed as a factorial under a randomized complete block design. A subcollection of 20 *P. oryzae* isolates (Table 3) obtained from wheat (leaf and head) and signal grass (leaf) were selected based on lineage determination (14 PoT = *Triticum* lineage representing the regions Triângulo Mineiro and Centro-Sul de Minas Gerais; and 6 PoU = isolates phylogenetically/phenotypically related to *Urochloa* spp. representing both distance from wheat and regions aforementioned). These isolates were used in cross-inoculation replicated experiments using wheat and signal grass.

A piece of filter paper corresponding to each isolate was recovered from the -10°C storage and re-activated on Potato Dextrose Agar (PDA). A 5-day-old mycelial plug was transferred to oatmeal-agar (OA) (replicated in five 9 cm-dishes per isolate). The fungus was cultured for seven days. To induce fungal sporulation, plates were scraped out using a Drigalski spatula and 5 ml of sterilized-distilled water. The dishes were incubated for a further seven days. Spores were harvested by adding 10 ml of distilled-sterilized water amended with 0.01% Tween-20, and carefully scraped using a Drigalski spatula. Spore suspension was filtered through two layers of cheesecloth. Spore concentration was adjusted to $1x10^5$ spore/mL using a Neubauer counting chamber. PDA and OA dishes were both supplemented with chloramphenicol and streptomycin at 100 µg/ml. Incubation was performed in a grown chamber with controlled temperature of 25°C (±2°), and photoperiod of 12/12 hours (fluorescent light/darkness) (Cruz et al. 2016a; Urashima et al. 2017).

Table 3. Information for isolates obtained from wheat blast (PoT = 14 isolates) or signal grass blast (PoU = 6 isolates) used in replicated cross-inoculation experiments.

Origin host	Region	Dist.*	Municipality	Date	Code	ID**
Urochloa brizantha	Triângulo Mineiro	Nearby	Patos de Minas	Feb. 2018	108	PoU
U. brizantha	Triângulo Mineiro	Nearby	Patos de Minas	Feb. 2018	110	PoU
U. brizantha	Triângulo Mineiro	Nearby	Patos de Minas	Feb. 2018	112	PoU
U. brizantha	Triângulo Mineiro	Away	Uberaba	May 2018	166	PoU
U. brizantha	CentroSul	Away	Formiga	Feb. 2019	209	PoU
U. brizantha	CentroSul	Away	Catas Altas da Noruega	Feb. 2019	656	PoU
U. brizantha	CentroSul	Within	Madre de Deus	May 2019	742	PoT
U. brizantha	CentroSul	Within	Madre de Deus	May 2019	758	PoT
U. humidicola	CentroSul	Away	São Gonçalo do Pará	Feb. 2019	213	PoT
Triticum aestivum	Triângulo Mineiro	Within	Patos de Minas	May 2018	167	PoT
T. aestivum	Triângulo Mineiro	Within	Ibiá	May 2019	238	PoT
T. aestivum	Triângulo Mineiro	Within	Ibiá	May 2019	239	PoT
T. aestivum	Triângulo Mineiro	Within	Uberaba	May 2019	367	PoT
T. aestivum	Triângulo Mineiro	Within	Santa Juliana	May 2019	375	PoT
T. aestivum	Triângulo Mineiro	Within	Patrocínio	May 2019	376	PoT
T. aestivum	CentroSul	Within	Boa Esperança	May 2019	309	PoT
T. aestivum	CentroSul	Within	Boa Esperança	May 2019	311	PoT
T. aestivum	CentroSul	Within	Madre de Deus	May 2019	604	PoT
T. aestivum	CentroSul	Within	Boa Esperança	May 2019	813	PoT

T. aestivum	BioTrigo	Within	Passo Fundo	2019	MoT01	PoT

*Sampling distance from wheat areas.

**The identification of the *P. oryzae* lineages was conducted using MoT3 and C17 primers in a PCR assay. PoT = *P. oryzae Triticum* lineage, PoU = isolates phylogenetically and phenotypically related to *Urochloa* spp..

2.8.1. Cross-inoculation assays on wheat and signal grass

Two wheat cultivars, BR 18-Terena (moderately resistant) and BRS Guamirim (susceptible), and one signal grass (Marandu) were used in replicated cross-inoculation experiments. In the case of wheat, the inoculations were carried out on both leaves and heads. Foliar infections were conducted on 35-day-old plants exhibiting three to four completely expanded leaves, growth stage 15 (Zadoks et al. 1974). Wheat head assays were conducted in approximately 60-day-old plants at early anthesis, growth stage 60 (Zadoks et al. 1974). Signal grass inoculations were performed only on the leaves, and the inoculation was made in 35-day-old plants, with four to five completely expanded leaves. Experiments were conducted twice under greenhouse conditions between March and September 2020.

2.8.2. Aggressiveness towards signal grass cultivars

After confirming cross-infections of PoU and PoT lineages in signal grass, both lineages were inoculated in three *U. brizantha* cultivars, Marandu, Xaraés, and Piatã, and *U. decumbens* cv. Basilisk. Inoculations were made on 35-days old plants, with five expanded leaves. Experiments were conducted twice under greenhouse conditions between October and December 2020.

2.9. Plant growth conditions

Wheat and signal grass cultivars were sown in 2-L plastic pots filled with substrate (Tropstrato - Vida Verde) which was a mixture of pine bark, peat, and expanded vermiculite. Basal fertilization was performed with monoammonium phosphate (12% N and 50% P_2O_5) (Comissão Brasileira de Pesquisa de Trigo e Triticale 2020). The number of plants per pot was reduced to eight and ten for wheat and signal grass, respectively. Plants were kept in the greenhouse under controlled environmental conditions (±11 hour of light and 25°C ±4°C) and watered daily until inoculation time. Side-dressing fertilization were conducted weekly adding to each pot 30ml of nutritive solution prepared with 6.4mg/L KCl, 3.48mg/L K2SO4, 5.01mg/L MgSO4.7H2O, 2.03mg/L (NH2)2CO, 0.009mg/L NH4MO7O24.4H2O, 0.054mg/L H3BO3, 0.222mg/L ZnSO4.7H2O, 0.058mg/L CuSO4.5H2O, 0.137mg/L MnCl2.4H2O, 0.27g/L FeSO4.7H2O and 0.37g/L disodium-EDTA prepared with distilled water (Xavier Filha et al. 2011).

2.10. Inoculation procedures

Plants on each pot were sprayed-inoculated (15 mL) with the spore suspension using a 0.5L manual plastic sprayer (Guarany® - Gifor). The plants were placed in the dark within a chamber adjusted to 25°C (±2%) and humidity >90% during 20 hours. The plants were moved to a growth chamber with controlled temperature at 28°C (±2°), humidity >80%, and 12/12 hours of fluorescent light/darkness during seven days, until performing the disease assessments (Cruz et al. 2016a).

2.11. Measures of disease incidence and severity

The assessment of leaf blast in wheat and signal grass was conducted at the seventh day post-inoculation (dpi). Leaf blast incidence was determined in ten leaves per potted plant (one photo), by counting the number of leaves displaying blast symptoms. Incidence (%) was determined as ([number of symptomatic leaf / number total leaves] x 100). Severity (percent area affected) was measured on ten representative leaves that were removed from each pot and photographed using a flatbed scanner on top (HP - LaserJet M1132 MFP) with a white background at

600-dpi resolution and JPEG file format. Images were analysed in ImageJ (Schneider et al. 2012) to threshold the symptomatic and asymptomatic area, and then calculating the severity (%) ([symptomatic area / total area] x 100).

Wheat head blast was quantified by counting the number of symptomatic and total number of spikelets on each of the five heads per pot. Head severity (%) was then determined as ([number of symptomatic spikelets / total number of spikelets] x 100) (Cruz et al. 2012; Cruppe et al. 2020).

2.12. Measures of fungal sporulation on leaves

Right after obtaining the photos for severity assessments, the leaves were placed into a humidity chamber box filled with moistened paper (3.5cm x 11cm x 11cm long). Boxes were moved to a 28°C (±2°) growing chamber with 12/12 hours of photoperiod (fluorescent light/darkness) during 72 hours to favor fungus sporulation (Pizolotto et al. 2019).

The leaves were placed two by two into a 15 mL Falcon tube filled with 5 mL of autoclaved water amended with Tween 20 (2 drops per liter) and shaken for 10 seconds using a Vortex Mixer (KASVI, K45-2810) (Kovaleski et al. 2020). The number of conidia in the suspension was determined using a hemocytometer chamber. A sample was composed of two leaves, totaling five observations per plastic pot. This experiment was conducted twice.

2.13. Experimental design and data analysis

Generalized linear mixed models (GLMM) were fitted to the data from the experiments using *glmmTMB* R package (Magnusson et al. 2020). Different models were fitted to data on leaf incidence, severity, and number of conidia, and wheat head severity. *P. oryzae* lineages (factor 1) and host (factor 2) were treated as fixed effects. Blocks and isolates within each lineage were treated as random effects. A two-level model was considered. Zero-inflated-GLMM was fitted to incidence of blasted spikelets, wheat and signal grass leaf severity from PoT-wheat and PoU-signal grass, and number of conidia produced in leaves. The best family for the data distribution was selected based on simulation of the residuals provided by *DHARMa* R package (Hartig 2021), which provides *p-values* for normality of residuals, overdispersion and outlier. The family data distribution considered in the GLMM fitted for each response variable were as follows: incidence (binomial family), severity (beta family), and number of conidia in PoT-wheat and PoU-signal grass (nbinom family), and number of conidia in aggressiveness towards signal grass cultivars (poisson family). Estimated means were submitted to analysis of variance using the *Anova()* function. Means of inoculated host and *P. oryzae* lineages were compared by Tukey's test at 5% probability (P < 0.05) using both *emmans* R package (Lenth et al. 2020) and *multcomp* (Hothorn et al. 2008). Data analysis was performed in R (R Core Team 2021).

3. RESULTS

3.1. Sampled hosts and isolate collection

A total of 1,368 plant samples (976 leaves and 392 heads) were collected during the four visits to fields, and 31 species of Poaceae could be identified (Table 4). The plants collected at the non-wheat regions were composed mainly of weeds of several taxa, but signal grass species were the most prevalent grass. Six species of signal grass (*U. brizantha, U. humidicola, U. plantaginea, U. ruziziensis*, *U. arrecta, U. decumbens*) were identified, with *U. brizantha* being the most prevalent (Table 4, Figures 4; 6). Some isolates were recovered from blast active sporulation on senescent leaves mainly of signal grass and wheat (Figure 7). Overall, the success of the isolation was 68.13%, which resulted in 932-monoconidial isolates in total (Table 4).

Characteristic eye-shaped lesions with a gray center surrounded by brown halo and coalescent-necrotic lesions were observed on wheat leaves (Figure 8A). Half to complete bleached heads presenting a bright-gray mass of conidiophore and conidia in the rachis was frequently observed across all wheat fields sampled (Figure 8B). Greater intensity of symptoms was found especially in signal grass (*Urochloa* spp), grown during the summer (February, wheat off-season), mainly in the 2019 season, and fewer during the fall season (May, wheat-growing season) (Figure 9). Blast symptoms in signal grass appeared as small eye-shaped lesions with gray center and dark red-brown halo, randomly on leaves. Senescent leaves of signal grass with active sporulating lesions were observed more frequently in pre-season, during February's survey. Blast symptoms in *P. maximum* leaves appeared as eye-shaped and bordered by red-dark halo mainly on the leaf edges. *E. indica* plants with high blast intensity were observed mainly in wheat areas, presenting red-brown-eye lesions on leaves and necrosis in panicles. Stalk blast symptoms commonly were associated with *R. roseum* and *U. humidicola* (Figure 7).

Table 4. Summary information for the total number of inspected and blast-infected plant samples for each of 31 Poaceae species, including wheat, from where and *Pyricularia* sp. isolates were obtained. Four visits were made to both wheat-producing regions (Triângulo Mineiro and Centro-Sul de Minas) and natural landscapes during summer (February, wheat off-season) and fall (May, wheat-growing season) 2018 and 2019, MG, Brazil.

Poaceae species	**Number of plant samples**		***Pyricularia* spp. isolates** [C]
	Total [A]	**Positive** [B]	
Andropogon virginicus	4	-	-
Cenchrus echinatus	21	15	25
Chloris polydactyla	4	-	-
Chrysopogon zizanioides	4	-	-
Cynodon dactylon	6	1	1
C. dictyoneura	1	-	-
C. plectostachyus	1	1	1
Cyperus rotundus	12	-	-
Digitaria horizontalis	37	14	21
D. insularis	46	15	20
D. sanguinalis	61	21	31
Echinochloa colonum	2	1	1
Eleusine indica	50	27	42
Eragrostis ciliaris	6	-	-
E. pilosa	1	-	-
Imperata brasiliensis	2	-	-
Melinis minutiflora	31	-	-

Panicum maximum	127	10	19
P. miliaceum	3	-	-
Paspalum notatum	4	-	-
Pennisetum sp.	28	2	2
Rhynchelytrum roseum	20	16	28
Setaria viridis	1	-	-
Sorghum arundinaceum	11	-	-
Triticum aestivum	505	377	670
Urochloa arrecta	1	-	-
U. brizantha	329	35	59
U. decumbens	2	-	-
U. humidicola	16	3	7
U. plantaginea	24	3	3
U. ruziziensis	8	1	2
Total	**1368**	**542**	**932**

[A] Sample composed of 5 to 10 leaves of wheat or Poaceae weeds, or 1 to 3 wheat heads.

[B] At least one *Pyricularia* sp. isolate.

[C] Number of monoconidial isolates per sample. In cases more than one isolate was obtained from a sample, but not from the same tissue (leaf or head).

Grass weeds infestation in wheat off-season

Grass landscape at non-wheat region

Wheat field surrounded by grass weeds

Grass landscape at non-wheat region

Wheat experimental area infested by grass weeds

Grass weeds roadside in non-wheat region

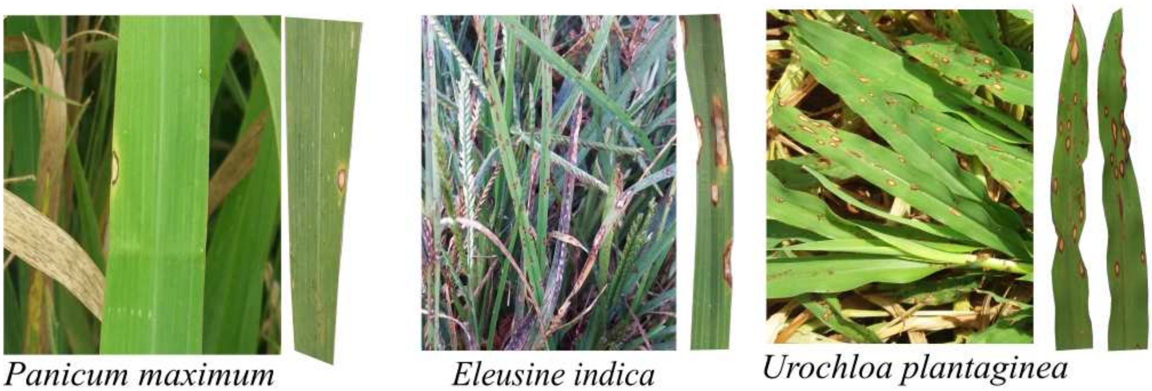
Wheat plots surrounded by blasted grass weeds

Natural landscape covered by many grass species

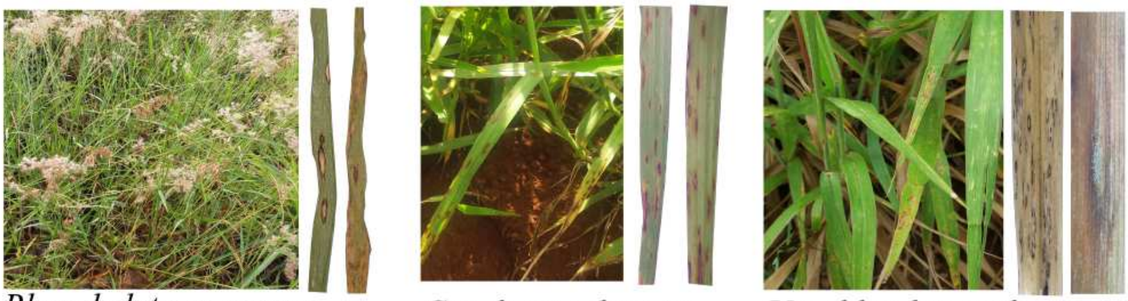
Senescent wheat leaves with active blast sporulation

Natural landscape covered by many grass species

Figure 6. Images of the natural landscape and wheat commercial fields where grass weeds and wheat were collected during surveys conducted during the pre-season summer (February) and within-season fall (May) in 2018 and 2019, at Triângulo Mineiro and Centro-Sul de Minas, Brazil.



Panicum maximum *Eleusine indica* *Urochloa plantaginea*



Rhynchelytrum roseum *Cenchrus echinatus* *Urochloa brizantha*

Digitaria sanguinalis *Hordeum vulgare* *Urochloa ruziziensis*

Pennisetum sp. *Digitaria horizontalis* *Urochloa humidicola*

Figure 7. Details of symptoms on full plants and leaves of species within Poaceae exhibiting typical blast symptoms. The surveys were conducted twice in 2018 and also 2019, at Triângulo Mineiro and Centro-Sul de Minas Gerais, Brazil. Plant identification was made at the species level, whenever possible, based on adult specimen morphological characteristics (Crispim and Branco 2002; Lorenzi 2014).

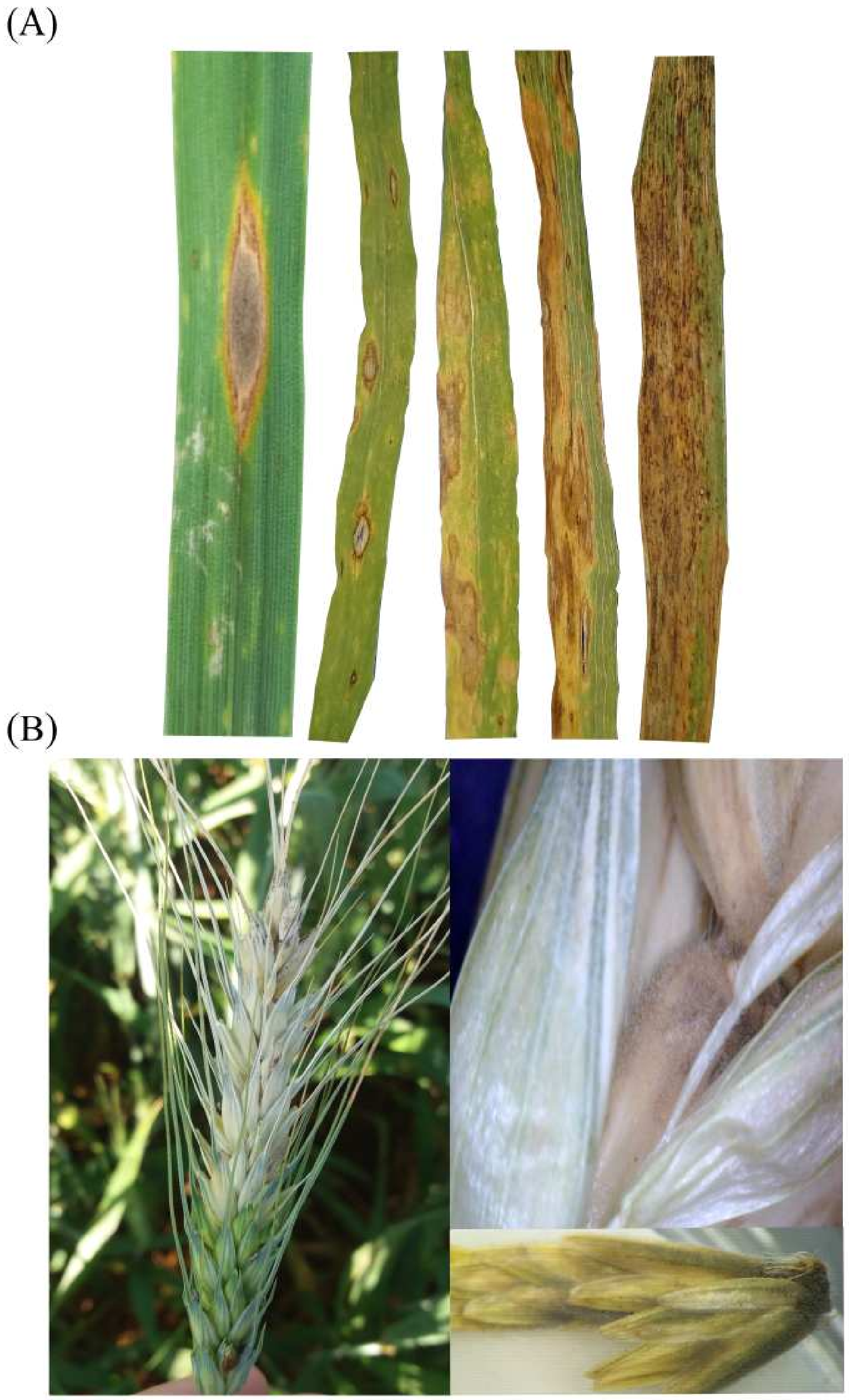


Figure 8. Blast symptoms on wheat leaves and heads under natural infection in commercial fields. A) Wheat leaf blast presenting a wide range of symptoms, from isolated eye-shaped lesion with gray center and brown delimitation to coalescent

necrotic lesions covering almost all leaf, in some cases co-infecting together other leaf spot pathogens; and B) bleached wheat head with visible gray sporulation at the rachis.

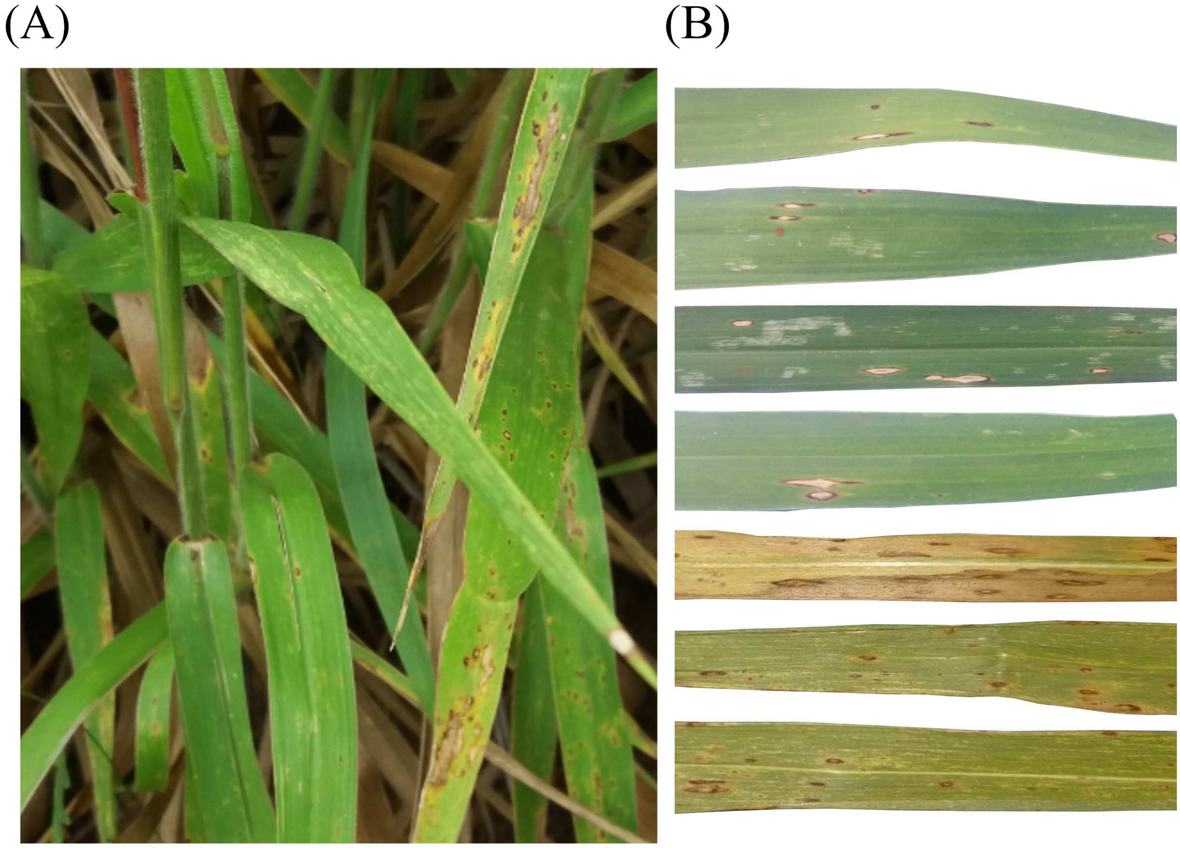


Figure 9. Blast symptoms observed on signal grass leaves naturally infected in the field. A) Leaves exhibiting blast lesions from which at least one *Pyricularia oryzae* isolate was recovered. B) Eye-shaped lesions with gray center and red-brown hallo, observed naturally on young, adult and senescent leaves of *Urochloa brizantha* cv. Marandu.

3.2. Species-specific molecular identification

From the subcollection of 572 isolates that were molecularly identified based on the CH7-BAC9 primer (Supplementary Table S1), 494 (86.4%) reactions were positive for *P. oryzae* (Figure 10, Table 5). These isolates were distributed across sixteen host species. The most represented host in the collection of strains was wheat (67%), followed by *Urochloa* spp. (13.56%), *E. indica* (8.1%), *R. roseum* (5.6%), and *P. maximum* (3,2%) (Table 5).

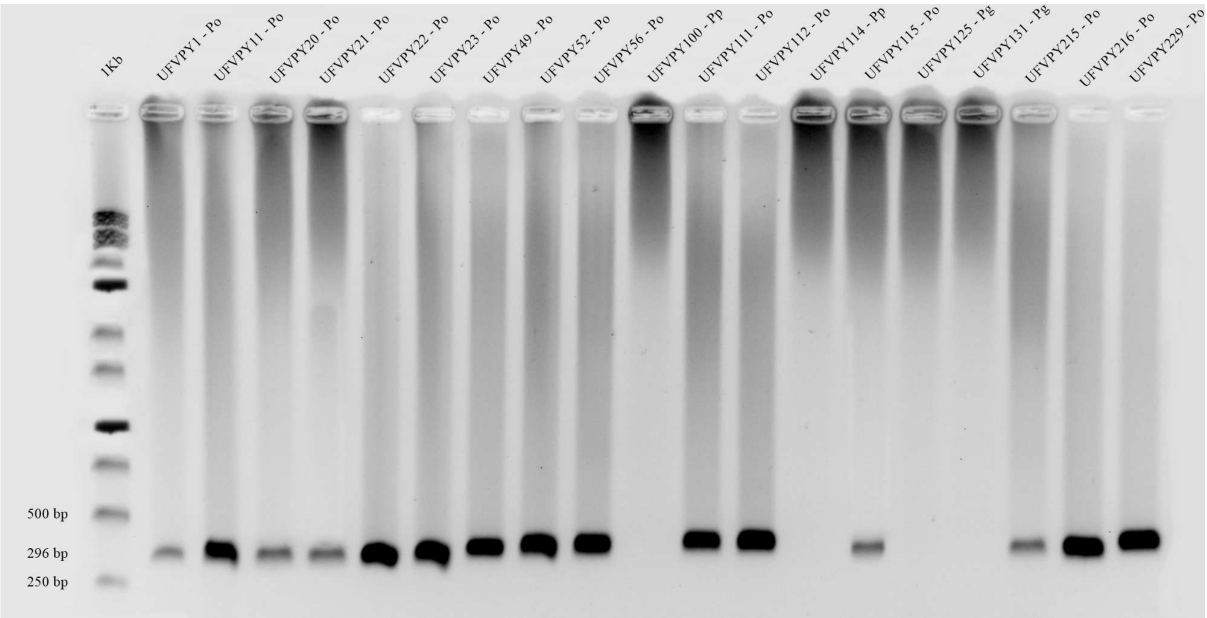


Figure 10. Gel image of a PCR assay of CH7-BAC9 locus used to identify *Pyricularia oryzae* against non-*P. oryzae* isolates from samples of wheat (leaf and head) and grass weeds (leaves) from Minas Gerais, Brazil. The fragment size of 296 bp is expected for *P. oryzae* strains. Negative reactions (non-*P. oryzae*), *P. pennisetigena* (UFVPY100 and UFVPY114) and *P. grisea* (UFVPY125* and UFVPY131) were previously identified by sequencing MPG1 locus (see Figure 11) and included as negative controls into PCRs assays. Po = *P. oryzae*; Pp = *P. pennisetigena*; Pg = *P. grisea*; 1 kb = 1 kb-DNA Ladder (KASVI). *Not included in phylogenetic analysis of MPG1 locus.

Maximum Parsimony phylogenetic tree reconstructed using sequences from MPG1 locus revealed that all eleven strains presenting CH7-BAC9 positive reactions grouped into *P. oryzae* clade. Strains with negative reactions in CH7-BAC9, UFVPY100, UFVPY114, and UFVPY131 clustered in the branches of *P. pennisetigena* and *P. grisea*, according to the host collected from (Figure 11, and Table 2).

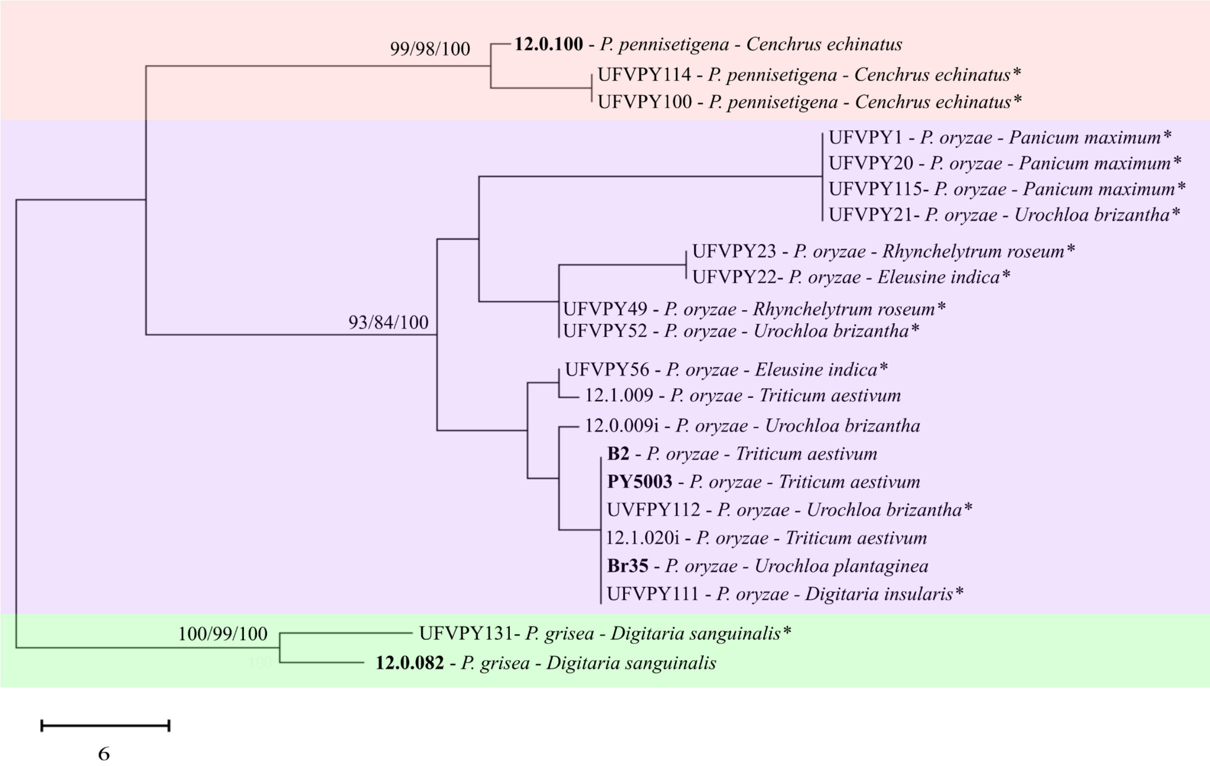
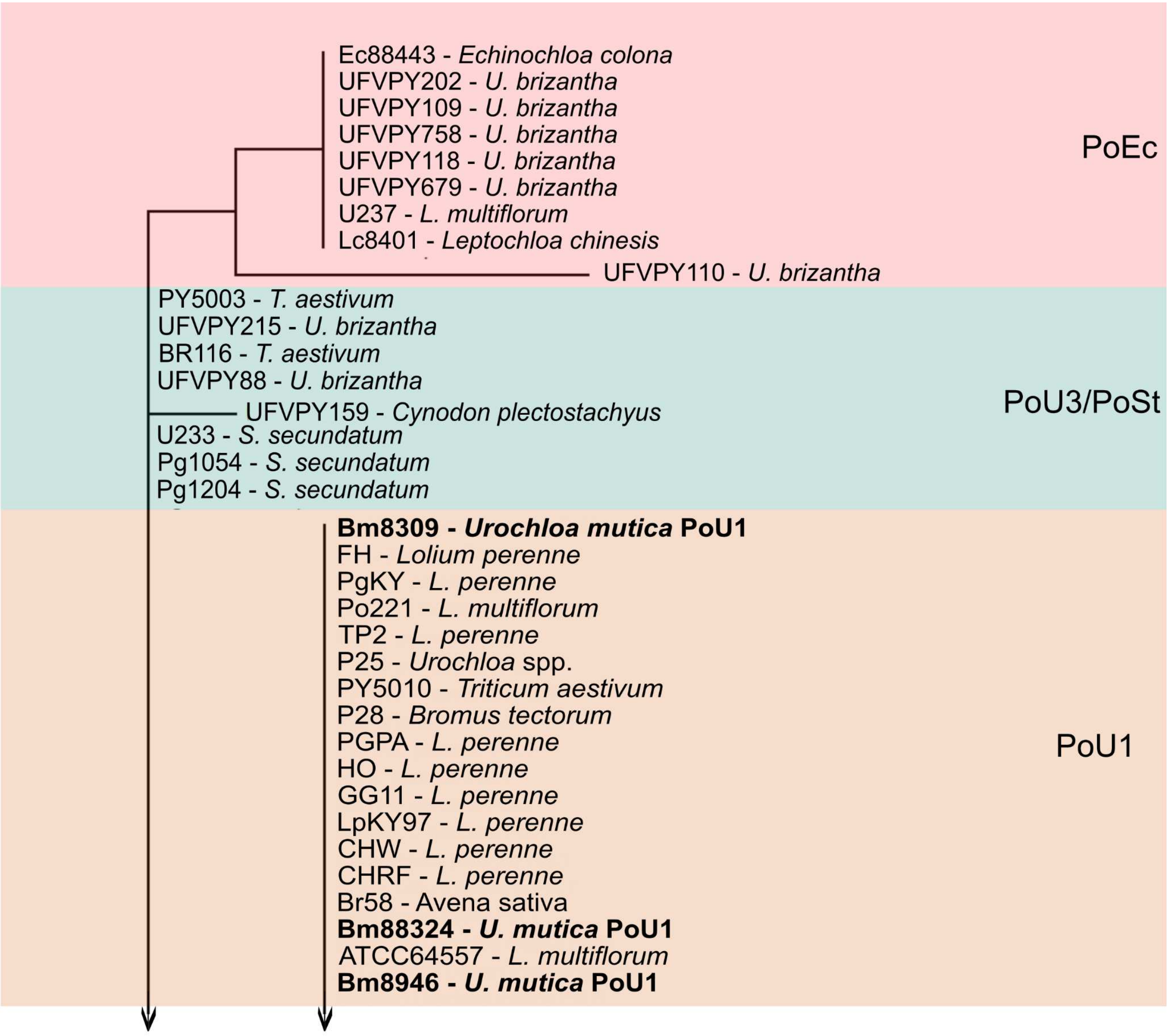
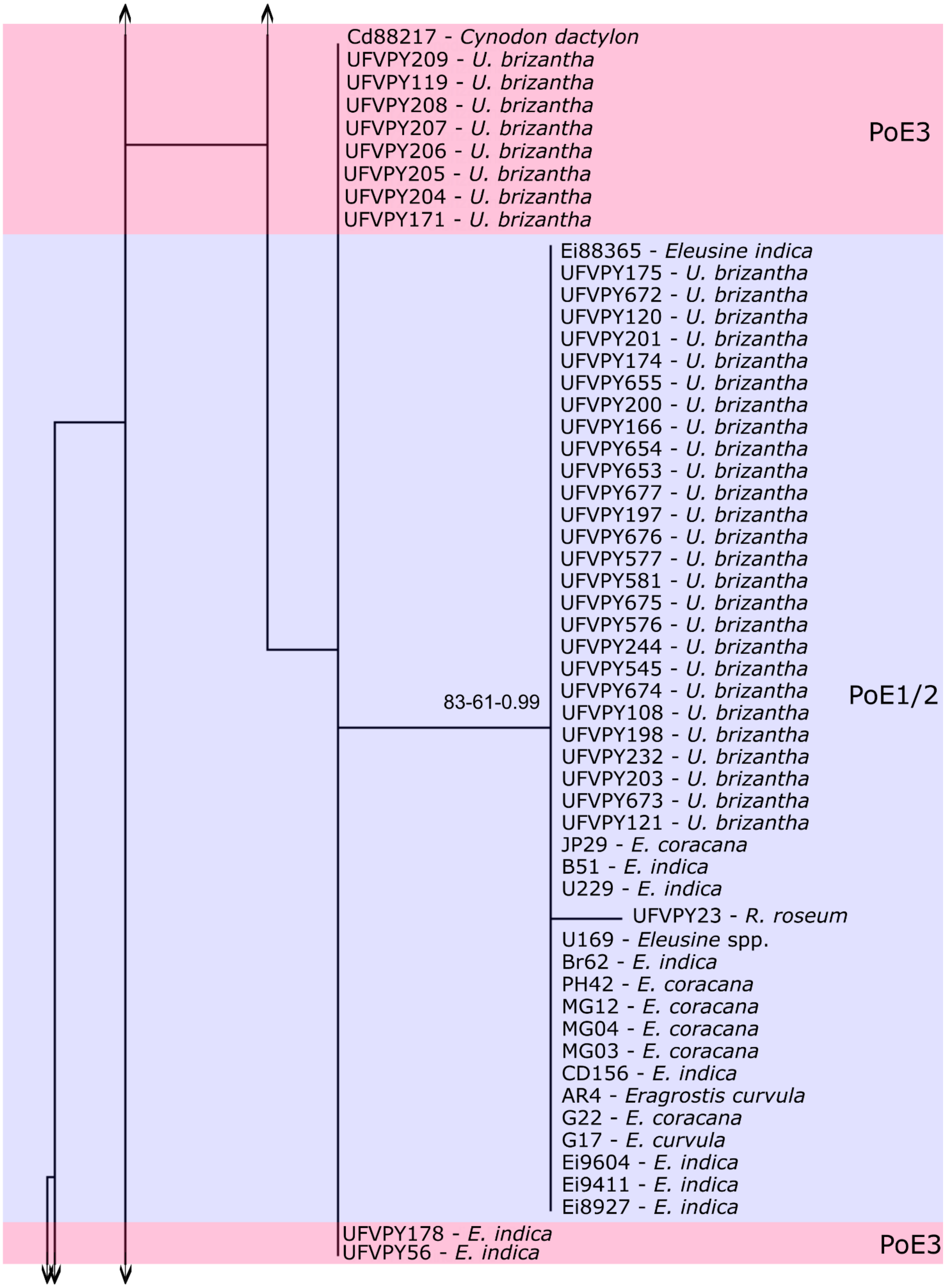


Figure 11. Maximum Parsimony (MP) tree reconstructed using nucleotide sequences of MPG1 locus from *Pyricularia oryzae*, *P. pennisetigena*, and *P. grisea*. Numbers on branches represented the support values of MP and Maximum Likelihood (ML) bootstrap, and Bayesian Posterior Probability (BPP) >95%. The best phylogenetic model adjusted to ML and Bayesian Inference was GTR+G. * Isolates sequenced in this study. Reference sequences in bold were downloaded from Genbank (Castroagudín et al. 2016; Gladieux et al. 2018).

Maximum Parsimony tree reconstructed using sequences of CH7-BAC9 locus demonstrated that the signal grass isolates are grouped together but in different clades. From the entire subcollection of signal grass (45) included in phylogenetic analysis, 34 sequences grouped together with *Eleusine* lineages E1, E2, and E3; six sequences with *Echinochloa* lineage, and one sequence (UFVPY742) collected from signal grass at surrounding wheat, grouped with *Triticum* lineage group. None of our sequences belonged to PoU1 or PoU2, however, three sequences grouped with PoU3/PoSt lineages. Two PoU isolates possibly formed a new phylogenetic lineage within *Urochloa,* called PoU4. This new phylogenetic group was represented by one isolate from signal grass (UFVPY92) and another from *R. roseum* (UFVPY49) (Figure 12), completely different from the others *Urochloa* isolates.




Cd88217 - *Cynodon dactylon*
UFVPY209 - *U. brizantha*
UFVPY119 - *U. brizantha*
UFVPY208 - *U. brizantha*
UFVPY207 - *U. brizantha*
UFVPY206 - *U. brizantha*
UFVPY205 - *U. brizantha*
UFVPY204 - *U. brizantha*
UFVPY171 - *U. brizantha*
PoE3
Ei88365 - *Eleusine indica*
UFVPY175 - *U. brizantha*
UFVPY672 - *U. brizantha*
UFVPY120 - *U. brizantha*
UFVPY201 - *U. brizantha*
UFVPY174 - *U. brizantha*
UFVPY655 - *U. brizantha*
UFVPY200 - *U. brizantha*
UFVPY166 - *U. brizantha*
UFVPY654 - *U. brizantha*
UFVPY653 - *U. brizantha*
UFVPY677 - *U. brizantha*
UFVPY197 - *U. brizantha*
UFVPY676 - *U. brizantha*
UFVPY577 - *U. brizantha*
UFVPY581 - *U. brizantha*
UFVPY675 - *U. brizantha*
UFVPY576 - *U. brizantha*
UFVPY244 - *U. brizantha*
UFVPY545 - *U. brizantha*
UFVPY674 - *U. brizantha*
83-61-0.99
UFVPY108 - *U. brizantha*
UFVPY198 - *U. brizantha*
UFVPY232 - *U. brizantha*
UFVPY203 - *U. brizantha*
UFVPY673 - *U. brizantha*
UFVPY121 - *U. brizantha*
JP29 - *E. coracana*
B51 - *E. indica*
U229 - *E. indica*
UFVPY23 - *R. roseum*
U169 - *Eleusine* spp.
Br62 - *E. indica*
PH42 - *E. coracana*
MG12 - *E. coracana*
MG04 - *E. coracana*
MG03 - *E. coracana*
CD156 - *E. indica*
AR4 - *Eragrostis curvula*
G22 - *E. coracana*
G17 - *E. curvula*
Ei9604 - *E. indica*
Ei9411 - *E. indica*
Ei8927 - *E. indica*
PoE1/2
UFVPY178 - *E. indica*
UFVPY56 - *E. indica*
PoE3

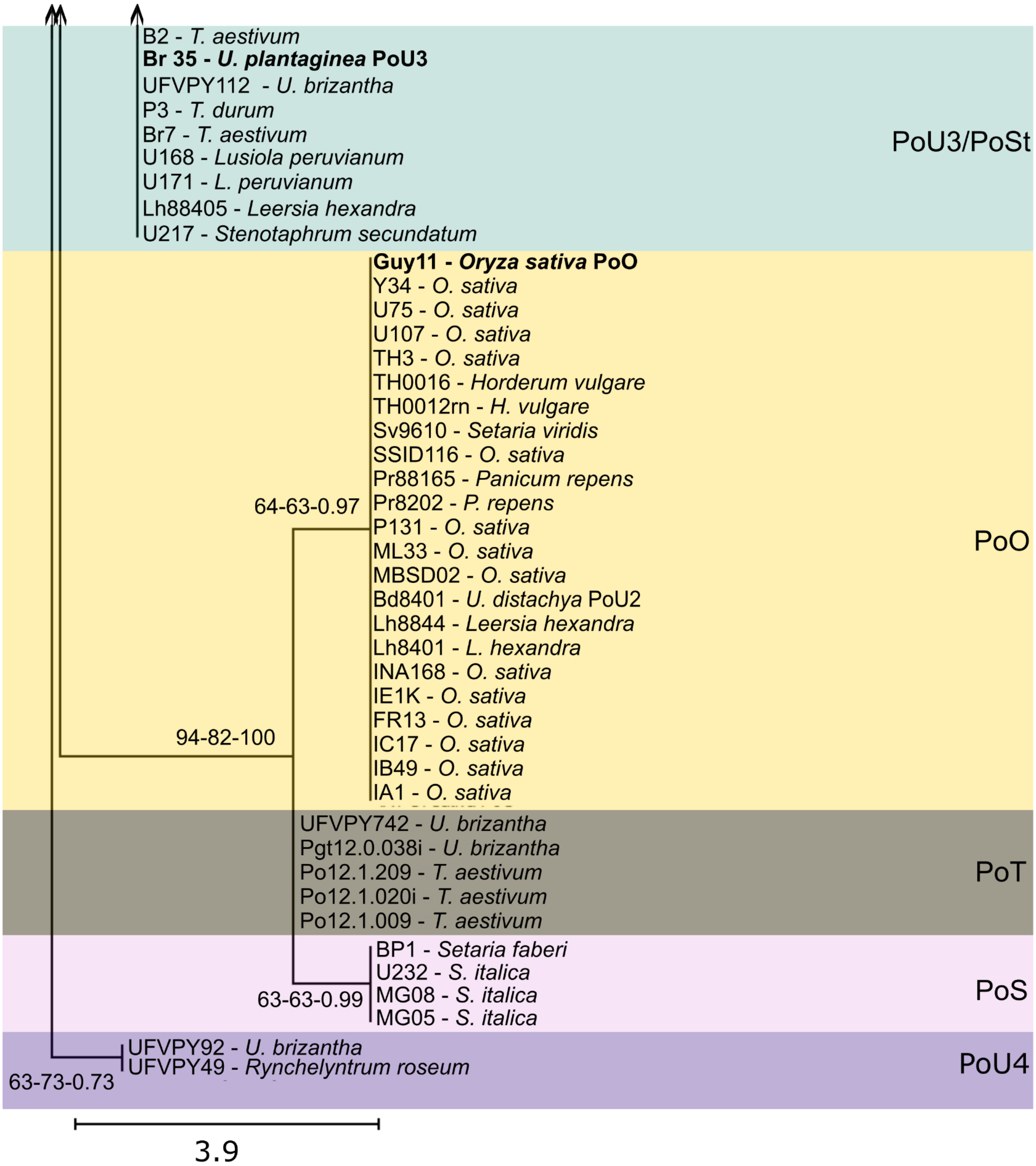


Figure 12. Maximum Parsimony (MP) tree reconstructed using nucleotide sequences of CH7-BAC9 locus of *Pyricularia oryzae*. Numbers on branches represented the support values of MP and Maximum Likelihood (ML) bootstrap, and Bayesian Posterior Probability (BPP >95%). The best phylogenetic model adjusted to ML and Bayesian Inference was GTR+I. *Bold sequences represent each one of the

Urochloa lineages PoU1, PoU2, PoU3, and PoU4. For complete information of isolates, see Table 2.

3.3. Lineage-specific molecular identification

All isolates that amplified portions of CH7-BAC9 were tested for two other diagnostic PCR primers, MoT3 and C17 primers. Positive C17 was indicative of PoT, as well as MoT3 (+/-). If C17 was negative, regardless of MoT3 results, strains were assigned to another lineage, hereafter designated as non-PoT. Considering the known failure rate for the MoT3 diagnostic (Yasuhara-Bell et al. 2019; Gupta et al. 2019), C17 (+) was used to more certainly assign an isolate to PoT. Negative controls, *P. pennisetigena* and *P. grisea,* as well as others *P. oryzae* lineages different from PoT showed negative reactions for both MoT3 (Figure 13A) and C17 (Figure 13B) PCR assays.

Among all 494 *P. oryzae* strains, the *Triticum* lineage was the most frequent (67.61%) with its large majority (97%) isolated from wheat (Table 5). Only 10 PoT strains were isolated from other hosts than wheat, including *C. echinatus* (1)*, E. indica* (3)*, P. maximum* (1)*, Pennisetum sp.* (1)*, Urochloa* spp. (3)*,* and *R. roseum* (1). Seven of those PoT strains were obtained from samples collected at the surroundings or infesting wheat fields, but only three from a non-wheat region placed in a natural landscape. The four PoT isolates from wheat (3) and *E. indica* (1) collected in Viçosa (non-wheat region) were also included into our collection, but they do not represent a natural distribution of the blast fungus, since they come from demonstrative wheat plants kept diseased under artificial inoculation at UFV-Infectario (Figure 14).

Table 5. Summary results of PCR assays in a subcollection of 572 strains from 16 Poaceae hosts recovered of wheat (leaf and head) and grass weeds (leaves) from wheat-producing regions (Triângulo Mineiro and Centro-Sul de Minas) and natural landscapes during summer (February, pre-season) and fall (May, wheat-growing season) 2018 and 2019, MG, Brazil.

Host collected from*	***Pyricularia* sp. [A]**	***P. oryzae* [B]**	**Lineages**	
			PoT [C]	**Non-PoT [D]**
Cenchrus echinatus	20	2	1	1
Cynodon dactylon	1	0	-	-
C. plectostachyus	1	1	-	1
Digitaria horizontalis	21	2	-	2
D. insularis	20	1	-	1
D. sanguinalis	18	5	-	5
Echinochloa colonum	1	0	-	-
Eleusine indica [E]	42	40	3	37
Away	8	8	1	7
Nearby	34	32	2	30
Panicum maximum [E]	16	16	1	15
Away	10	10	-	10
Nearby	5	5	1	4
Inside	1	1	-	1
Pennisetum sp.	2	1	1	-
Rhynchelytrum roseum [E]	28	28	1	27
Away	27	27	1	26
Nearby	1	1	-	1

Triticum aestivum [E]	333	331	324	7
Leaf	127	127	126	1
Head	206	204	198	6
Urochloa brizantha [E]	57	56	2	54
Away	43	42	-	42
Nearby	12	12	-	12
Inside	2	2	2	-
U. humidicola [E]	7	7	1	6
Away	5	5	1	4
Nearby	2	2	-	2
U. plantaginea	3	2	-	2
U. ruziziensis	2	2	-	2
Total	**572**	**494**	**334**	**160**

[*] Poaceae species which had at least one lineage (PoT and other) splitted into sub-levels of plant tissue (leaf and head) or sample-distance from wheat (away, nearby, and within).

[A] Obtained through morphological characteristics on PDA plates based on 2-sept-pyriform conidia shape (Klaubauf et al. 2014).

[B] Polymerase Chain Reaction (PCR) screening using CH7-BAC9 locus, which is specifically found in the *P. oryzae* population (Couch et al. 2005).

[C] Specific primers used in PCR analysis identifies *P. oryzae Triticum* lineage (PoT) as follows: C17(+) and MoT3 (+/-) (Pieck et al. 2017; Thierry et al. 2020).

[D] The non-PoT lineage was assigned when obtaining PCR reactions as follows: C17 (-) and MoT3 (+/-) (Pieck et al. 2017; Thierry et al. 2020).

[E] Once counted the total number for the host, splitted numbers were written just to better understand sampling location.

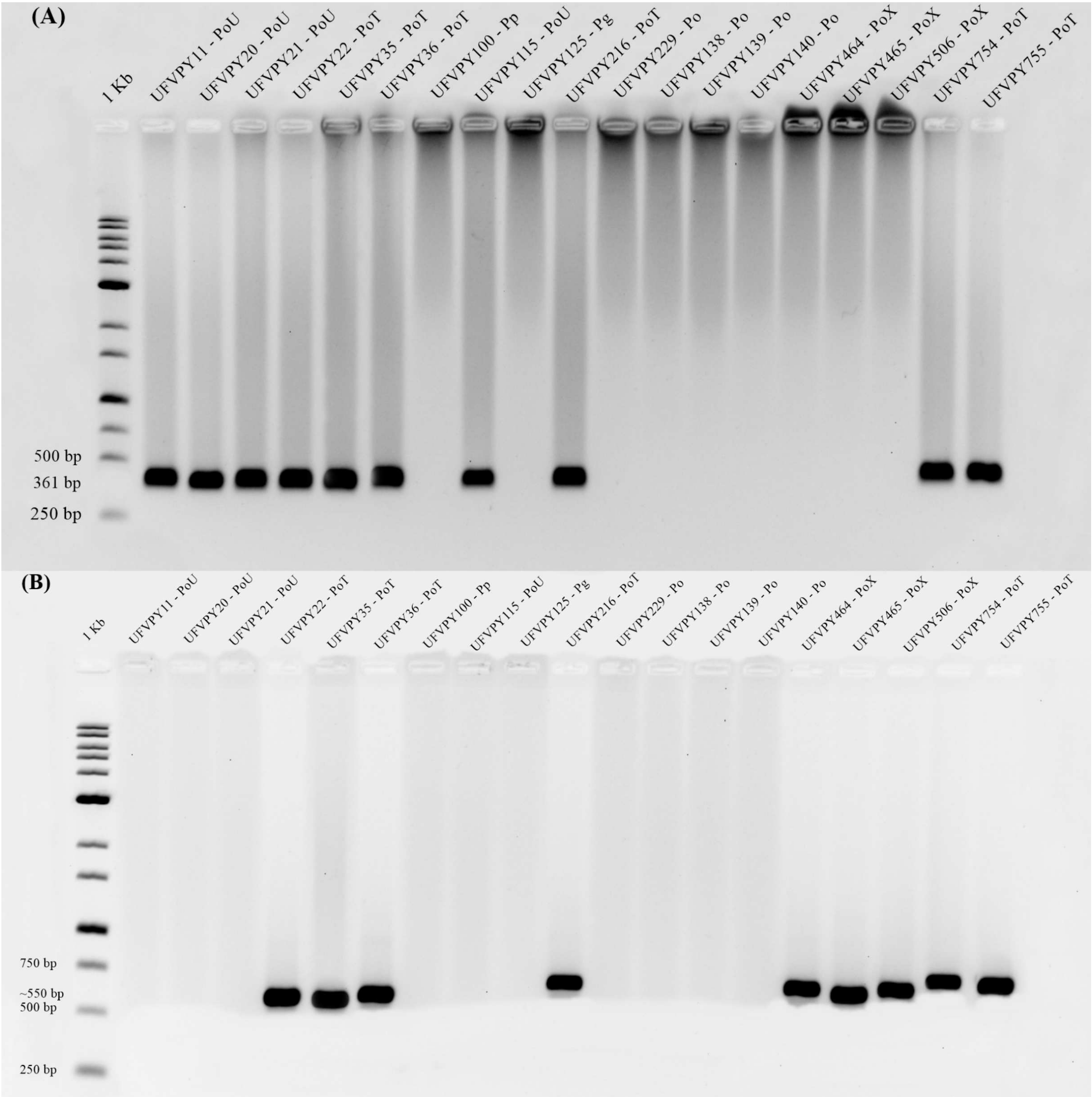


Figure 13. Specificity of conventional Polymerase Chain Reaction using genomic DNA as template. 1%-agarose gel presenting positive (presence of bands) and negative (no bands) reactions for both A) MoT3 (361 bp) and B) C17 (500 bp) primers allowed the *Pyricularia oryzae Triticum* lineage and non-*Triticum*. PoT = MoT3 (+/-) and C17 (+); Po = MoT3 (+/-) and C17 (-). Legend: PoT = *P. oryzae Triticum*; Po = other *P. oryzae* lineages different than PoT; Pp = *P. pennisetigena*; Pg = *P. grisea*; 1 kb = DNA Ladder (KASVI).

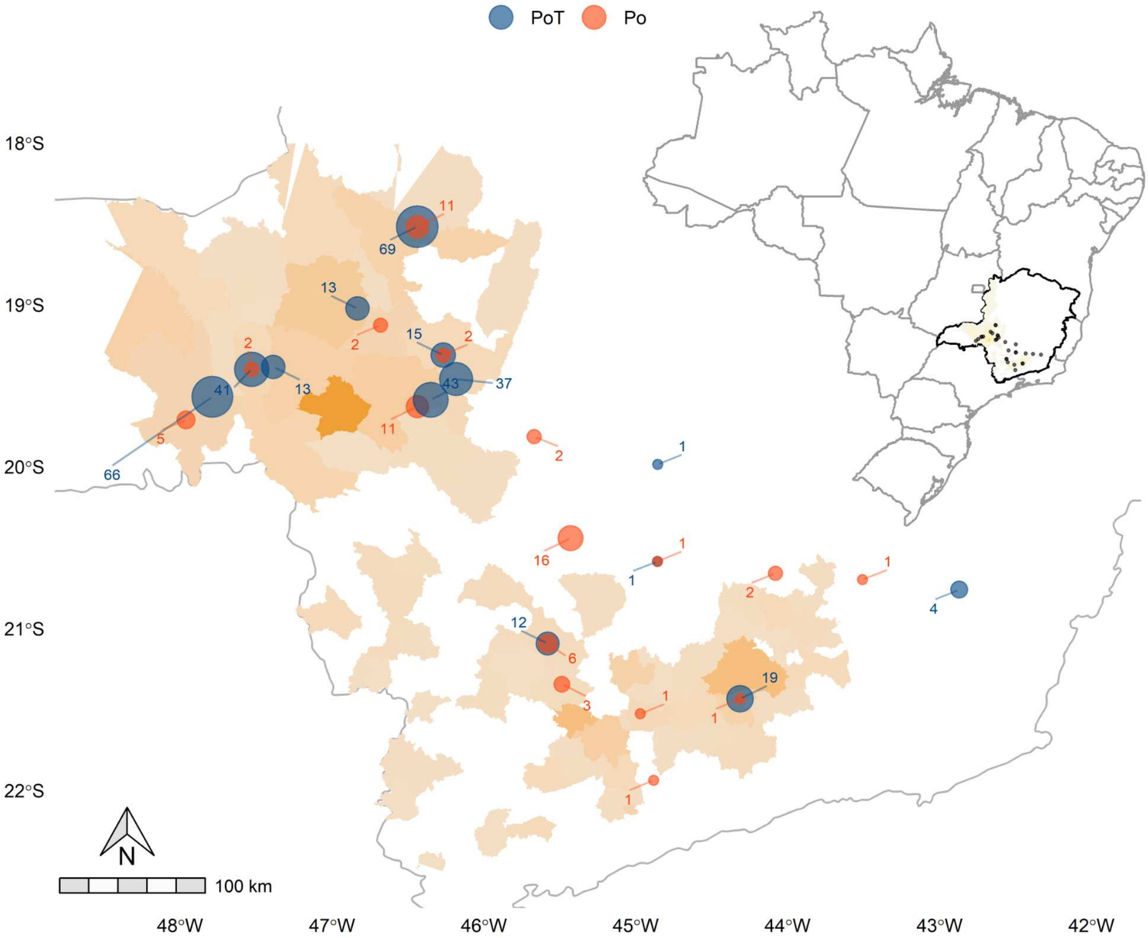


Figure 14. Minas Gerais state map depicting estimated wheat planting area per municipality (color gradient) and location (dots) of *Pyricularia oryzae* isolates of wheat and natural grass. Dots size and color refer to the number of *Triticum* (PoT) and non-PoT. Source: (IBGE 2017).

The non-PoT lineages represented 32.39% of all 494 *P. oryzae* isolates (Table 5), which were isolated not only from *Urochloa* spp. (40%), but also in others four hosts species, including *E. indica* (23.12%), *R. roseum* (16.87%), *P. maximum* (9.37%), and also from *T. aestivum* (4.37%) (Table 5). Non-PoT in wheat was found more in the head (6 isolates) than in the leaf (one isolate). The *Urochloa* isolates were evenly distributed across the Triangulo Mineiro (n = 33 strains) and Centro-Sul (n = 34) regions. In the latter region, most of the non-PoT isolates were collected far away from a wheat field. PoT occurrence was reduced as the sampling distanced from wheat areas, being more restricted to grasses near or inside wheat fields. Only two PoT were found in a non-wheat host and far away from the wheat fields. PoT isolates obtained in Viçosa, a non-wheat region, do not represent the natural distribution of PoT pathogens, as they were isolated from a demonstrative wheat plot (Figure 14).

3.4. Cross-inoculation assay: PoT-wheat and PoU-signal grass

3.4.1. Leaf blast symptom characteristics

The characteristics of the lesions varied according to the host vs. lineage interaction (Figure 15). First symptoms on the leaves appeared as water-soaked lesions three days after inoculation. Inoculated leaves showed a distinct symptomatic pattern compared with natural infections. For example, hypersensitive responses that were randomly distributed on the leaf surface (Figure 15A; D); eye-shaped lesions with gray center and red-brown halo (induced by PoU) in wheat (Figure 15C), and edge-chlorotic or necrotic lesions (induced by PoT) (Figure 15D) developed in signal grass. Coalescent-necrotic lesions on the entire leaf area were predominantly caused by PoT (Figure 15B) and some PoU (Figure 15C) isolates in the primary host.

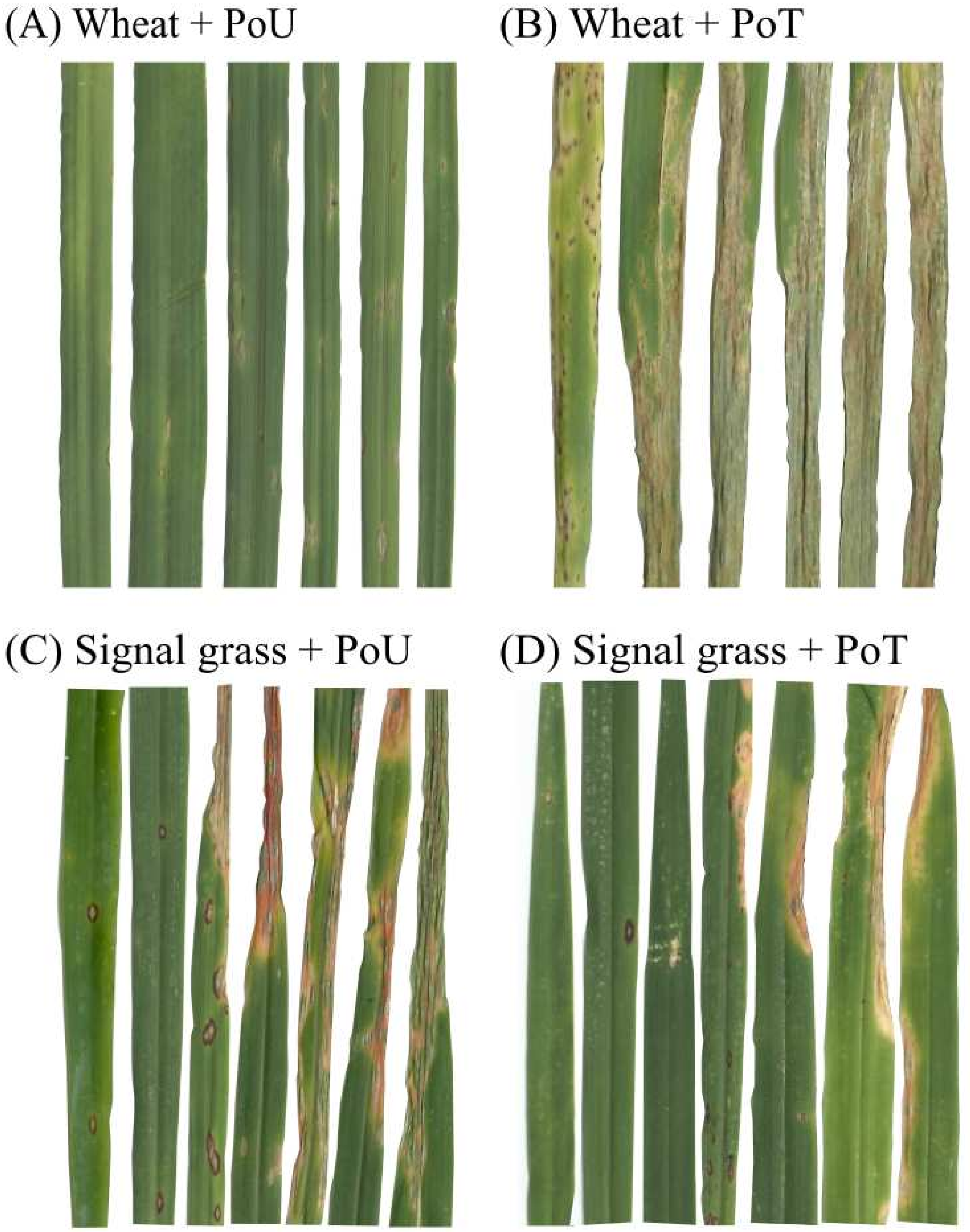


Figure 15. Leaf blast disease symptoms resulting from cross-inoculations of *Pyricularia oryzae* lineages (PoT = *Triticum* lineage isolated from wheat; PoU = *Urochloa* lineage isolated from signal grass) on *T. aestivum* (cvs. BRS Guamirim and BR 18-Terena) and *U. brizantha* (cv. Marandu) under greenhouse conditions.

3.4.2. Leaf blast intensity

The interaction factor (lineage x host-cultivar) was significant ($P < 0.0001$) for incidence, severity and number of conidia/leaf. In general, the isolates within each lineage were consistently and significantly more aggressive on their primary host and less on the alternative host (Table 6). Foliar incidence and severity induced by PoT in wheat were, on average, greater than 90% and 50%, respectively. In signal grass, cv. Marandu, incidence and severity values induced by PoT were less than 10% and 4%, on average, respectively (Table 6, Figures 16A; B). Incidence and severity induced by PoU in signal grass were around 60% and 10%, respectively, while in wheat these values were reduced by half. There was a significant variation of severity among isolates within the same lineage, especially within PoU inoculated in signal grass and within PoT inoculated on wheat (Table 6, Figures 16A; B; Supplemental Figures S1; S2).

Similarly, conidia production was greater on the primary than the alternative host for both lineages. For example, conidia of PoT produced on wheat were at least 200 thousand times greater than in signal grass. On average, conidia production by PoU was 8x lower in wheat than in signal grass (Table 6, Figures 16C, Supplemental Figure S3). Number of conidia resulting from the lineages vs. hosts inoculated were consistent with severity, showing a strong and positive association between severity and conidia production for PoT ($\rho = 0.80$) and PoU ($\rho = 0.86$).

Table 6. Generalized linear mixed model estimates for the means of leaf blast incidence, severity and number of conidia/leaf as a result of cross-infecting *P. oryzae Triticum* and *Urochloa* lineage in BR18-Terena, BRS Guamirim, and Marandu.

Variable	**Lineage**	**Wheat cultivar**		**Signal grass**
		BR 18- Terena	**BRS Guamirim**	**Marandu**
Incidence	PoT	97.40 bB	98.15 bB	8.19 aA
	PoU	30.96 aA	34.13 aA	63.30 bB
Severity	PoT	50.30 bB	65.98 bC	3.28 aA
	PoU	4.01 aA	3.96 aA	10.09 bB
Number of conidia/leaf (x1000)	PoT	164.96 bB	213.15 bB	1.13 aA
	PoU	4.53 aA	3.45 aA	35.65 bB

Means with different lowercase letters in the column and uppercase in the row differ from each other at 5% probability.

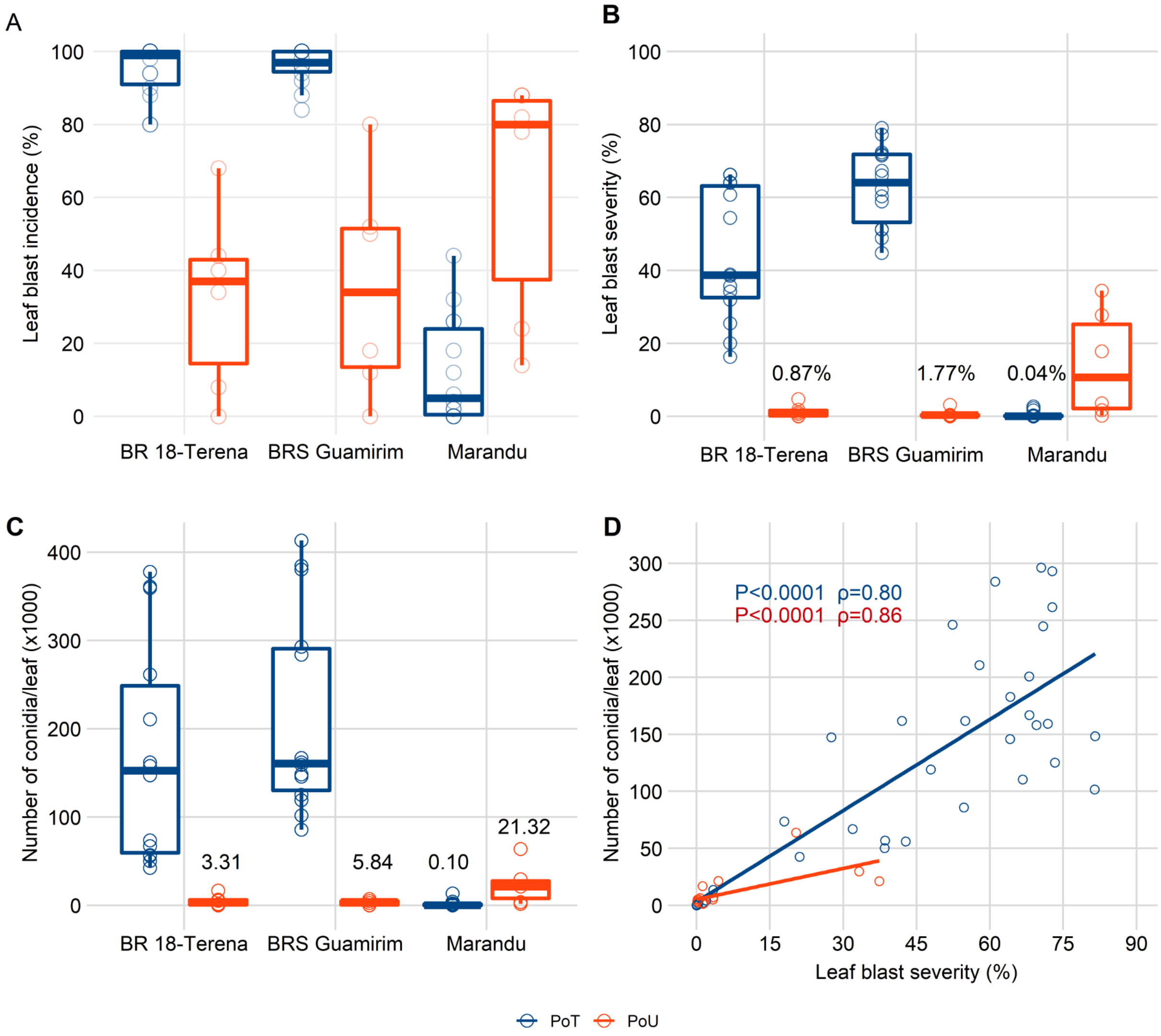


Figure 16. Box-plot for the foliar (A) incidence, (B) severity, (C) number of conidia/leaf, (D) Spearman correlation between conidia production and leaf blast severity induced by strains of two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Each empty dot represents a single isolate on wheat (*T. aestivum,* BR 18-Terena and BRS Guamirimim) or signal grass (*U. brizantha,* Marandu). Each empty dot represents a single isolate. The solid line in the box represents the median. The lower and upper hinges correspond to the interquartile (between 25 and 75%) range (IQR). The upper (lower) whisker extends from the hinge to the largest (smallest) value no further than 1.5 IQR from the hinge. Solid lines represent a linear model regression adjusted to y ~ x, correlation *P-value* = *P*, and Spearman's correlation coefficient (*ρ*).

3.4.3. Wheat head blast symptoms and severity

Head blast symptoms became visible four days after inoculation, starting with small reddish-brown to dark-gray spots at spikelets. Half bleaching heads, as usually occurs in natural infections (Figure 8B), was uncommon in inoculated heads (Figure 18). Small lesions on heads were produced by PoU isolates, infecting randomly the spikelets or causing hypersensitivity lesions. On the other hand, mostly PoT isolates were highly aggressive and killed the entire head, but only a few PoU isolates affected the entire wheat head (Figure 18).

Wheat head + PoU

Wheat head + PoT

Figure 18. Head blast disease symptoms resulting from cross-infecting *Pyricularia oryzae* lineages (PoT and PoU) in *Triticum aestivum* (BRS Guamirim and BR

18-Terena cultivar) under greenhouse conditions. PoT = *Triticum* lineage, isolated from wheat; PoU = *Urochloa* lineage isolated from signal grass.

The interaction factor (lineage vs. cultivar) was not significant (*P = 0.692*) and there was weak evidence of cultivar effect (*P = 0.049*) on head blast severity. However, PoT isolates were statistically (*P < 0.0001*) more aggressive than PoU, which induced around 50% severity compared with more than 95% severity on average by PoT isolates (Figure 19; Supplemental Figure S4).

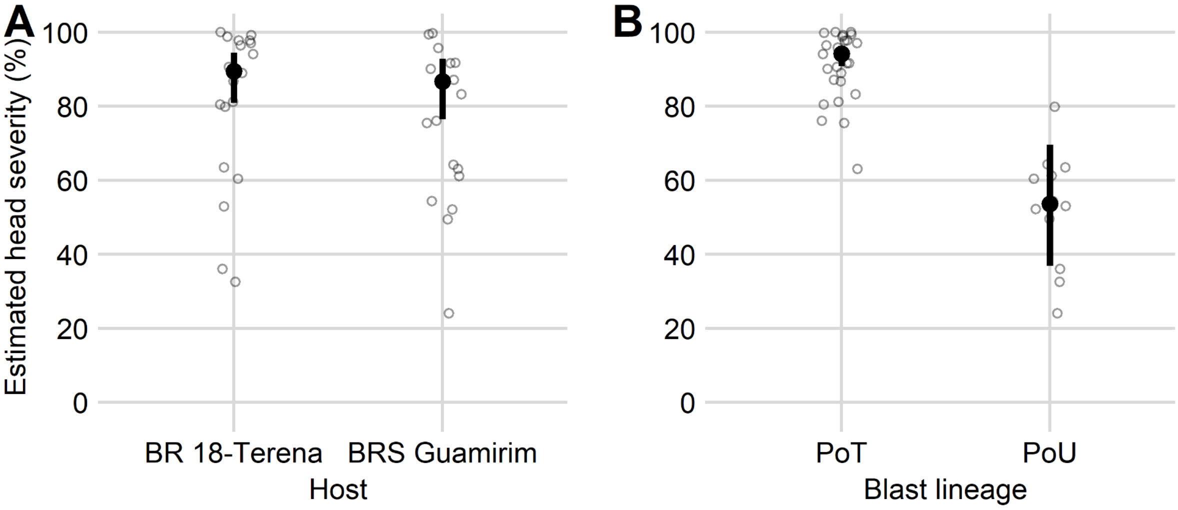


Figure 19. Wheat head blast severity (percent of symptomatic spikelets within a head) induced by two *Pyricularia oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*) on two wheat cultivars (BR 18-Terena and BRS Guamirim, *Triticum aestivum*). Each dot represents a single isolate. Filled dots represent the mean severity and extended lines the 95%-confidence interval from the adjusted GLMM.

3.5. Aggressiveness towards signal grass cultivars

The effect of the interaction (lineage vs. host) was significant (*P <0.0001*) for incidence, severity, and number of conidia. In general incidence and severity by PoT and PoU did not differ between them for most cultivars with the exception of Marandu, where PoU was four times more aggressive (severity) than PoT. In fact, the largest blast intensity values (> 75% incidence and > 22% severity) were observed in cv. Marandu inoculated with PoU (Table 8, Figure 21A; B; Supplemental Figures S5; S6). Almost all diseased leaves had at least one sporulating lesion. Patterns of conidia production were similar between the two lineages on Basilisk and Xaraés, but not in Marandu and Piatã. There was a greater variation in conidia production among isolates within PoU lineage than PoT (Figure 21C; Supplemental Figure S7). There was a significant and positive correlation between conidia production and severity for PoT ($\rho = 0.81$) and PoU ($\rho = 0.85$) (Figure 21D).

Table 8. Generalized mixed model estimates for the means of leaf blast incidence, severity and number of conidia/leaf as a result of cross-infecting *P. oryzae Triticum* and *Urochloa* lineage in Marandu, Piatã, and Xaraés, and Basilisk.

Variable	**Lineage**	**Signal grass cultivars**			
		Marandu	**Basilisk**	**Piatã**	**Xaraés**
Incidence	PoT	41.48 aB	45.40 aB	10.84 aA	10.00 bA
	PoU	75.87 bD	39.33 aC	16.45 aB	4.95 aA
Severity	PoT	4.88 aB	5.56 aB	2.22 aA	2.68 aA
	PoU	22.37 bC	4.33 aB	2.35 aAB	1.90 aA
Number of conidia/leaf (x1000)	PoT	35.10 aD	30.10 aC	11.70 aA	16.00 aB
	PoU	98.00 bD	31.30 aB	44.00 bC	16.80 aA

Means with different lowercase letters in the column and uppercase in the row differ from each other at 5% probability.

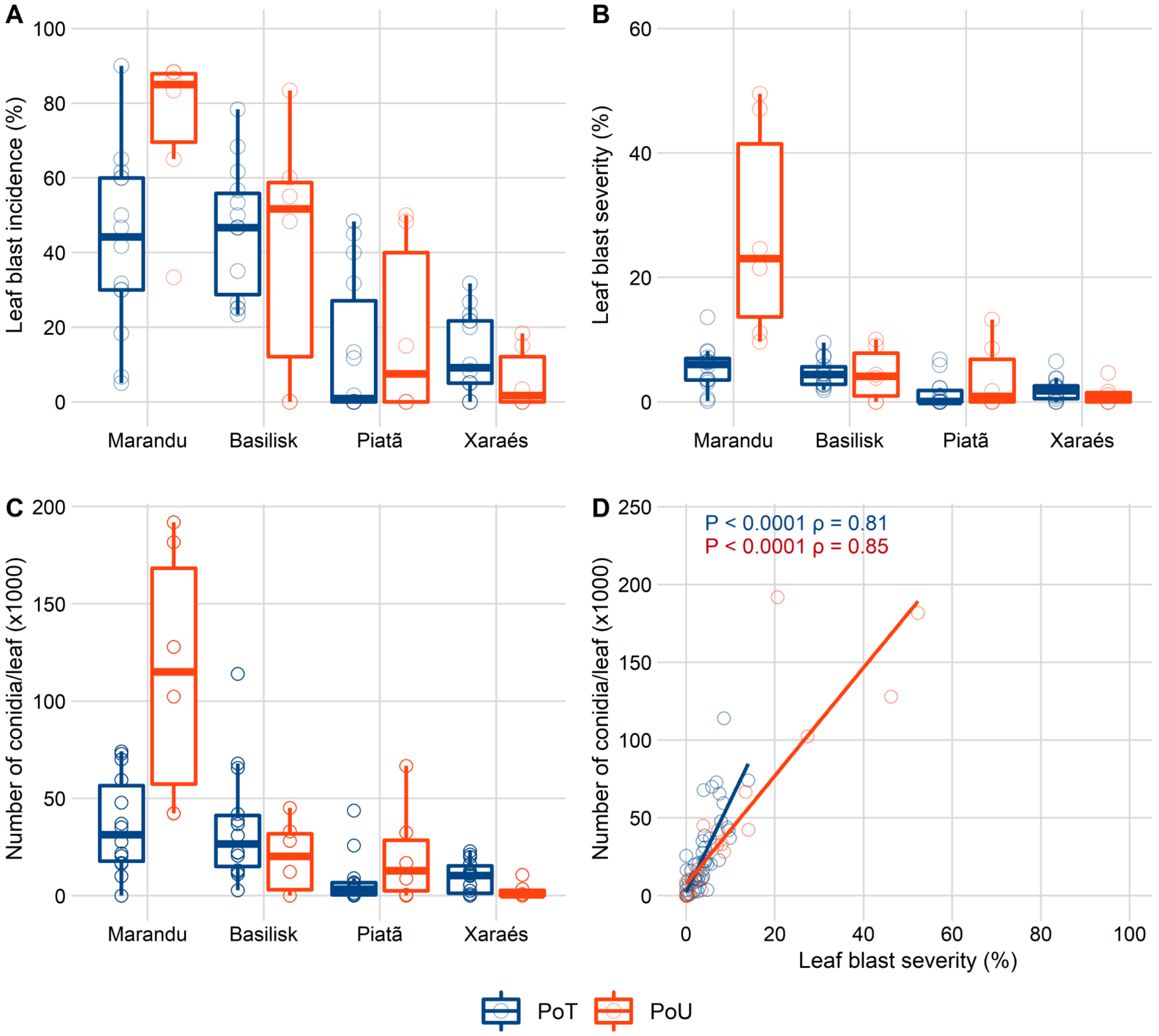


Figure 21. BoxPlot of blast incidence (A), severity (B), number of conidia (C), and relation between number of conidia and leaf blast severity (D) of four signal grass cultivars (Marandu, Piatã, Xaraés, and Basilisk) induced by two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Each empty dot represents a single isolate. The solid line in the box represents the median. The lower and upper hinges correspond to the interquartile (between 25 and 75%) range (IQR). The upper (lower) whisker extends from the hinge to the largest (smallest) value no further than 1.5 IQR from the hinge. Solid lines represent a linear model regression adjusted to y ~ x, correlation *P-value* = *P*, and Spearman's correlation coefficient (*ρ*).

4. DISCUSSION

This is the first comprehensive survey of the blast disease in wheat as well as in several other *Poaceae* plants growing nearby or hundreds of kilometers away from commercial wheat fields cultivated in the Minas Gerais state. Using CH7-BAC9 sequences, we report *P. oryzae* as the dominant species (87%; 494 isolates) in a relatively large collection of isolates (572 isolates) obtained from 16 Poaceae plant species, including wheat. In fact, all but two isolates (species not identified) obtained from blast-symptomatic leaves or heads of wheat belonged to *P. oryzae*. This further confirms that other species (e.g. *P. pennisetigena, P. zingibericola* and *P. grisea*) that infect grasses are not important contributors to wheat blast epidemics, as it has been shown under artificial conditions (Reges et al. 2016; Cazal-Martínez et al. 2021). It is worth noting that we did not identify all other species present in our collection, because the identification of *P. oryzae* was based solely on sequences of the CH7-BAC9 primer for which the positive reactions were indicative of *P. oryzae*. Nevertheless, we did analyze a few *P. oryzae* and non-*P. oryzae* isolates based on MPG1 sequences for which a phylogeny tree showed grouping of isolates with *P. oryzae*, *P. grisea,* and *P. pennisetigena*.

Although a few species other than *P. oryzae* can cause blast symptoms in wheat under artificial inoculation conditions, the observed severity levels have been rather low compared with *P. oryzae* (Reges et al. 2016; Perelló et al. 2017). It is well known that these other species occur frequently in both the natural landscape and cultivated areas of non-wheat plants including *C. echinatus, Digitaria* spp., *Chloris distichophylla*, *Panicum* spp.*, Eragrostis* spp., *Echinochloa* sp., *Sorghum* spp., *Pennisetum* spp., and *Urochloa* spp. (Reges et al. 2016; Perelló et al. 2017; Durante et al. 2018; Chandra et al. 2019; Qi et al. 2019; Pordel et al. 2020; Rahnama et al. 2020; Chung et al. 2020; Sharma et al. 2021).

Our survey showed that *P. oryzae* was associated not only with wheat, as 33% (163/494) of isolates of this species were found in other hosts, including *E. indica*, *R. roseum*, *P. maximum*, and *Urochloa* spp. This finding is in agreement with previous nationwide surveys of *P. oryzae* in alternative hosts growing nearby wheat fields (Maciel et al. 2014; Castroagudín et al. 2015, 2016).

The testing of two PCR primers, MoT3 and C17, which are diagnostic of the PoT pathotype (Pieck et al. 2017; Thierry et al. 2020) on the entire subcollection of *P. oryzae* suggested that all but seven isolates obtained from wheat leaves or heads were assigned to PoT (98%; 324/331 isolates). The primer MoT3 was considered to be specific for targeting PoT. However, it has been shown an error rate, such as the absence of amplification for a wheat-infecting isolate and presence of amplification for a *Bromus tectorum* isolate collected inside a wheat field (Pieck et al. 2017). Another research group tested the specificity of MoT3 which failed to distinguish between rice and wheat isolates from Bangladesh (Gupta et al. 2019). In response, the authors of the MoT3 diagnostic primer argued that different PCR conditions, reagents, and thermocycler machines were used, which resulted in unexpected amplicons. After correcting those conditions, the specificity of the MoT3 was reconfirmed using the same strains (Yasuhara-Bell et al. 2019). Moreover, the loss of the MoT3 allele may be possible due to hybridization events through inter-lineages recombination, which may explain the small failure rate, according to the authors (Pieck et al. 2017; Yasuhara-Bell et al. 2018a, 2019).

In our study, MoT3 produced 2.5% (10/394) false negatives, when compared with results by the C17, for isolates obtained from both wheat (9) and *E. indica* (1) infesting a wheat field. On the other hand, the primer C17, which was designed based on a polymorphism specific to the *Triticum* lineage, showed 100% specificity in both conventional and quantitative PCR in the original study (Thierry et al. 2020). For those nine PoT isolates obtained from wheat with MoT3-negative reaction in our study, the C17 reactions were all positive, in agreement with the original study (Thierry et al. 2020). To our knowledge, this is the first study to utilize the C17 diagnostic primer using a Brazilian blast collection from wheat and natural grasses. Here, we observed 41% (64/157) of possibly false positive reactions of MoT3 (when comparing to C17, which yielded all negative results) for isolates obtained from grasses, mainly signal grass (n = 49). Therefore, caution should be taken when using MoT3 to detect PoT isolates from natural grasses, since the authors did not include

Brazilian isolates from grass, specifically from *Urochloa*. Up to now, no studies have argued against C17 specificity for detecting PoT.

Based on the C17 results, PoT was found almost exclusively in wheat; only 10 PoT (2%) isolates were found infecting mainly *Urochloa* spp. (n = 3) and *E. indica* (n = 3), but also *C. echinatus, P. maximum, Pennisetum sp., R. roseum* (one isolate each) plants sampled mostly nearby or within (7/10) of wheat fields. Collectively, our data confirm the hypothesis that the *P. oryzae* diversity is strongly shaped by the host, even when sampled from alternative hosts grown nearby wheat fields in the studied region. Similar to our study, PoT and non-PoT isolates have also been isolated from alternative hosts growing nearby wheat fields, further suggesting that cross-host infection is common in the field, and that the alternative host could serve as a source of inoculum for epidemics in wheat. However, it is possible that, at the time, the authors of those studies (Castroagudin et al. 2017; Ceresini et al. 2018, 2019; Dorigan et al. 2019; Poloni et al. 2021) have either failed to correctly identify the pathotypes occurring in the alternative hosts, for example: false positive for PoT infecting grass, or, they have indeed sampled the PoT strains from other hosts, particularly from signal grass, growing nearby wheat fields from other regions than Minas Gerais. The testing of those isolates using the C17 assays could be instructive to shed light on this issue.

We further studied the *Urochloa* blast population, and a subcollection of 45 isolates from signal grass were analyzed through phylogenetics using CH7-BAC9 sequences (Couch et al. 2005). Analysis of a larger number of whole genome from a international blast collection, supported the existence of host-specialized subpopulations within *P. oryzae*, and the authors additionally reported the occurrence of three phylogenetic groups (PoU1, PoU2, PoU3) of a international collection of isolates obtained from signal grass (Farman et al. 2017; Gladieux et al. 2018). We included a portion of those sequences, at least one of each group, in our CH7-BAC9 phylogeny.

Five phylogenetic groups were clearly formed: over one half of *Urochloa* sequences composed a large clade together with *E. indica* lineages, and a half dozen sequences with *Echinochloa* lineage. Besides, none sequences grouped with

PoU1 or PoU2 *Urochloa* lineages, there were three signal grass isolates grouping in PoU3 clade, and two sequences (one from signal grass) forming a new phylogenetic *Urochloa* lineage (PoU4), completely separated from the others. Mixed composition of the clades may be due to events such as gene flow among blast lineages leading to chromosome rearrangements. Genetic variability increases through recombination across lineages (Gladieux et al. 2018; Monsur and Kusaba 2018), mutations in avirulence genes through selecting (lost/gain of pathogenicity-related genes) frequently occurs (Orbach et al. 2000), or through the movement of a Pot3 transposon across avirulence genes (Kang et al. 2001), leading to pathogenicity gain in new host species (Inoue et al. 2017; Gómez Luciano et al. 2019; Duan et al. 2021). All these factors increase the genetic variation within *P. oryzae* species, as previously shown (Zhang et al. 2011, 2016; Yoshida et al. 2016; Urashima et al. 2017; Gladieux et al. 2018). In addition, the less defined grouping is expected when using a single gene in the phylogenetic analyses, in contrast to when the whole genome was used in phylogenomic analysis (Gladieux et al. 2018).

Given the phylogenetic support/evidence of the presence of at least two *Urochloa* lineages (PoU3 and PoU4) in C17-negative strains from signal grass, six *Urochloa* and 14 PoT isolates were selected and cross-inoculated in wheat and signal grass (*U. brizantha*). Again, two groups were formed, PoT more aggressive on wheat (leaves and heads) and *Urochloa* more aggressive on signal grass and moderately aggressive on wheat heads. Despite depicting up to 50% of infected spicklets, the percentage of diseased area was rather low, and the symptoms of PoU were in general characterized by small reddish-brown to dark-gray spots at spikelets, or even hypersensitive reactions, very different from the aggressive symptoms occasioned by PoT isolates. *Triticum* pathotype is usually more aggressive on their primary host, where the fungal colonization at the rachis vassel causes partial or complete head bleaching, leading to larger yield losses in favorable climate conditions at field conditions (Goulart and Paiva 2000; Goulart et al. 2007; Urashima et al. 2009; Pagani et al. 2014). Instead, non-*P. oryzae* or non-PoT isolates demonstrated low aggressiveness when inoculated in wheat, even under controlled conditions (Kato et al. 2000; Reges et al. 2016, 2018, 2019; Chung et al. 2020).

In our work, the wheat-infecting blast pathogen was least aggressive on signal grass cultivars, and even when infecting two cultivars (Marandu and Basilisk), the production of PoT conidia was low. On the other hand, *Urochloa*-infecting isolates were moderately aggressive to wheat heads under highly conducive conditions to infection, which contrasts with our sampling on wheat heads, where only seven non-PoT isolates were recovered from wheat heads. Our results corroborated previous findings that also reported low aggressiveness of blast isolates cross-inoculated in relation to their primary host (Kato et al. 2000; Oh et al. 2002; Perelló et al. 2017; Urashima et al. 2017; Reges et al. 2018; Martínez et al. 2018; Chung et al. 2020), which suggests that cross-infection may also occur in field conditions contributing to new host pathogenicity gain (Valent et al. 2021).

Collectively, our results challenge the dominant hypothesis that signal grass is the major natural reservoir for the wheat blast pathogen (PoT) (Reges et al. 2018, 2019; Ceresini et al. 2019; Dorigan et al. 2019; Poloni et al. 2021b). Actually, considering the strong association with its primary hosts in nature, phylogenetic relationships, and pathogenic specialization, signal grasses from MG are mainly infected by *Urochloa* pathotypes, regardless of their distance to wheat fields. These findings are critical for wheat blast management, especially related with a recommendation of elimination of signal grass at the surroundings of wheat areas. However, we can not disregard the *Urochloa* blast inoculum growing in leaves or senescent tissue before wheat season, considering the larger extension of pastures areas in Brazil. On the other hand, during the surveys at commercial fields, no wheat residues (plant tissues) were observed, which suggests little or no importance as an inoculum source to the next season.

We propose a new hypothesis, that signal grass may not serve as a natural inoculum source of wheat blast pathogen, but, as some PoT and PoU were able to infect *Urochloa* and wheat cultivars used in this work, many questions arise to be tested in future research: 1) How competitive are PoU and PoT isolates in mixed infections? 2) If signal grasses serve as an inoculum source of PoT or PoU, when do they disperse and land on wheat plants?; 3) How long do PoT and PoU survive in signal grass residues? 4) Is there a specific marker to diagnose the PoU lineage? 5)

Is there an aggressiveness difference across PoU isolates towards other grasses than signal grass? With regards to wheat blast: 1) Where does the PoT initial inoculum come from?; 2) Are early leaf infections crucial to lead to severe head blast epidemics? During ongoing head blast epidemics, is the secondary infection cycle due to external inoculum or from within the canopy? How is the interaction among resistant wheat lines with PoT and PoU inoculum? These issues should be studied using both controlled and in field studies, providing crucial information for increasing our understanding of wheat blast epidemiology.

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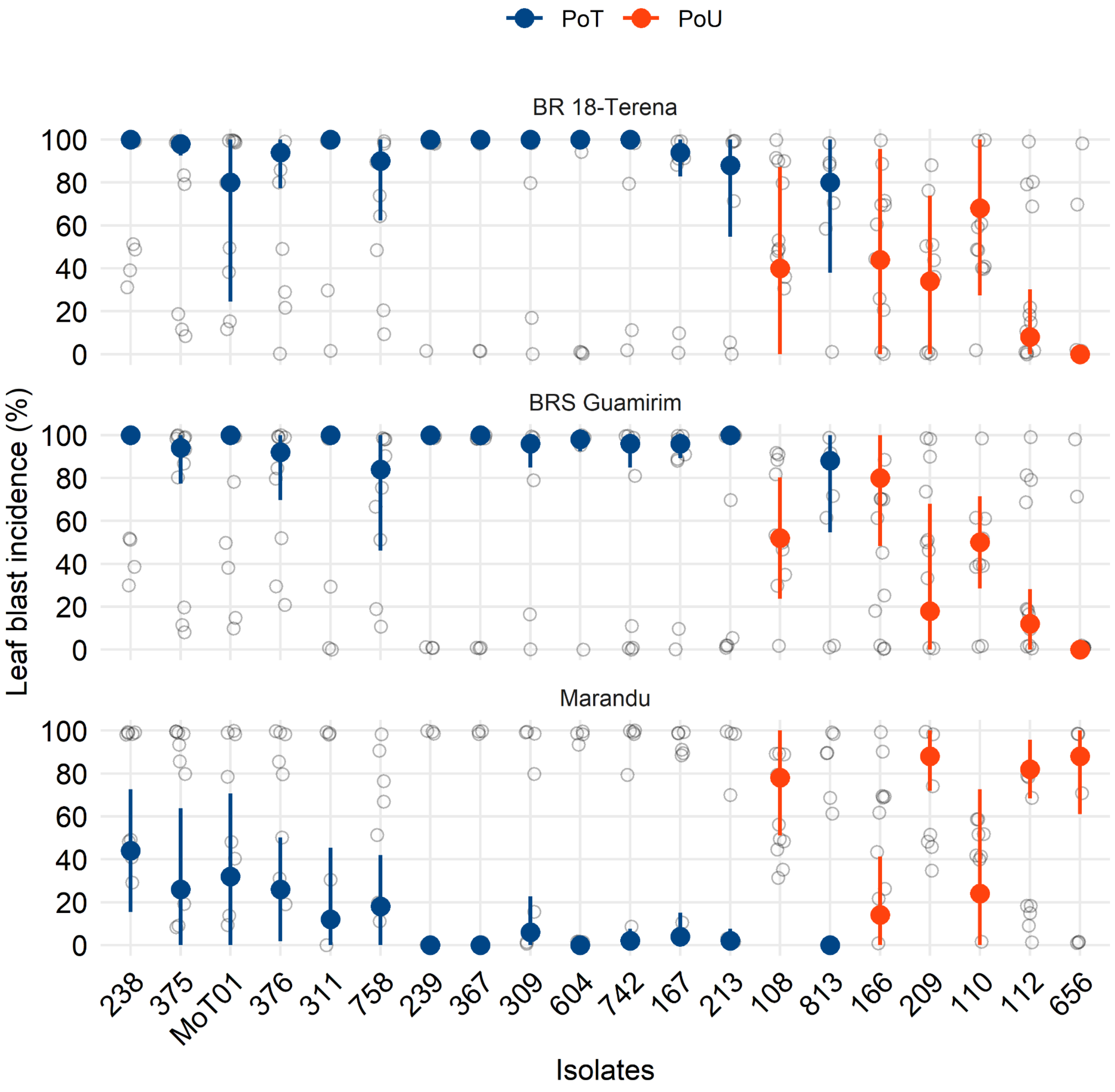
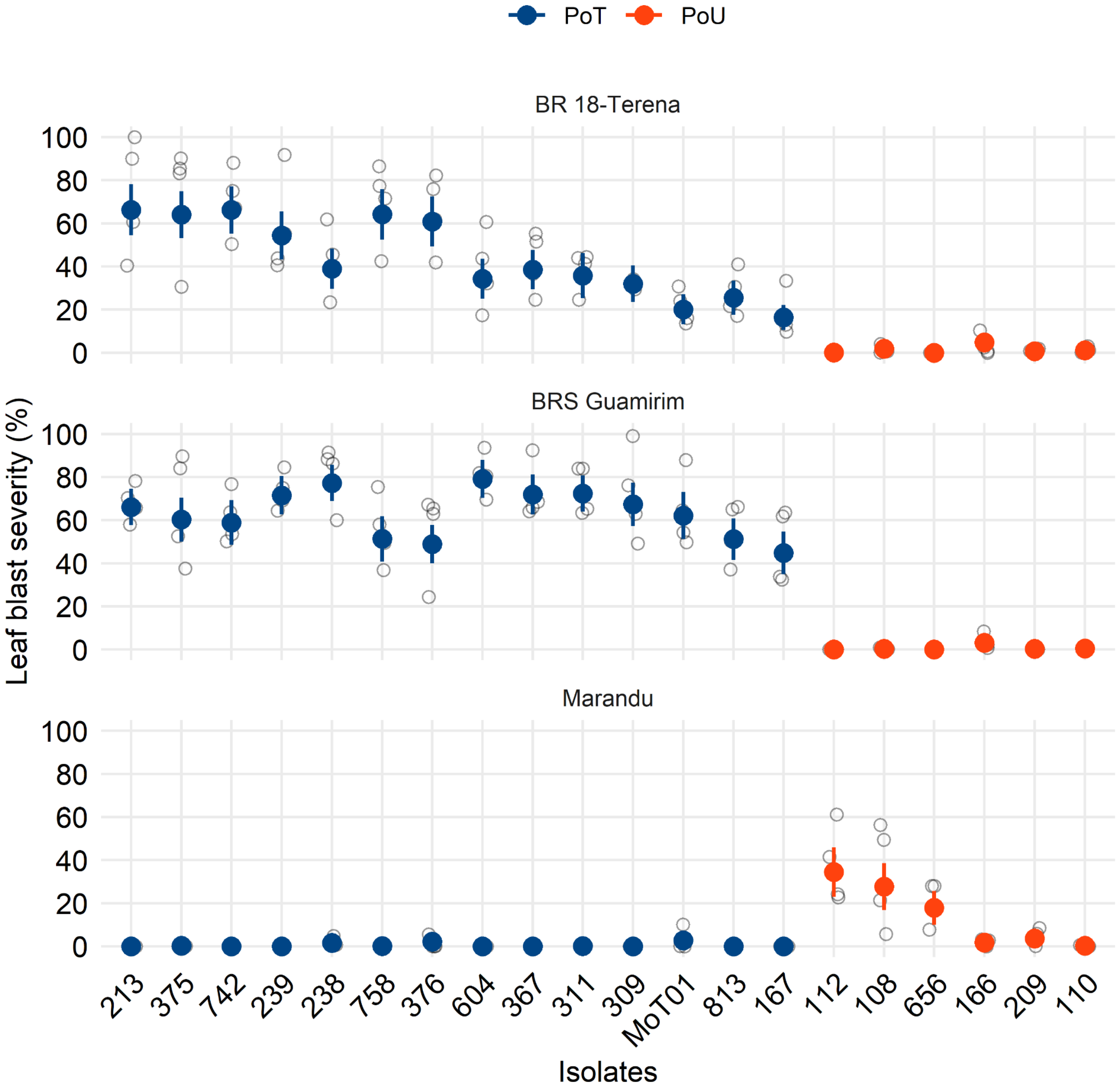
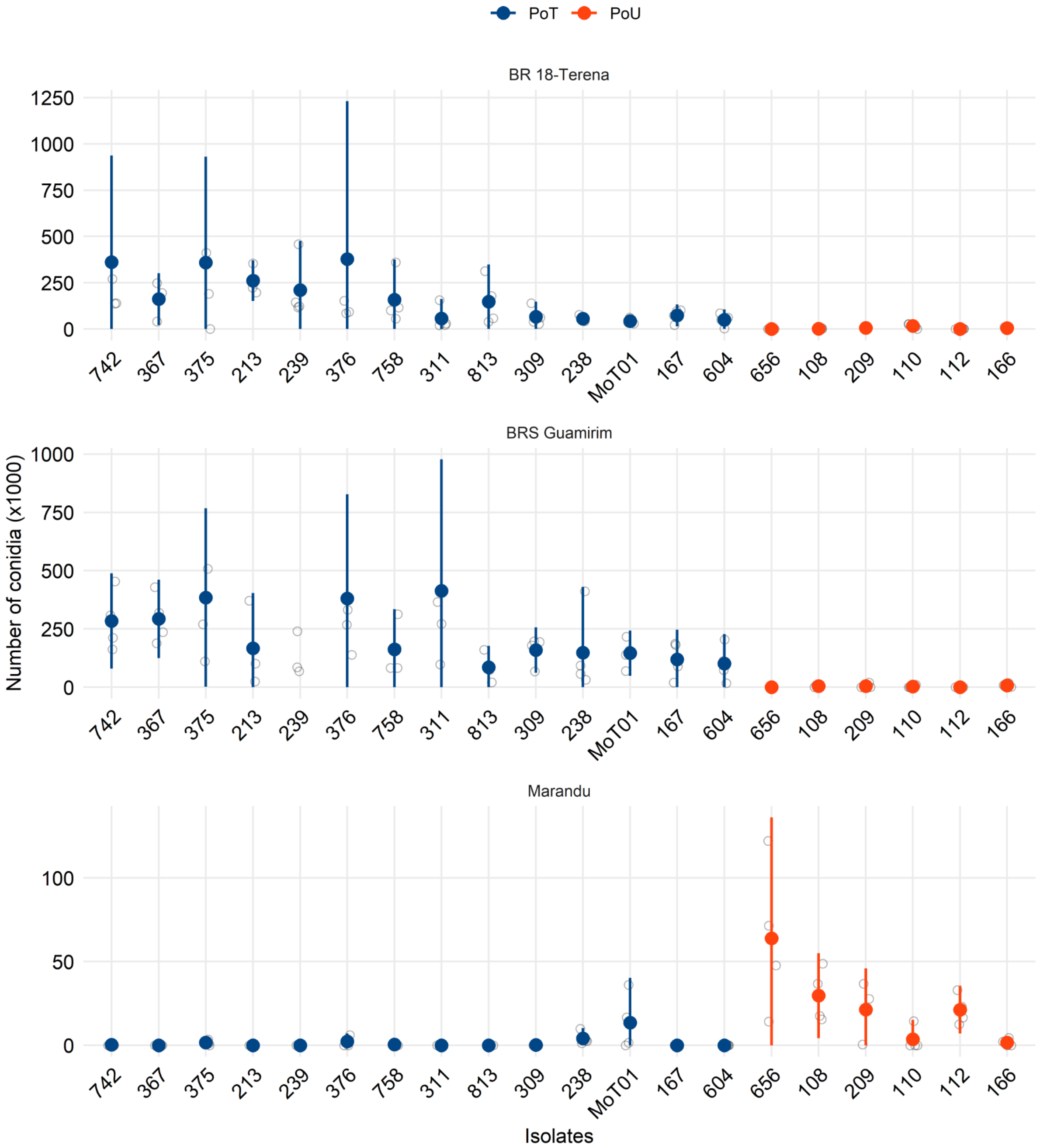
6. SUPPLEMENTARY MATERIAL



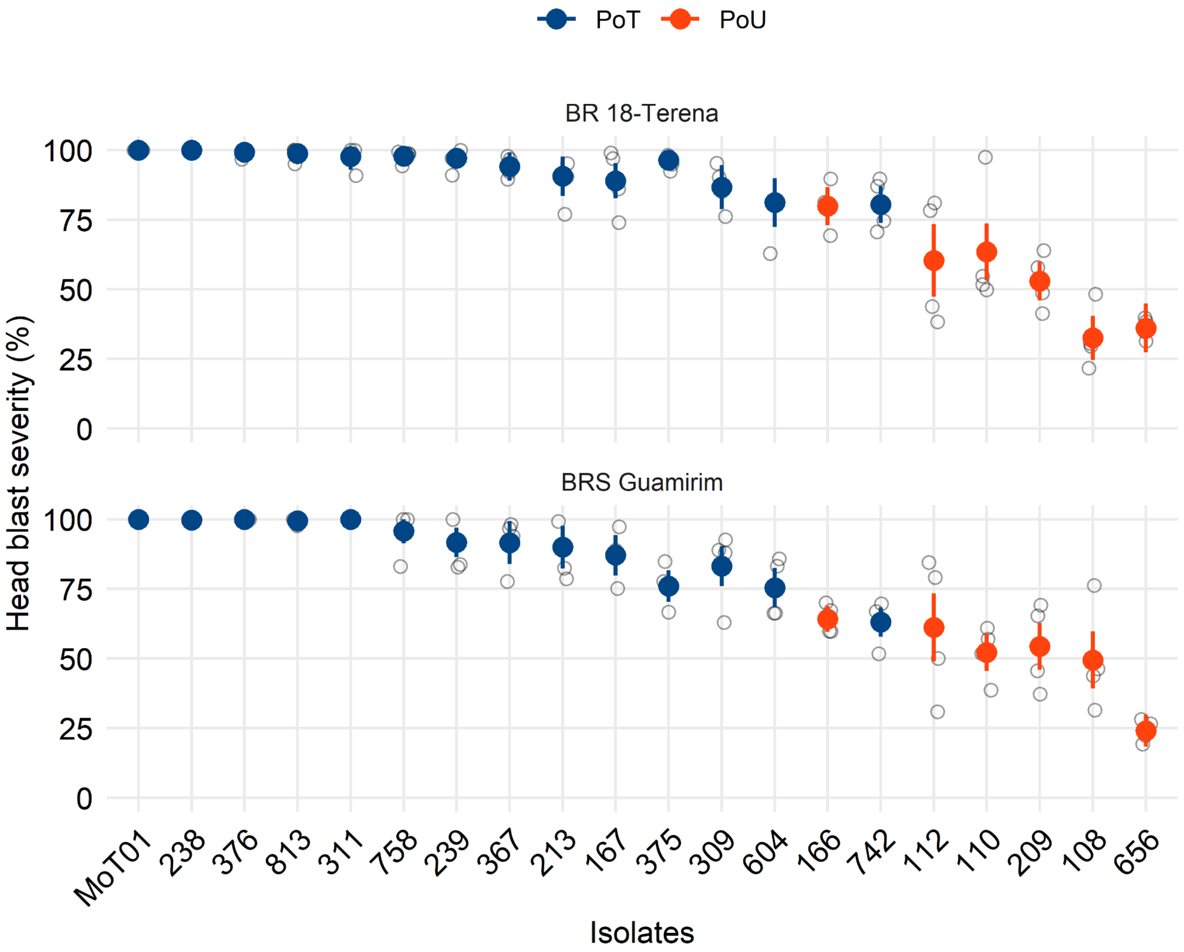
Supplemental Figure S1. Leaf blast incidence in leaves of wheat (*T. aestivum,* BR 18-Terena and BRS Guamirimim) or signal grass (*U. brizantha,* Marandu) induced by strains of two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Filled dots represent the mean incidence and filled lines the 95%-confidence interval. Empty dots were the observed incidence values to each replicated.



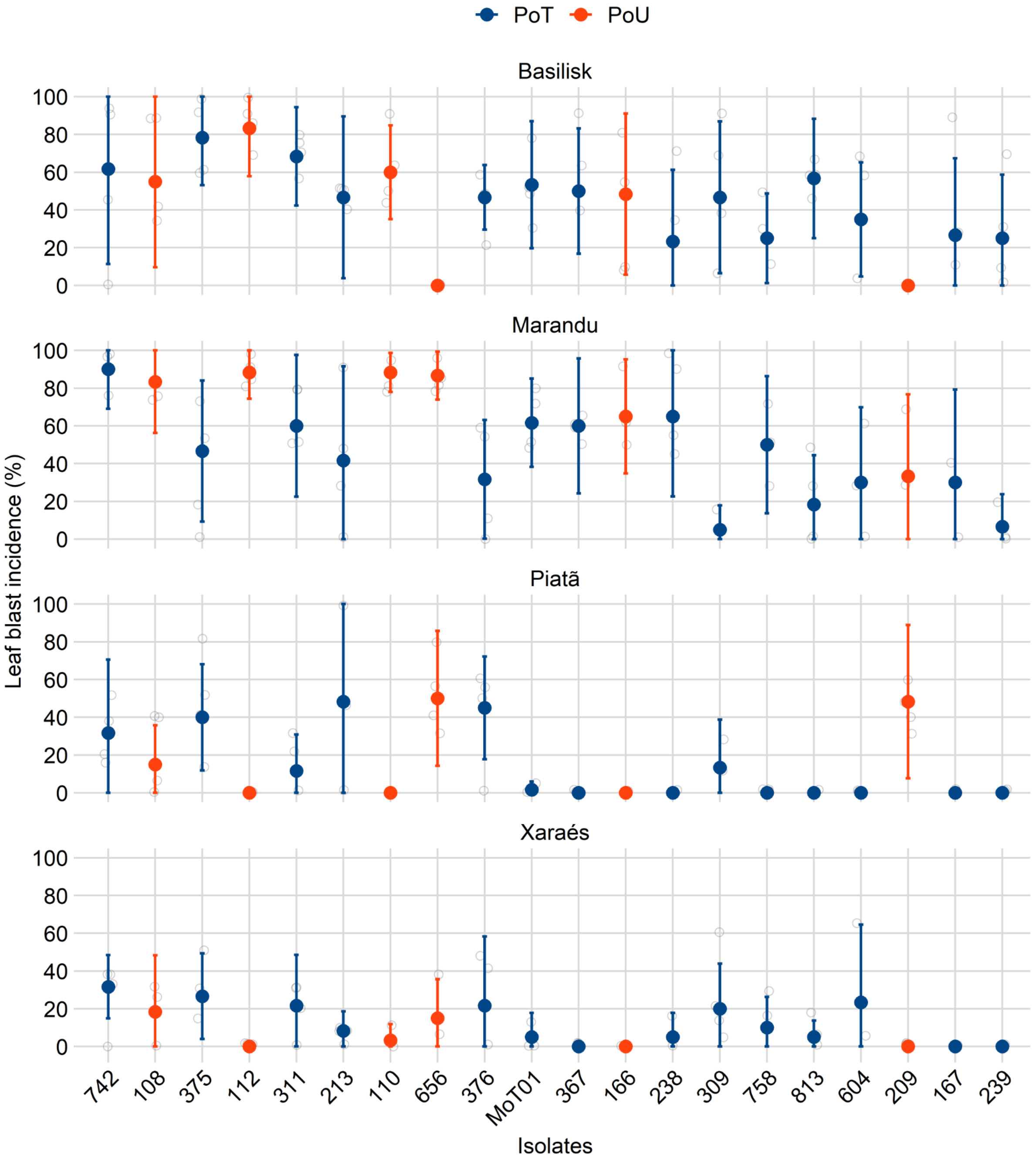
Supplemental Figure S2. Leaf blast incidence in leaves of wheat (*T. aestivum,* BR 18-Terena and BRS Guamirimim) or signal grass (*U. brizantha,* Marandu) induced by strains of two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Filled dots represent the mean incidence and filled lines the 95%-confidence interval. Empty dots were the observed incidence values to each replicated.



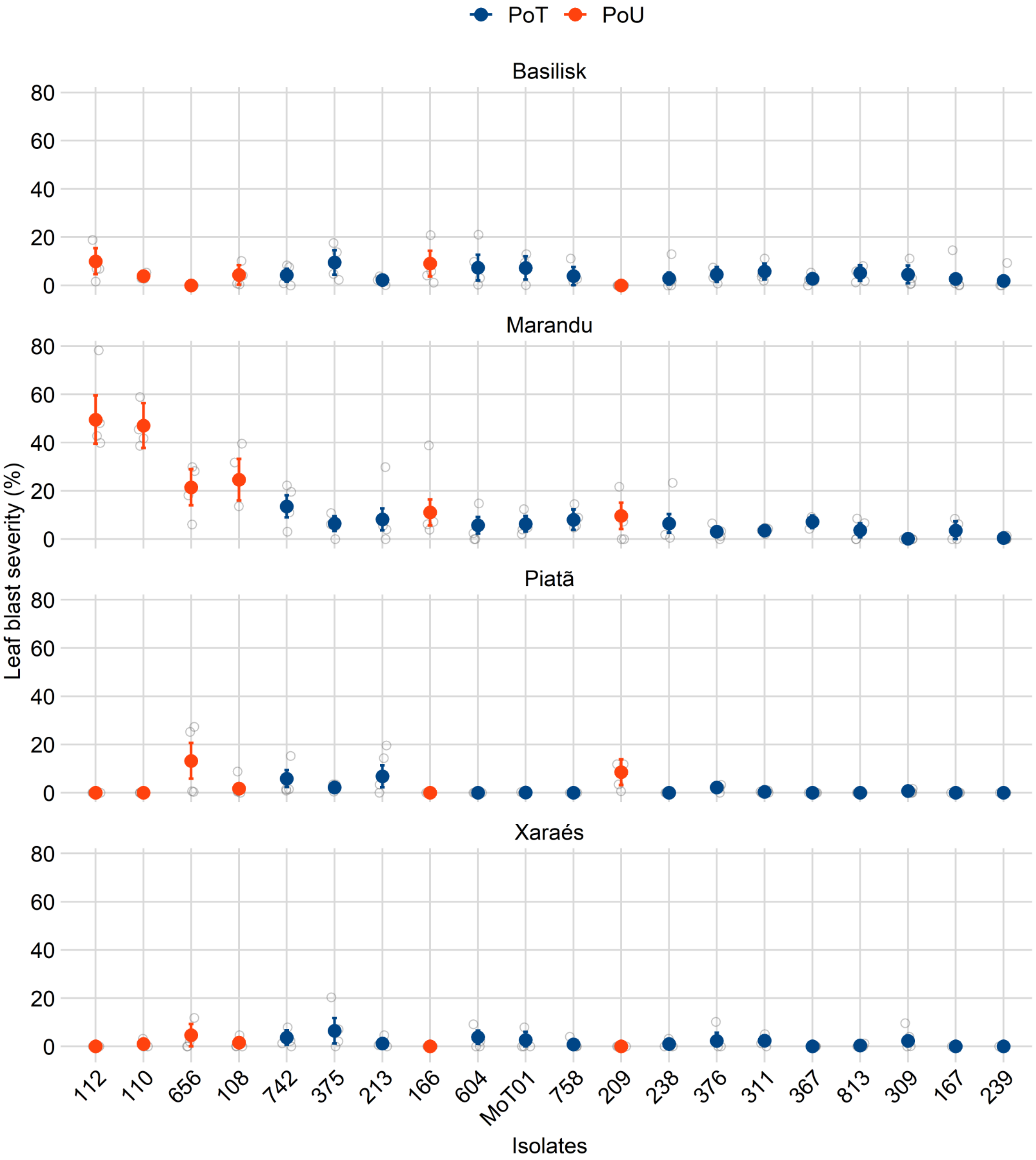
Supplemental Figure S3. Production of conidia in wheat (*T. aestivum,* BR 18-Terena and BRS Guamirimim) or signal grass (*U. brizantha,* Marandu) by strains of two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Filled dots represent the mean incidence and filled lines the 95%-confidence interval. Empty dots were the observed number of conidia values to each replicated.



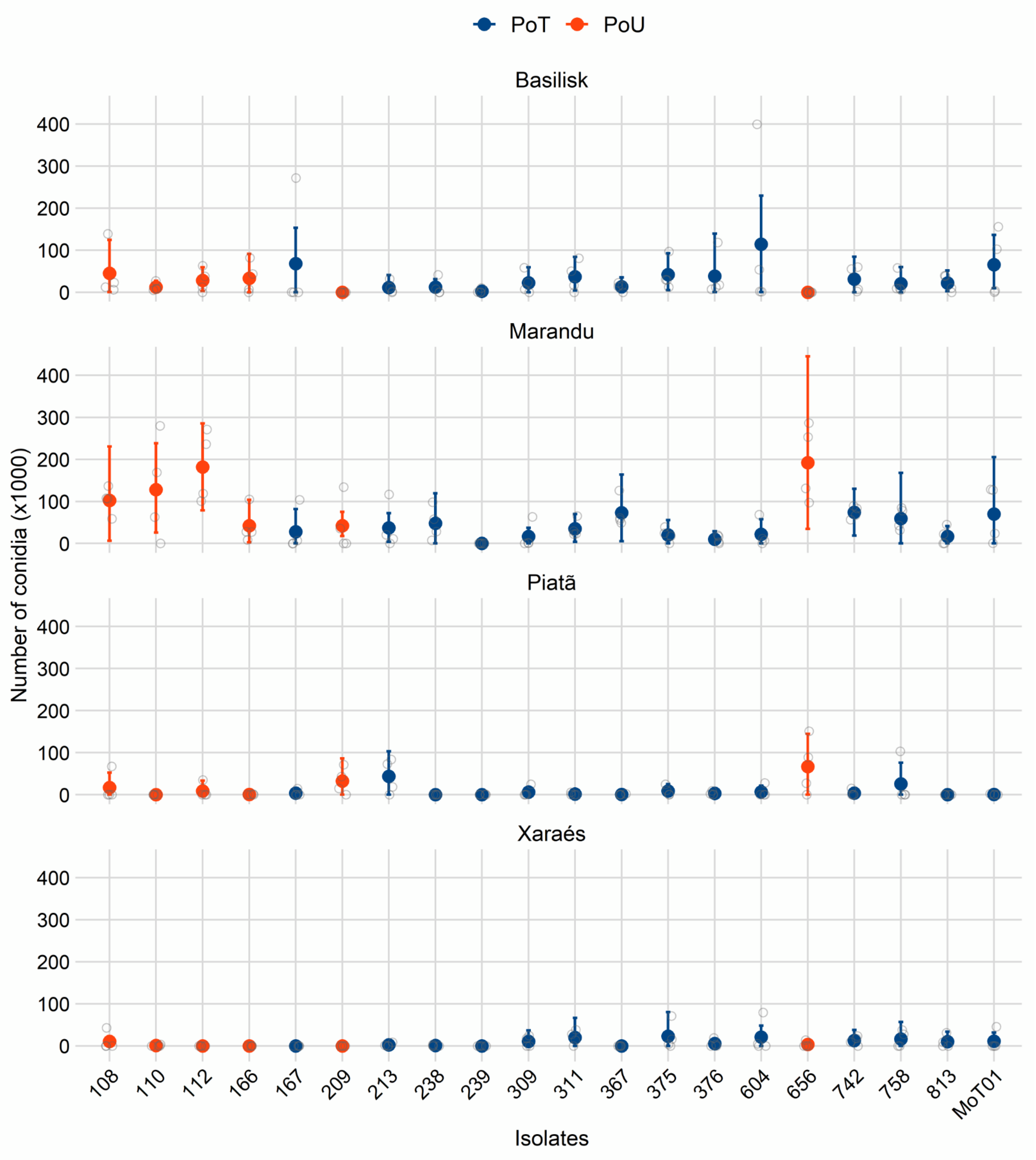
Supplemental Figure S4. Head blast severity in wheat heads (*T. aestivum,* BR 18-Terena and BRS Guamirimim) induced by strains of two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Filled dots represent the mean severity and filled lines the 95%-confidence interval. Empty dots were the observed incidence values to each replicated.



Supplemental Figure S5. Leaf blast incidence in leaves of four signal grass cultivars (*Urochloa brizantha:* Marandu, Piatã, Xaraés, *U. decumbens:* Basilisk) induced by strains of two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Filled dots represent the mean incidence and filled lines the 95%-confidence interval. Empty dots were the observed incidence values to each replicated.



Supplemental Figure S6. Leaf blast severity in leaves of four signal grass cultivars (*Urochloa brizantha:* Marandu, Piatã, Xaraés, *U. decumbens:* Basilisk) induced by strains of two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Filled dots represent the mean incidence and filled lines the 95%-confidence interval. Empty dots were the observed severity values to each replicated.



Supplemental Figure S7. Production of conidia in four signal grass cultivars (*Urochloa brizantha:* Marandu, Piatã, Xaraés, *U. decumbens:* Basilisk) induced by strains of two *P. oryzae* lineages (PoT = *Triticum* and PoU = *Urochloa*). Filled dots represent the mean incidence and filled lines the 95%-confidence interval. Empty dots were the observed number of conidia values to each replicated.

Table S1. Molecular screening of 572 *Pyricularia* sp. isolates collected in wheat (leaf and head) and natural grass at both Triângulo Mineiro and CentroSul de Minas regions at MG State, Brazil. Isolates were screened by CH7-BAC9 (B), Mot3 (M), and C17 (C) and lineage characterized.

Code	**Date**	**City**	**Host**	**B**	**M**	**C**	**Species**	**Lin**
UFVPY1	Feb. 2018	Uberaba	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY2	Feb. 2018	Boa Esperança	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY4	Feb. 2018	Cruzília	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY5	Feb. 2018	Cruzília	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY6	Feb. 2018	Cruzília	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY7	Feb. 2018	Boa Esperança	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY8	Feb. 2018	Uberaba	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY9	Feb. 2018	Boa Esperança	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY10	Feb. 2018	Boa Esperança	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY11	Feb. 2018	Boa Esperança	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY12	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY13	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY14	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY15	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY16	Feb. 2018	Uberaba	*Pennisetum sp.*	-	-		*Pyricularia spp.*	
UFVPY17	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY18	Feb. 2018	Madre de Deus	*Eleusine indica*	-	-		*Pyricularia spp.*	
UFVPY19	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY20	Feb. 2018	Boa Esperança	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY21	Feb. 2018	Madre de Deus	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY22	May 2018	Patos de Minas	*Eleusine indica*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY23	May 2018	Uberaba	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY24	May 2018	Uberaba	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY25	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY26	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY27	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY28	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY29	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY30	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY31	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY32	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY33	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY34	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY35	May 2018	Viçosa	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY36	May 2018	Viçosa	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY37	May 2018	Uberaba	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY38	May 2018	Uberaba	*Cynodon dactylon*	-	-		*Pyricularia spp.*	
UFVPY39	May 2018	Uberaba	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY40	May 2018	Uberaba	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY41	May 2018	Uberaba	*Eleusine indica*	-	-		*Pyricularia spp.*	
UFVPY42	May 2018	Uberaba	*Echinochloa colonum*	-	-		*Pyricularia spp.*	
UFVPY43	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY44	Feb. 2018	Cruzília	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY45	Feb. 2018	Madre de Deus	*Digitaria sanguinalis*	+	-	-	*Pyricularia oryzae*	Po
UFVPY46	Feb. 2018	São Gotardo	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY47	Feb. 2018	Uberaba	*Panicum maximum*	+	-	-	*Pyricularia oryzae*	Po

UFVPY48	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY49	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY50	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY51	Feb. 2018	Uberaba	*Urochloa humidicola*	+	-	-	*Pyricularia oryzae*	Po
UFVPY52	Feb. 2018	Caxambu	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po
UFVPY53	Feb. 2018	Madre de Deus	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY54	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY55	Feb. 2018	São Gotardo	*Digitaria horizontalis*	+	-	-	*Pyricularia oryzae*	Po
UFVPY56	May 2018	Viçosa	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY57	Feb. 2018	São Gotardo	*Urochloa plantaginea*	-	-		*Pyricularia spp.*	
UFVPY58	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY59	Feb. 2018	Uberaba	*Panicum maximum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY60	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY61	Feb. 2018	São Gotardo	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY62	Feb. 2018	São Gotardo	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY63	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY64	Feb. 2018	Cruzília	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY65	Feb. 2018	Madre de Deus	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY66	Feb. 2018	Cruzília	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY67	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY68	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY69	Feb. 2018	Madre de Deus	*Digitaria sanguinalis*	+	-	-	*Pyricularia oryzae*	Po
UFVPY70	May 2018	Viçosa	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY71	Feb. 2018	Madre de Deus	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY72	Feb. 2018	Cruzília	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	

UFVPY73	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY74	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY75	May 2018	Viçosa	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY76	Feb. 2018	São Gotardo	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY77	Feb. 2018	Madre de Deus	*Digitaria sanguinalis*	+	-	-	*Pyricularia oryzae*	Po
UFVPY78	Feb. 2018	Madre de Deus	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY79	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY80	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY81	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY82	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY83	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY84	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY85	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY86	Feb. 2018	São Gotardo	*Digitaria sanguinalis*	+	-	-	*Pyricularia oryzae*	Po
UFVPY87	Feb. 2018	Madre de Deus	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY88	Feb. 2018	São Gotardo	*Urochloa plantaginea*	+	+	-	*Pyricularia oryzae*	Po
UFVPY89	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY90	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY91	Feb. 2018	Madre de Deus	*Digitaria sanguinalis*	+	-	-	*Pyricularia oryzae*	Po
UFVPY92	Feb. 2018	Caxambu	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY93	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY94	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY95	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY96	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY97	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	

UFVPY98	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY99	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY100	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY101	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY102	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY103	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY104	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY105	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY106	Feb. 2018	Madre de Deus	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY107	Feb. 2018	São Gotardo	*Urochloa plantaginea*	+	+	-	*Pyricularia oryzae*	Po
UFVPY108	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY109	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY110	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY111	Feb. 2018	Patos de Minas	*Digitaria insularis*	+	+	-	*Pyricularia oryzae*	Po
UFVPY112	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY113	Feb. 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY114	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY115	Feb. 2018	Serra do Salitre	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY116	Feb. 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY117	Feb. 2018	Perdizes	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY118	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY119	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY120	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY121	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY122	Feb. 2018	Perdizes	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	

UFVPY123	Feb. 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY124	Feb. 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY125	Feb. 2018	Serra do Salitre	*Urochloa brizantha*	-	-		*Pyricularia spp.*	
UFVPY126	Feb. 2018	Serra do Salitre	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY127	Feb. 2018	Cruzília	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY128	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY129	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY130	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY131	May 2018	Uberaba	*Digitaria sanguinalis*	-	-		*Pyricularia spp.*	
UFVPY132	May 2018	Uberaba	*Triticum aestivum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY133	May 2018	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY134	May 2018	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY135	Feb. 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY136	Feb. 2018	Uberaba	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY137	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY138	Feb. 2018	Uberaba	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY139	Feb. 2018	Uberaba	*Digitaria horizontalis*	+	-	-	*Pyricularia oryzae*	Po
UFVPY140	Feb. 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY141	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY142	Feb. 2018	Uberaba	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY143	Feb. 2018	Uberaba	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY144	May 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY145	May 2018	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY146	May 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY147	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	

UFVPY148	Feb. 2018	Uberaba	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY149	May 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY150	Feb. 2018	Uberaba	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY151	Feb. 2018	Uberaba	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY152	May 2018	Patos de Minas	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY153	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY154	Feb. 2018	Uberaba	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY157	May 2018	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY158	May 2018	Uberaba	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY159	May 2018	Uberaba	*Cynodon plectostachyus*	+	-	-	*Pyricularia oryzae*	Po
UFVPY160	May 2018	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY161	May 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY163	May 2018	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY165	May 2018	Uberaba	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY166	May 2018	Uberaba	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY167	May 2018	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY168	May 2018	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY169	May 2018	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY170	Feb. 2018	Uberaba	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY171	May 2018	Patos de Minas	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY172	Feb. 2018	Patos de Minas	*Digitaria insularis*	-	-		*Pyricularia spp.*	
UFVPY173	Feb. 2018	Patos de Minas	*Cenchrus echinatus*	-	-		*Pyricularia spp.*	
UFVPY174	May 2018	Uberaba	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po
UFVPY175	May 2018	Uberaba	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po

UFVPY178	May 2018	Viçosa	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY179	May 2018	Viçosa	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY180	May 2018	Viçosa	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY181	May 2018	Viçosa	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY182	May 2018	Viçosa	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY183	May 2018	Viçosa	*Eleusine indica*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY184	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY185	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY186	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY187	Feb. 2019	São Gonçalo do Pará	*Urochloa humidicola*	+	-	-	*Pyricularia oryzae*	Po
UFVPY188	Feb. 2019	São Gonçalo do Pará	*Urochloa humidicola*	+	-	-	*Pyricularia oryzae*	Po
UFVPY189	Feb. 2019	São Gonçalo do Pará	*Urochloa humidicola*	+	-	-	*Pyricularia oryzae*	Po
UFVPY190	Feb. 2019	São Gonçalo do Pará	*Urochloa humidicola*	+	-	-	*Pyricularia oryzae*	Po
UFVPY191	Feb. 2019	Luz	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY192	Feb. 2019	Luz	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY193	Feb. 2019	Luz	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY194	Feb. 2019	Luz	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY195	Feb. 2019	Luz	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	
UFVPY196	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY197	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY198	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY199	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY200	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po

UFVPY201	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY202	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY203	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY204	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY205	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY206	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY207	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY208	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY209	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY210	Feb. 2019	Santana da Vargem	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY211	Feb. 2019	Santana da Vargem	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY212	Feb. 2019	Santana da Vargem	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY213	Feb. 2019	São Gonçalo do Pará	*Urochloa humidicola*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY215	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY216	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY217	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY218	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY219	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY220	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY221	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY222	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY223	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY224	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY225	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY226	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY227	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY228	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY229	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY230	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY231	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY232	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY233	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY234	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY235	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY236	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY237	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY238	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY239	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY240	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY241	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY242	Feb. 2019	São Gonçalo do Pará	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY243	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY244	Feb. 2019	Formiga	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY245	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY246	Feb. 2019	Luz	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY251	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY252	Feb. 2019	Luz	*Digitaria horizontalis*	-	-		*Pyricularia spp.*	

UFVPY253	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY254	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY255	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY257	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY258	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY259	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY260	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY261	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY262	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY263	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY264	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY265	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY266	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY267	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY268	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY269	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY270	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY271	May 2019	Campos Altos	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY272	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY273	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY274	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY275	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY276	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY277	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY278	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY279	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY280	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY281	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY282	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY283	May 2019	Campos Altos	*Triticum aestivum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY284	May 2019	Ibiá	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY285	May 2019	Ibiá	*Eleusine indica*	+	-	-	*Pyricularia oryzae*	Po
UFVPY286	May 2019	Ibiá	*Eleusine indica*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY287	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY288	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY289	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY290	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY291	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY292	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY293	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY294	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY295	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY296	May 2019	Ibiá	*Triticum aestivum*	-	-		*Pyricularia spp.*	
UFVPY297	May 2019	Ibiá	*Cenchrus echinatus*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY298	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY299	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY300	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY301	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY302	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY304	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY305	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY306	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY307	May 2019	Ibiá	*Cenchrus echinatus*	+	-	-	*Pyricularia oryzae*	Po
UFVPY308	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY309	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY310	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY311	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY312	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY313	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY314	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY315	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY316	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY317	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY318	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY319	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY320	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY321	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY322	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY323	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY324	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY325	May 2019	Santa Juliana	*Triticum aestivum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY326	May 2019	Santa Juliana	*Triticum aestivum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY327	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY328	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY329	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY330	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY331	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY332	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY333	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY334	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY335	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY336	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY337	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY338	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY339	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY340	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY341	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY342	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY343	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY344	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY345	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY346	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY347	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY348	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY349	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY350	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY351	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY352	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY353	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY354	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY355	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY356	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY357	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY358	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY359	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY360	May 2019	Patos de Minas	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY361	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY362	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY363	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY364	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY365	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY366	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY367	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY368	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY369	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY370	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY371	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY372	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY373	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY374	May 2019	Santa Juliana	*Triticum aestivum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY375	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY376	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY377	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY378	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY379	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY380	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY381	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY383	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY384	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY385	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY386	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY387	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY388	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY389	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY390	May 2019	Patos de Minas	*Urochloa humidicola*	+	-	-	*Pyricularia oryzae*	Po
UFVPY391	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY392	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY393	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY394	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY395	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY396	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY398	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY399	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY400	May 2019	São Gotardo	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY401	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY402	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY403	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY404	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY405	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY406	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY407	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY408	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY409	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY410	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY412	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY413	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY414	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY415	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY416	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY417	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY418	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY419	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY420	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY421	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY422	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY423	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY424	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY425	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY426	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY427	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY428	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY429	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY430	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY431	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY433	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY434	May 2019	Uberaba	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY436	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY437	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY438	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY439	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY440	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY441	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY442	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY443	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY444	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY445	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY446	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY447	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY448	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY449	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY450	May 2019	Uberaba	*Panicum maximum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY451	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY452	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY453	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY454	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY456	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY457	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY458	May 2019	Patos de Minas	*Triticum aestivum*	-	-		*Pyricularia spp.*	
UFVPY459	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY460	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY461	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY462	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY463	May 2019	Uberaba	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY464	May 2019	Patos de Minas	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY465	May 2019	Patos de Minas	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY466	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY467	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY469	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY470	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY471	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY472	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY473	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY474	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY475	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY476	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY477	May 2019	Bom Despacho	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po
UFVPY478	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY479	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY480	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY481	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY482	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY483	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY484	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY485	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY486	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY487	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY488	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY489	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY490	May 2019	Santa Juliana	*Pennisetum sp.*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY491	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY492	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY493	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY495	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY497	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY498	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY500	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY501	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY502	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY503	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY505	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY506	May 2019	Santa Juliana	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY507	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY508	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY509	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY510	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY511	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY512	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY513	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY514	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY516	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY528	May 2019	Santa Juliana	*Triticum aestivum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY529	May 2019	Santa Juliana	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY537	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY545	May 2019	Bom Despacho	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po
UFVPY546	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY576	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po
UFVPY577	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY578	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY581	Feb. 2019	Luz	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY582	Feb. 2019	Campo Belo	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po
UFVPY583	Feb. 2019	Catas Altas da Noruega	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY584	Feb. 2019	Lumunárias	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po
UFVPY593	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY597	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY599	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY603	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY604	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY609	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY610	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY611	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY612	May 2019	Campos Altos	*Triticum aestivum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY652	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY653	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY654	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po

UFVPY655	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY656	Feb. 2019	Catas Altas da Noruega	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY657	Feb. 2019	Entre Rios de Minas	*Urochloa ruziziensis*	+	+	-	*Pyricularia oryzae*	Po
UFVPY661	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY662	Feb. 2019	Boa Esperança	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY672	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY673	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	-	-	*Pyricularia oryzae*	Po
UFVPY674	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY675	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY676	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY677	Feb. 2019	Campos Altos	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY678	Feb. 2019	Santana da Vargem	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY679	Feb. 2019	Luminárias	*Urochloa brizantha*	+	+	-	*Pyricularia oryzae*	Po
UFVPY680	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY701	Feb. 2019	Entre Rios de Minas	*Urochloa ruziziensis*	+	+	-	*Pyricularia oryzae*	Po
UFVPY702	Feb. 2019	Oliveira	*Rhynchelytrum roseum*	+	-	-	*Pyricularia oryzae*	Po
UFVPY727	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY728	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY730	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY731	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY733	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY741	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY742	May 2019	Madre de Deus	*Urochloa brizantha*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY754	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY755	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY756	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY757	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY758	May 2019	Madre de Deus	*Urochloa brizantha*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY759	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY760	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY787	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY788	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY793	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY800	May 2019	Uberaba	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY801	May 2019	Uberaba	*Triticum aestivum*	+	-	+	*Pyricularia oryzae*	PoT
UFVPY802	May 2019	Patos de Minas	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY811	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY813	May 2019	Boa Esperança	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY815	May 2019	Madre de Deus	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY833	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY834	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY838	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY840	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY844	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY846	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY886	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY887	May 2019	Ibiá	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY888	May 2019	São Gotardo	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

UFVPY889	May 2019	Patrocínio	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY893	May 2019	Boa Esperança	*Panicum maximum*	+	+	-	*Pyricularia oryzae*	Po
UFVPY913	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY914	May 2019	Campos Altos	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY926	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY931	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY932	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY933	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY935	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT
UFVPY936	May 2019	Perdizes	*Triticum aestivum*	+	+	+	*Pyricularia oryzae*	PoT

Unfilled spaces with the symbol “+” or “-” at CH7-BAC9, MoT3, and C17 columns, mean that there was no PCR assay.