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SHORT COMMUNICATION

The growth inhibitory potential of eudicot-based preparations against plant pathogenic fungi

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Abstract

The infection of certain plants with pathogenic fungi species results in a significant loss in the production yield of these plants, some of which are with high economical importance. In the current study, we studied the growth inhibitory potential of several eudicot plant preparations (*Lavandula angustifolia*, *Matricaria chamomilla* L. and *Saponaria officinalis* L.) against certain plant pathogenic fungi species, namely, *Phytophthora infestans, Rhizoctania solani, Fusarium oxysporum. f.* sp. *lycopersici* and *Macrophamina phaseolina.* We found that solutions prepared with these plants mostly show concentration-dependent inhibitory effect on the growth of these fungi species. These plant-based anti-fungal preparations might potentially be used in the control of fungi species studied in the present study, in order to increase the production yield of their host plants. Further research is required to identify the mechanisms of action of these plant-based solutions on pathogenic fungi growth.

Keywords *Lavandula angustifolia* · *Matricaria chamomilla* L. · *Saponaria officinalis* L. · Plant pathogens · Fungicides · Pathogenic fungi

Lavandula angustifolia is a flowering plant from the *Lamiaceae* family and is widely used in the cosmetic and pharmaceutical industries due to its content of high quality essential oils (Kara and Baydar 2013). This plant species is native to the Mediterranean region; however, it can also be grown in multiple other geographic locations in order to produce essential oils with a high economic value (Wells et al. 2018). *Lavandula angustifolia* preparations have been shown to have various pharmacological effects including antiepileptic, antioxidant (Rahmati et al. 2013), anxiolytic (Cline et al. 2008), antibacterial (Sasaki et al. 2015), anticholinesterase (thus, the prevention of destruction of the neurotransmitter acetylcholine) (Costa et al. 2011) and antifungal activities (Zuzarte et al. 2012) in the literature. *Matricaria chamomilla* L., which belongs to the *Asteraceae* family, is used in various food and cosmetic industries (Giannoulis et al. 2020). *Matricaria chamomilla* L. is commonly grown in Germany, Yugoslavia, Russia, Hungary, France and Brazil (Singh et al. 2011). *Matricaria chamomilla* L. has been reported to have anti-inflammatory, anti-allergic, anti-microbial, anti-antispasmodic and sedative properties (Wu et al. 2012; Stanojevic et al. 2016). *Saponaria officinalis* L., which is often called soapwort and belongs to *Caryophyllaceae* family, is a plant native to Europe and Asia, and is used as an expectorant in bronchitis, also as an ingredient in certain products which are used against skin complaints as well as rheumatic disorders (Lu et al. 2015; Pavela et al. 2017). The biological activity of *Saponaria officinalis* L. including anti-inflammatory, antifungal, hemolytic, antiproliferative, cytotoxic and antibacterial effects have been described in previous studies (Petrović et al. 2018).

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Certain pathogenic fungi species cause decreased quality in fruits and vegetables in terms of their appearance, nutritional value, organoleptic properties and shelf life, leading to losses in the production yield (Dellavalle et al. 2011). The increasing production demand leads to the more frequent use of agricultural chemicals; however, their use should be restricted due to their highly environmentally-toxic characteristics, and this makes the need for the search for new eco-friendly control strategies against plant pathogenic fungi more clear (Alkhail 2005). For this reason, interest in agents derived from environmentally friendly natural products is recently increasing (Özbek et al. 2020). In the present study, we determined anti-fungal properties of *Lavandula angustifolia*, *Matricaria chamomilla* L. and *Saponaria officinalis* L. plant preparations against four plant pathogenic fungi species, namely, *Phytophthora infestans*, *Rhizoctania solani*, *Fusarium oxysporum*. f. sp. *lycopersici* and *Macrophamina phaseolina*.

Lavandula angustifolia, *Matricaria chamomilla* L. and *Saponaria officinalis* L. plant samples were provided from the collection of medicinal plants at Hekim Sinan Botanical Garden of Medicinal and Aromatic Plants (Kütahya). Ethyl acetate, chloroform and methanol were purchased from Sigma Aldrich (St. Louis, Missouri, USA). Four fungi species used in the current study (*Phytophthora infestans*, *Rhizoctania solani*, *Fusarium oxysporum*. f. sp. *lycopersici* and *Macrophamina phaseolina*) were obtained from the stock cultures in Phytopathology Laboratory at Faculty of Agriculture, Tokat Gaziosmanpasa University, Turkey.

In this study, 1:1 (*w/w*) methanol-chloroform mixture was used to obtain *Lavandula* and *Matricaria chamomilla* L. extracts, while only ethyl acetate was used for *Saponaria officinalis* L. 100 g dried plants were mixed with 500 mL methanol-chloroform or ethyl acetate solutions separately after grinding, and stirred for 48 h with a magnetic stirrer. Then, plant particles in solvents were filtered out, solvents were evaporated at approximately 40–60 °C, and subsequently extracts were obtained in a viscous form. These extracts were then diluted with 10% acetone, and kept at 4 °C as 50% stocks for further use.

Lavandula angustifolia, Matricaria chamomilla and *Saponaria officinalis* L. extracts prepared with different solvents were used in in vitro anti-fungal tests to test the inhibitory potential of these plant preparations on the growth of fungi species. Plant extracts dissolved in solvents were added to autoclaved Potato Dextrose Agar (PDA) as final concentrations of 1.0%, 1.5%, 2.0% and 2.5%. 5 mm mycelium disks for *Phytophthora infestans*, *Rhizoctania solani*, *Fusarium oxysporum*. f. sp. *lycopersici* and *Macrophamina phaseolina* were inoculated on solidified PDA growth media and placed in a 25 °C incubator. PDA media without plant extracts were used as controls in the study. After 7 day incubation period, fungi mycelium radius measurements were carried out. Experimental results were obtained in triplicates. In these anti-fungal tests, percent inhibition values of plant extracts against pathogenic fungi species were determined by comparing mycelium radial growth measurements of pathogens treated with prepared solutions with that of controls.

Figures were drawn in R statistical programming environment (R Core Team 2018). Following R packages were used in data analysis and visualization: tidyverse (a collection of R packages including ggplot2 designed for common data science tasks such as data cleaning and visualization) (Wickham et al. 2019), readxl (data import into R from excel) (Wickham and Bryan 2019). The following convention for star symbols indicating statistical significance was used in the plots: ns: $p > 0.05$, *: $p \leq 0.05$, **: $p \leq 0.01$, ***: $p \leq 0.001$, ****: $p \leq 0.0001$ (ggpubr package) (Kassambara 2020).

The inhibitory potential of *Lavandula angustifolia* solutions at different concentrations was analyzed against four different fungi species, which were given in Fig. 1. Except for one fungi species (*Macrophamina phaseolina*), solutions of this plant showed mostly concentration-dependent inhibitory effects on fungi growth in our experimental set up. Most sensitive fungi species to this treatment was found to be *Rhizoctania solani* among fungi species tested in the current study. For this fungi species, even 1.5% concentration of *L. angustifolia* solution resulted in more than 75% growth inhibition. Dose-dependent growth inhibitory effect of this plant solution is clearly seen especially in *Phytophthora infestans* (Fig. 1).

In addition, the representative experimental images showing differential growth rates of fungi species grown with different *Lavandula angustifolia* solution concentrations were given as compared to controls where no plant solutions (only solvent) were applied, in Supplementary Fig. 1.

The growth inhibitory effect of *Matricaria chamomilla* L. solutions at two different concentrations was analyzed against four different fungi species whose names were given in Fig. 2. Most sensitive fungi species to this treatment was found to be *Phytophthora infestans* among other fungi species tested. Even the lowest concentration (2.0%) of *Matricaria chamomilla* L. solution resulted in an almost complete growth inhibitory effect on this fungi

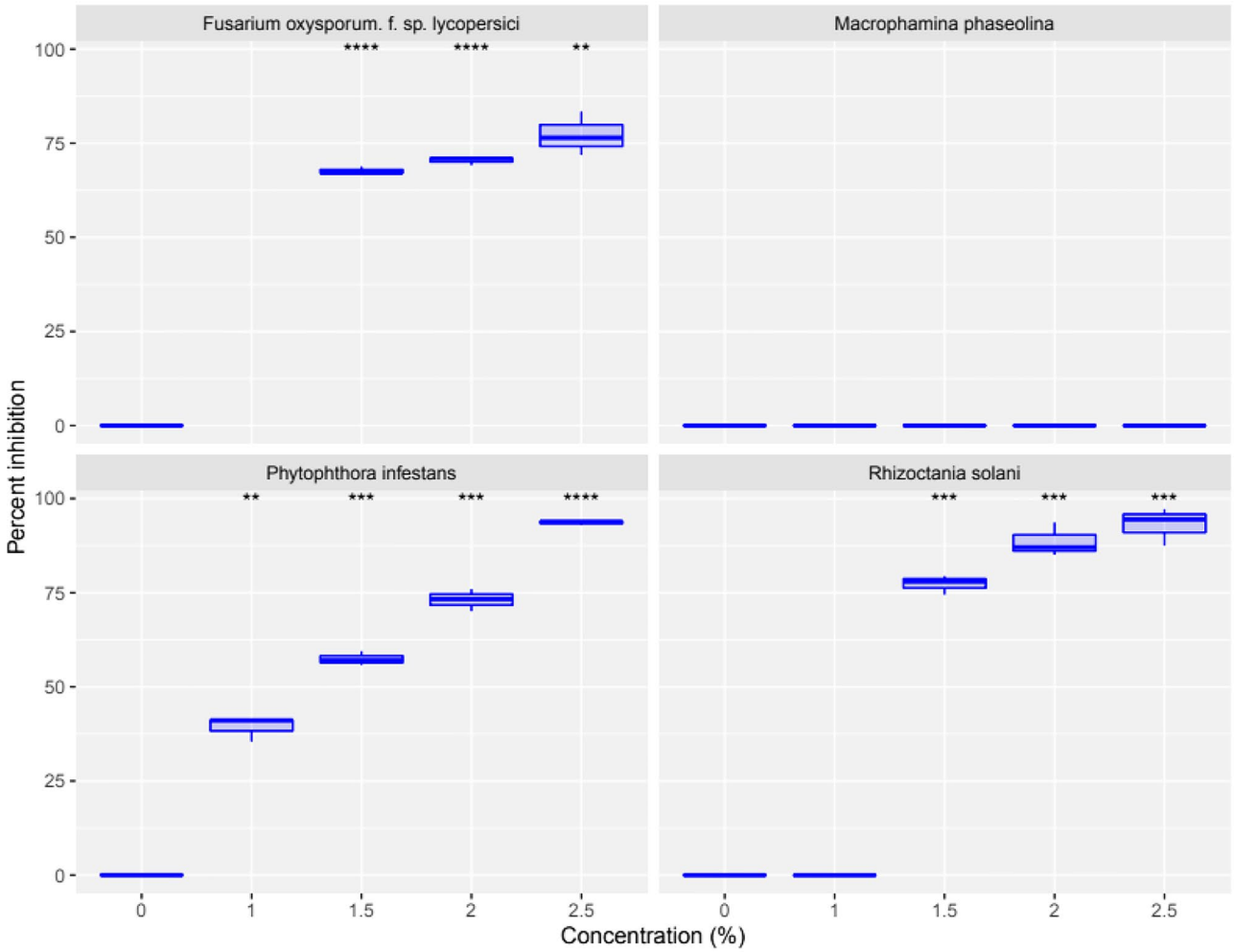

Fig. 1 Percent inhibition rates of given fungi species grown in different concentrations of *Lavandula angustifolia* extracts

species. For other fungi species, concentration-dependent growth inhibition was also observed (Fig. 2). At concentration 2.5%, *Matricaria chamomilla* L. solution led to more than 50% inhibition on the growth of all four fungi species. The representative experimental images showing differential growth rates of fungi species grown with different *Matricaria chamomilla* L. solution concentrations were given as compared to controls in Supplementary Fig. 2.

Anti-fungal properties of *Saponaria officinalis* L. solutions was analyzed against four different fungi species which were indicated in Fig. 3. Most sensitive fungi species to this treatment was found to be *Phytophthora infestans* as also observed with *Matricaria chamomilla* L. Plant solution with 1.0% concentration did not result in any growth inhibition in two fungi species, *Macrophamina phaseolina* and *Rhizoctania solani.* For higher concentrations of *Saponaria officinalis* L. solutions, significant growth inhibition was observed for all fungi species tested. At concentration 2.0% or higher, growth of all fungi species were inhibited more than 50% (Fig. 3). The representative experimental images showing differential growth rates of fungi species grown with different *Saponaria officinalis* L. solution concentrations were given as compared to controls in Supplementary Fig. 3.

In the current study, we found that solutions prepared with *Lavandula angustifolia, Matricaria chamomilla* L. and

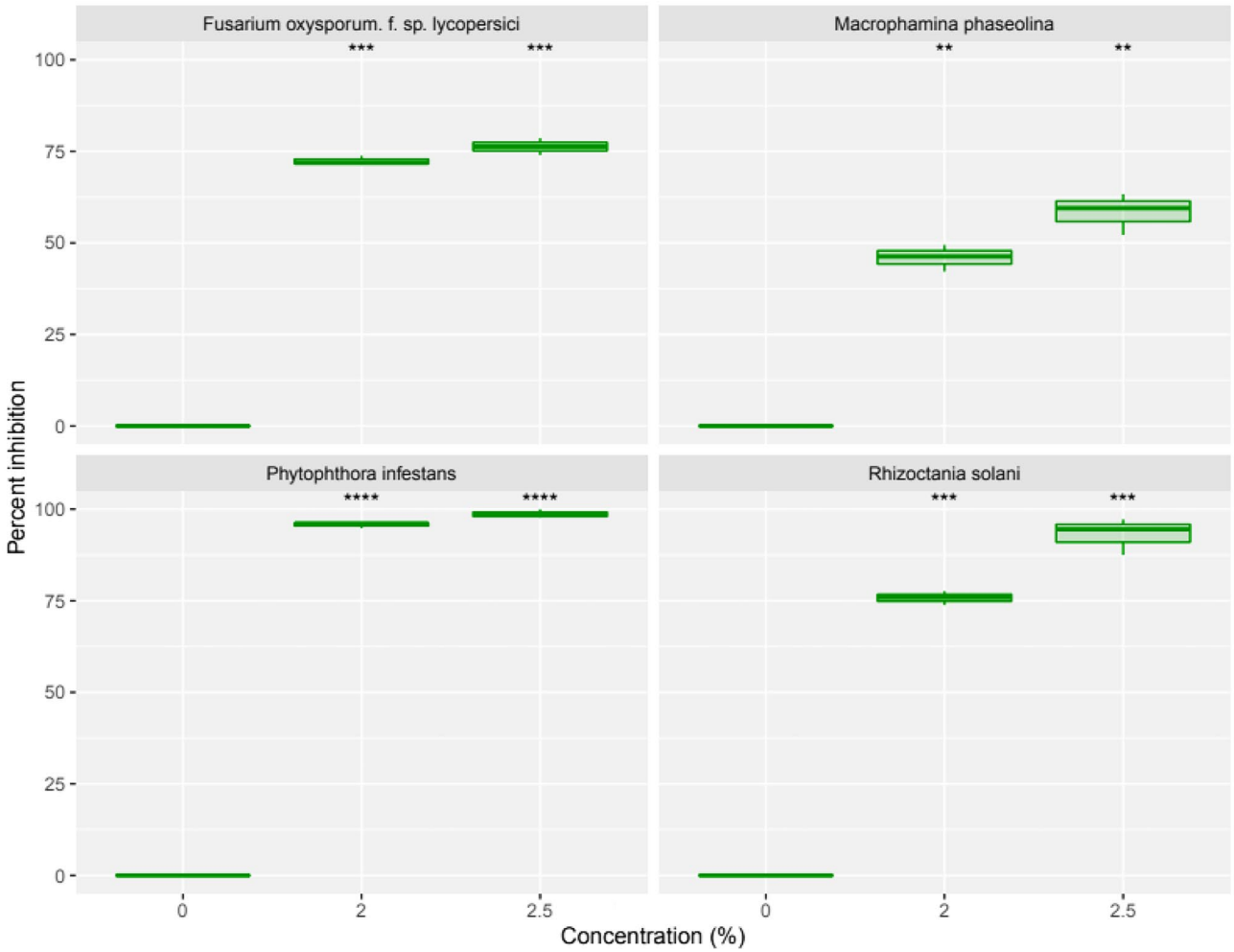

Fig. 2 Percent inhibition rates of given fungi species grown in different concentrations of *Matricaria chamomilla* L. extracts

Saponaria officinalis L. plant species were highly effective as growth inhibitory preparations against multiple plant pathogenic fungi species. Their anti-fungal effects were shown to be mostly increasing in a concentration-dependent manner. For most plant solution concentrations tested in the study, more than 50% growth inhibition was achieved against certain plant pathogenic fungi. Findings of the current study suggest that preparations made with these plant extracts can be used as potential anti-fungal solutions against certain plant pathogenic fungi species. Due to their plant based formulations, these solutions might be superior to other currently used anti-fungal preparations which are relatively toxic to environment. Furthermore, low cost and the ease of preparation of these plant-based solutions can make them more

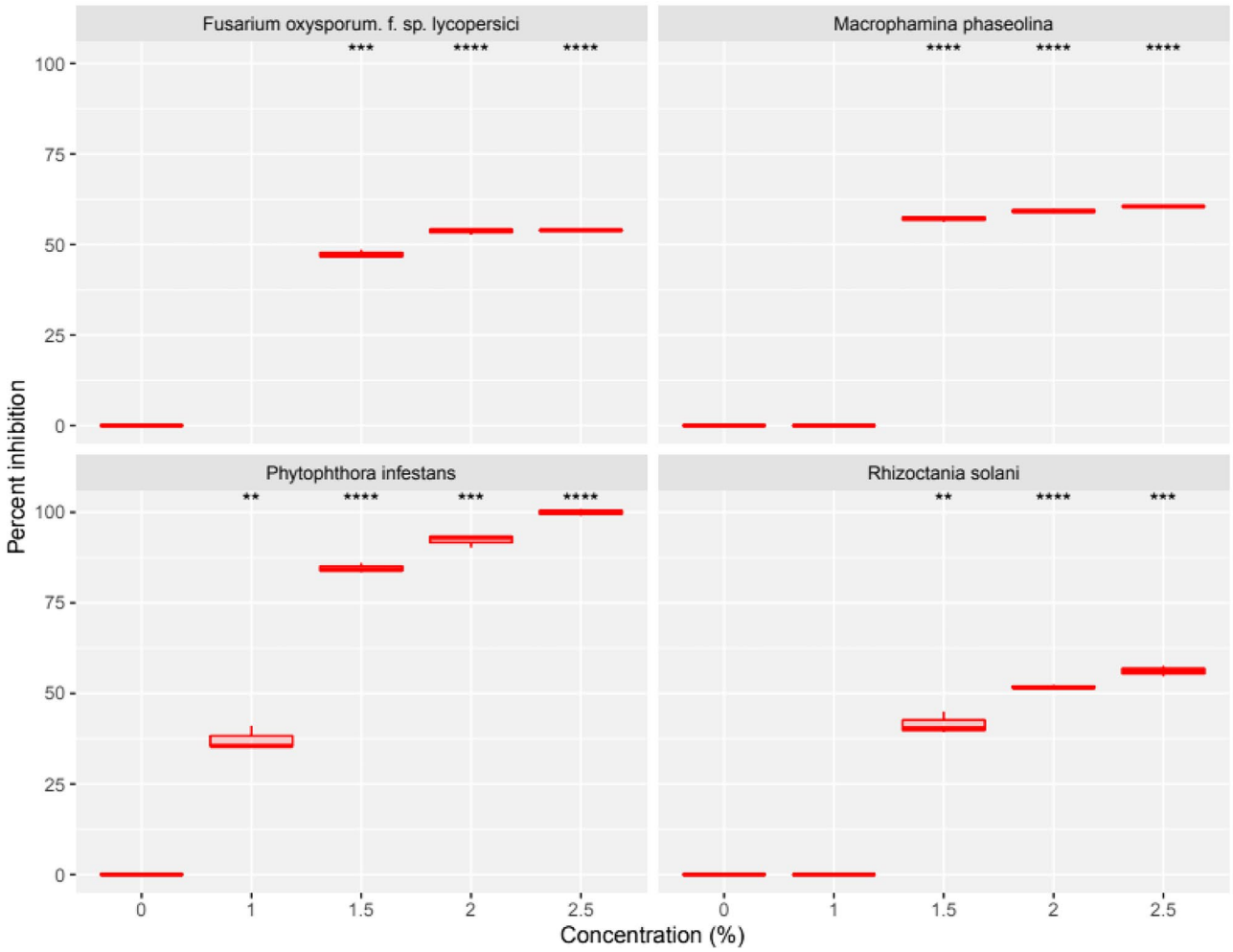

Fig. 3 Percent inhibition rates of given fungi species grown in different concentrations of *Saponaria officinalis* L. extracts

preferable compared to alternative anti-fungal products, which are used against plant pathogenic fungi species studied in the present study, especially in the settings of agricultural communities with limited income or those with ecological health concerns. Environmentally-friendly plant-based anti-fungals such as those studied in the current study have the potential to increase the production yield of certain plant host species with a high economical value without causing any harmful effects on the environment and on the health of farmers.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s42360-021-00366-8.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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