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(54) Title: A METHOD FOR CONTROLLING RUST

(57) Abstract: A combination comprising a multi-site contact fungicide, a first systemic fungicide and optionally a second systemic

A METHOD FOR CONTROLLING RUST

Technical Field of the invention:

The present invention relates to a method for the prevention and/or treatment of phytopathogenic fungi. More particularly, the present invention relates to a method of using fungicides for the prevention and/or treatment of Asian soybean rust in leguminous plants.

Background of the invention:

The fungus of the genus Phakopsora is known to infect legumes. Two most prominent strains of the genus are *Phakopsora pachyrhizi* and *Phakopsora meibomiae.* Soybean rust caused by *Phakopsora pachyrhizi* is the most damaging disease affecting the yield of leguminous plants causing widespread damage to crops and depleting yield from 10 to 90% if not treated in time. Commonly known as Asian Soybean Rust (ASR), *Phakopsora pachyrhizi* infections must be detected early and treated early so as to prevent the geographic spread of the disease, which is airborne and causes severe loss of yield. The disease spreads through spores called urediniospores which are carried through the environs, resulting in wide spread damage. The disease earlier restricted to Asia and Australia has spread to Africa and in the past two decades, spread to South and North America. The first detection in the Americas was in 2001 in South America; from there it spread to North America where it was first detected in 2004.

Phakopsora pachyrhizi is known to infect over 30 legumes including commercially important edible beans as well as kudzu. The additional host crops serve as a reservoir for spores which can settle over the winter on the host crops and then spread in warmer weather. Early detection and treatment of *Phakopsora* is very essential to prevent the spread of disease and the loss of yield. Fungicides typically recommended for the treatment of this disease include Qo inhibitors (Quinone outside inhibitors), DM inhibitors (demethylation inhibitor), SDH Inhibitors (succinate dehydrogenase inhibitors). These fungicides when applied alone provided some control but, resistance was quickly observed, specifically in DM inhibitors (**K**

Schmitz et.al, Pest Management Science, Vol. 69, Issue 10 (2013)). Combination of Qo and DM inhibitors are also known in the art for the treatment of the disease, however, the treatment is not effective in controlling the disease and improving yields at the same time. Also, resistance to DM inhibitors effectively renders such combination compositions useless as the ASR strains can effectively overcome the effects of DM inhibitors. **Venancio et.al (Poster #24, 2011 Field Crops Rust Symposium)** taught the use of combination of stroilurins (Qo inhibitors) and triazoles (DM inhibitors) for the treatment of ASR, the control of the disease was found to be favorable; however, yield was significantly low, and some combinations showed lower disease control and significantly poor yield. Older studies have demonstrated the use of multi-site inhibitor fungicides such as chloronitriles and dithiocarbamate for the treatment of Soybean Rust; however, none of the multi-site inhibitor fungicides were successful in the control of the disease or the increase in yield.

The most important factor in Soybean Rust is the loss of foliage that results in the loss of nutrients and decrease in the overall yield of the crop. Numerous papers have been published that demonstrate moderate increase in yield with the application of fungicides. However, there is a need for a method of treatment that demonstrates improved yields along with preventive and/or curative capabilities in the treatment of Soybean Rust.

Compositions comprising the single actives used in the treatment of ASR have demonstrated very little control as compared to combinations, however, the cost and concentrations of such combination fungicides used in the treatment of ASR is significantly higher. There is therefore a need in the art for a method of treatment that provides excellent control over Asian Soybean Rust in host plants, as well as provides high yields, maintain nutrition and quality of the plants.

Hartman, G. L., Saadaoui, E. M., and Tschanz, A. T., Scientific eds. 1992, *Annotated bibliography of soybean rust (Phakopsora pachyrhizi Sydow), AVRDC Library Bibliography Series 4-1*, Tropical Vegetable Information Service. Taipei: Asian Vegetable Research and Development Center, recommended the use of triadimefon,

thiabendazole, chlorothalonil and certain ethylenebis-dithiocarbamates for the control of soybean rust. The protection offered by triadimefon was inconsistent, in comparison to mancozeb, although it successfully prevented yield losses. However, triadimefon required frequent applications at 10-20 day intervals, starting from the flowering stage in order to retain its effectiveness. Thiabendazole was found to be less effective than certain ethylenebis-dithiocarbamates, and further was found effective only when used with oxycarboxin. Thiabendazole was also found to be phytotoxic. Chlorothalonil offered equal or worse rust control vis-à-vis the other fungicides recommended in this paper.

The use of ethylenebis-dithiocarbamates such as mancozeb, zineb or maneb alone has been found effective for the control of soybean rust when applied 7 to 21 days apart, provided the first application was made three weeks after planting and continued as late as till the flowering stage. Moreover, not all the studied showed yield increase due to the individual applications of ethylenebis-dithiocarbamates.

Oxycarboxin was found less effective than ethylenebis-dithiocarbamates, was found inconsistent in rust control and yield protection varied with the particular study. Oxycarboxin is also required to be applied when lesions first appear and then at 7-intervals for effective control, which is expensive and inconvenient.

Azoxystrobin is another fungicide, which has been recommended for soybean rust control. However, it is known in the art that a single late application of azoxystrobin does not control soybean rust or protect yield losses.

A recent survey by the present applicant found that a limited number of about 8-10 fungicides were approved to be used for the control of soybean rust, which are:

(A) Conazole type fungicides such as myclobutanil, propiconazole, tetraconazole and tebuconazole;

(B) Strobilurin type fungicides such as azoxystrobin and pyraclostrobin;

(C) Combinations of conazole and strobilurin type fungicides such as propiconazole + trilfoxystrobin; and

(D) Ethylenebis-dithiocarbamates such as mancozeb.

Thus, additional fungicides are needed for soybean rust control due to economic reasons as well as for resistance management strategies. However, the choice of fungicides for soybean is not straightforward.

Soybean is not usually treated with foliar fungicides. Therefore, the choice of a protective foliar fungicide leaves open the question of its application methods or the effect of the particular selected fungicide on the crop. The pathogen for soybean rust is usually found on the lower leaves of the plant where the lesion numbers increases as the inoculum builds up. As the plant begins to flower, this inoculum builds up increases and the infection moves up the plant as the lower leaves die off and drop. The crop needs protection from flowering stage to the pod fill stage, during which the plant canopy is very dense. The dense canopy is an effective barrier to penetration of fungicides applied over the top of the canopy. Therefore, foliar fungicides are not preferred during this stage of fungicidal control, or even the systemic fungicides that do not move down the plant system present a problem.

US 8044084 discloses a method for controlling harmful fungi by applying a combination of a strobilurin fungicide with an ethylene modulator. It was found that the host plants are damaged to a lesser extent than after the treatment with a customary fungicide. Specifically, this patent teaches a combination of pyraclostrobin with prohexadione-Ca in weight ratio of from 20:1 to 0.05:1.

US 2011/0312493 teaches a method for controlling Asian soybean rust. The method comprises treating a glyphosate tolerant soybean plant propagation material with a fungicide selected from flutriafol, triticonazole, tebuconazole, ipconazole, epoxyconazole, orysastrobin, prothioconazole, fluoxastrobin, azoxystrobin, furametpyr, cyproconazole and subsequently with glyphosate.

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