ABSTRACT

The present invention relates to a method for the enhancement of the potency, systemicity, and breadth of spectrum of a fungicidal composition containing a triazolopyrimidine fungusicide which comprises adding to said composition a fungicidally-enhancing amount of an admixture selected from the group consisting of a non-ionic water-soluble mixed polyalkoxylated aliphatic alcohol surfactant; a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant; an amine ethoxylate; a micronized polymeric wax; and a mixture thereof.
ENHANCEMENT OF THE EFFICACY OF TRIAZOLOPYRIMIDINES

BACKGROUND OF THE INVENTION

[0001] As a rule, inert carrier ingredients must be used to bring crop protection agents, for example, fungicidal agents, into a form such that the user can apply said agents either directly or after dilution with water. The choice of formulation type and inert ingredients often determines to a significant extent whether said agent can display its full activity upon application.

[0002] The efficacy of the crop protection agent can often be improved by the addition of other crop protection agents. The observed efficacy of the combination of crop protection agents can sometimes be significantly higher than that which would be expected from the amounts of the individual agents used, thus indicating synergism from the active components of the combination.

[0003] The usual components of formulations such as carriers and inert ingredients (e.g., organic solvents, suspension agents, emulsion agents, wetting agents, solubilizing agents) which do not themselves possess biological activity, however, do not usually lead to an unexpected increase in efficacy.

[0004] Triazolopyrimidine compounds and their fungicidal use are described in U.S. Pat. Nos. 4,567,263; 5,593,996; and 5,756,509, among other publications. The enhancement of the fungicidal efficacy of said triazolopyrimidines by the addition of selected adjuvants is described in EP 943,241. However, there is a need for continued effort to discover suitable adjuvants which when used in combination with a triazolopyrimidine fungicide provide a means to lower the dose of said fungicide required for effective disease control.

[0005] Therefore, it is an object of this invention to provide a method for the enhancement of the efficacy of a triazolopyrimidine fungicide composition.

[0006] It is another object of this inventions to provide an economic, efficient and environmentally compatible method for the control of phytopathogenic disease.

[0007] It is a further object of this invention to provide a fungicidal composition having enhanced potency, systemicity and breadth of spectrum of disease control.

[0008] These and other objects and features of the invention will become apparent from the detailed description set forth herein below.

SUMMARY OF THE INVENTION

[0009] The present invention provides a method for the enhancement of the fungicidal activity of a composition containing a triazolopyrimidine fungicide which method comprises adding to said composition an adjuvant selected from the group consisting of

[0010] a) a non-ionic water-soluble mixed polyalkoxylated aliphatic alcohol surfactant;

[0011] b) a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant;

[0012] c) an amine ethoxylate;

[0013] d) a micronized polymeric wax; and

[0014] e) a mixture thereof.

[0015] The present invention also provides fungicidal compositions and methods of phytopathogenic fungal disease control.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Due to the continual risk of disease resistance and ecological concerns over dosage levels of pesticides, there is ongoing research to identify suitable adjuvants which when used in combination with a biologically active agent, such as a fungicide, will provide a means to lower the dose of said fungicide required for effective disease control.

[0017] It has now been found that compositions containing a triazolopyrimidine fungicide when applied in combination with one or more adjuvants selected from the group consisting of

[0018] a) a non-ionic water-soluble mixed polyalkoxylated aliphatic alcohol surfactant;

[0019] b) a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant;

[0020] c) an amine ethoxylate;

[0021] d) a micronized polymeric wax; and

[0022] e) a mixture thereof demonstrate enhanced potency, systemicity and increased breadth of spectrum of disease control.

[0023] The term adjuvant as used in the specification and claims designates a substance which can increase the biological activity of an active ingredient but is not itself significantly biologically active.

[0024] Triazolopyrimidine fungicides contemplated for use in the method of invention are those compounds of the triazolopyrimidine class of chemistry which demonstrate in vivo and in vitro fungicidal activity. Said fungicides are known in the art and descriptions thereof may be found in, for example, in U.S. Pat Nos. 4,567,263; 5,593,996; and 5,756,509, among other publications.

[0025] Preferred triazolopyrimidine fungicides suitable for use in the inventive method are compounds of formula 1

\[ \text{[0026] } \]

wherein

[0027] \( R_1 \) and \( R_2 \) each independently represent hydrogen or an optionally substituted alkyl, alkenyl, alkynyl, alkadienyl, haloalyl, aryl, heteroaryl, cycloalyl, bicycloalyl or heterocyclyl group, or

[0028] \( R_3 \) and \( R_4 \) together with the adjacent nitrogen atom represent an optionally substituted heterocyclic ring;

[0029] \( R_5 \) represents a halogen atom or an alkyl or alkoxy group;

[0030] \( n \) represents an inter of 0 to 5; and

[0031] Hal represents a halogen atom.
More preferred triazolopyrimidine fungicides are those compounds of formula I wherein 

R₁ represents C₁-C₆ alkyl, C₁-C₆ haloalkyl, or a C₅-C₁₀ cycloalkyl group; 

R₂ represents a hydrogen atom or a C₁-C₆ alkyl group or 

R₁ and R₂ together with the adjacent nitrogen atom represent an optionally substituted 6-membered heterocyclic ring; 

R₃ represents a chlorine or fluorine atom; 

n represents an integer of 2 or 3; and 

Hal represents a chlorine atom.

Particularly preferred fungicides are those triazolopyrimidine compounds of formula I wherein R₁ represents C₁-C₆ haloalkyl; R₂ represents a hydrogen atom; R₃ represents a chlorine or a fluorine atom; and n represents an integer of 3.

The non-ionic water-soluble mixed polyalkoxylated or ethoxylated aliphatic alcohol adjuvant suitable for use in the method of the invention is Pluralaf® LF 300, commercially available from Tensid-chemie, Köln, Germany or BASF AG, Ludwigshafen, Germany.

Non-ionic water-soluble polyethoxylated surfactants suitable for use in the method of the invention are straight-chained or branched C₂₅-C₃₂ alcohols ethoxylated with 10 to 25 ethoxy groups. A preferred polyethoxylated surfactant is Lubrol® 17A17, commercially available from Uniqema, Everberg, Belgium.

Amine ethoxylate adjuvants suitable for use in the inventive method are tertiary amine ethoxylates based on primary amines such as oleyl amine and tallow amine. Preferred amine ethoxylates are those commercially available under the trademarks Berol 381®, Berol 303®, and Ethomeen® S22 (Akzo Nobel Surface Chemistry, Sweden).

Among the micronized polymeric waxes suitable for use in the method of the invention is a modified polyethylene wax commercially available under the trademark Ceridust® 9615A (Clariant GmbH, Augsburg, Germany).

The adjuvants of the present invention may be included in the triazolopyrimidine fungicial composition or added separately in a tank mix. When being tank-mixed, said adjuvants may be added with other components such as a dispersing agent or an antifoam agent, and, where desirable, with further adjuvants so as to ensure that they are homogeneously dispersed in the tank mix.

The present invention also provides a fungicial composition which comprises a triazolopyrimidine fungicide and a fungicially-enhancing amount of an adjuvant selected from the group consisting of 

- a non-ionic water-soluble mixed polyalkoxylated aliphatic alcohol surfactant;
- a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant;
- an amine ethoxylate;
- a micronized polymeric wax; and
- a mixture thereof.

Preferred triazolopyrimidine fungicides suitable for use in the composition of the invention are compounds of formula I

wherein R₁, R₂, R₃, n and Hal are as defined hereinabove.

In general, fungicidally-enhancing amounts of the adjuvant are present in a wt/wt ratio of triazolopyrimidine fungicide to adjuvant of about 1.0:0.75 to 1.0:1,000, preferably about 1.0:0.9 to 1.0:500, more preferably, about 1.0:1.25 to 1.0:50. It has been found that in general, fungicidal efficacy may be enhanced to a higher degree by the addition of larger amounts of the adjuvant.

The recommended dose rates for various applications of the triazolopyrimidine fungicide are known. Advantageously, the inventive composition may (depending on the particular triazolopyrimidine fungicide, the adjuvant and their amounts) reduce the amount of said fungicide required per hectare by half or more, thereby enhancing the breadth of disease control at a reasonable dose rate.

Although dose rates may vary according to prevailing conditions such as mode of application, degree and type of fungal infection, target crop species, weather conditions, or the like, compositions of the invention may be applied at rates of about 40 to 4000 ml/ha, preferably about 50 to 3000 ml/ha, more preferably about 60 to 2000 ml/ha.

Surprisingly, the composition of the invention demonstrates rapid onset and high persistence of activity. These properties enlarge the period for application of the fungicide and, hence, increases its utility in the field. Advantageously, the fungicidal compositions of the invention may be used both prophylactically and curatively.

Aqueous dispersions and emulsions, for example compositions obtained by diluting the formulated product according to the invention with water, also lie within the scope of the invention.

The adjuvants according to the invention, the triazolopyrimidine fungicides and usual adjuvants and carriers may be formulated as any one of the conventional fluid or dispersible solid formulations known in the art, for example, as a solution, an emulsion, a wettable powder, a suspension concentrate, an emulsion concentrate, a low volume or ultra low volume preparation, a water dispersible granule, or any other conventional form known to be suitable for agricultural and horticultural applications.

Fluid or solid carriers or solubilising agents such as organic solvents, i.e. ketones, alcohols, fluid aliphatic, aliphatic or aromatic compounds, fine natural or synthetic silicates or carbonates; ionic or non-ionic surfactants which function as emulsion, dispersing or wetting agents; antifoam and antifreeze agents; or any suitable adjuvant and carrier substances which are described in the literature may be included in the inventive composition.

A carrier which will provide slow release of the pesticidal compounds into the environment of the target plant is particularly suitable for use in the composition of the invention.
The present invention also provides a method for the enhanced control of phytopathogenic fungi which comprises applying to the locus of said fungi an effective amount of a composition containing a triazolopyrimidine fungicide and a fungicidally-enhancing amount of an adjuvant selected from the group consisting of:

- a non-ionic water-soluble mixed polyalcoholacies surfactant;
- a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant;
- an amine ethoxylate;
- a micronized polymeric wax; and
- a mixture thereof.

Plant diseases which may be combated with the method of the invention include diseases caused by Ascomycete fungi, such as Erysiphe, for example Erysiphe cichoracearum or Uncinula necator, or Dothideales, for example Venturia inaequalis or Septoria tritici (Myosphaerella graminicola).

For a more clear understanding of the invention, specific examples thereof are set forth herein below. These examples are merely illustrative, and are not to be understood as limiting the scope and underlying principles of the invention in any way.

EXAMPLE 1
Evaluation of the Curative and Residual Fungical Activity Obtained by the Application of a Triazolopyrimidine Composition Plus an Adjuvant or Mixture of Adjuvants

The triazolopyrimidine composition used in this evaluation is prepared as an aqueous suspension concentrate having concentrations of 100, 20, and 4 ppm active ingredient. The composition is tank-mixed with from 0 ppm to 1,000 ppm of an adjuvant, or mixture of adjuvants, and applied to greenhouse plants using a single-nozzle overhead track sprayer at an application rate of 200 litre/ha. When two adjuvants are added to the composition, the concentration of each adjuvant is 500 ppm.

Barley seedlings (var. 'Golden Promise') and wheat seedlings (var. 'Kazlner') are grown to the primary leaf stage (ca. 1 week old) in 6-cm-diameter pots in the greenhouse. Plants for both curative and residual tests are sprayed at the same time and inoculations of the pathogens are done on different days.

For curative tests, barley and wheat plants are inoculated 2 days prior to test composition treatment by dusting with conidia of Blumeria (Erysiphe) graminis f.sp. hordei or B. graminis f.sp. tritici to create powdery mildew diseases. Plants are kept in the greenhouse until treated. After treatment, the plants are kept until powdery mildew disease symptoms develop on untreated plants. Plants are then evaluated for percent disease on the treated primary leaves. For curative rust tests, wheat plants are inoculated 2 days prior to test composition treatment by spraying with auredinospore suspension in 0.05% aqueous Tween® 20 (1 mg spores per ml) of Puccinia recondita, and kept in a moist infection chamber for one day. After treatment, the plants are kept in the greenhouse until disease symptoms develop on untreated plants. Plants are then evaluated for percent disease on the treated primary leaves.

Residual tests, plants are treated first and then kept for 4 days in the greenhouse before being inoculated with the pathogens as described for curative tests. Inoculated plants are kept in the greenhouse until disease symptoms develop on untreated plants. Plants are then evaluated for percent disease on the treated primary leaves.

Disease control is calculated using the following formula:

% disease control = 100 - \( \frac{\% \text{ infected leaf area in treated plants}}{\% \text{ infected leaf area in untreated plants}} \)

The mean values for the % control of the three concentrations of active ingredient is reported in Table I. The adjuvant concentrations are the same at all the concentrations used.

As can be seen from the data shown on Table I, the addition of one or more adjuvants to a triazolopyrimidine fungicide composition according to the method of the invention significantly enhances the fungicidal activity of said composition.

Active Ingredient Employed

| Compounds / Active Ingredients: | 5-Chloro-7-[(2,2,2-trifluoro-1-methylthyl)amino]-6-(2,4,6-trifluorophenyl)-1,3,5 triazolopyrimidine. |

ADJUVANTS EMPLOYED

<table>
<thead>
<tr>
<th>Commercial Product</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planfac® LF300, (BASF; Ludwigshafen, Germany)</td>
<td>non-ionic water-soluble mixed polyalcoholacies surfactant</td>
</tr>
<tr>
<td>Labol® 17A17 (Uniques; Everberg, Belgium)</td>
<td>non-ionic water-soluble ethoxylated aliphatic alcohol surfactant</td>
</tr>
<tr>
<td>Berol® 381 (Akzo Nobel; Sweden)</td>
<td>amine ethoxylate</td>
</tr>
<tr>
<td>Etilux® S22 (Akzo Nobel; Sweden)</td>
<td>amine ethoxylate</td>
</tr>
<tr>
<td>Cericult® 9615A (Chirant GMBH; Augsberg, Germany)</td>
<td>micropolymerized polymeric wax</td>
</tr>
</tbody>
</table>

Composition A: Suspension Concentrate

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount [g/l]</th>
<th>Ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>triazolopyrimidine</td>
<td>100.0</td>
<td>Compound 1A</td>
</tr>
<tr>
<td>fungicide</td>
<td>1.0</td>
<td>Atlas G50004</td>
</tr>
<tr>
<td>defoliant</td>
<td>10.0</td>
<td>Sypermectin A7</td>
</tr>
<tr>
<td>fungicide</td>
<td>3.0</td>
<td>Rhododendr® 426 R2</td>
</tr>
<tr>
<td>preservative</td>
<td>2.0</td>
<td>Proxel® OXL3</td>
</tr>
<tr>
<td>surfactant</td>
<td>3.0</td>
<td>Rhododol® 235</td>
</tr>
<tr>
<td>antifreeze agent</td>
<td>50.0</td>
<td>propylene glycol</td>
</tr>
<tr>
<td>water</td>
<td>to 1000 ml</td>
<td></td>
</tr>
</tbody>
</table>

4 Uniques; Everberg, Belgium
5 Rhodol GmbH, Frankfurt, Germany
6 Zeneca GmbH, Frankfurt, Germany
TABLE I

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Disease Control</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 Day Cursive</td>
<td>4 Day Residual</td>
<td>2 Day Cursive</td>
<td>4 Day Residual</td>
<td>2 Day Cursive</td>
</tr>
<tr>
<td>Composition A</td>
<td>16</td>
<td>42</td>
<td>48</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>Composition A &amp; Plurafac LF 300 (1000 ppm)</td>
<td>49</td>
<td>40</td>
<td>69</td>
<td>28</td>
<td>69</td>
</tr>
<tr>
<td>Composition A &amp; Lubrol 17A17 (1000 ppm)</td>
<td>42</td>
<td>40</td>
<td>79</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>Composition A &amp; Plurafac LF 700 (500 ppm) &amp; Lubrol 17A17 (500 ppm)</td>
<td>55</td>
<td>49</td>
<td>78</td>
<td>38</td>
<td>57</td>
</tr>
<tr>
<td>Composition A &amp; Plurafac LF 300 (500 ppm) &amp; Lubrol 17A17 (500 ppm)</td>
<td>52</td>
<td>47</td>
<td>72</td>
<td>23</td>
<td>54</td>
</tr>
<tr>
<td>Composition A &amp; Berol 381 (1000 ppm)</td>
<td>53</td>
<td>48</td>
<td>72</td>
<td>22</td>
<td>56</td>
</tr>
<tr>
<td>Composition A &amp; Ethomeen S22 (1000 ppm)</td>
<td>29</td>
<td>45</td>
<td>62</td>
<td>27</td>
<td>35</td>
</tr>
<tr>
<td>Composition A &amp; Cericid 9615A (1000 ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*WPM = wheat powdery mildew; WLR = wheat leaf rust; BPM = barley powdery mildew

What is claimed is:

1. A method for the enhancement of the fungicidal activity of a composition containing a triazolopyrimidine fungicide which method comprises adding to said composition an adjuvant selected from the group consisting of:

   a) a non-ionic water-soluble mixed polyalkoxylated aliphatic alcohol surfactant;

   b) a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant;

   c) an amine ethoxylate;

   d) a micronized polymeric wax; and

   e) a mixture thereof.

2. The method according to claim 1 wherein said adjuvant is present in a wt/wt ratio of adjuvant to triazolopyrimidine fungicide of about 1.0:0.75 to 1.0:1,000.

3. The method according to claim 2 wherein said ratio is about 1.0:0.9 to 1.0:500.

4. The method according to claim 3 wherein said ratio is about 1.0:1.25 to 1.0:50.

5. The method according to claim 1 wherein said triazolopyrimidine fungicide is a compound of formula I.

\[
\text{R}_1\text{N} = \text{R}_2
\]

wherein

\(\text{R}_1\) and \(\text{R}_2\) each independently represent hydrogen or an optionally substituted alkyl, alkenyl, alkynyl, alkenylenyl, haloalkyl, aryl, heteroaryl, cycloalkyl, bicycloalkyl or heterocyclic group, or

\(\text{R}_1\) and \(\text{R}_2\) together with the adjacent nitrogen atom represent an optionally substituted heterocyclic ring;

\(\text{R}_3\) represents a halogen atom or an alkyl or alkoxy group; and

\(n\) represents an integer of 0 to 5; and

\(\text{Hal}\) represents a halogen atom.

6. The method according to claim 1 wherein said composition is a suspension concentrate composition.

7. The method according to claim 6 wherein said adjuvant is a non-ionic water-soluble mixed polyalkoxylated aliphatic
alcohol surfactant, a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant or a mixture thereof.

8. The method according to claim 7 wherein said ethoxylated alcohol surfactant is an aliphatic C₁₀₋C₂₅ alcohol ethoxylated with 10 to 25 ethoxy groups.

9. The method according to claim 7 wherein said mixed polyalkoxylated alcohol surfactant is Plurafac® LF 300.

10. A fungicidal composition which comprises a triazolopyrimidine fungicide and a fungicidally-enhancing amount of an adjuvant selected from the group consisting of

a) a non-ionic water-soluble mixed polyalkoxylated aliphatic alcohol surfactant;

b) a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant;

c) an amine ethoxylate;

d) a microrized polymeric wax; and

e) a mixture thereof.

11. The composition according to claim 10 wherein the triazolopyrimidine fungicide is a compound of formula 1

\[ \text{R}_1 \text{N} \text{N} \text{R}_2 \text{N} \text{R}_3 \text{Hal} \]

wherein

\( \text{R}_1 \) and \( \text{R}_2 \) each independently represent hydrogen or an optionally substituted alkyl, alkenyl, alkynyl, alkenyl, haloalkyl, aryl, heteroaryl, cycloalkyl, bicycloalkyl or heterocyclyl group, or \( \text{R}_1 \) and \( \text{R}_2 \) together with the adjacent nitrogen atom represent an optionally substituted heterocyclic ring;

\( \text{R}_3 \) represents a halogen atom or an alkyl or alkoxy group;

\( n \) represents an integer of 0 to 5; and

\( \text{Hal} \) represents a halogen atom.

12. The composition according to claim 10 wherein the non-ionic water-soluble mixed polyalkoxyalted aliphatic alcohol surfactant is Plurafac® LF 300.

13. The composition according to claim 10 wherein said fungicide and said adjuvant are present in a wt/wt ratio of fungicide to adjuvant of about 1.0:0.75 to 1.0:1.000.

14. The composition according to claim 13 wherein said ratio is about 1.0:0.9 to 1.0:500.

15. The composition according to claim 14 wherein said ratio is about 1.0:1.25 to 1.0:50.

16. A method for the enhanced control of phytopathogenic fungi which comprises applying to the lous of said fungi an effective amount of a composition having triazolopyrimidine fungicide and a fungicidally-enhancing amount of an adjuvant selected from the group consisting of

a) a non-ionic water-soluble mixed polyalkoxyalted aliphatic alcohol surfactant;

b) a non-ionic water-soluble ethoxylated aliphatic alcohol surfactant;

c) an amine ethoxylate;

d) a micorized polymeric wax; and

e) a mixture thereof.

17. The method according to claim 16 wherein said fungi is Ascomyce fungi.

18. The method according to claim 16 wherein said fungi is Dothideales or Erysipheales fungi.

19. The method according to claim 16 wherein the non-ionic water-soluble mixed polyalkoxyalted aliphatic alcohol surfactant is Plurafac® LF 300.

20. The method according to claim 19 wherein said triazolopyrimidine fungicide is 5-chloro-7-[[2,2,2-trifluoro-1-methyl-ethyl]amino]-6-(2,4,6-trifluorophenyl)-[1,2,4]triazolo[1,5-a]pyrimidine.