Field suppression of Fusarium wilt disease (Foc race 1-VCG 0124) and plant growth promotion mediated by native microbes and botanical Zimmu in banana cv. Grand Naine

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Fusarium wilt devastated field in Tamil Nadu
Characterization of Cavendish wilt pathogen

VCG test using Australian and Indian nit-M testers

Volatile production

[Images of petri dishes and laboratory flasks showing varying stages of bacterial growth and volatiles.]
Fusarium wilt disease severity map of India

- 0 – 25%
- 26 - 50%
- 51 – 75%
- 76 – 100%
Aggravation and spread of Fusarium wilt by Stem borer
### Details of antagonistic microbial isolates and evaluation against *Foc*

<table>
<thead>
<tr>
<th>Antagonists</th>
<th>Fungus</th>
<th>Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Endophytic</td>
<td>Rhizospheric</td>
</tr>
<tr>
<td>Total number of isolates isolated</td>
<td>43</td>
<td>19</td>
</tr>
<tr>
<td>No. of isolates effective against <em>Foc</em> under <em>in vitro</em> condition</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>No. of isolates effective against <em>Foc</em> under glass house condition (Individual)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>No. of combination of antagonists effective against <em>Foc</em> under glass house condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective combination of antagonists against <em>Foc</em> under Field condition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Focus on Bioagents with multiple function, activities and versatility

Bioagents (Functions and activities)

Biocontrol activity

- F. Acid degrading ability
- Siderophore
- HCN
- Chitinase production
- Protease production

Plant Growth Promotion

- Mycelial & Spore germination inhibition
- Protease production
- Chitinase production
- PO₄ Sol.
Mass Production of *Trichoderma* spp. at the farm condition
Bioagents of multiple functions of endophytic and rhizospheric nature

1. Combined application of fungal endophytic *Penicillium pinophilum* Bc2 + rhizospheric *Trichoderma* sp. NRCB3,

2. Liquid formulation containing endophytic *Trichoderma asperellum* Prr2 + *Bacillus flexus* Tvpr1 and

3. Zimmu leaf extract (50% conc)

Time of application
i) at the time of planting
ii) 2\(^{nd}\) month after planting
iii) 4\(^{th}\) month after planting
Abandoned field due to Fusarium wilt disease (> 80% incidence) in Theni district of Tamil Nadu, India
Bio priming of TC plants
Field application of Zimmu leaf extract in the farmer’s field
Field application of Bioagents/botanical
Field trial on the biocontrol management of Fusarium wilt disease in Cavendish banana in Theni district of Tamil Nadu (3rd year demonstration trial)
Effect of formulated native endophytic and rhizospheric fungal and bacterial antagonistic microbes and botanical leaf extract on the Fusarium wilt disease and bunch weight of cv. Grand Naine (AAA)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Bunch weight</th>
<th>Internal wilt disease score (1-6 scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endo. <em>Burkholderia</em> sp. (GcTcr1) + endo. <em>Ochrobactrum</em> sp. (pjrl)</td>
<td>28.7c</td>
<td>4.6 c</td>
</tr>
<tr>
<td>Endo. <em>Bacillus</em> sp. (Enbr1) + endo. <em>Burkholderia</em> sp. (GcTcr1)</td>
<td>28.6c</td>
<td>4.3 c</td>
</tr>
<tr>
<td>Endo. <em>Bacillus</em> sp. (Enbr1) + endo. <em>Ochrobactrum</em> sp. (pjrl)</td>
<td>27.3cd</td>
<td>4.1c</td>
</tr>
<tr>
<td>Endo. <em>Bacillus</em> sp. (Enbr1) + endo. <em>Bacillus</em> sp. (GcTc2)</td>
<td>26.8cd</td>
<td>3.3 b</td>
</tr>
<tr>
<td>Endo. <em>Acrhomobacter</em> sp. (Gcr1) + rhizo. <em>Bacillus cereus</em> (Jrb5)</td>
<td>26.1cd</td>
<td>2.0a</td>
</tr>
<tr>
<td>Endo. <em>Pseudomonas putida</em> (C4r4) + rhizo. <em>Bacillus cereus</em> (Jrb1)</td>
<td>26.4cd</td>
<td>2.2a</td>
</tr>
<tr>
<td>Liquid formulation [Endo. <em>Bacillus flexus</em> (Tvpr1) + endo. <em>T.asperellum</em> (Prr2)]</td>
<td>44.0a</td>
<td>1.7a</td>
</tr>
<tr>
<td>Rice chaffygrain formulation [endo. <em>Penicillium pinophilum</em> (Bc2) + rhizo. <em>Trichoderma sp.</em> (NRCB3)]</td>
<td>38.6b</td>
<td>1.8a</td>
</tr>
<tr>
<td>Zimmu leaf extract</td>
<td>36.4b</td>
<td>2.1a</td>
</tr>
<tr>
<td>Carbendazim</td>
<td>23.3d</td>
<td>4.4c</td>
</tr>
<tr>
<td>Control (untreated)</td>
<td>16.2e</td>
<td>5.4d</td>
</tr>
<tr>
<td>CD(.05)</td>
<td>4.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Excellent stand of banana crop in the abandoned field due to the application of bioagents/botanical (100% harvest)
Effect of drenching of liquid formulation (*T.har* + *B. cereus*) on the suppression of Fusarium Wilt disease in cv.Grand Naine under field condition

Control

Drenching of Liquid formulation (*T.har* + *B. cereus*)
Effect of biocontrol application on the bunch weight

Endophytic *P. pinophilum* (Bc2) + rhizospheric *T. asperellum*

Endo *T. asperellum* + *B. cereus*
Foc infected banana plant cv. Grand Naine (Untreated control plant)

A: Bunch emergence at the middle of pseudostem
B: Bunch emergence at the upper of pseudostem
C: Bunch very small in size