Utilization of actinomycetes having broad-spectrum of plant growth-promoting and biocontrol traits in chickpea, sorghum and rice

By

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Introduction

- Agricultural sector - burden from many ways - lower soil nutrients, attack of pathogen, pest and weeds and abiotic stresses - leads to economic consequences.
- Low cost investment - sustainable agriculture
- Key partners - Plant growth promoting (PGP) microbes - resides in rhizospheric region/plant tissues

Mechanisms
- Direct mechanisms - nitrogen fixation, phosphate solubilization, iron chelation and phytohormone production
- Indirect mechanisms - suppression of plant pathogens and induction of host plant resistance

Research focus
- Plant growth promotion
- Biocontrol of plant pathogens
Microbial strains

- *Streptomyces* sp., CAI-17 (GenBank Acc. no: JQ682619)
- *Streptomyces* sp., CAI-68 (GenBank Acc. no: JQ682622)
- *Streptomyces* sp., CAI-78 (GenBank Acc. no: JQ682623)
- *Streptomyces* sp., KAI-26 (GenBank Acc. no: JQ682624)
- *Streptomyces* sp., KAI-27 (GenBank Acc. no: JQ682625)

Assessment of PGP traits - *in vitro*

- Siderophore production - Schwyn and Neilands (1987)
- Indole acetic acid - Patten and Glick (1996)
- Hydrocyanic acid - Lorck (1948)
- β-1,3-glucanase - Singh et al. (1999)
- Cellulase - Hendricks et al. (1995)
- Chitinase - Hirano and Nagao (1988)

Assessment of PGP traits – Green house and field trials

- Crops
  - Chickpea (ICCV2 & JG-62)
    - CRBD
    - Greenhouse & Field 2012-13
      - Agronomic performance
      - Soil properties
      - Biocontrol against *Fusarium* wilt
  - Rice (Sampada)
    - CRBD
    - Field 2011-12
      - Agronomic performance
      - Soil properties
  - Sorghum (R16)
    - CRBD
    - Green house
      - Agronomic performance
      - Biocontrol against charcoal rot
Results
Plant growth promotion – *in vitro*

- Siderophore, HCN, IAA, β-1,3-glucanase – All the five actinomycetes
- Cellulase - KAI-32 and KAI-90
- Chitinase - CAI-24, KAI-32 and KAI-90
Plant growth promotion - Rice
At harvest

Tiller number: 9-28%;     Panicle number: 5-18%
At harvest

Grain yield: up to 10%;  Stover yield: up to 25%
At harvest

Root length: 3–18%;  Root volume: 2–19%;  Root dry weight: 4–25%
Effect of PGP *Streptomyces* sp. on rhizospheric soil health

<table>
<thead>
<tr>
<th>Isolates</th>
<th>MBC (µg g⁻¹ soil)</th>
<th>MBN (µg g⁻¹ soil)</th>
<th>DA (µg TPF g⁻¹ soil 24 h⁻¹)</th>
<th>Total N (g Kg⁻¹ soil)</th>
<th>Available P (mg g⁻¹ soil)</th>
<th>OC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI-24</td>
<td>1715</td>
<td>60</td>
<td>94</td>
<td>2.45</td>
<td>0.133</td>
<td>1.49</td>
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<td>CAI-121</td>
<td>3293</td>
<td>65</td>
<td>113</td>
<td>1.99</td>
<td>0.117</td>
<td>1.47</td>
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<td>CAI-127</td>
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<td>194</td>
<td>2.64</td>
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<td>1.52</td>
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<td>KAI-32</td>
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<td>65</td>
<td>135</td>
<td>2.14</td>
<td>0.122</td>
<td>1.66</td>
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<td>KAI-90</td>
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<td>62</td>
<td>136</td>
<td>2.16</td>
<td>0.129</td>
<td>1.62</td>
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<tr>
<td>Control</td>
<td>2861</td>
<td>58</td>
<td>111</td>
<td>1.19</td>
<td>0.087</td>
<td>1.47</td>
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<tr>
<td>LSD</td>
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<td>12</td>
<td>29.7</td>
<td>0.229</td>
<td>0.019</td>
<td>0.116</td>
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<tr>
<td>CV%</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>4</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

MBC - Microbial biomass carbon; MBN - Microbial biomass nitrogen; DA - Dehydrogenase activity; OC - Organic carbon; LSD – Least Significant Difference; CV – Co-efficient of Variation.

- Total N – 122%; available P – 53%; organic carbon – 13%
- Microbial biomass carbon - 41%; microbial biomass nitrogen - 52%; Dehydrogenase activity - 75%
RESEARCH

Plant growth-promoting activities of *Streptomyces* spp. in sorghum and rice

Subramaniam Gopalakrishnan*, Vadlamudi Srinivas, Meesala Sree Vidya and Abhishek Rathore
Plant growth promotion - Chickpea
At 30 DAS

Nodule number and nodule weight: up to 150%
At 60 DAS

Pod number: up to 51%; pod weight: up to 117%
At harvest

- Stover yield: up to 39%; grain yield: up to 12%
### Effect of PGP *Streptomyces* sp. on rhizospheric soil health

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<tr>
<th>Isolates</th>
<th>MBC (µg g⁻¹ soil)</th>
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<th>Total N (ppm)</th>
<th>Available P (ppm)</th>
<th>OC (%)</th>
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<td>CAI-24</td>
<td>1041</td>
<td>71.1</td>
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<tr>
<td>Control</td>
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<td>632</td>
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<td>0.47</td>
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<tr>
<td>LSD</td>
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<td>27.7</td>
<td>0.88</td>
<td>0.019</td>
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<tr>
<td>CV% (0.05)</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

MBC - Microbial biomass carbon; DA - Dehydrogenase activity; OC - Organic carbon; LSD – Least Significant Difference; CV – Co-efficient of Variation.

Total N – up to 5%; available P – up to 37%; organic carbon – up to 9%

Microbial biomass carbon – up to 55%; Dehydrogenase activity – up to 17%
Evaluation of *Streptomyces* sp. obtained from herbal vermicompost for broad spectrum of plant growth-promoting activities in chickpea

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Plant growth promotion - Sorghum
Plant height - 51%; stem weight - 39%; root length - 18%; root volume - 9%; root dry weight - 25%
Biocontrol – *Fusarium* wilt
PGP *Streptomyces* against FOC on chickpea JG-62 under greenhouse

- 21-76% reduction of DI at 29 DAS
- Reduced DI: CAI-24 < CAI-127 < CAI-121 < KAI-32 < KAI-90

M1 - inoculation of the potting mixture with respective actinomycete culture along with FOC two weeks before sowing; M2 - inoculation of the seeds by soaking in the respective actinomycete culture for 1 h; M3 - inoculation of the sprouted seeds by soaking in the respective actinomycete culture for 1 h; M4 - inoculation of the potting mixture with actinomycete culture at the time of sowing (10 ml of actinomycete culture [10^8 CFU ml^-1] was applied on the seed and covered with soil) and M5 - inoculation of the seedlings after emergence with actinomycete culture (10 ml of actinomycete culture [10^8 CFU ml^-1])
M1-inoculation of the seeds by soaking in the respective actinomycete culture for 1 h; M2-inoculation of the sprouted seeds by soaking in the respective actinomycete culture for 1 h; M3-inoculation of the soil with respective actinomycete culture (5 ml per seed, $10^8$ CFU ml$^{-1}$) at the time of sowing and M4-inoculation of the seedlings after emergence with the respective actinomycete culture (5 ml per seedling, $10^8$ CFU ml$^{-1}$).
Evaluation of actinomycete isolates obtained from herbal vermicompost for the biological control of *Fusarium* wilt of chickpea

Subramaniam Gopalakrishnan*, Suresh Pande, Mamta Sharma, Pagidi Humayun, Bandru Keerthi Kiran, Dasyam Sandeep, Meesala Sree Vidya, Kanala Deepthi, Om Rupela

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Biocontrol – Charcoal rot
PGP Streptomyces against Macrophomina phaseolina under green house

- Inhibitory activity on *M. phaseolina* by PGP *Streptomyces* sp., by dual culture assay
- Extension of charcoal rot reduction: 20–81%
- Highest reduction by *Streptomyces* sp., KAI-90
Plant growth promotion mechanisms
Colonization capacity of PGP actinomycetes on chickpea roots
Expression of PGP genes

- Up-regulation on gene expression of PGP genes including IAA (10 fold) and siderophore (12.6 fold) and also biocontrol genes, β-1,3-glucanase (2.4 fold)
Conclusions

- The five PGP *Streptomyces* CAI-24, CAI-121, CAI-127, KAI-32 and KAI-90 were found show plant growth promotion effects on chickpea, rice and sorghum under greenhouse and/or field conditions.

- They also showed biocontrol on chickpea and sorghum pathogens such as FOC and MP respectively.

- They also found to enhance soil fertility by enhancing C, N and P contents.

- Usage of such potential PGP actinomycetes will helps for reducing the chemical inputs.
Acknowledgement

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Thank you