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

By

Dr. A. Sathya, V. Srinivas & Dr. S. Gopalakrishnan
Research Associate – Grain Legumes
International Crops Research Institute for the Semi-Arid Tropics
Hyderabad, India

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

Experimental Section

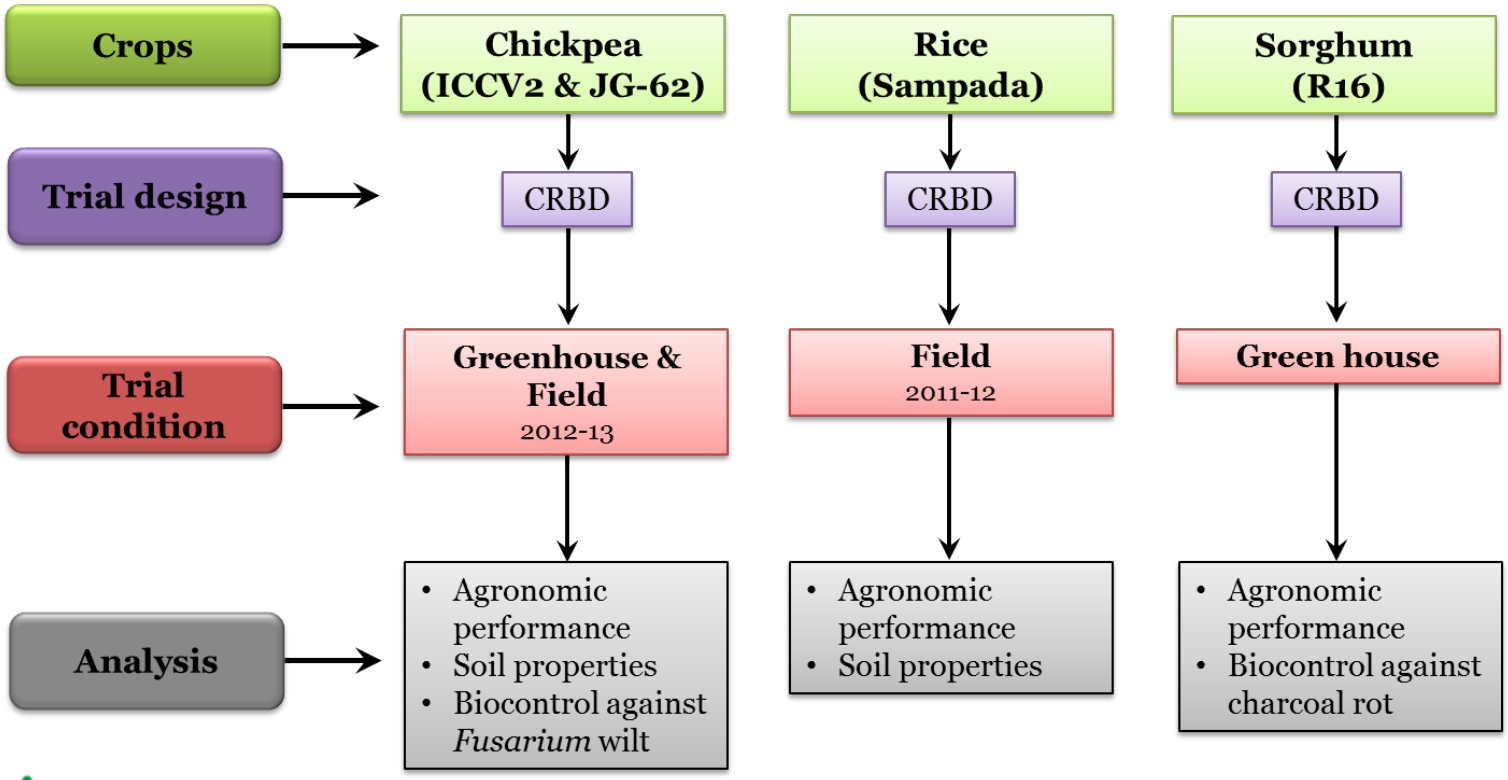
Microbial strains

- *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*

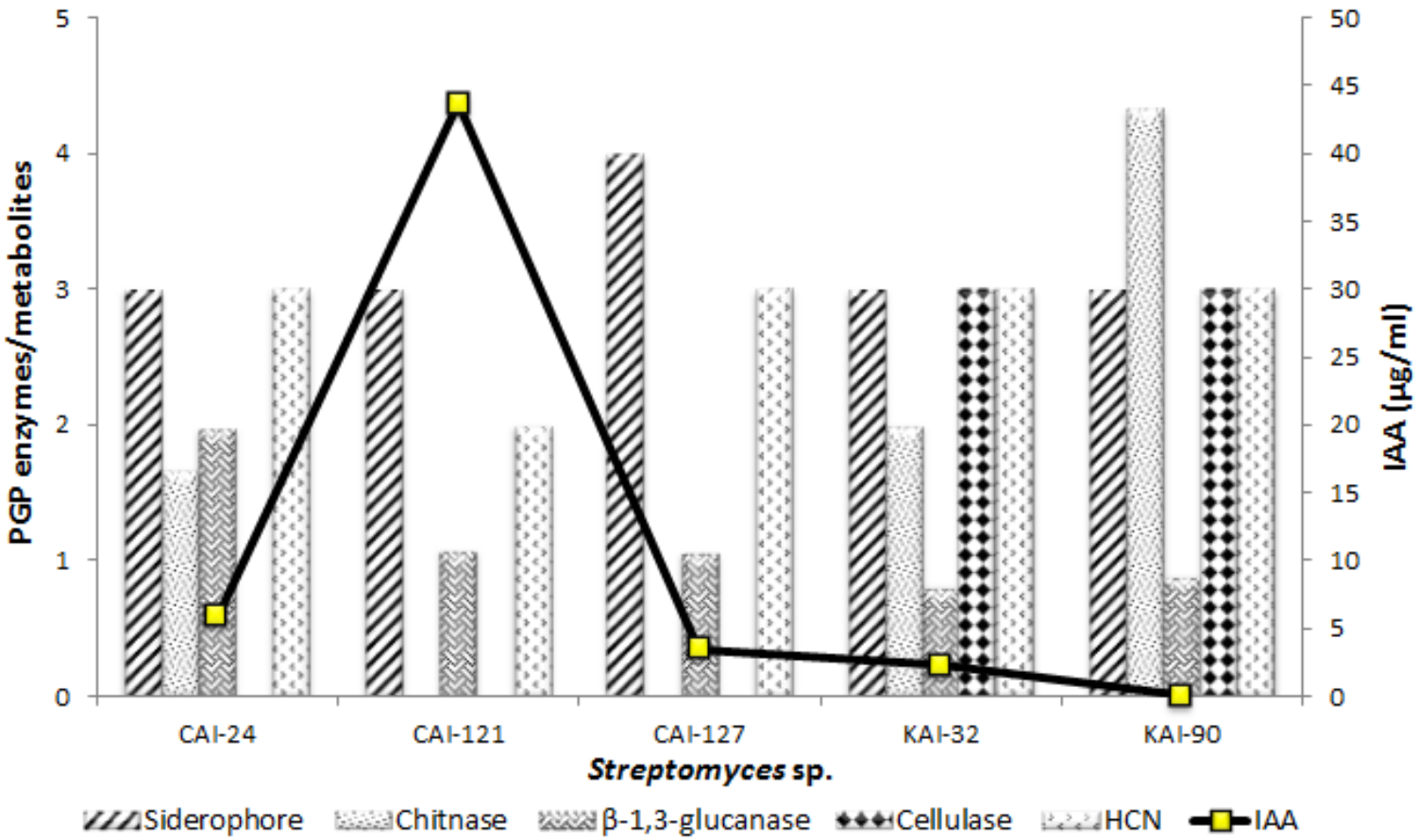
- Siderophore production - Schwyn and Neilands (1987)
- Indole acetic acid - Patten and Glick (1996)
- Hydrocyanic acid - Lorck (1948)
- β-1,3-glucanase - Singh et al. (1999)
- Cellulase - Hendricks et al. (1995)
- Chitinase - Hirano and Nagao (1988)

Assessment of PGP traits – Green house and field trials



Results

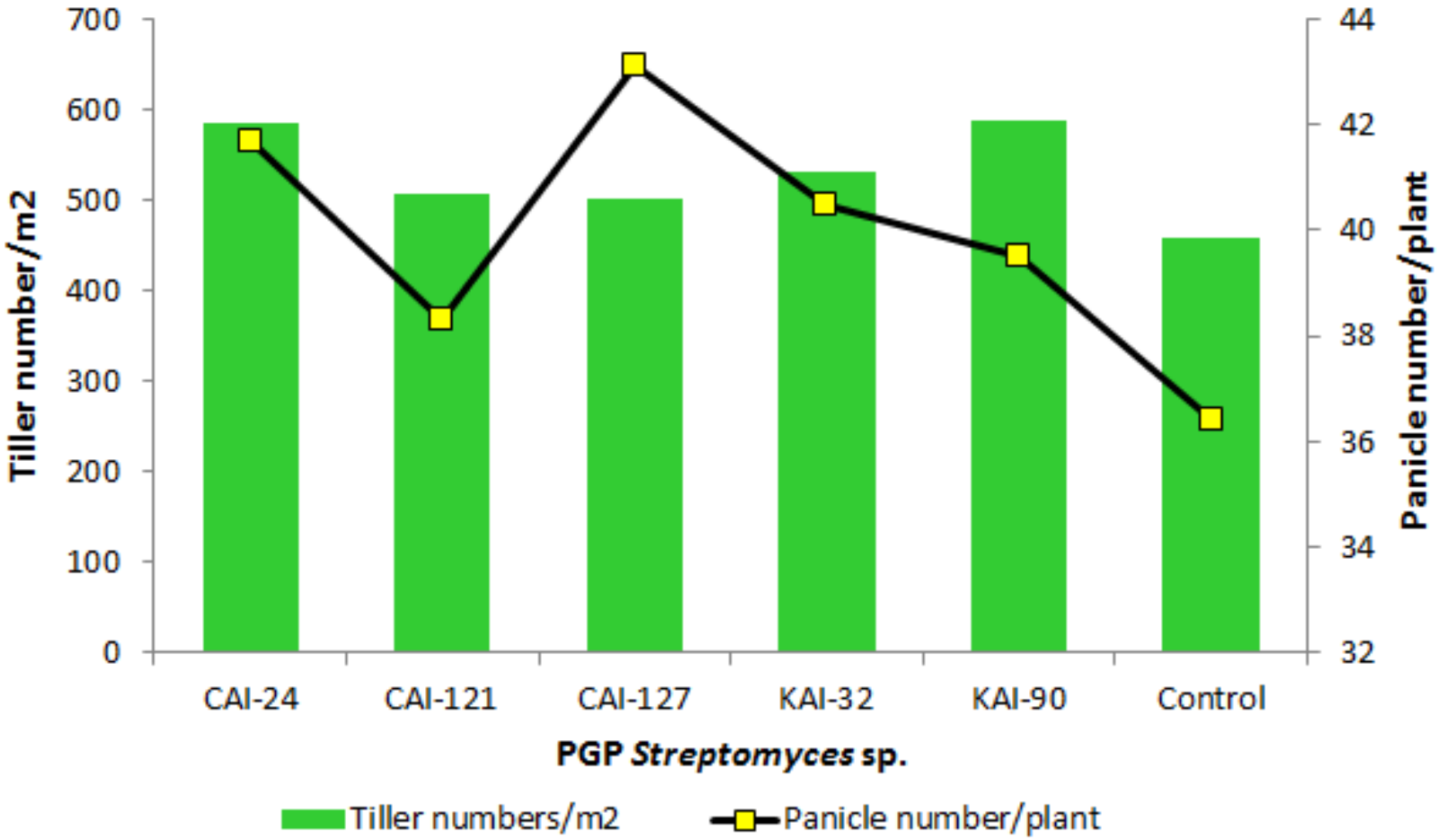
Plant growth promotion – *in vitro*



- 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

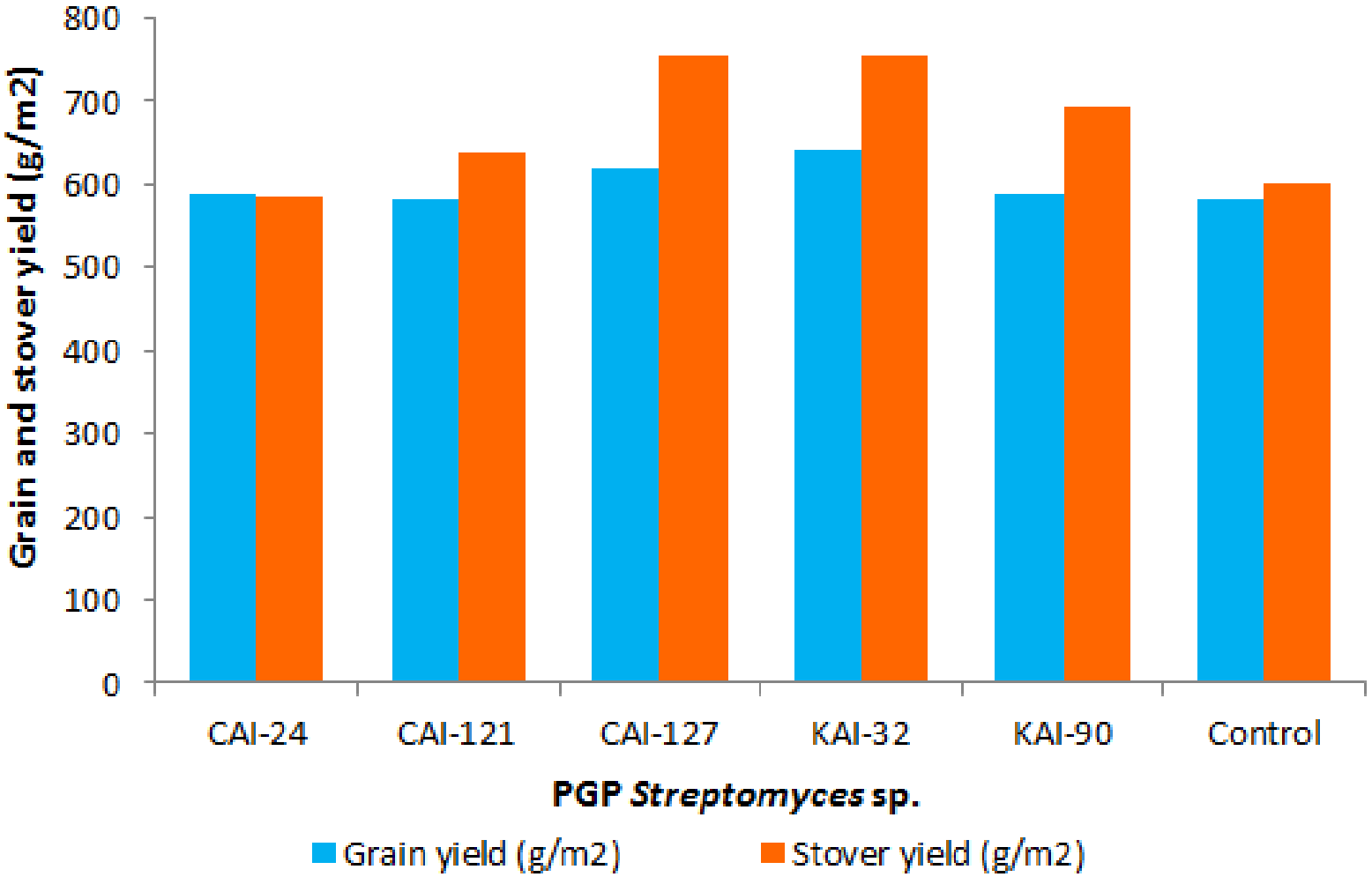
Plant growth promotion - Rice

At harvest



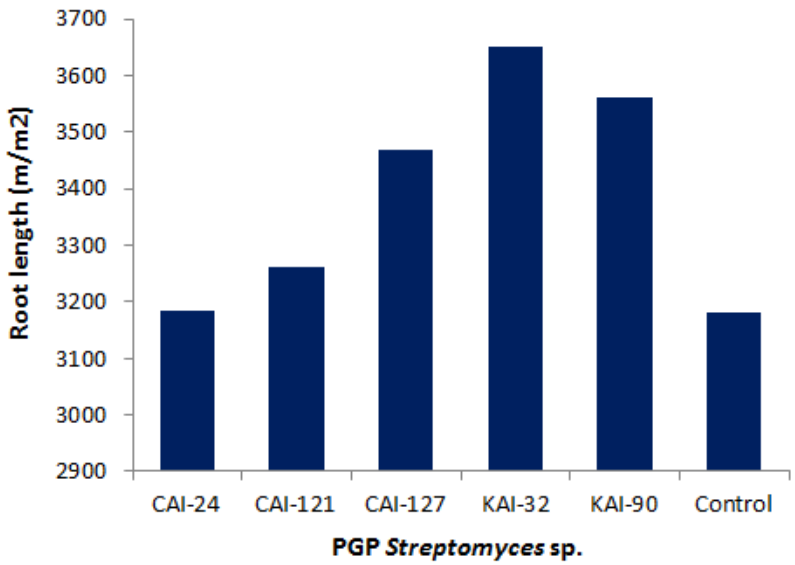
Tiller number: 9-28%; **Panicle number: 5-18%**

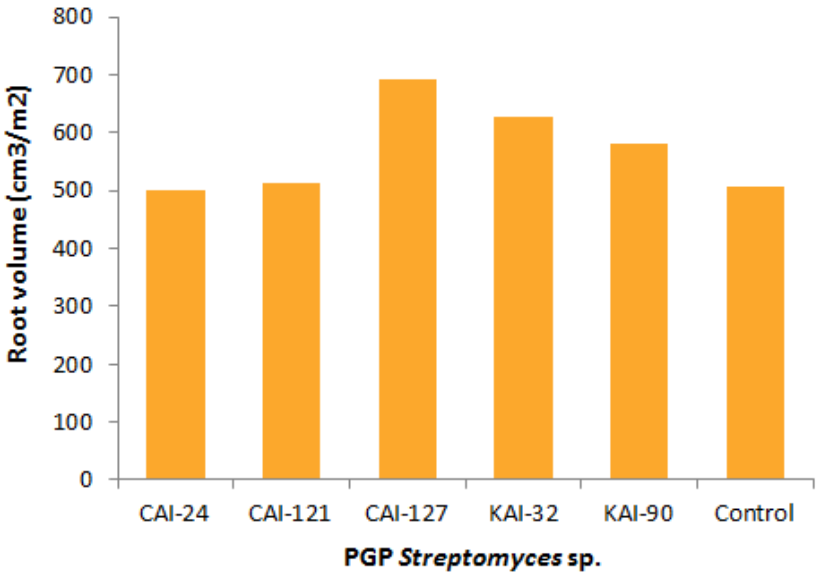
At harvest

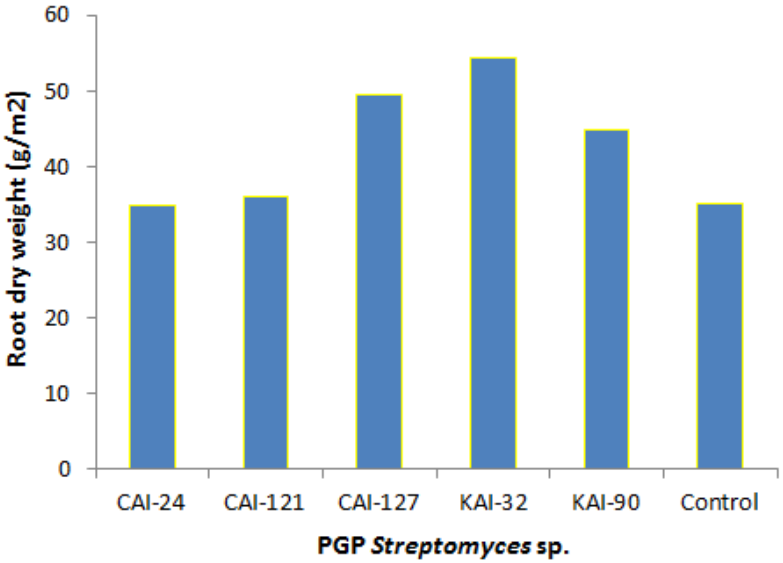


Grain yield: up to 10%; **Stover yield: up to 25%**

At harvest







Root length: 3–18%; Root volume: 2–19%; Root dry weight: 4–25%

Effect of PGP *Streptomyces* sp. on rhizospheric soil health

Isolates	MBC ($\mu g\ g^{-1}$ soil)	MBN ($\mu g\ g^{-1}$ soil)	DA (μg TPF g^{-1} soil 24 h^{-1})	Total N (g Kg^{-1} soil)	Available P (mg g^{-1} soil)	OC (%)
CAI-24	1715	60	94	2.45	0.133	1.49
CAI-121	3293	65	113	1.99	0.117	1.47
CAI-127	2875	88	194	2.64	0.115	1.52
KAI-32	4020	65	135	2.14	0.122	1.66
KAI-90	2946	62	136	2.16	0.129	1.62
Control	2861	58	111	1.19	0.087	1.47
LSD	520.7	12	29.7	0.229	0.019	0.116
CV%	9	10	12	4	6	3

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%

Gopalakrishnan *et al. SpringerPlus* 2013, **2**:574
http://www.springerplus.com/content/2/1/574

SpringerPlus
a SpringerOpen Journal

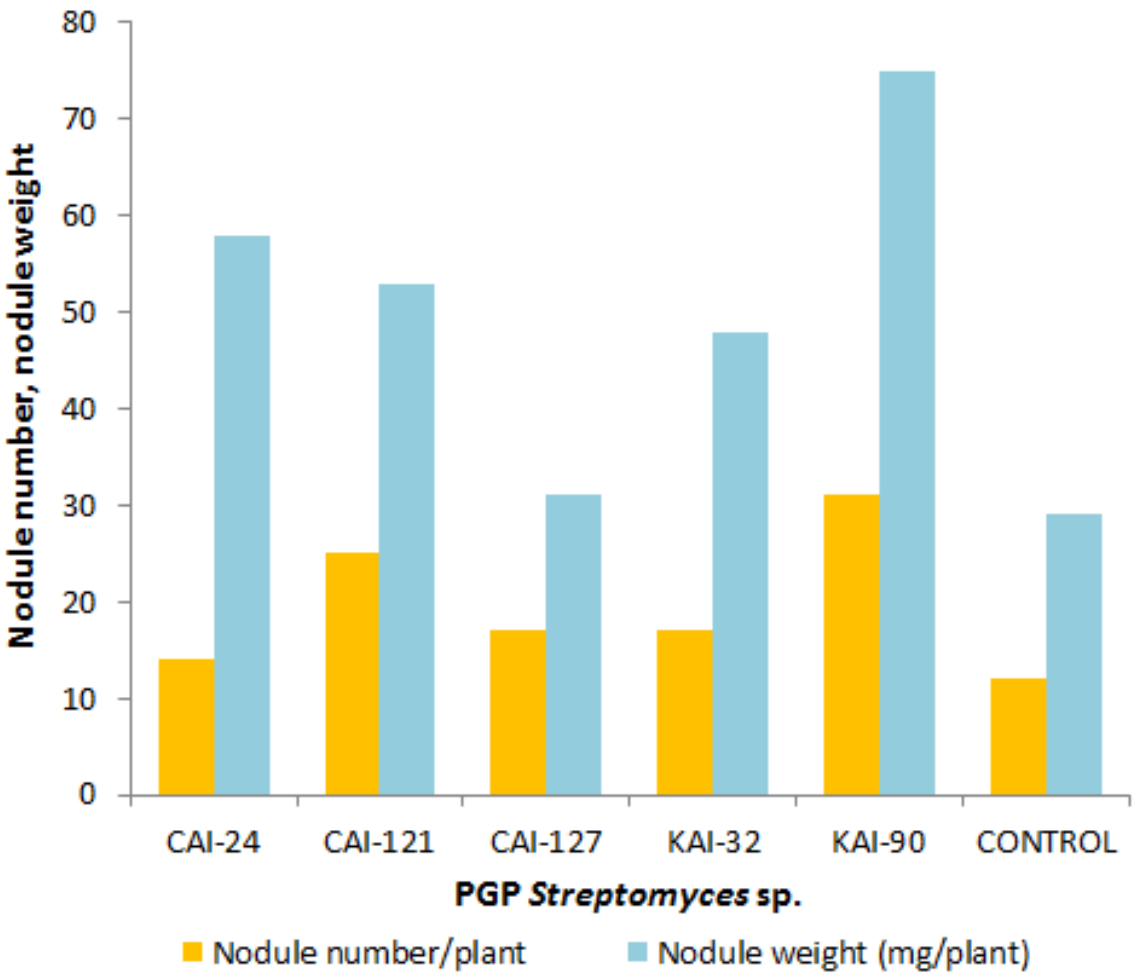
RESEARCH **Open Access**

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

Subramaniam Gopalakrishnan*, Vadlamudi Srinivas, Meesala Sree Vidya and Abhishek Rathore

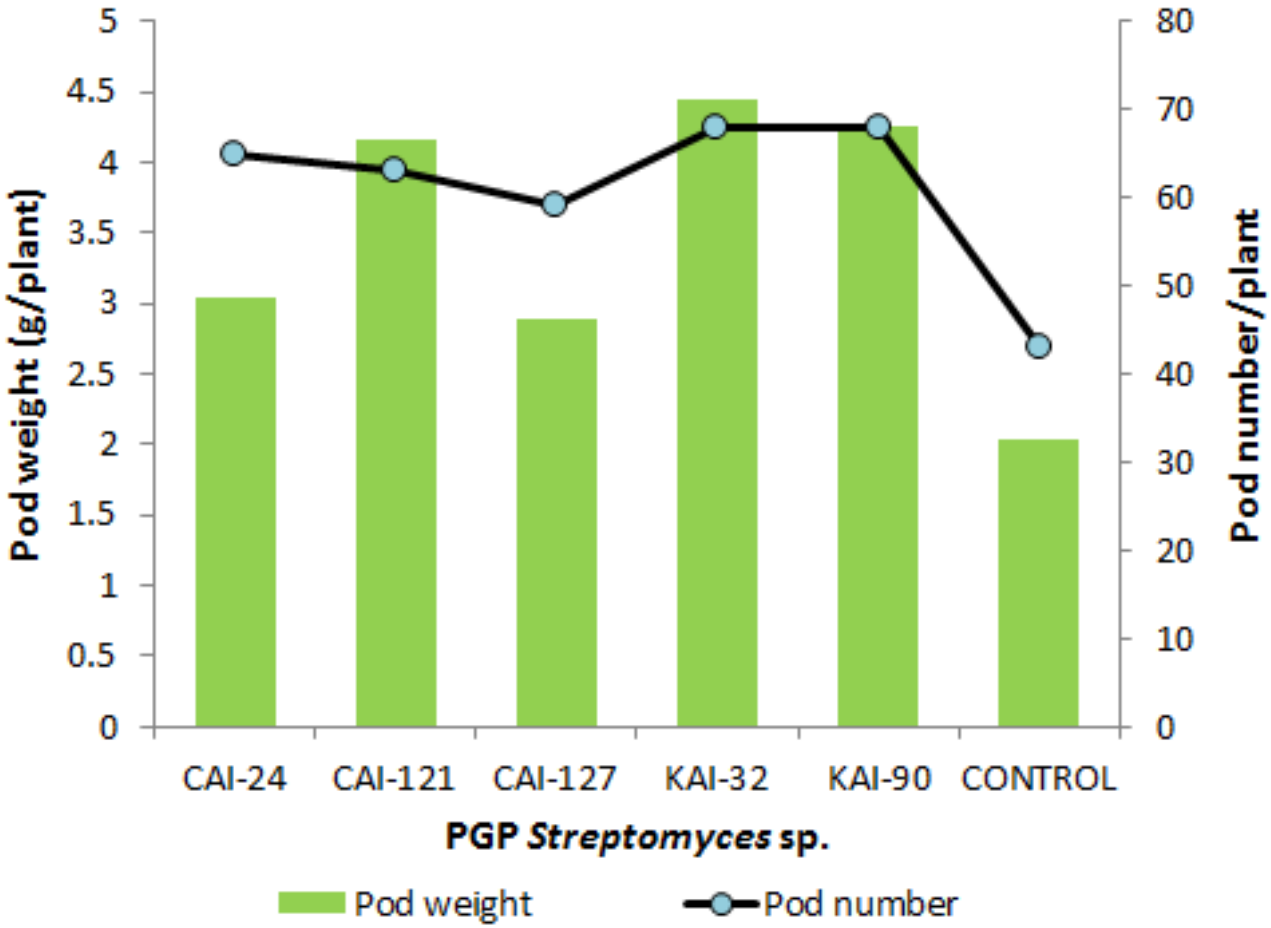
Plant growth promotion - Chickpea

At 30 DAS



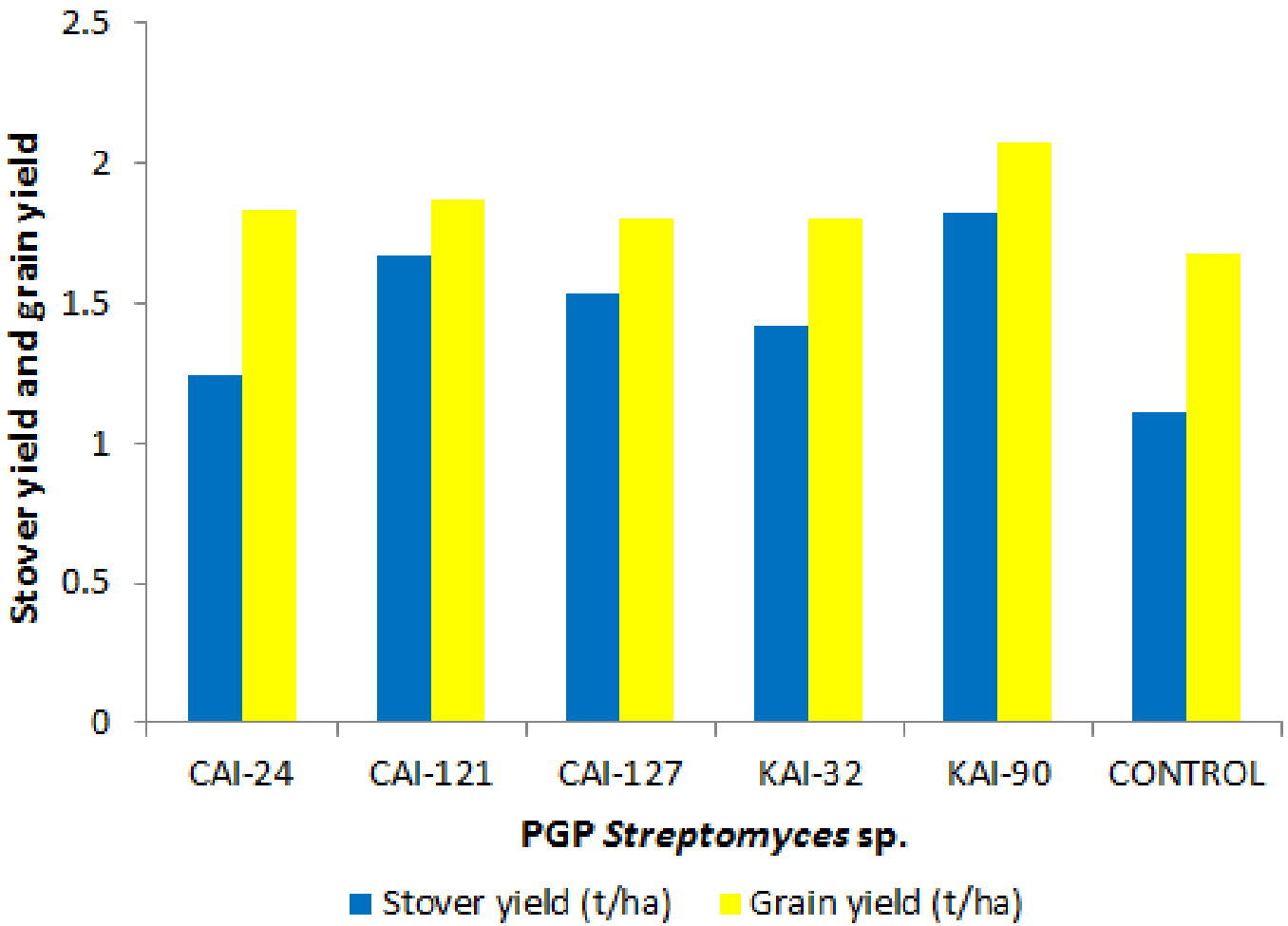
Nodule number and nodule weight: up to 150 %

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%**

At harvest

Effect of PGP *Streptomyces* sp. on rhizospheric soil health

Isolates	MBC (µg g^{-1} soil)	DA (µg TPF g^{-1} soil 24 h^{-1})	Total N (ppm)	Available P (ppm)	OC (%)
CAI-24	1041	71.1	668	10.3	0.5
CAI-121	1157	58.9	667	11.1	0.54
CAI-127	1070	59.1	644	19.3	0.52
KAI-32	1430	58.8	642	17.8	0.5
KAI-90	1134	62.7	701	10.9	0.49
Control	752	53.1	632	10.1	0.47
LSD	231	2.4	27.7	0.88	0.019
CV% (0.05)	8	3	2	3	2

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%

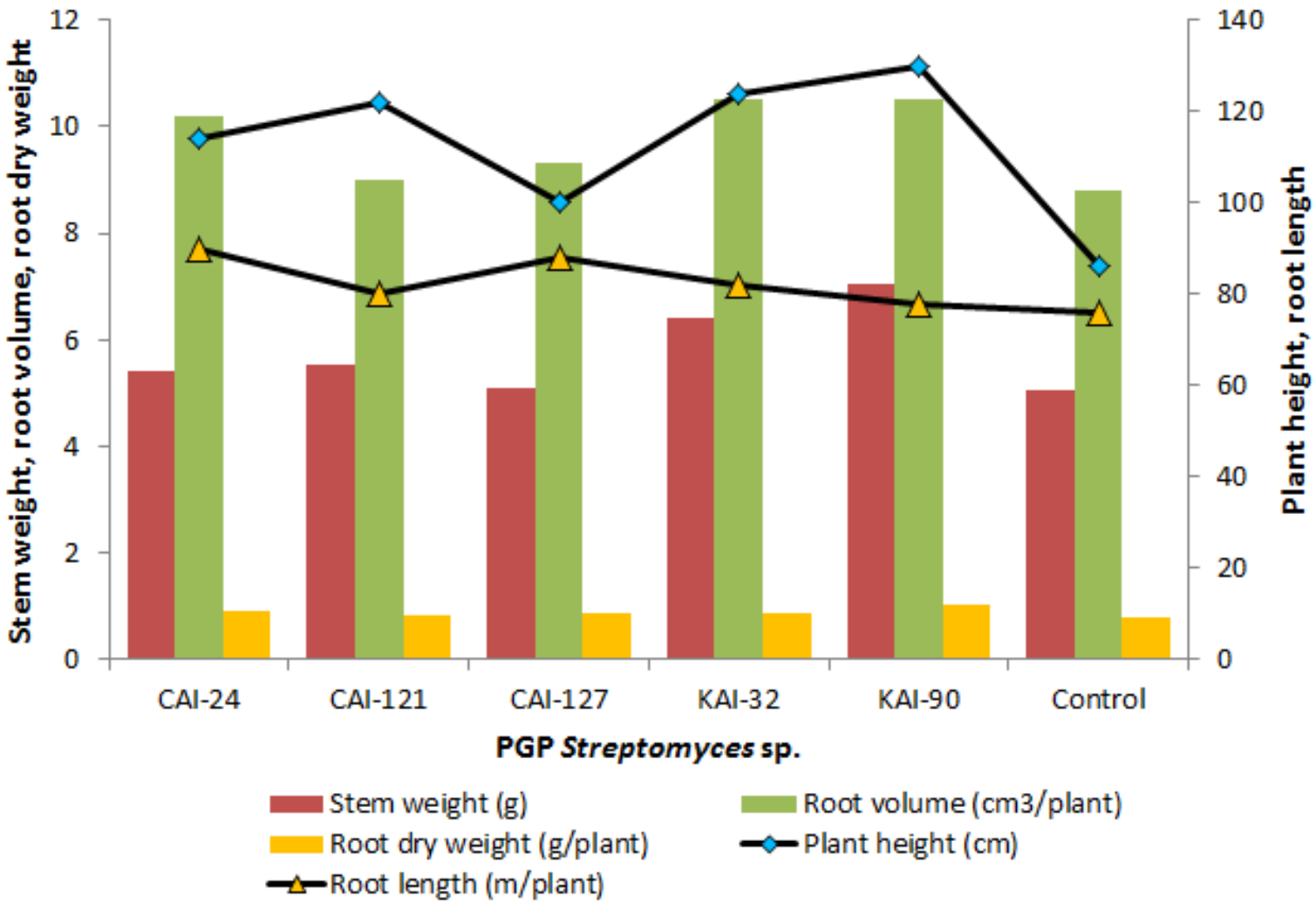
Org. Agr.
DOI 10.1007/s13165-015-0099-1

Evaluation of *Streptomyces* sp. obtained from herbal vermicompost for broad spectrum of plant growth-promoting activities in chickpea

S. Gopalakrishnan · V. Srinivas · G. Alekhya · B. Prakash · H. Kudapa · R. K. Varshney

Received: 18 December 2014 / Accepted: 11 February 2015

Plant growth promotion - Sorghum

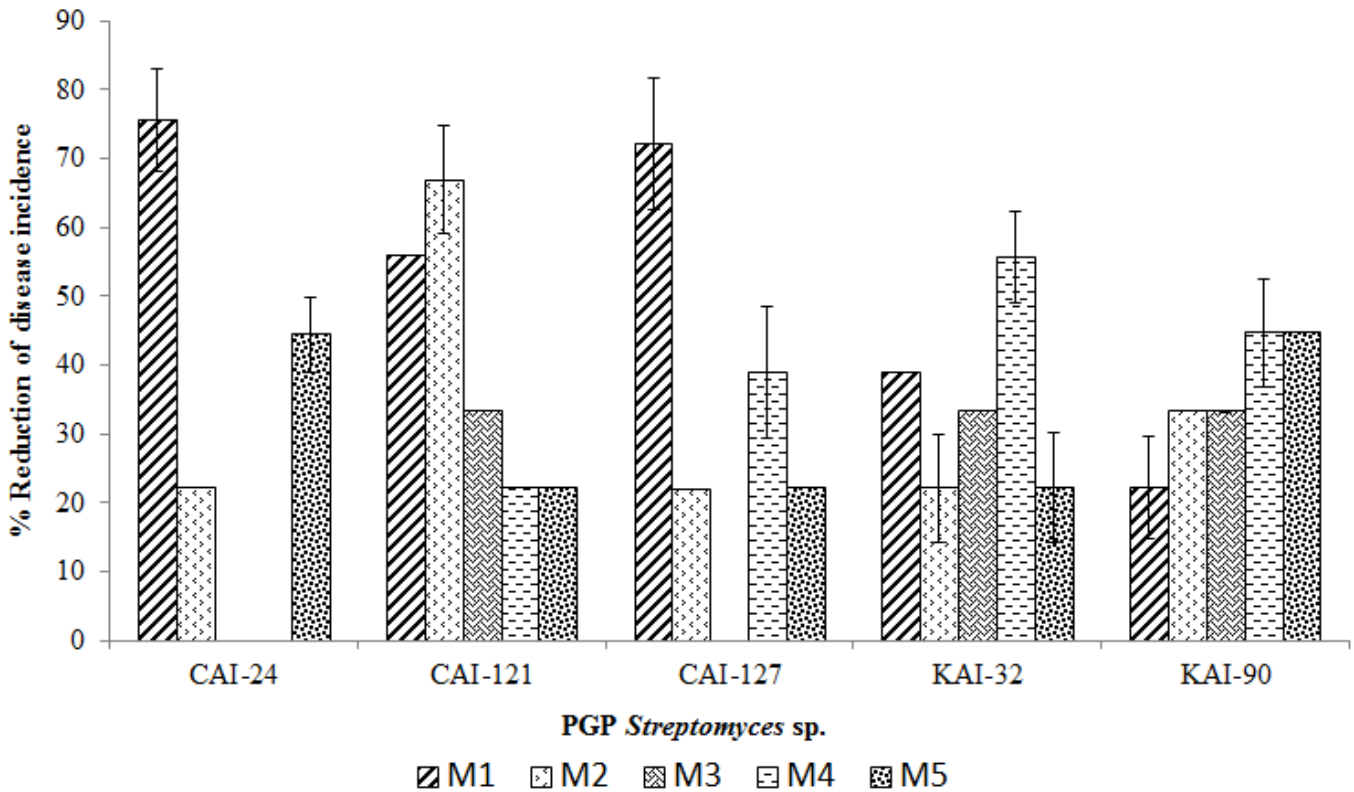


Plant height - 51%; stem weight - 39%; root length - 18%; root volume - 9%; root dry weight - 25%

Biocontrol – *Fusarium* wilt

PGP *Streptomyces* against FOC on chickpea JG-62 under greenhouse

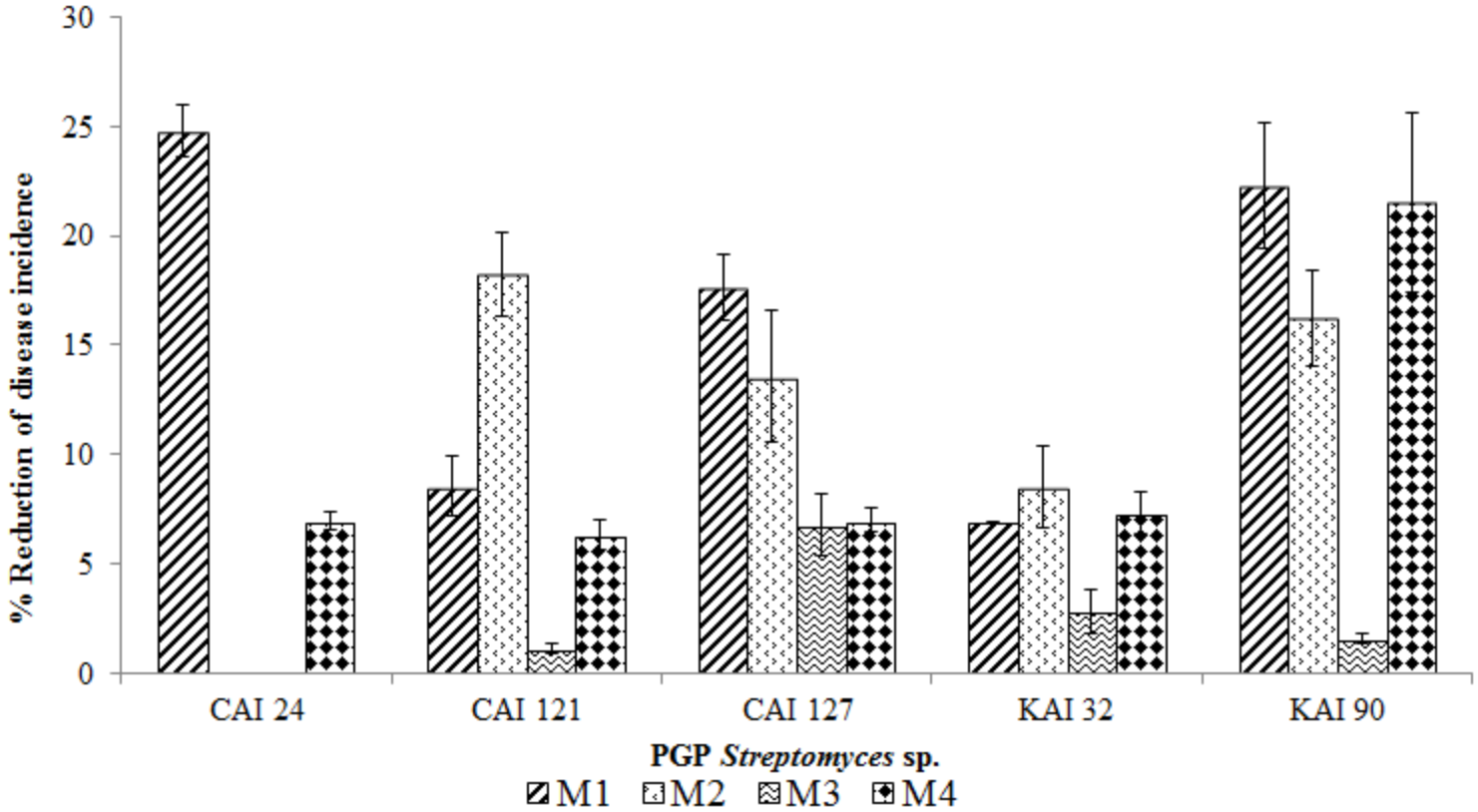
- **21-76% reduction of DI at 29 DAS**
- **Reduced DI: CAI-24 < CAI-127 < CAI-121 < KAI-32 < KAI-90**



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}]

PGP *Streptomyces* against FOC on chickpea JG-62 under wilt sick plots

- **Reduced DI: KAI-90 > CAI-127 > CAI-121 > KAI-32 > CAI-24**
- **Reduced disease incidence: 3-25% at 24 DAS**



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}).

Crop Protection 30 (2011) 1070–1078

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

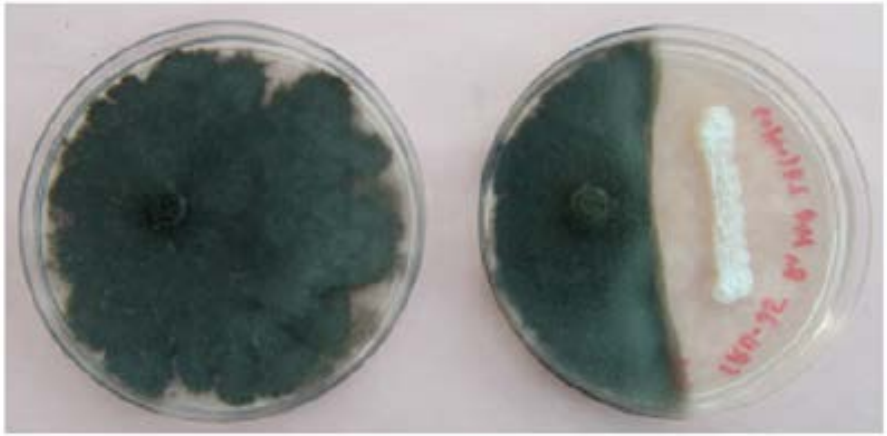
Evaluation of actinomycete isolates obtained from herbal vermicompost for the biological control of *Fusarium* wilt of chickpea

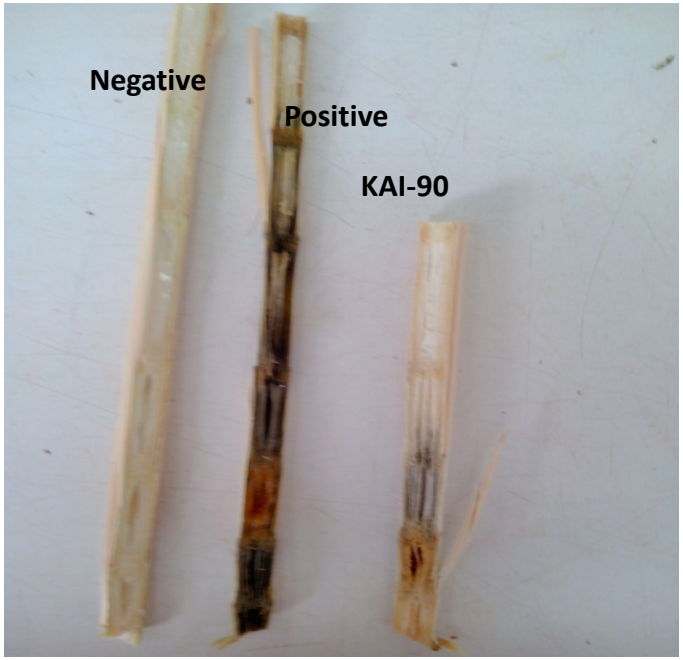
Subramaniam Gopalakrishnan*, Suresh Pande, Mamta Sharma, Pagidi Humayun, Bandru Keerthi Kiran, Dasyam Sandeep, Meesala Sree Vidya, Kanala Deepthi, Om Rupela

Global Theme-Crop Improvement, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, 502 324 Andhra Pradesh, India

Biocontrol – Charcoal rot

PGP *Streptomyces* against *Macrophomina phaseolina* under green house

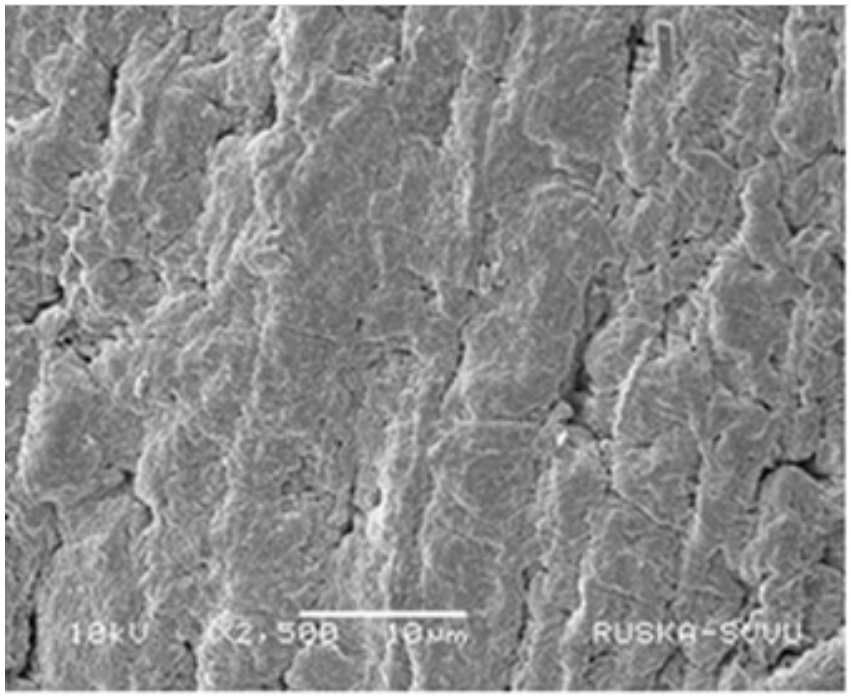




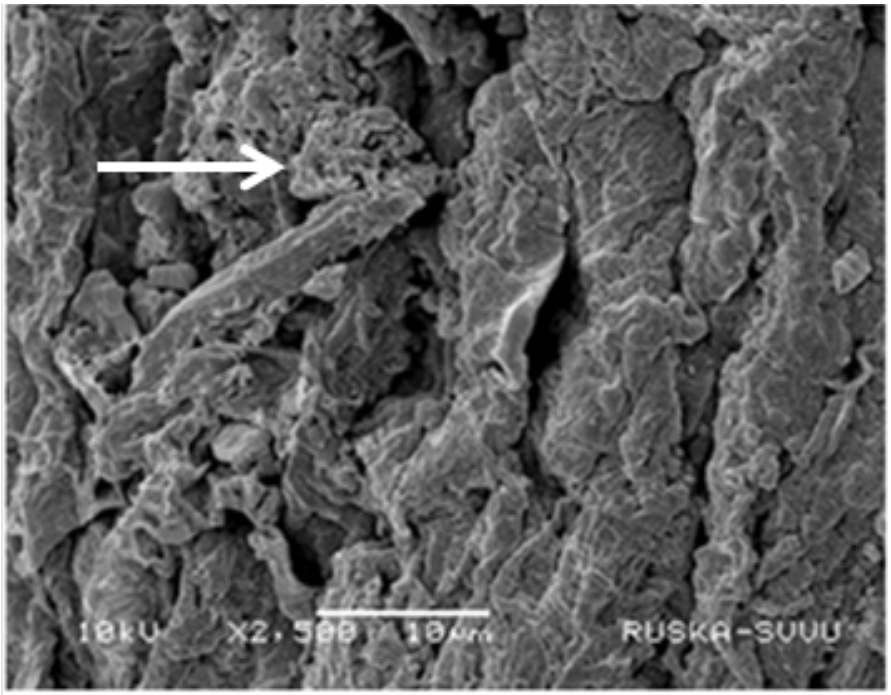
- **Inhibitory activity on *M. phaseolina* by PGP *Streptomyces sp.*, by dual culture assay**
- **Extension of charcoal rot reduction: 20–81%**
- **Highest reduction by *Streptomyces sp.*, KAI-90**

Plant growth promotion mechanisms

Colonization capacity of PGP actinomycetes on chickpea roots



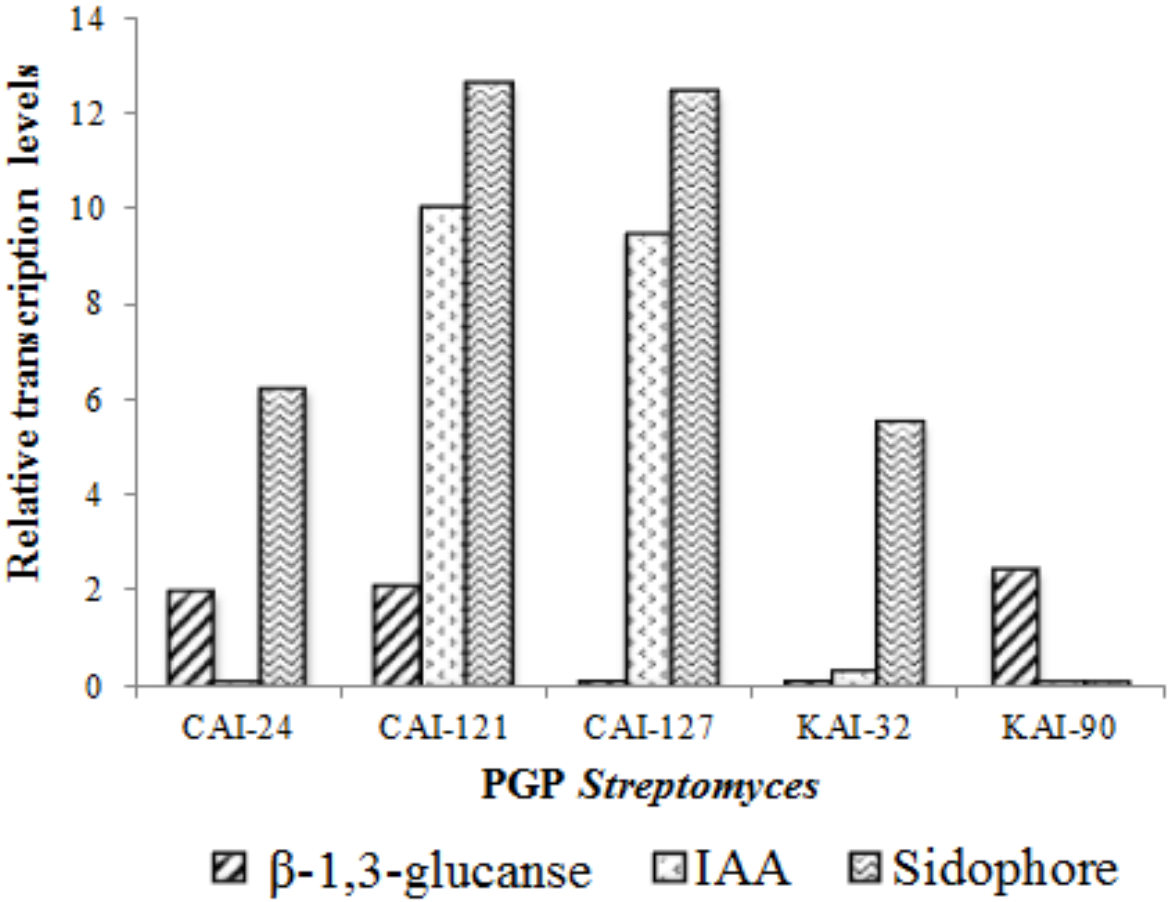
Control



KAI-90

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-glucanse (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 green house 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

- This work was undertaken as part of the CGIAR Research Program on Grain Legumes. ICRISAT is a member of CGIAR Consortium.

- I, place my sincere thanks to Drs. S. Gopalakrishnan, Hari K. Sudini and Rajiv K Varshney for helping in all the ways for attending and presenting in the 4th Asian PGPR Conference for Sustainable Agriculture.

Thank you