

ABSTRACT

Three rhizobacterial strains i.e., *Serratia sp.*, *Paenibacillus polymyxa* and *Pseudomonas fluorescens* were examined *in vitro* for achieving the traits that being related to plant growth promoting effects as well as, two pot experiments were carried out to study the impacts of rhizobacterial co-inoculation on growth and productivity of lupine or chickpea plants under sand soil conditions infested with *Fusarium solani* or *Rhizoctonia solani*, respectively. Rhizobacterial strains were applied either singly or combined with nodulating *Bradyrhizobium* (lupine) or *Mesorhizobium* (chickpea) plants or as mixed inoculants. The qualitative assay revealed that the tested PGPRs expressed variable magnitudes of PGP-related properties with superiority of *P. polymyxa* and *Serratia sp.* in IAA, cyanide, siderophores, chitinase and protease production as well as P-solubilization and fungal antagonistic effect. The quantities of IAA by rhizobacteria were 12.0, 13.5, 14.01, 21.8 and 26.5 µg/ml synthesized by *Mesorhizobium ciceri*, *Bradyrhizobium sp. (lupinus)*, *P. polymyxa*, *Serratia* and *Ps. fluorescens*, respectively. Concerning the damping-off of lupine and chickpea plants caused by *Fusarium* and *Rhizoctonia*, respectively, results revealed that all tested co-inoculants had ability to suppress the pre and post emergence damping-off for the two plants, particularly *Serratia in vivo*. Furthermore, there is significant depression occurred in the nodulation, growth aspects and yield of lupine and chickpea plants due to artificial infection with pathogens under investigation. However, co-inoculation approach resulted in improving the nodulation status and plant vigor and consequently the productivity of lupine and chickpea plants. Moreover, co-

inoculants which comprised *Bradyrhizobium* or *Rhizobium* with *Serratia* exhibited superiority for hastening all parameters under investigation.

Key Words: PGPR, *Bradyrhizobium*, *Rhizobium*, *Serratia* sp., *Paenibacillus polymyxa*, *Pseudomonas fluorescens*, Co-inoculation, Lupine, Chickpea, *Fusarium solani* and *Rhizoctonia solani*.

CONTENTS

	Page
1. INTRODUCTION	1
2. REVIEW OF LETRATURE	3
2.1. Plant growth promoting rhizobacteria (PGPR)	4
2.2. Mechanisms of PGPR	5
2.2.1. Mechanisms of Promotion (Direct effects)	5
2.2.1.1. IAA Production	5
2.2.1.2. Siderophores production	9
2.2.1.3. Phosphate solubilization	11
2.2.2. Mechanisms of bio-controlling (indirect effects).....	13
2.3. Biological nitrogen fixation	16
2.4. Enhancement of legume-rhizobia symbiosis via co-inoculation with PGPR	20
3. MATERIALS AND METHODS.....	25
3.1. Materials.....	25
3.1.1. Microbial organisms and inoculum preparations	25
3.1.2. Culture media	28
3.1.3. Soil used	33
3.2. Methods	33
3.2.1. Assay of rhizobacteria activities in	

<i>in vitro</i>	33
3.2.1.1. Detection of indole acetic acid production	33
3.2.1.2 Detection of hydrogen cyanide	35
3.2.1.3. Phosphate solubilization	35
3.2.1.4 Siderophores production	35
3.2.1.5. Detection of chitinase enzyme production	35
3.2.1.6. Detection of protease enzyme production	36
3.2.1.7. Antibiosis against fungal pathogen	36
3.2.1.8. Relationship amongst the tested rhizobacteria on the synthetic media	36
3.3. Evaluation of rhizobacteria as plant growth promoting and bioprotecting rhizobacteria in <i>in vivo</i>	37
3.4. Analytical methods.....	38
3.4.1. Soil analysis	38
3.4.2. Plant materials	39
3.4.2.1. Chlorophyll contents	39
3.4.2.2. Root surface area	39
3.4.2.3. Nitrogenase enzyme activity	40
3.5. Statistical analyses	40
4. RESULTS AND DISCUSSION.....	41
4.1. <i>In vitro</i> characteristics of some rhizobacteria concerning the promotion of plant growth	41

4.1.1. IAA production	41
4.1.2 Cyanide production	45
4.1.3. Phosphate solubilization	47
4.1.4. Siderophores production	49
4.1.5. Assessment of chitinolytic and proteolytic activities	51
4.2. Exploitation of rhizobacteria as bioagents under in vitro and in vivo conditions	54
4.2.1 <i>In vitro</i> assessment	55
4.2.2. Relationship amongst the tested rhizobacteria on the synthetic media.....	58
4.2.3 In vivo testing of suppressive ability of rhizobacteria against the damping-off of lupine and chickpea plants	60
4.3. Influence of co-inoculation with <i>Bradyrhizobium</i> and some rhizobacteria on lupine plants (<i>Lupinus albus</i>) grown in infected and uninfected sandy soil	63
4.3.1. Nodulation status:	63
4.3.2. Growth aspects	69
4.3.3. Nitrogen and phosphorus contents	77
4.3.4. Lupine yield and its components	82
4.4. Influence of rhizobacterial co-inoculation on the chickpea-rhizobia symbiotic system in absence or presence of artificial infection with <i>Rhizoctonia solani</i>	

under sandy soil conditions	89
4.4.1. Nodulation status	89
4.4.2. Growth aspects	94
4.4.3. Nutrient status of chickpea.....	103
4.4.4. The yield and other related components..	109
5.SUMMARY.....	119
6.REFERENCES.....	125
ARABIC SUMMARY.....	

LIST OF ABBREVIATIONS

ADP	Adenosine di phosphate
ATP	Adenosine tri phosphate
CAS	Chrome-azurol S
DCP	Di calcium phosphate
HCN	Hydrogen cyanide
HDTMA	Hexa- decyl trimethyl ammonium bromide
IAA	Indole-3-acetic acid
IPM	Integrated pest manager
ISR	Induced systemic resistance
LB	Luria- Bertani
LCO	Lipo-chitooligosaccharide analogue
NPR	Nodulation promoting rhizobacteria
PBPR	Plant bioprotecting and promoting rhizobacteria
PDA	Potato dextrose agar
PGPBR	Plant growth promoting and bioprotecting rhizobacteria
PGPR	Plant growth promoting rhizobacteria
PSM	Phosphate solubilization microorganisms
RZT	Root zone temperature
TPF	2,3,5- triphenyl formazane
TTC	2,3,5-triphenyle triphenyl tetrazolium chloride
