Novel PGPR isolated from Cactaceae growing in Tehuacán-Cuicatlán

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Introduction. Plant and bacteria interplay in all gradations ranging from commensalism to parasitism. Rhizosphere bacteria that directly or indirectly improve plant growth are defined as Plant Growth-Promoting Rhizobacteria (PGPR) (1). The Tehuacán-Cuicatlán Valley is a semi-arid region comprising around 10 000 km^2, it was declared natural reserve because of its important diversity and endemism of cactus species (2). The reserve harbors 9.5% of the Mexican Cactaceae (3), with 28 species endemic of the valley (4). In this study several isolates from the rhizosphere of *Mammillaria carnea*, *Stenocereus stellatus* and *Opuntia pilifera* were obtained, characterized and screened for their plant growth promoting activities in vitro and their effects on plant growth were registered.

Methods. Isolation was intended in TY and Nfree media, with rhizosphere samples of the three cacti listed above. Isolates were grouped by DGGE-based ribotyping and the most abundant ribotypes were selected to test their PGPR traits. Among them: the effect of bacterial inoculation on development of cacti seedlings, the production IAA and organic acids, phosphate dissolution and presence of ACC deaminase (*acdS*) following previously described protocols (5, 6).

Results. 75 bacterial strains were obtained in both media. After ribotyping and 16S rDNA sequence analysis 14 genera were recognized. The most represented bacterial genera in the three cacti rhizosphere were *Ochrobactrum, Burkholderia* and *Leifsonia.* Strains listed on Table 1 were inoculated on seedlings of the three cacti, development was assessed by weighting and sizing roots and shoots and their respective ratios. Statistical analyses were performed to all combinations of parameters, strains and cactus species. Data were analyzed using analysis of variance (ANOVA) and a Dunnett´s test ($P<0.05$) Significant effects on *S. stellatus* root size was observed. Post hoc comparisons showed that only *O. lupini* (F17) and *Burkholderia* sp. (F26) increase the root size of *S. stellatus* compared with non-inoculated seedlings. Meanwhile, shoot weights of *M.* carnea were increased by the inoculation of *Burkholderia* sp. (F7), contrasted with control seedlings. Moreover, *O. lupini* (F1) and *Burkholderia* sp. (F7) showed a positive effect on the shoot size of *M.* carnea matched with control . Finally, no strain showed a positive effect on *O. pilifera* development. When the ratios of weigth/size were analyzed *Burkholderia* sp. (F26) showed a positive effect on *O. pilifera* shoots. Also *Burkholderia* strains F7 and F13 and *O. lupini* (F15) exhibited a beneficial effect on *M. carnea* shoots.

Table 1. The PGPR traits of selected cacti rhizobacteria

Bacterial isolate	IAA prodt (μgml^{-1})	P. sol. (μgml^{-1})	*acdS* detec.	*Organic acids**
Ochrobactrum lupini (F1)	11.1	69.8	-	M, L
Burkholderia sp. (F7)	0.4	68.0	+	G, M, L
Leifsonia shinshuensis (F10)	8.6	30.4	-	A, M, L
Burkholderia sp. (F13)	1.4	93.8	+	G, M, L
Ochrobactrum lupini (F15)	11.4	48.9	-	L
Ochrobactrum lupini (F17)	11.0	46.5	-	L
Ochrobactrum lupini (F19)	11.2	37.4	-	F
Ochrobactrum lupini (F22)	10.1	35.9	-	F
Burkholderia sp. (F26)	0.81	90.6	-	L

*Malonic (M), Gluconic (G), Lactic (L), Acetic (A), Formic (F)

Conclusions. All bacterial strains tested were able to solubilize phosphate and produce organic acids in a culture medium with insoluble calcium phosphate. Only strains belonging to genera *Ochrobactrum* and *Leifsonia* were IAA producers. While, *Burkholderia* strains were the only harboring *acdS* gene. Members of *Ochrobactrum* and *Burkholderia* genera can be postulated as PGPR on *M. carnea* and *S. stellatus*. So far, any strain belonging to these genera has been proposed as PGPR in cactus.

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