

()

(Sinorhizobium meliloti)

*

(/ / : // :)

()

H.M.

(...)

(**p<0.05**)

(%)

/

:

...

() ()
()) ()
() () ()

()) ()

() ()

()

()
) ()
() ()
()

()

()

)

()

(

()

SAS

Excel 97

(S. E.)

:()

()

$$S.E = \frac{A-B}{C-D} \times 100$$

(Plant Infection Test)

- = A
- = B
- = C
- = D

()

()

4. Symbiotic Effectiveness

1. Bioremediation

HgCl₂

3. Nitrogen Free Plant Nutrition Solution (NFPNS)

. () H. M.	
()	
NaH ₂ PO ₄	
NH ₄ Cl	()
MgSO ₄ .7H ₂ O	
CaCl ₂ .2H ₂ O	HEPES H. M.
FeCl ₃ .6H ₂ O	.(, ,) MES
Na ₂ SO ₄	
MES	
HEPES	

)	
cellml ⁻¹) (CdCl ₂)
	H. M.	(
	H. M.	.()
pH	/	NaOH
		PSI
- (Tolerant)	(/
		(
(Partially Tolerant)	(H. M.
(Sensitive)	(H.M.

...

:

. ()

MRL

(P < /)

()

Minitab

()

()

()

(%)

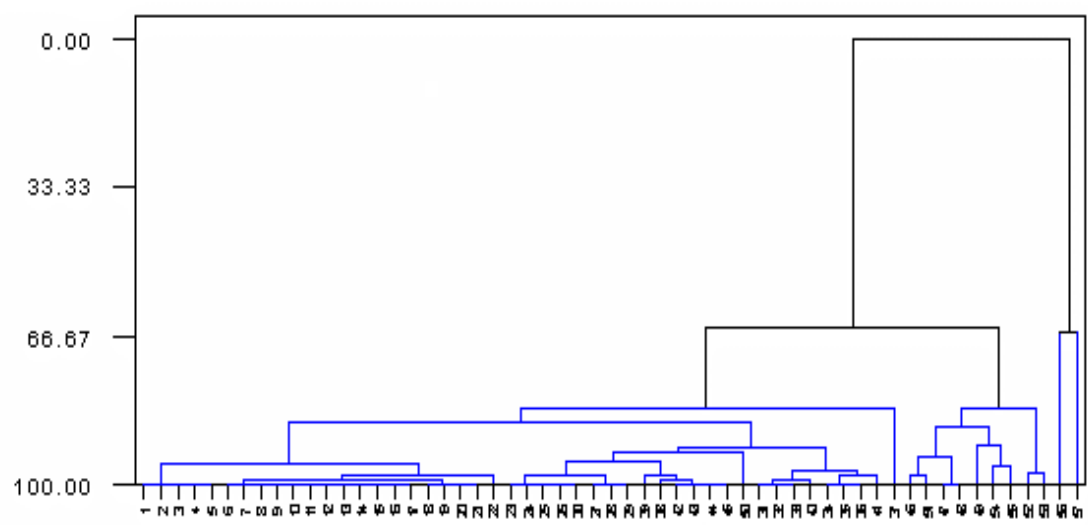
()

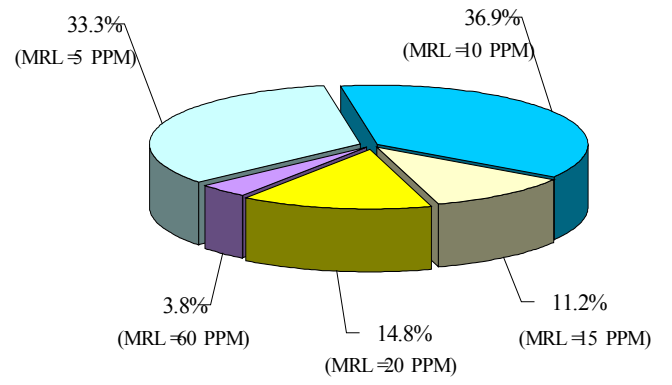
! ()

/

1. Maximum Resistant Level

/ /





()

()

()

:

pH
()

()

)

(

»

// «

REFERENCES

1. Alloway, B. J. 1990. Heavy metals in soils. Blackie and Son Ltd.
2. Angle, J. S. & R. L. Chaney. 1991. Heavy metal effects on soil population and heavy metal tolerance of *Rhizobium meliloti*, nodulation and growth of alfalfa. *Water, Air and Soil Pollution*, 57-58: 597-604.
3. Angle, J. S., P. S. Mc Grath & M. A. Chaudri. 1992. Effects of media components on toxicity of Cd to rhizobia. *Water, Air and Soil Pollution*. 64: 627-633.
4. Balsalobre, C., J. Calonge., E. Jimenez., R. Lafuente., M. Mourino., M. T. Muno., M. Riquelme & J. Mas-Castella. 1993. Using the metabolic capacity of *Rhodobacter sphaeroides* to assess heavy metal toxicity. *Environmental Toxicology and Water Quality*, 8: 437-450.
5. Beck, D. P., L. A. Materun & F. Afandi. 1993. Practical Rhizobium-legume Technology Manual. Technical Manual, No: 19, ICARDA. Syria.
6. Berdicevsky, L., L. Duek., D. Merzbach & S. Yannai. 1993. Susceptibility of different yeast species to environmental toxic metals. *Environmental Pollution*, 80: 41-44.
7. Brown, P. E. & Mingen G. A. 1916. The effect of some manganese salts on ammonification and nitrification. *Soil Science*, 1:67-85.
8. Collins, Y. E. & G. Stotzky. 1989. Factors affecting the toxicity of heavy metals to microbes. PP. 31-90. In: Beveridge T. J. & R. J. Doyle (eds.). *Metal ions and bacteria*. John Wiley and sons. New York.
9. Dean-Ross, D. 1991. Effects of combined treatments of zinc and pH on attached bacterial abundance and activity. *Can. J. Microbiol.*, 37: 491-496.
10. Et-Aziz, R., J. S. Angle & R. L. Chaney. 1991. Metal tolerance of *Rhizobium meliloti* isolated from heavy-metal contaminated soils. *Soil Biol. Biochem.*, 23: 795-798.
11. Freedman, B. & T. C. Hutchinson. 1980. Effects of smelter pollutants on forest litter decomposition near a nickel copper smelter at Sudbury, Ontario. *Canadian Journal of Botany*, 58: 1722-1736.
12. Gadd, G. M. 1986. In H. Eccles and S. Hunt. (eds.) *Immobilization of ions bio-sorption*, Cheichester, Ellis Horwood, PP.135-147.
13. Gadd, G. M. 1986. In R. A. Heerbert and G. A. Codd. (eds.). *Microbes in Extreme Environments*, London, Academic Press, PP. 83-110.
14. Gadd, G. M. 1989. In: H. J. Rehm and G. Reed. (eds.). *Biotechnology. A comprehensive treatise*, Vol. 6b, Weinheim, VCH Verlagsgesellschaft.
15. Gadd, G. M. 1992. Metals and microorganisms: A problem of definition. *FEMS Microbial. Lett.*, 100: 197-204.
16. Giller, K. E., R. Nussbaum, A. M. Chaudri & S. P. Mc Grath. 1993. *Rhizobium meliloti* is less sensitive to heavy metal contamination in soil than *R. leguminosarum* bv. *trifolii* or *R. loti*. *Soil Biol. Biochem.*, 25: 273-278.
17. Giller, K. E., S. P. Mc Grath & P. R. Hirsch. 1989. Absence of nitrogen fixation in clover grown on soil subject to long-term contamination with heavy metals is due to survival of only ineffective Rhizobium. *Soil Biol. Biochem.*, 21: 841-848.

18. Ibekwe, A. M., J. S. Angle, R. L. Chaney & P. Van Berkum. 1998. Zinc and cadmium effects on rhizobia and white clover using chelator-buffered nutrient solution. *Soil. Sci. Soc. Am. J.*, 62: 204-211.
19. Johnston, A. E. & R. W. M. Wedderburn. 1974. The Woburn market garden experiment, 1942-69. I. A history of the experiments, details of the treatments and yields of the crops. Rothmasted Experimental Station Report for 1974, Part 2, PP.79-101. U.K.
20. Leita, L., M. de Nobili, G. Muhlba Chova, C. Mondini, L. Marchiol & G. Zerbig. 1995. Bioavailability and effects of heavy metals on soil microbial biomass survival during laboratory incubation. *Biol. Fertil. Soils*, 19: 103-108.
21. Lipman, C. B. & P. S. Burgess. 1914. The effects of copper, zinc, iron and lead salts on ammonification and nitrification in soils. University of California Publications in Agricultural Science, 1: 127-139.
22. Obbard, J. P. & K. C. Jones. 1993. The effects of heavy metals on dinitrogen fixation by *Rhizobium* in metal contaminated soils. *Environ. Pollut.* 79: 105-112.
23. Romandini, P., L. Tallandini., M. Beltramini., B. Salvato & M. Manzanom. 1992. Effects of copper and cadmium on growth, superoxide dismutase and catalase activities in different yeast strains. *Comparative Biochemistry and Physiology*, 103c, 255-262.
24. Schubert, K. R., N. T. Jennings & H. J. Evans. 1978. Hydrogen reactions of nodulated leguminous plants. *Plant Physiol.*, 61: 398-401.
25. Smith, S. 1990. Effects of sewage sludge application on soil microbial processes and soil fertility. Water Research Center Report No. FR0034. Foundation of Water Research, Marlow Bucks, U.K.
26. Strojan, C. L. 1978. Forest leaf litter decomposition in the vicinity of a zinc smelter. *Oecologia*, 32: 203-212.
27. Torslov, J. 1993. Comparison of bacterial toxicity tests based on growth, dehydrogenase activity and esterase activity of *Pseudomonas fluorescens*. *Ecotoxicology and Environmental Safety.*, 25: 33-40.
28. Tyler, G. 1975. Effect of heavy metal pollution on decomposition and mineralization rates in forest soil. PP. 217-226 In: *Heavy Metals in the Environment*, T. C. Hutchinson, A. L. Page and J. C. Loon (eds.), Canada.
29. Zahran, H. H. 1999. Rhizobium-legume symbiosis and nitrogen fixation under severe conditions and in an arid climate. *Microbiol. Mol. Biol. Rev.*, 63: 968-989.