

## Effect of Plant Growth Promoting Rhizobacteria on Tomato Diseases in an Integrated Management Program

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### ABSTRACT

Three rifampicin-resistant strains of *Bacillus* spp. (*B. subtilis* MI600, *B. subtilis* GBO3 and *B. amyloliquefaciens* IN937) were integrated in an intensive tomato management program that included mulch, drip irrigation and a forecasted fungicide spray program to improve fresh market tomato growth and productivity and reduce the intensity of diseases caused by *Alternaria solani*, *Septoria lycopersici* and *Pseudomonas cichorii*. *Bacillus* spp. population densities were  $10^4 - 10^6$  CFU g<sup>-1</sup> root during the seedling stage and dropped to less than  $10^3$  CFU g<sup>-1</sup> root during the flowering and fruiting stages when fungal and bacterial diseases were observed. Significant increases in plant height were observed in all *Bacillus*-inoculated tomato plants, however, foliar diseases incited by *A. solani* and *S. lycopersici* were not reduced. GBO3+IN937-inoculated plants were more susceptible to bacterial stem rot caused by *P. cichorii* than those inoculated with MBI600 or non-inoculated control plants. Plants grown on rye mulch had lower severity of foliar diseases and stem rot than those grown on plastic mulch. No significant increase in yield was induced by *Bacillus* spp. In a dry year, marketable yields were 64 and 32 ton/ha for plants grown under plastic and plant residue mulches, respectively. In a wet year, marketable yields were 10 and 23 ton/ha for plants grown under plastic and plant residue mulches, respectively.

### SUMMARY

The intensive management of tomato includes water management, use of black plastic mulch, and use of fungicides. Water management not only affects uptake and utilization of nutrients, but also the development of certain diseases, herbicide activation and quality and quantity of tomato production. Drip irrigation is one of the most common delivery systems, in which water under pressure flows through a pipe. Water deficiency during vegetative, flowering or fruiting stages results in yield reductions of 25, 52 and 43 % respectively (Rutledge *et al.* 1999). The use of black plastic mulch is widely accepted since plastic mulch controls weeds and reduces certain diseases, conserves moisture and increases quality and quantity of marketable fruit. The main disadvantage of the use of plastic is the expense associated with installation, removal and disposal of the black plastic (Rutledge *et al.* 1999). Mulching fresh market tomato with residue from the previous winter annual crop may be an alternative to plastic mulch to control weeds and reduce production costs and impact on the environment. The fact that the severity of foliar diseases in fresh market tomato is lower in plants grown under plant residue mulch compared with those grown on plastic mulch is also attractive (Mills *et al.* 2002). The most important fungal foliar diseases in Ohio are early blight (*Alternaria solani*) and septoria leaf spot (*Septoria lycopersici*). Management of foliar diseases of tomato is achieved by crop rotation, balanced nutrition, destruction of infected leaves, eradication

of weed or volunteer plants (Jones, 1997; Pitblado, 1994) and the use of fungicides. Amistar 80WG, Bravo Weather Stik, Dithane M45, Tanos 50DF, Kocide 2000, Manzate75DF, and Cabrio 20 WG are among the fungicides applied to manage foliar and fruit diseases, particularly early blight (*Alternaria solani*), septoria leaf spot (*Septoria lycopersici*), and anthracnose (*Colletotrichum gloeosporioides*, *C. coccodes*) on tomato.

The use of plant growth-promoting rhizobacteria (PGPR) represents a potentially attractive alternative disease management approach since PGPR have been reported to increase yield and protect crops simultaneously (Ramamoorthy *et al.* 2002; Raupach, 1998). PGPR have been reported to stimulate plant growth and improve stand under stress conditions (van Loon *et al.* 1998). Three strains of PGPR, *Bacillus subtilis* MBI600 (Microbio, Bolder, CO) and GBO3 (Gustafson, Inc., Plano, TX), and *Bacillus amyloliquefaciens* IN937 (Auburn University, Auburn, AL), have been reported to act as biological control agents against various plant pathogens in numerous field and vegetable crops (Martinez-Ochoa, 2000; Zehnder *et al.* 2000; Raupach, 1998; Ryu *et al.* 2000; EPA, 2004a,b). Plant disease control using PGPR has been variable across locations and crops; several factors may influence the ability of PGPR to affect plant growth parameters and disease suppression such as colonization (Bloemberg and Lugtenberg 2001; Benizri *et al.* 2001), soil moisture (Meikle *et al.* 1995), competition (Young *et al.* 1995), nutrients, inorganic compounds and plant-derived factors (Milner *et al.* 1995; Rodriguez and Pfender, 1997). These observations may help explain the variable effectiveness of PGPR in numerous studies. The goal of this study was to evaluate the effect of soil moisture and mulch type on PGPR colonization of tomato rhizospheres and subsequent effect on plant height, foliar diseases and yield of tomato. Our observations indicated that *Bacillus* spp. colonize tomato roots and act as PGPR, but under our conditions do not reduce the severity of foliar diseases. In fact, bacterial stem rot was higher in plants colonized by two of the *Bacillus* spp. strains than in the control or in plants inoculated by a third strain. The effect of mulch type on tomato yield was linked to weather conditions during this study; in a dry year, yields were higher for plants grown with plastic mulch than with rye residue mulch, while the opposite was true in a wet year.

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