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Combined application of dazomet and *Trichoderma asperellum* as an efficient alternative to methyl bromide in controlling the soil-borne disease complex of bell pepper

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ABSTRACT

Bell pepper (*Capsicum annuum*) is an important greenhouse crop in central Europe. However, due to its monoculture cultivation soil-borne pathogens, especially *Verticillium dahliae*, are a significant yield-limiting factor. Apart from treatment with methyl bromide (MB) phytopathogens can be controlled by several alternative soil treatments. However, a universal control agent such as methyl bromide does not exist and there is crop specificity with respect to efficient treatments. Thus, the efficacy of chemical (dazomet), biological (*Trichoderma asperellum*) and combination of both treatments in the control of soil-borne pathogens of bell pepper in comparison with MB was examined. In 3 consecutive years six demonstration trials were conducted on commercial farms in Poland. In five of the six trials, the application of MB resulted in the best control of Verticillium wilt. However, there were no differences between the AUDPC values of MB and dazomet (DZ) alone or DZ combined with *T. asperellum* B35. Among tested alternatives, the most consistent effect on the yield, as well as on control of the root rot disease complex and Verticillium wilt, was observed for treatment with DZ in combination with *Trichoderma asperellum*. The average increase in yield induced by this treatment (40.1%) was similar to that of MB (41.4%). There was a correlation ($r = 0.790$) between Verticillium wilt disease severity and root rot symptom scores at the end of the vegetation season. Verticillium wilt reduced fruit yield to a larger extent than the root rot associated with a complex of pathogenic soil-borne fungi (*Colletotrichum coccodes*, *Fusarium* spp.). Dazomet, combined with *T. asperellum*, provided the highest net marginal return and a higher return on investment than MB. The efficacy of *T. asperellum* applied alone was too variable (coefficient of variation 76%) to be accepted by the pepper growers.

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1. Introduction

After tomato and cucumber, bell pepper (*Capsicum annuum* L.) is the third most important greenhouse crop in Poland. It is grown on an area of about 1300 ha, almost exclusively in unheated plastic tunnels. In protected and open field cultivation of bell pepper, several soil-borne plant pathogens exhibit a very strong yield depressing potential. Among them, present at diverse pepper growing areas, the most important seem to be *Phytophthora capsici* Leonian, *Verticillium dahliae* Kleb., *Rhizoctonia solani* Kühn, *Fusarium* spp. and *Pyrenochaeta lycopersici* Schneider et Gerlach (Cartia et al., 1989; Douira et al., 1995; Tsror (Lahkim) et al., 1998; Ślusarski and Dobrzanska, 1999; Di Vito et al., 2000; Sonogo, 2003). In recent years, Verticillium wilt of pepper has become a significant yield-limiting factor in greenhouse production in Poland. This is associated with the tendency of monoculture of peppers in major cultivation regions (Ślusarski and Dobrzanska, 1999).

There are several pepper cultivars with fair to good levels of resistance to *P. capsici* but currently there are no commercially acceptable cultivars that are fully resistant to Verticillium wilt (Sonogo, 2003). In many pepper growing countries, soil fumigation is the primary method of controlling soil-borne diseases and nematodes, which can be attributed to the lack of suitable cultivars resistant to Verticillium wilt, and until 2005, the principal fumigant was methyl bromide (MB) (Cantlife et al., 1995; Lacasa et al., 2002; Lynch, 2002; MBTOC, 2002; Gullino et al., 2003). Since the implementation of the Montreal Protocol, alternative MB replacements that combine cultural practices, biocontrol agents and resistant

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