Effects of transplant type, plant growth-promoting rhizobacteria, and soil treatment on growth and yield of strawberry in Florida

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Abstract

The effects of transplant type and soil treatment on growth and yield of strawberries (*Fragaria x ananassa* Duch.) produced in annual hill culture were evaluated for three years in Florida field trials. ‘Sweet Charlie’ and ‘Camarosa’ strawberry transplants were propagated as bare root, plug, and plugs amended with a plant growth-promoting rhizobacterial (PGPR) treatment, LS213. The transplant treatments were evaluated in combination with methyl bromide, 1, 3-dichloropropene (Telone II), an unregistered iodine-based compound (Plantpro 45), and untreated soil. ‘Camarosa’ plugs amended with LS213 had higher overall yields than bare root transplants in all three years. Both ‘Camarosa’ and ‘Sweet Charlie’ plug and LS213 plug plants produced yields approximately two weeks earlier than bare root transplants in all years. Regardless of transplant type, and in both consecutive years of Plantpro 45 and Telone application, treatment with Plantpro 45 resulted in smaller and less healthy root systems than other soil treatments, and treatment with Telone resulted in yields comparable to methyl bromide.

Abbreviations: PGPR – plant growth-promoting rhizobacteria; 1, 3-D – 1,3-dichloropropene; MeBr – methyl bromide

Introduction

Methyl bromide has provided strawberry (*Fragaria x ananassa* Duch.) growers with reliable control of nematodes, weeds and soilborne pathogens since it was first reported to control Verticillium wilt in 1961 (Wilhelm et al., 1961). The loss of methyl bromide as a soil fumigant will significantly impact strawberry production in the United States, particularly in California and Florida where most strawberry growers rely exclusively on this broad-spectrum fumigant to disinfect soil prior to planting. In California, 42% of the total amount of methyl bromide used is for preplant soil fumigation in strawberries (CADPR, 2001), while 9% of the methyl bromide used in Florida is for this application (FASS, 1999).

Increased strawberry vigor and yield with methyl bromide fumigation has been demonstrated repeatedly (Yuen et al., 1991) and was recently quantified in Florida where production was reduced by 54% and 68% in consecutive years in nonfumigated compared to methyl bromide-fumigated soil (Chandler et al., 2001). Similar results, obtained in an area without high levels of lethal strawberry pathogens, were also observed in California (Fort et al., 1996) where strawberry vigor and fruit yield were substantially increased with methyl bromide fumigation without identifiable pathogen problems present. Important soilborne fungal pathogens of strawberry controlled by soil fumigation with methyl bromide formulations include *Phytophthora fragariae*, *P. cactorum*, *Colletotrichum acutatum*, and several species of *Verticillium* (Wilhelm, 1998). Black root rot is another important disorder believed to be caused by interactions among
several factors including fungal pathogens, nematodes and a variety of soil conditions (Wilhelm, 1998). In Florida, the most serious nematode parasite of strawberry currently controlled by fumigation is sting nematode (*Belonolaimus longicaudatus*).

In recent years, there has been considerable research on chemical alternatives to methyl bromide for strawberry production. These alternatives include 1,3-dichloropropene (1, 3-D), dazomet, chloropicrin, and metam sodium. However, certain issues surrounding alternatives remain unresolved, including performance inconsistencies, label restrictions regarding use, and the need for personal protective equipment to be worn in the field during application (Carpenter et al., 2001; Noling and Gilreath, 1998). Recent improvements in technology for broadcast application of 1, 3-D improved product performance and eliminated the need for personnel to be present in the field, thus minimizing issues regarding personal protective equipment (McAvoy, 2000). In order to implement effective chemical alternatives to methyl bromide, it will be necessary for growers to target specific pests and select the appropriate combination of control measures. It is likely that production systems including combinations of chemicals, as well as cultural and biological tactics, will be required to maintain strawberry yields at economically viable levels in the absence of methyl bromide.

Cultural and biological approaches that may be incorporated into strawberry production systems include modification of water use practices, application of biological control agents and reduced-risk chemicals, and incorporation of traditional or induced host resistance. One cultural practice typically used in strawberry production that has the potential to be modified to reduce chemical applications is the use of bare root transplants. Many serious strawberry root pathogens found in production fields often originate on planting material grown in soil (Butler et al., 2002). Also, establishment of bare root transplants in the field requires extensive use of overhead irrigation for several weeks after transplanting. These irrigation practices aggravate problems with many pathogens, leach preplant herbicides and fertilizer from soil, and increase weed pressure. The use of transplants produced in a soilless growth medium as plugs would eliminate some of the problems associated with the establishment of bare root transplants. Additionally, use of plugs would provide an alternative to methyl bromide fumigation of soil in strawberry nursery production, where it has been difficult to identify alternative fumigants that do not negatively impact runner plant production (Larson and Shaw, 2000). Other advantages of plug transplants over bare root transplants include improved stand establishment and plant vigor, and earlier flowering and fruit set (Morey, 2001; Sances, 2000). It has also been demonstrated that under stressful conditions, plug transplants produce higher yields than bare-root transplants (Waldo and Duval, 2001).

Transplant media as a means for introduction of biological agents is currently being investigated in a variety of crops. Kurze et al. (2001) evaluated a chitinolytic rhizobacterium, *Serratia plymuthica* strain HRO-C48, as a bare root transplant dip for strawberries and had good success in reducing disease caused by *Verticillium* and *Phytophthora* and increasing yields. Soil-less transplant media such as that used for production of strawberry plugs, amended with a formulation of plant growth-promoting rhizobacteria (PGPR) designated LS213 (Gustafson LLC, Plano, TX) has been shown to improve plant vigor, reduce disease severity and increase yield of tomato, pepper (Kokalis-Burelle et al., 2002), muskmelon and watermelon (Kokalis-Burelle et al., 2003) in Florida. LS213 contains the PGPR isolates *Bacillus subtilis* strain GBO3 and *Bacillus amyloliquefaciens* strain GB99 in a formulation that also includes chitin, an organic material previously shown to elicit low levels of resistance responses in tomato (Benhamou et al., 1998).

The objectives of this research were (1) to evaluate bare root, plug, and PGPR amended plug strawberry transplants for earliness and yield and (2) to evaluate the three transplant types in combination with methyl bromide alternative soil treatments. The objectives are examined for both ‘Camarosa’ and ‘Sweet Charlie’ cultivars, which currently constitute 70–90% of the strawberry acreage in Florida.

**Materials and methods**

**Experimental design**

Field trials were conducted in the fall of 1998, 1999, and 2000 at the Uniroyal Chemical Company Inc., Florida Research Station, Sanford, FL. Two trials were performed each year, one for ‘Sweet Charlie’ and one for ‘Camarosa’.

Experiments contained split plots with three subplots consisting of the three transplant types. Main plots consisted of two soil treatments in 1998, and