Grafting: An Integrated Approach for Soilborne Disease Management

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ABSTRACT

Due to the recent phaseout of methyl bromide, and strong domestic demand for sustainable pest management alternatives, interest in the use of tomato grafting has made a dramatic increase in the United States. This technology has been utilized in Asian horticultural practices since the early 20th century, and has been recognized as a prominent IPM approach in the Mediterranean. The objectives of this research were to devise a protocol for grafting, and develop a research-based body of knowledge as to how this practice can be implemented in the United States. Field research plots were initiated in 2005 and 2006 to investigate how grafting with resistant and highly vigorous rootstock could be utilized to decrease soilborne disease incidence and increase crop productivity for organic heirloom tomato production in the southeast. Grafting with resistant genotypes CRA 66 and Hawaii 7996 showed excellent resistance to bacterial wilt (caused by *Ralstonia solanacearum*). Rootstock-specific hybrids 'Maxifort' and 'Robusta' showed good control of fusarium wilt (caused by *Fusarium oxysporum* f. sp. *lycopersici*). Shoot biomass accumulation indicated that 'Maxifort' rootstock is able to functionally compensate for a lack of rotation in mountain production where verticillium wilt (caused by *Verticillium dahliae*, race 2) is prevalent. Preliminary work with alternative training systems has shown that the integrated use of grafting and "twin-heading" cultural techniques can have a synergistic effect in regards to crop productivity under little disease pressure from soilborne pathogens.

SUMMARY

Bacterial Wilt. Bacterial Wilt, caused by *Ralstonia solanacearum* is a problematic soilborne disease in many southeastern US crops including: tomato, potato, tobacco, and eggplant. This bacterium causes severe losses worldwide due to its wide geographic distribution and unusually broad host range, including more than 50 plant families (6). The pathogen is a soil inhabitant and is able to persevere in the soil environment through long crop rotations (7). The incidence and perseverance of bacterial wilt, caused by *Ralstonia solanacearum* has led to the abandonment of tomato production fields in eastern NC. Genetic resistance is available for BW, but fruit quality is often poor, resulting in small, unmarketable fruit (8). Heirloom cultivars are highly marketable, but resistance to most diseases, including bacterial wilt, is often poor. Field trials were implemented in 2005 and 2006 to investigate the efficacy of grafting susceptible heirloom cultivars onto resistant rootstock under naturally-infested field conditions. Heavy bacterial wilt disease incidence was observed among non-grafted controls (75% and 79% incidence in 2005 and 2006, respectively), and grafted treatments with resistant genotypes CRA 66 and Hawaii 7996 showed no symptoms of wilt in both years. Yields in 2005 were significantly higher in Hawaii 7996 rootstock treatments compared to non-grafted control (P=0.04). CRA 66 and Hawaii 7996 genotypes used as resistant rootstock for heirloom tomato production were highly effective at preventing bacterial wilt from endemic populations of *R. solanacearum* in eastern NC.

Fusarium Wilt. In 2006, field trials were implemented to determine the efficacy of using highly vigorous rootstock genotypes 'Maxifort' and 'Robusta' to increase crop productivity for organic heirloom tomato production. These trials were located at Peregrine Farms in Alamance County, NC and Maple Spring Gardens, in Orange County, NC. In the Alamance County trial, fusarium wilt, caused by *Fusarium oxysporum* f.sp. *lycopersici*, occurred unexpectedly throughout the field. The self-grafted and non-grafted controls were highly susceptible and generated similar terminal incidence values of 50% and 46%, respectively 'Maxifort' rootstock completely controlled the incidence of wilt and Robusta offered moderate control with a terminal incidence of 29%. Marketable yield and total yield were not impacted by fusarium wilt incidence. The use of highly vigorous rootstock in organic production was effective at managing fusarium wilt, caused by *Fusarium oxysporum* f.sp. *lycopersici*. The use of major resistance genes to manage this disease is well documented (4), but specific research regarding grafting with susceptible scion has not been seen. The 'Maxifort' treatment showed no symptoms of disease within the trial. 'Maxifort' is resistant to race 1 and 2 of *Fusarium oxysporum* f.sp. *lycopersici*, and 'Robusta' is resistant to race 2. This information suggests that the race endemic in the field trial was most likely race 1. Interestingly, 'Robusta' showed intermediate resistance to this pathogen, even though the 'Robusta plants' ultimately succumbed to fusarium wilt. The yield impact of grafting with 'Maxifort' and 'Robusta' showed no increase from the use of highly vigorous rootstock in a typical organic production system when grown under regionally-optimized production systems. Even under moderate disease pressure from *Fusarium oxysporum* f.sp. *lycopersici*, these rootstocks showed no yield increase. The fusarium wilt epidemic was not only slight, but was initiated late in the season. This is probably typical of many organic field production systems where crop rotation is employed.

Verticillium Wilt. Verticillium wilt is one of the most important soilborne diseases in the mountain growing regions of North Carolina, and is caused by *Verticillium dahliae* (race 2) (2). Endemic populations of this pathogen in the mountain region continue to plague growers as there is no genetic resistance available in tomato. Pathogenicity assays have shown reductions in plant growth even as early as the seedling stage (1,5), indicating the deleterious effect of the pathogen before symptoms occur aboveground. The reduction in plant growth ultimately leads to a poor platform for fruit production and can eventually cause plant death (3). Many breeders and plant pathologists have attempted to overcome the functional affects of this pathogen by developing lines that are highly vigorous, and can provide adequate nutrients and water before the pathogen overcomes the plant late in the season (Gardner, 2006-personal communication). Plant vigor was assessed through two destructive samplings throughout the 2006 growing season. On the first sampling date (35 DAT), continuous tomato production suppressed plant biomass accumulation compared to tomato plant growth observed in rotational plots (P=0.003). Maxifort rootstock enhanced plant growth compared to self-grafted and non-grafted controls (P=0.008). 75 days after transplanting, 'Maxifort' significantly improved plant growth compared to self-grafted and non-grafted controls within a given rotational management system (P=0.0003). Under continuous management, ‘Maxifort’ had similar or better plant vigor than non- and self-grafted treatments in a rotational production system. This dramatic compensation of ‘Maxifort’ is highlighted by plotting plant growth over time. The plant biomass accumulation of the self-grafted and non-grafted plants is limited between 35 and 75 days after transplanting, whereas biomass accumulation for plants on ‘Maxifort’ rootstock maintained a strong positive slope. Because the accumulation of biomass in the continuous ‘Maxifort’ treatment was similar to that of the rotational non-grafted treatment, these results suggest that the use of grafting with highly vigorous rootstock may be able to functionally compensate for a lack of rotation in field tomato production. Interestingly, the enhanced growth of the ‘Maxifort’ treatment within the continuous plots resulted in a lack of statistical significance (P=0.06) for this rootstock between main plots. This further suggests that the use of ‘Maxifort’ in a continuous production system will outweigh the affects of rotation alone. Grafting with highly vigorous rootstock lines may be an alternative way of managing verticillium wilt by giving the plant an elevated advantage over the pathogen in regards to plant growth.

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