Title

Studies on fresh-market tomato production in a plastic high tunnel in low-input alternative systems using cover crops and livestock compost [an abstract of dissertation and a summary of dissertation review]

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Studies on fresh-market tomato production in a plastic high tunnel in low-input alternative systems using cover crops and livestock compost

（緑肥と家畜堆肥を活用した低投入システムによるプラスチックハウス内での生食トマト生産に関する研究）

Tomato (*Solanum lycopersicum* L.) is one of the most widely grown and eaten vegetables in the world, and is the second most important vegetable crop after potato worldwide. Fresh-market tomato production systems rely on heavy input of synthetic N fertilizer to obtain high yields and maximize net returns, in part, because of low N recovery by tomatoes. However, high N inputs have been associated with groundwater pollution through nitrate leaching, salt accumulation in the soil, as well as depletion of soil organic C (SOC) and total N (STN), therefore, alternative systems which rely less on synthetic N fertilizer by incorporating organic amendments such as cover crops and compost that can potentially contribute significant amounts of N to tomato production and C to improve soil quality are needed. The ability of the cover crops [hairy vetch (*Vicia villosa* R.) and rye (*Secale cereale* L.)] and livestock compost to improve soil quality, especially SOC, tomato yield, and fruit quality, while minimizing environmental problems were examined in two field experiments under greenhouse conditions. In these experiments cover crops and compost were applied with a reduced level of N fertilizer equivalent to 33%—50% of the recommended fertilizer rate across different regions in Japan.

In chapter 2, the effects of hairy vetch and livestock compost on soil properties, tomato yield, and fruit quality were evaluated in 2016 and 2017. Averaged across years, the marketable yield was 10%—15% greater in hairy vetch, compost, and in the mixture of hairy vetch and compost treatments than in no hairy vetch and no compost treatment. Fruit soluble solids content improved slightly with hairy vetch and compost because of the increase in soil EC. However, fruit vitamin C improved with compost only possibly due to the increased concentration and accumulation of calcium in the fruit. Hairy vetch and compost also improved SOC and STN at 0─10 cm depth, especially STN, compared with the initial SOC and STN before the initiation of the examination.

In chapter 3, the effects of hairy vetch and rye residues management on soil C and N pool and tomato yield were examined in 2017 and 2018. Hairy vetch incorporation and mulch
treatments improved the marketable and total yields, soil N availability, and microbial biomass
N in both years compared with fertilized bare treatment. However, the effectiveness of the
biculure of hairy vetch and rye treatment varied with the seeding ratio (hairy vetch: rye) or C:
N ratio of residues. With a C: N ratio of 17.6 obtained with a seeding ratio of 2:1, the biculure
showed the greatest yield (16%–17% greater than that in hairy incorporation and mulch,
respectively) and residue-N recovery; whereas with the change in seeding ratio to 1: 1 that
resulted in a C: N ratio of 23.7, the biculure showed the least yield, residue-N recovery, soil N
availability, and microbial biomass N compared with hairy vetch incorporation and mulch
treatments. Cover crop treatments, including rye tested in 2018 only, improved slightly SOC
and STN at 0─10 cm and 20─30 cm depths. Averaged across depths and years, hairy vetch
incorporation and mulch treatments showed greater residual inorganic N compared with the
biculure. Rye also showed greater residual N compared with the biculure in 2018. A
supplemental N fertilization rate of 150 kg N·ha⁻¹ was shown to be excessive because increased
residual N and low N recovery (28%) compared with unfertilized bare treatment.

In order to understand the reasons for the increased effectiveness of the biculure in
increasing fruit yield and N recovery reported in chapter 3, a pot examination using the isotopic
dilution technique was conducted in chapter 4. The results suggested that the increased yield
and N recovery in the biculure were related to the increased N contribution from both rye and
hairy vetch during the reproductive stage (between 4 to 8 weeks after transplanting). The N
collection of rye residues applied to the soil with hairy vetch to tomato production increased
by 7.1% compared to that of rye residues applied to the soil as a monoculture. However, hairy
vetch in the biculure seems to play a major role by contributing more N than rye to tomato
production, and rye, in addition, may regulate the N release from hairy vetch by decreasing the
hairy vetch N contribution to tomato production during the first 4 WAT (vegetative stage) in
favor of to the period after 4 WAT (reproductive stage).

Overall, compost application and the biculure of hairy vetch with rye were found as the
best management practices that can be integral components of future low-input systems.
Compost may increase tomato yield, especially from the second year onward, soil quality, and
fruit quality. In turn, the biculure can increase tomato yield and N recovery efficiency, and soil
quality with the least N leaching potential. Because the effectiveness of the biculure in
increasing tomato yield depends on the C: N ratio of residues, an adequate seeding ratio should
be used and the seeding ratio (hairy vetch: rye) 2:1 is highly recommended. A supplemental N
fertilization rate of about 100 kg N·ha⁻¹ as controlled-release N fertilizer is also recommended.