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Author(s)	MUCHANGA, RAFAEL ALEXANDRE
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学 位 論 文 内 容 の 要 旨

博士（環境科学）　　氏　名　Rafael Alexandre Muchanga

学 位 論 文 題 名

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 biculture 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 biculture 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 biculture 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 biculture. Rye also showed greater residual N compared with the biculture in 2018. A supplemental N fertilization rate of 150 kg $N \cdot ha^{-1}$ 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 biculture 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 biculture 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 contribution 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 biculture 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 biculture 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 biculture can increase tomato yield and N recovery efficiency, and soil quality with the least N leaching potential. Because the effectiveness of the biculture 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 $N \cdot ha^{-1}$ as controlled-release N fertilizer is also recommended.