Changes of Soil Microbe communities in Plastic Film House by Green Manure Crops Cultivation

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Abstract

To improve the soil condition for no-tillage organic pepper cultivation, four different green manure crops were cultivated. Fertilizer supply was depended on the biomass of the cultivated green manure crops, nitrogen supplies were 314kg in Vicia villosa and 341kg ha^{-1} in Vicia angustifolia. In the microbial community analyzed by phospholipid fatty acid (PLFA) method, soil microbe populations were different among the green manure crops and fungi group was increased at Vicia angustifloia and Vicia villosa. The biological ratio indexes of fatty acids in the soils, the ratio of Gram-negative to Gram-positive bacterial PLFA and Ratio of aerobes to anaerobes were high at Vicia hirsute and Vicia tetrasperma suggesting the enrich of the aerobic conditions. The ratio of saturated to unsaturated fatty acids increased at Vicia angustifloia and Vicia villosa suggesting anaerobic conditions. Abundant biomass and uncomposted organic matter, the ratio of fungi to bacteria was increased at Vicia angustifloia and Vicia villosa.

Introduction

Winter annual green manure crops may be an effective tool for organic agriculture systems and these systems also improve soil structure and accumulation of organic matters. According to a definition of organic agriculture proposed by Codex alimentarius commission, organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity (CODEX 1999). The organic cover cropped soil had the largest and most heterogeneous microbial population while the biomass of the organic-manure amended soil was the least heterogeneous, and the most metabolically active (Wander *et al.* 1995). Soil management practices affect soil microbial communities, which mediate many processes essential to the productivity and sustainability of soil. Especially no tillage practices increased soil organic matter contents not only improves soil structure and water retention, but also serves as a nutrient reservoir for plant growth and an substrate for soil microorganisms (Feng *et al.* 2003). Red hot pepper is one of the most important vegetable crops for seasoning foods in Korea. However, the yield of peppers grown in the plastic film house was decreased because of injury by continuous cultivation of pepper single crop (Kim & Chung 2005). Therefore, this study was carried out to improve the soil condition by

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cultivation of green manure crops in winter season and to investigate the differences of soil microbe populations by different manure crops for reducing the injury caused by continuous single cropping for long time.

Materials and methods

To select promising green manure and covering crops for the no tillage organic red pepper cultivation. Four different crops, *Vicia tetrasperma, Vicia hirsute, Vicia angustifolia and Vicia villosa* were fall-seeded at a rate of 60 kg ha^{-1} in continuously red pepper cultivated plastic film house soil. At just before transplanting pepper seedlings, growth characteristics of seven-month grown green manure crops were measured and biomass also examined. No additional herbicides and fertilizers were added to any cover crop plots and the pepper grown without tillage. A randomized block design was used with three replications and individual plots were approximately 40 m^2 (4 X 10m) for this research.

Soils were sampled to a depth of 10 cm with a soil probe (diameter: 5 cm) at three points in each plot before the red pepper were transplanted. The sampled soils were dried at shady place and passed through a 2-mm mesh sieve and stored within closed plastic bags at -80℃ in the dark until analysis. Microbe populations were analyzed by phospholipid fatty acid (PLFA) method (Feng 2003). In brief, lipids were extracted from soils by a one-phase chloroform, methanol and water extractant, and then fractionated into neutral lipids, glycolipids and phospholipids on a silicic acid column. The phospholipids were then subjected to alkaline methanolysis and analysis on a gas chromatograph with a flame ionization detector. Statistical analysis of data was carried out using SAS and to determine the significance among the means of treatments, LSD was computed at the 5 % probability level.

Results

As the plant height was high the biomass also increased, so that significant differences were found on fresh and dry weight among the green manure crops. Dry weights were 435g in *V. tetrasperma*, 579g in *V. hirsute*, 699g in *V. villosa* and 724g per m^2 in *V. angustifolia* (Table 1). Nutrition composition was not different among the four green manure crops, means that the fertilizer supply was depended on the biomass of the cultivated green manure crops. Nitrogen supplies were 191kg in *V. tetrasperma*, 269kg in *V. hirsute*, 314kg in *V. villosa* and 341kg per ha in *V. angustifolia* (Table 2).

Tab. 1: Growth of green manure crop cultivated in plastic film house in winter season.

Green manure crops	Plant height (cm)	Root length (cm)	Fresh weight (g/m^2)	Dry weight (g/m^2)	Dry/fresh weight
Vicia tetrasperma	49.6±3.4	16.3±0.8	2,093± 40	597±20	0.29
Vicia hirsute	46.5±1.9	21.7±0.9	1,593± 27	435±26	0.27
Vicia angustifolia	59.3±3.0	21.6±0.3	2,883±311	724±90	0.25
Vicia villosa	81.3±2.0	20.4±1.9	3,157±539	699±46	0.22

* Values are means±SD

Tab. 2: Nutrition compositions and supply amount of nitrogen, phosphate and potassium of green manure crops cultivated in plastic film house in winter season.

Green manure crops	Nutrition composition (%)					Fertilizer supply (kg ha^{-1})		
	T-N	T-C	P_2O_5	K_2O	C/N	N	P_2O_5	K_2O
Vicia tetrasperma	4.5	41.0	1.0	3.8	9.1	269±25	59.7± 5.9	227±15
Vicia hirsute	4.4	42.3	0.9	3.1	9.7	191±16	39.1± 4.7	135± 4
Vicia angustifolia	4.7	41.1	0.9	5.2	8.8	341±37	65.2±10.7	376±24
Vicia villosa	4.5	41.7	1.0	4.5	9.3	314±27	69.9± 3.1	315±87

Values are means±SD

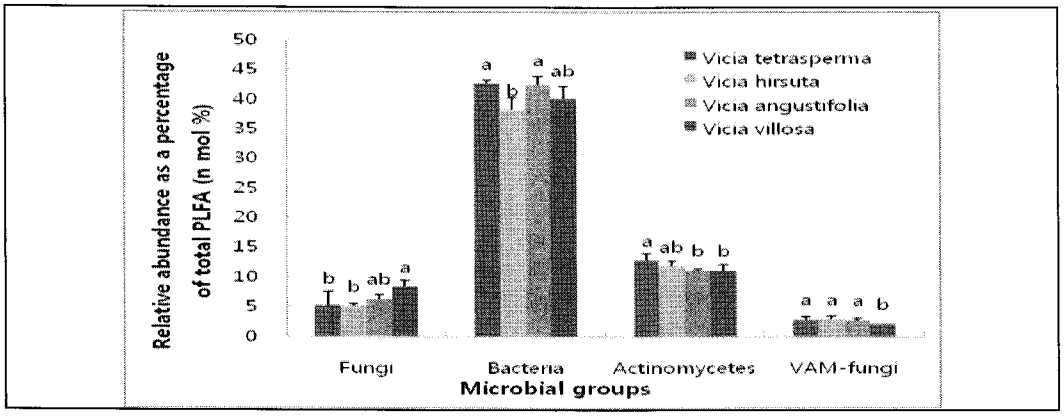

Figure 1: Relative abundance of fungi, bacteria, actinomycetes and VAM-fungi by the analysis of phospholipid fatty acids in the soils with four different green manure crops cultivation. The vertical bars indicate the standard deviation of the means

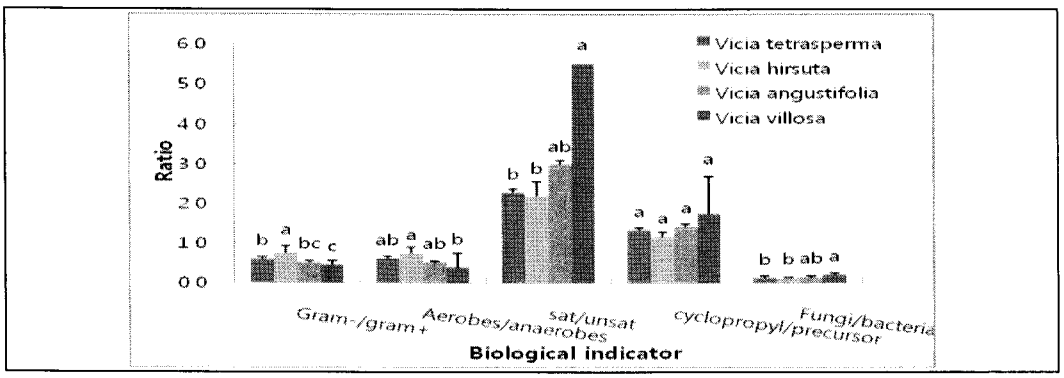

Figure 2: Changes in the biological ratio indexes of fatty acids in the soils amended with four different green manure crops cultivation. The vertical bars indicate the standard deviation of the means

In the soil microbe populations analyzed by PLFA, it was different among the green manure crops. Fungi groups was increased at *V. angustifloia* and *V. villosa*, bacteria was increased at *V. tetrasperma* and *V. angustifolia*, actinomycetes group was increased at *V. tetrasperma*, and VAM-fungi group was decreased at *V. villosa* (Figure 1). In changes of the biological ratio indexes of fatty acids in the soils, the ratio of Gram-negative to Gram-positive bacterial PLFA and that of aerobes to anaerobes were high at *V. hirsute* and *V. tetrasperma.* It suggested that more aerobic soil conditions were made by these two crops cultivation. The ratio of saturated to unsaturated fatty acids increased at *V. angustifloia* and *V. villosa.* The ratio of fungi to bacteria was also increased at *V. angustifloia* and *V. villosa* (Figure 2).

Discussion

Winter grown green manures reduced nitrogen losses significantly, which secures a higher N supply for succeeding crops, resulted in changes of the soil nitrogen utilization and growth of pepper due to different cover crops (Sung *et al.* 2008). In present study, the supply amounts of fertilizer were also different depending on the kind of green manure crops. Fertilizer supply was higher in *V. villosa* and *V. angustifolia* compared to other cover crops, but the long plant height of *V. villosa* inhibited the pepper growth at early stage on the no-tillage organic cultivation (data not shown). Soil management practices and cultivation of cover crops affected soil microbial communities, which in turn influence soil ecosystem processes (Peng *et al.* 2003). In present study, only one year cultivation practices differed the microbial communities under different green manure crops. The soil biomass decreased the gram-negative bacteria and aerobes increased under *V. hirsute* and *V. tetrasperm*, suggesting the more aerobic conditions at the soil surfaces. However as the biomass increased the ratio of saturate to unsaturated fatty acid and the ratio of cyclopropyl fatty acids to precursor were increased, it could be concluded that anaerobic conditions increased soils covered with *V. angustifloia* and *V. villosa*. High ratios of fungi to bacteria, which mean abundant biomass and uncomposted organic matter, were measured soil covered with *V. angustifloia* and *V. villosa* which have more biomass.

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