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Sustainable assessment of a vegetable farm using grass mulch in Japan

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Grass mulch is a traditional farming practice until the 1900's and now only organic farmers use this practice. Farmers believes it has many benefits sush as preventing soil erosion, decreasing weed pressure, supplying nutrients to soil and preserving soil moisture. However, there is little study on grass mulch. Therefore the effects on soil properties, soil fauna and yield by grass mulch with different farming practices were examined at an experimental field in Ibaraki Universiry in Japan in 2014. The study revealed additional grass mulch and dead leaves compost increased eggplant yields with increases of soil earthworm population and micrbiological activities. Additions of these organic matters provided habitats for soil animals improved soil aggregate structure. As a result, it accelerated mineralization of nitrogen and reduced N_2O emissions in NT sites. Therefore grass mulch could be a good practice to promote sustainable agriculture.

Keywords: grass mulch, soil biodiversity, vegetable, environmentally-friendly farming

1 Introduction

The demands of organic agricultural products has been increasing yet organic agriculture is practiced at only 16,000 ha of crop lands (0.4 % of total agricultural fields) in Japan (MAFF 2013). To promote organic agricultural practice, the Ministry of Agricutulture, Forestry and Fisheries has started a direct payment system to the farmers who use several environmentally-friendly agricultural practices since 2011. The practices include such as cover crops or manure application. However, the application of these practices are limited to use because Japanese agricultural fields are very diverse from the north to the south. The system needs more alternatives to promote sustainable agriculture in Japan. Grass mulching (karijiki in Japanese) is one of traditional agricultural practices in Japan until the begenning of the 1900's. Farmers know it provides nutrients to soil and keep low weed pressure by their experience. However, there is little study in pleiotropic functions of grass mulching. Therefore this study aimed to reveal how grass mulch affect soil properties, soil fauna, microbiological activities and crop yields and interact with other farming practices such as tillage or fertilizer application.

2 Material and Methods

2.1 Material

This study was conducted at an experimental field of the Field Science Center (FSC), College of Agriculture, Ibaraki Universiry (36°02'N, 140°13'E) in Japan. The mean air temperature is 14.7 °C and the annual precipitation was 1154mm in 2014. The soil type is classified Mollic Andosol contaning 18 % clay, 30 % silt and 52 % sand. The first factor was tillage, two levels: No-Tillage (NT) and Conventional tillage (CT) and the second factor was fertilizer application, two levels: Natural fertilizer application (F) and No fertilizer application

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(NF). The final factor was grass mulch application, two levels: Additonal weed mulch (AM) and no weed mulch (NM). A 2 x 2 x 2 factorial experiment in a randomized split-plot design with four replications (5 x 2.5 m area per plot) was conducted from May 2014. Eggplant (*Solanum melongena*) was planted as a crop and 10 kg (fresh weight) of mowed weeds was applied as additional grass mulch on each AM plot. 25 kg of dead leaves compost was applied as a natural fertilizer on each F plot. Weeds were manually removed in CT sites.

2.2 Methods

0-30cm long soil core samples were taken two times on 9 June and 20 October 2014 to measure soil properties. Soil fauna was collected by hand sorting method on 17 June and 21 October 2014.

The following items are measured;

a) Soil chemical properties: NH_4, NO_3, active soil carbon and available P by SPCA-6210 (Shimadzu, Kyoto), T-N and T-C by CN analyzer (J-Science lab JM3000CN, Kyoto)
b) Earthworm poluation and biomass by hand sorting method
c) Bacteria and fungus ratio by SIR (Substrate Induced Respiration) method
d) N_2O emission by closed chamber method to estimane nitrofication/denitrofication.
e) Crop yields from July to September were recorded by each plot.

The collected data were analyzed by analysis of variance using Stat view (version 5.0, SAS institute Inc. Cary, NC).

3 Results

a) Soil chemical properties: T-C and active C were significantly higher at 0-2.5 cm and 2.5-7.5 cm in NT sites. NO_3 concentrations in AM sites were higher than NM sites in October.
b) Earthworm poluation and biomass: NT-NM site had the highest in poluation and biomass while there was no earthworm on CT-NM site and a few on CT-AM site in the June. However, the population on CT-AM site increased as same as NT-AM in October.
c) Bacteria and fungus ratio: the activities of bacteria and fungi were larger in NT sites in general. There was no effect by AM however, AM increased fungai activities in NT site with over time.
d) NT sites had the lowest N_2O emission and it increased by tillage and additional mulching rather than application of natural fertilizer.
e) Crop yield: In the no mulch condition, conventional tillage strongly affected the yield. On the other hand, there was no significant difference by tillage between NF-AM and F-AM sites (Fig. 1). But the yield improved with the increas of earhworms and microbes activities (Fig. 2).

4 Discussion and Conclusions

Active carbon and NO_3 concentration increased in AM sites because it worked like cover crops. As Komatsuzaki et. al (2012) reported weed biomass contains similer nutrient to cover crops such as Sesbania rostrata and Clotararia juncea, the result showed weed mulch can also provide nutrients to soil. There is a clear relationship between soil aggregation size and fungi SIR (Nakamoto et al 2012). In this study, the earthworm population associated with fungi SIR as well. It is because the soil aggregate structure changed with the increase of earthworm polulation. Dead leaves compost application also increased earthworms and microbe activities. It is because NT practice and organic matter application provided habitat for soil fauna. As a result, the more microbes and animal are in soil, the more mineralization could be occured by the soil fauna. The results that NT practice reduced N_2O emission and

incresed soil carbon were consistent with the study by Yagioka et al (2015). According to Akiyama et al (2006), poorly drained soils increase N_2O emission because it creates more anaerobic condition in soil. Earthworms created larger soil aggregates and improved soil drainrage. This change in soil physical structure could lead to N_2O reduction. In addition,the change in soil fauna contributed to increase eggplant yields. Therefore this study scientifically proved that grass mulching improved soil property and soil biodiversity. It is a useful practice to promote sustainable agriculture. This practice could apply to developing countries with limited fertilizer access to supplement soil nutrients.

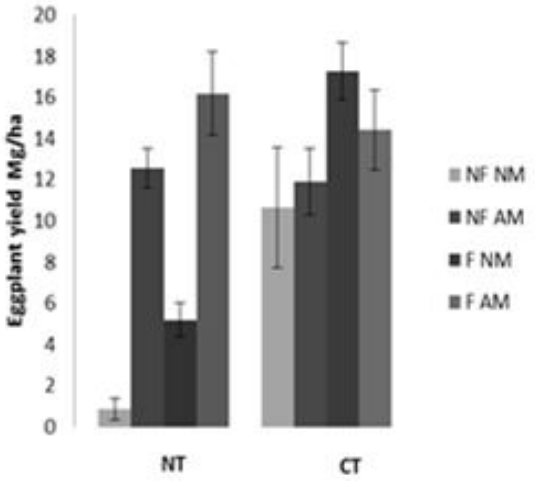

Figure 1 Total yields at each treatment

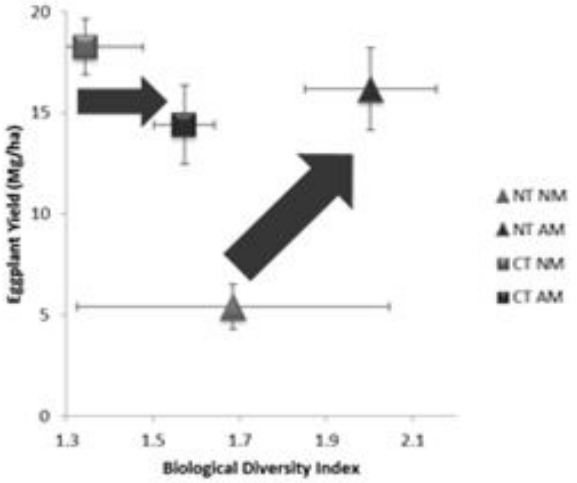

Figure 2 Relationship between yield and biodiversity

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