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Article

Effect of Rice Straw and Woodchip Application on Greenhouse Soil Properties and Vegetable Crops Productivity

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There have been increasing concerns about decreasing crop productivity due to salt accumulation in greenhouse soils. The objective of the study was to investigate the impact of rice straw and woodchip application to a salt accumulated greenhouse soil on crop productivity and soil quality. The application of rice straw (RS) and woodchip (W) increased tomato yield and decreased blossom end rot, and increased yield of Chinese cabbage compared with standard recommended fertilization (204-103-122 kg ha^{-1} N-P_2O_5-K_2O for tomato and 222-64-110 kg ha^{-1} N-P_2O_5-K_2O for Chinese cabbage), while less soil residual nitrate, phosphatephosphorus, and potassium. In addition to the organic material application, fertilization reduction based on soil testing may also contribute to relatively low level of soil residual nutrients. Application of the organic material reduced soil bulk density presumably because of improved soil aggregation and structure, and increased biomass C and dehydrogenase activity. In comparison to rice straw, woodchip application resulted in higher crop yield, less amount of soil residual nitrate and lower soil EC, and greater biomass and dehydrogenase activity. The results obtained in this study indicateshowed that woodchip amendment along with reduced fertilization based on soil testing can be one of essential management practices for salt accumulated greenhouse soils.

Key words: Chinese cabbage, Greenhouse soil, Rice straw, Soil testing, Tomato, Woodchip

Introduction

The area of greenhouse in Korea increased from 18,275 ha in 1984 to 85,608 ha in 2004 (Ministry of Agriculture and Forestry, 2005) because of year-round crop cultivation by controlling growing environment including temperature, humidity, and soil moisture. Multiple cropping in a year leads to repeated application of chemical fertilizers and various composts including animal by-products. Moreover, farmers generally applied excess amount of the fertilizers and composts to soils than the nutrients required for crops planted. As a result, the excess nutrients are remained after crop harvest and accumulated in the greenhouse soil, even harmful level for crop cultivation. Average content of available phosphate phosphorus (P_2O_5) and exchangeable potassium (K) were 1,092 mg kg 1 and 1.27 cmol$^+$ kg^{-1} compared to the optimum level of 350-500 mg kg^{-1} and 0.7-0.8 cmol$^+$ kg^{-1}, resulting 70-80% of greenhouse soils contain higher P_2O_5 and K than the optimum level (Jung et al., 1998). Additionally, soil nitrate nitrogen (NO_3-N) and electrical conductivity (EC) were also higher than the optimum level; 155 mg kg^{-1} and 2.94 dS m^{-1}, respectively. The nutrient accumulation in greenhouse soils may eventually cause negative impacts on soil and water environments in addition to crop yield and quality. The detrimental effects include root uptake depression of water and other essential nutrients due to low soil water potential and imbalanced nutrients (Jung and Yoo, 1975; Kang et al., 1996), accumulation of toxic constituents in crops such as NO_3-N (Jin et al., 2004; Sohn and Oh, 1993), proliferation of pathogenic microorganisms (Jun and Park, 2001), and leaching loss of nutrient which causes pollution of groundwater and surface water by NO_3-N and K (Lee and Lee, 1994).

For sustainable crop productivity and environment-friendly agriculture, the nutrient accumulation in soils should be prevented or reduced before causing any problems to crops, human health, and environment. Many management practices have been proposed to reduce the salt accumulation in greenhouse soil (Khoshgoftarmanesh et al., 2003; Jun et al., 2002; Jung and Yoo, 1975; Kim et

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al., 2001; Kim et al., 2003; Kim et al., 2006; Kwak et al., 2003), but they have strength and weakness (RDA, 2002). For example, flooding can leach soluble nutrients such as nitrate and chloride in well-drained fields, but sparingly soluble nutrients such as phosphate phosphorus may not be removed and furthermore it can waste valuable water resource and evoke groundwater contamination. Explosive subsoiling may also cause groundwater contamination by nutrients and demand special equipment. Mixing surface soil with subsurface soil or reversion of subsurface soil can be a temporary solution of the problem so that the same phenomena may eventually occur again. Removal of surface soil and application of unfertilized soil may be also short term solutions and require labor and transportation. Cultivation of nutrient favor crops such as maize in greenhouse may cause economic loss compared with high value vegetables. Although the installation of perforated drainage tiles in the subsoil layer can effectively remove the accumulated salts in greenhouse soils, it may be an expensive method.

When plant residues having a high carbon/nitrogen (C/N) ratio are applied to soils, intense competition between microorganisms and plants for inorganic nutrients may cause reduction of available nutrients to crops because soil microorganisms also require nutrients to build essential organic compounds and obtain energy for life processes (Brady and Well, 2002). Under salt accumulation condition in greenhouse soils, the incorporation of high C/N materials including rice straw and woodchip will consume the soil's accumulated nutrients because of the microbial demand for nutrients. For instance, soil microorganisms scavenge inorganic N to make up the deficit during decomposition of the high C/N materials. The nutritional requirements of microorganisms may result in reduction of excess salt concentrations. Additionally, organic materials with high polyphenol compounds and/or lignin may inhibit decomposition and consequently inorganic nutrients from the decomposed plant residues are slowly released (Brady and Well, 2002). On the other hand, about 4.2 million m^3 wood remnants are annually left in mountain and forest, making disasters of flooding in rainy season and wildfire in drought season worse (Park and Park, 2004). To reduce damages from flooding and wild fire, the left wood remnants in mountain need to be collected and utilized. One of the agricultural uses of the wood remnants is a moisture control agent during composting of animal manure with high water content.

Since application of organic matter can improve soil physical and biological properties in addition to soil chemical characteristics, integrating the chemical parameters with the physical and microbiological parameters could be useful for a better assessment of change in soil quality by different treatments. Organic matter application can enhance soil aggregation formation and structure stability, resulting in decreased bulk density and increased porosity. The improved soil structure may supply better condition for plant root elongation and respiration by proper aeration in soil and drainage of excess water (Arshad et al., 1996).

Microbial biomass carbon (C) may indicate potential microbiological activity because C within the microbial biomass is stored energy for microbial processes (Rice et al., 1996). Since microbial biomass is a living part of soil organic matter, microbial biomass can be used to estimate the direction of change in organic matter content. In addition, microbial biomass and soil aggregate stability are strongly related because microbes play a critical role in the formation and maintenance of soil aggregates (Haynes and Swift, 1990; Tisdall and Oades, 1982). Soil enzyme assays can be an integrative soil biological index for determining the potential to degrade or transform substrates including organic materials and chemical fertilizers applied to the soil (Dick, 1994). For example, urease activity can discriminate effect of plant residue amendment from that of chemical fertilizer application (Dick et al., 1996). Acid phosphomonoesterases provide available inorganic phosphorus to plant through mineralization of organic phosphorus and the enzyme activity may be an early indicator of the direction of change in soil phosphorus level.

The objective of the study was to test if the application of rice straw and woodchip to a salt accumulated greenhouse soil can improve the soil quality in addition to maintain crop productivity.

Materials and Methods

Tomato (*Lycopersicon esculentum*) and Chinese cabbage (*Brassica oleracea*) were planted in a greenhouse of a Gyuam silty loam (coarse silty, mixed, nonacid, mesic Aquic Fluventic Eutrochrepts) in spring and fall, respectively, located in Chuncheon, Gangwon. The greenhouse soil significantly showed salt accumulation phenomena including permanent wilting of previously planted crops. The contents of exchangeable cations and the EC value were pretty high. The treatments consisted of standard fertilizationrecommended fertilization (SFRF), fertilization based on soil testing (FT), and amendment of rice straw application (RS), woodchip (W), and woodchip compost (WC) to each 2 by 6 m plot in a greenhouse. The organic materials were applied at a rate of 20 Mg ha^{-1} on a fresh weight basis. The rice straw was cut to about 5 cm long before the amendment and size of the woodchip ranged 2 to 5 cm. The woodchip compost was obtained by composting 70% of hardwood chip with 30% of swine manure on a fresh weight basis for more than 6 months. The organic materials were evenly mixed with the surface soil using a shovel. Fertilizer application rates for SFRF were 204 kg ha^{-1} N, 103 kg ha^{-1} P_2O_5, and 122 kg ha^{-1} K_2O for tomato and 222-64-110 kg ha^{-1} N-P_2O_5-K_2O for Chinese cabbage. Application rate of chemical fertilizers for FT, RS, W, and WC was determined based on soil testing; 90-103-27 kg ha^{-1} N-P_2O_5-K_2O for tomato and 181-0-0 kg ha^{-1} N-P_2O_5-K_2O for Chinese cabbage. The chemical compositions of three organic materials are presented in Table 2. Nutrient contents of woodchip compost were higher than those of woodchip due to swine manure added to woodchip during composting. The treatments were arranged in a completely randomized design with three replicates. The experiment was conducted for two consecutive years (2001-2002). Tomato yield was calculated by summing the fresh weight of marketable tomato at each harvest time in each plot and convertedting to yield per unit area (ha). Yield of Chinese cabbage was obtained by weighing the fresh weight in each plot at harvest time.

The surface soils collected at the 15 cm depth were air-dried, passed through a 2 mm sieve, and used to determine soil chemical properties including soil pH, EC, organic matter, available phosphorus, and exchangeable cations by soil analysis method recommended by (National Institute of Agricultural Science and Technology, (2000). Briefly, soil pH and EC were measured after mixing soil with H_2O at a ratio of 1:5. Soil organic matter and available phosphatephosphorus were determined by Tiiyyurin (reference is needed) and Lancaster method (reference is needed, respectively. Exchangeable cations such as potassium, calcium, and magnesium were analyzed by extracting them with 1N ammonium acetate (pH 7). Amounts of exchangeable cation were determined by inductively coupled plasma spectrophotometer (ICP, GBC Integra XMP, GBC Scientific Equipment Pty Ltd, Victoria, Australia). Soil exchangeable nitrate level was obtained by Kjeldahl distillation using devarda alloy after removing ammonium and nitrite with sulfamic acid and MgO from 2M KCl extracts. Core sampler was used to determine the bulk density (BD).

For determination of soil biomass and enzyme activities, surface soil samples were sieved through a 2-mm sieve and kept field moist and cool (4℃) without air dry until the determination. Soil microbial biomass was obtained using the method of Rice et al. (1996). Briefly, about 50 g of moist soil samples were placed in a vacuum desiccator containing a beaker of 50 mL of ethanol-free chloroform and antibumping granules, and fumigated with chloroform for 48 h after evacuation and ventilation three times. To each of the fumigated and nonfumigated control sample flasks, 100 mL of 0.5 M K_2SO_4 was added. The solutions were mixed for 30 min and filtered. Eight milliliters of the filtrates was boiled under reflux for 30 min with a dichromate oxidizing reagent followed by dilution with 25 mL of H_2O. The excess dichromate was determined by back-titration with 33.3 mM ferrous ammonium sulfate in 0.4 M H_2SO_4 using 25 mM 1,10-phenanthroline-ferrous sulfate complex solution as an indicator. The organic C level was calculated assuming that 1 mL 66.7 mM $K_2Cr_2O_7$ is equivalent to 1.2 mg C. Determination of soil enzyme activities such as urease, acid phosphatase, and dehydrogenase was conducted following the method of Dick et al. (1996). For determination of urease activity, 0.2 mL of toluene and 9 mL of 0.05 M tris(hydroxymethyl)aminomethane buffer were added to 5 g of soil and mixed for a few seconds. After adding 1 mL of 0.2 M urea solution, the soil suspension was incubated at 37℃ for 2 h. The contents were filled to 50 mL with KCl-Ag_2SO_4. Ammonium-nitrogen (NH_4-N) in the soil suspension was determined by steam distillation of 20 mL suspension with 0.2 g of MgO. To obtain activity of acid phophatase, 0.2 mL of toluene, 4 mL of modified universal buffer (pH 6.5), and 1 mL of 0.05 M *p*-nitrophenyl phosphate solution were added to 1 g of soil and mixed for a few seconds. The soil suspension was incubated at 37℃ for 1 h. After adding 1 mL of 0.5 M $CaCl_2$ and 4 mL of 0.5 M NaOH, the soil suspension was filtered and the *p*-nitrophenol content of the filtrate was obtained by measuring absorbance at 410 nm. For dehydrogenase activity measurement, 1 mL of 3% 2,3,5-triphenyltetrazolium chloride solution and 2.5

mL of H_2O were added to 6 g of mixture of soil and $CaCO_3$ (100:1). After incubation at 37°C for 24 h, 10 mL of methanol was added and mixed for 1 min. The suspension was filtered and diluted to 100 mL with methanol. The amount of produced triphenyl formazan was determined by measuring absorbance at 485 nm.

Results and Discussion

Selected chemical properties of the soil in the site are shown in Table 1. The contents of exchangeable cations and the EC value were pretty high. The chemical compositions of three organic materials are presented in Table 2. Nutrient contents of wood chip compost were higher than those of woodchip due to swine manure added to woodchip during composting. The application of woodchip showed higher tomato yield than the other treatments but the difference was not statistically significant (Table 3). Reduced tomato yield for FT may imply that more nutrients may need to be applied to the greenhouse soil to get high tomato yield than fertilization rates based on the soil testing and fertilization suggestion equation. However, extensive soil types and soil conditions should be tested and environmental aspect also should be considered in addition to crop productivity. Greater blossom-end rot was observed at SF and FT than RS, W, and Wcall the treatments. Reasons for the disorder include reduced uptake of water and nutrients by salt accumulation in soil, calcium uptake depression by excess absorption of potassium from plant roots, and abrupt soil moisture change in soil. The highest Chinese cabbage yield was obtained by woodchip amendment followed by woodchip compost application. Apparent wilting phenomena were observed in transplanted seedlings of SFRF and some of them were eventually died. Retarded growth at the early stage may also cause the lowest yield in RF. Phosphorus, potassium, calcium, and magnesium levels in Chinese cabbage leaves for RF were relatively low compared to the other fertilization treatments based on soil testing, although the

Table 1. Chemical properties of the greenhouse soil used in this study.

pH (H_2O,1:5)	Electrical conductivity	Organic matter	Extractable NO_3	Available P_2O_5	Exchangeable cation		
					K	Ca	Mg
	dS m^{-1}	g kg^{-1}	mg kg^{-1}	mg kg^{-1}	---------------- cmol$^+$ kg ----------------		
5.9	4.2	29	367	521	2.0	10.8	3.7

Table 2. Chemical composition of the organic materials used in this study.

Organic material	N	P_2O_5	K_2O	CaO	MgO	Moisture content
	------------------------------------ g kg^{-1}, dry base ------------------------------------					%
Rice straw (RS)	10	3.5	7.4	6.4	3.3	21
Woodchip (W)	4	0.5	1.4	5.7	0.8	33
Woodchip compost (WC)	12	2.6	7.7	6.6	2.9	36

Table 3. Yield of tomato (*Lycopersicon esculentum*) and Chinese cabbage (*Brassica oleracea*).

Treatment†	Tomato		Chinese cabbage			
	Yield	Blossom end rot	Heigh	Width	Leaf number	Yield
	ton ha^{-1}	ton ha^{-1}	cm	cm		ton ha^{-1}
SFRF	27.6ab‡	8.4a	24.2	17.0	72	58.3 b
FT	22.0 b	8.7a	26.8	18.0	74	68.0ab
RS	28.8ab	5.1b	25.9	18.0	75	63.2ab
W	30.9 a	4.1b	26.4	18.5	77	75.3 a
WCWC	28.2ab	5.0b	26.6	17.9	74	72.9 a

† RF, recommended fertilization; FT, fertilization based on soil testing; RS, rice straw application; W, woodchip application; WC, woodchip compost application.

‡ Treatments with same letter in each column are not significantly different at the 0.05 probability level by t test.

Table 4. Contents of plant nutrients in Chinese cabbage (*Brassica oleracea*) leaves.

Treatment[†]	Total Nitrogen	P_2O_5	K_2O	CaO	MgO
	------	------	------ % ------	------	------
SFRF	4.1a[‡]	0.61 a	5.1 a	1.1 a	0.31 a
FT	4.0a	0.73ab	5.8bc	1.7 c	0.42 c
RS	4.1a	0.62 a	6.0 c	1.5bc	0.38bc
W	4.1a	0.79bc	5.3ab	1.4bc	0.36ab
WC	4.1a	0.87 c	5.3ab	1.3 a	0.33ab

[†] RF, recommended fertilization; FT, fertilization based on soil testing; RS, rice straw application; W, woodchip application; WC, woodchip compost application.

[‡] Treatments with same letter in each column are not significantly different at the 0.05 probability level by t test.application.

differences were not statistically significant (Table 4). SF. Plant nutrient levels in Chinese leaves for SF were relatively low compared to the other fertilization treatments based on soil testing (Table 4). It is well known that salt accumulation in soil of root area leads to reduced water and nutrient absorption of by plant roots due to osmotic potential stress.

As shown in Table 5, slightly higher amounts of residual nitrate, phosphorus, and potassium were detected in RF soil after crop harvest compared with the other treatments, but it was not significantly different. As shown in Table 5, greater amounts of nutrients including nitrate, phosphatephophorus, and potassium were remained in SF soil after crop harvest compared with the other treatments. As a result, the SFRF showed the relatively higherer soil EC value than the other treatments. Although nitrate, potassium, and soil EC for SFRF were lower than the values before the experiment, relatively high levels may result in detrimental effect on the following crop cultivation, soil microbial community, and water environment. The result implies that soil testing and fertilization adjustment in salt accumulated greenhouse soils need to be performed to keep long term crop productivity and reduce the potential of contamination of soil and aquatic environments with residual nutrients.

Based on crop yields and soil chemical properties (Table 3 and Table 5), woodchip is considered to be a better organic source for greenhouse soils than rice straw because of higher yield and lower nitrate level and EC after the cultivation. It is interesting that application of woodchip or woodchip compost resulted in reduced nitrate, calcium, and magnesium left in the soil, consequently decreased soil EC. When organic materials with high C/N ratio are applied to salt accumulated greenhouse soils, microorganisms scavenge inorganic N to make up the deficit during decomposition of the high C/N materials (Brady and Well, 2002). The nutritional requirements of microorganisms can result in reduction of excess salt concentrations in greenhouse soils. Additionally, organic materials with high polyphenol compounds and/or lignin may inhibit decomposition and consequently inorganic nutrients from the decomposed residues are slowly released (Brady and Well, 2002). Lignin and polyphenols contents in woodchip are generally 13-47% and 4-5%, respectively, which is higher than those in rice straw, 5% and 0.5%, respectively (Brady and Well, 2002). woodchip are 13-

Table 5. Soil chemical properties after the study.

Treatment[†]	pH	EC	Organic matter	Extractable NO_3-N	Available P_2O_5	Exchangeable cation		
						K	Ca	Mg
	1:5	$dS\ m^{-1}$	$g\ kg^{-1}$	$mg\ kg^{-1}$	$mg\ kg^{-1}$	------	cmol$^+$ kg	------
SFRF	5.9 a[‡]	3.8a	26 a	346 a	715a	2.0a	8.4 a	3.3a
FT	6.3ab	3.5a	28ab	284 a	664a	1.7a	8.1ab	3.3a
RS	6.4ab	3.3a	29ab	212ab	663a	1.6a	8.8 a	3.4a
W	6.5 b	1.1b	28ab	60 c	693a	1.8a	6.9 b	2.2b
WC	6.1ab	1.4b	30 b	96bc	669a	1.0a	6.7 b	2.4b

[†] RF, recommended fertilization; FT, fertilization based on soil testing; RS, rice straw application; W, woodchip application; WC, woodchip compost application.

[‡] Treatments with same letter in each column are not significantly different at the 0.05 probability level by t test.

47% and 4-5%, respectively, which is higher than those in rice straw, 5% and 0.6%, respectively. Therefore, woodchip may have a relatively limited potential for microbial decomposition and mineralization of plant nutrients compared with rice straw.

Soil bulk density and porosity areis presented in Fig. 1. The bulk densities for RS, W, and WC were significantly less than the value for SFRF. Amendment of organic materials including rice straw and woodchip can decrease soil bulk density by enhancing soil aggregation formation and structure stability. Organic matter application can enhance soil aggregation formation and structure stability, resulting in decreased bulk density and increased porosity. The improved soil structure may supply better condition for plant root elongation and respiration by proper aeration in soil and drainage of excess water (Arshad et al., 1996).

Microbial biomass carbon (C) may indicate potential microbiological activity because C within the microbial biomass is stored energy for microbial processes (Rice et al., 1996). Biomass values for RS, W, and WC were greater than those for SFRF and FT (Table 6). The greater biomass may contribute to improved soil structure as shown in Fig. 1. Microbial biomass and soil aggregate stability are strongly related because microbes play a critical role in the formation and maintenance of soil aggregates (Haynes and Swift, 1990; Tisdall and Oades, 1982). Since microbial biomass is a living part of soil organic matter, microbial biomass can be used to estimate the direction of change in organic matter content. Soil organic matter levels for RS, W, and WC were also greater than the values for SFRF and FT (Table 5). Microbial biomass can be closely related with soil aggregate stability and soil organic matter content (Haynes and Swift, 1990; Tisdall and Oades, 1982).

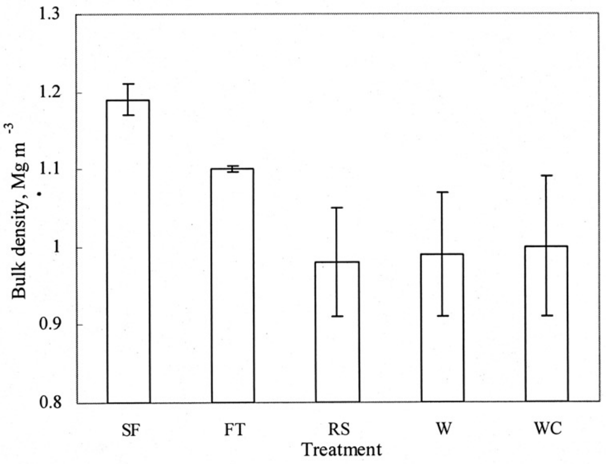

Fig. 1. Soil physical properties, soil bulk density and porosity after the study. Error bars indicate ±1 standard deviation. RF, recommended fertilization; FT, fertilization based on soil testing; RS, rice straw application; W, woodchip application; WC, woodchip compost application.

Soil enzyme assays can be an integrative soil biological index for determining the potential to degrade or transform substrates including organic materials and chemical fertilizers applied to the soil (Dick, 1994). Soil enzyme activities were also determined and are presented in Table 6. Although Dick et al (1996) reported that urease activity could discriminate effect of plant residue amendment from that of chemical fertilizer application, Although urease activity can discriminate effect of plant residue amendment from that of chemical fertilizer application (Dick et al., 1996), statistically significant differences among treatments were not found in this study. Urease may not be an adequate enzyme to assess greenhouse soils with high ammonium content because tThe activity may be confounded with high level of ammonium in the greenhouse soilssoils (86-259 mg kg^{-1}), thus urease may not be an adequate enzyme to assess greenhouse soils with high ammonium content. Acid phosphomonoesterases provide available inorganic phosphorus to plant through mineralization of organic

Table 6. Soil biomass and enzyme activities after the study.

Treatment†	Biomass	Urease	Acid phosphatase	Dehydrogenase
	mg C kg^{-1}	mg NH_4-N kg^{-1} $2h^{-1}$	mg p-nitrophenol kg^{-1} h^{-1}	mg TPF kg^{-1} $24h^{-1}$
SFRF	111 b‡	84 a	263 c	32 b
FT	123 b	71 a	305bc	29 b
RS	240ab	83 a	438 a	43ab
W	353 a	100 a	302bc	93 a
WC	208ab	52 a	362 b	23 b

† RF, recommended fertilization; FT, fertilization based on soil testing; RS, rice straw application; W, woodchip application; WC, woodchip compost application.

‡ Treatments with same letter in each column are not significantly different at the 0.05 probability level by t test.

phosphorus and the enzyme activity may be an early indicator of the direction of change in soil phosphate level. The highest phosphatase activity was obtained in RS soils that had relatively high available phosphatephosphorus (Table 5). Relatively low phosphatase activity for SFRF may be due to the high level of available phosphatephosphorus by high phosphatephosphorus fertilization because phosphatephosphorus fertilizers can suppress the phosphatase activity (Dick, 1994). Dehydrogenase may be closely related to average activity of microbial populations and play a major role in oxidation of organic matter. Dehydrogenase activities measured in this study (23-93 mg TPF kg^{-1} 24h 1mg TPF kg^{-1} $24h^{-1}$) were comparable to the result of Lee et al. (2000) who reported that the optimum levels of the enzyme activity were 40-80 mg TPF kg^{-1} $24h^{-1}$ for sandy loam soils, 46-107 mg TPF kg^{-1} $24h^{-1}$ for loam, and 47-105 mg TPF kg^{-1} $24h^{-1}$ for clay loam. Relatively high activities were observed in RS and W compared with the other treatments. It should be noted that any enzyme assay determines potential activity not in situ activity because it is run under optimal conditions.

This study showed amendment of woodchip to greenhouse soils would be one of practical uses of natural resources. About 4.2 million m^3 wood remnants are annually left in mountain and forest, making disasters of flooding in rainy season and wildfire in drought season worse (Park and Park, 2004). To reduce damages from flooding and wild fire, the left wood remnants in mountain need to be collected and utilized.

Conclusion

Application of woodchip or rice straw resulted in greater yields of tomato and Chinese cabbage than standard recommended fertilization, while lower level of soil residual nutrients including nitrate, phosphatephosphorus, and potassium. In addition to the organic material application, fertilization reduction based on soil testing is also required to prevent or reduce salt accumulation by excess nutrients. The amendment of the organic materials improved soil physical properties by reducing soil bulk density and increasing porosity, and increased biomass C and dehydrogenase activity. Of the two organic materials, woodchip can be a better organic material than rice straw for salt accumulated greenhouse soils according to crop yields and soil properties including chemical, physical, and biological parameters. Additionally, integrating the chemical parameters with the physical and microbiological parameters could be useful for a better assessment of change in soil quality by different treatments. properties.

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볏짚과 파쇄목 시용이 시설하우스 토양 성질과 작물 수량에 미치는 영향

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시설하우스 토양의 염류 집적은 연작장해로 인한 작물의 수량성 감소뿐만 아니라 지하수 등 수계의 오염 가능성을 높이고 있다. 본 연구는 이러한 시설하우스 토양의 염류집적 양상을 개선하는 한 방법을 제시하고자 시행되었다. 볏짚 (RS)과 파쇄목 (W)의 시용으로 토마토의 수량은 높아졌고 배꼽 썩음과의 발생은 줄었으며, 배추의 수량도 표준시비했을 때보다 증가되었다. 토양에 잔류하는 질산과 인산, 카리의 함량 및 전기전도도가 표준시비 처리구보다 낮았는데, 이는 토양검정을 기준으로 한 비료 시용량 절감도 한 이유일 것이다. 또한, 볏짚과 파쇄목의 시용은 토양 가비중을 낮춰 공극량을 높였으며, 토양 미생물체 탄소와 dehydrogenase 활성을 증가시켰다. 파쇄목의 시용은 볏짚과 비교하여 토마토와 배추의 수량이 높았으며, 작물 수확 후 토양에 질산과 인산이 덜 잔류하였고, 토양 미생물체와 dehydrogenase 활성은 높았다. 본 연구는 파쇄목 시용과 검정시비에 의한 화학비료의 절감이 하우스토양의 염류집적을 경감시킬 수 있는 가능성을 제시하였으며, 토양의 화학성뿐만 아니라 물리성과 미생물성도 함께 검토하면 토양 질의 변화에 미치는 영향을 평가하는 데 도움이 됨을 보여주었다.