

Changes of Organic Matter and Available Silica in Paddy Soils from Fifty-six Years Fertilization Experiments

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Abstract

The changes of organic matter (OM) and available silica (Av. SiO₂) contents in paddy soils (sandy loam) were assessed from data of the 56 years fertilization plots in which the continuous rice cropping experiment started in 1954 at the National Academy of Agricultural Science, Suwon, Korea. The treatments were no fertilization (control), inorganic fertilization (NPK), inorganic fertilizer plus rice straw compost (NPK+C) and inorganic fertilizer plus silica fertilizer as a soil amendment (NPK+S). After 41 years, OM content in NPK+C treatment in surface soils (0-15 cm) reached at the highest, followed by maintaining a plateau level for 8 years and showing a tendency to decrease afterward. Available silica contents in NPK+S in surface soil reached at the highest content (250 mg/kg) after 49 years and then levelled off. OM and available silica contents in subsurface soil (25-30 cm) were higher in NPK+ C and NPK+S treatments than those in other treatments. Continuous application of rice straw compost and silica fertilizer affected significantly on the levels of OM and av. silica, respectively, in surface and subsurface soils. The combined applications of inorganic fertilizers with organic compost and silica as a soil amendment are recommended as the best fertilization practice for fertilizer use efficiency and enhancement of soil fertility status in the continuous rice cropping system in Korea.

Key Words

Long-term application, organic matter, available silica, paddy soil, rice straw compost, silica fertilizer.

Introduction

OM and silica are important for production and quality of rice in paddy soils. Silica is of particular importance for the healthy growth of rice and recognized as an essential fertilizer in Korea. The input of silica fertilizer in paddy soils is thus increasing with the government subsidy (NIAST, 2008). However, the content of organic matter in paddy soil has been decreased without return of organic biomass resources such as rice straw that has been supplied to livestock feed in many regions of Korea. Previous research showed that soil fertility has declined with continuous application of inorganic fertilizers without organic inputs (Cai *et al.* 2006). Objectives of this study were to assess the changes of organic matter and available silica contents during a long-term fertilization experiment on which to base a proper use of fertilizer and soil amendment for a sustainable agriculture in rice production.

Methods

The fifty-six years continuous fertilization experiments from 1954 to the present have been conducted in the rice experimental station located in National Academy of Agricultural Science (NAAS), Suwon, Korea (37°16'27" N, 126°59'36" E). The paddy soil series is Gangse (coarse-loamy, mixed, nonacid, mesic family of Fluvaquentic Eutrudepts) (HARI 2003). The treatments were no fertilization (control), inorganic fertilization (NPK), inorganic fertilizer plus rice straw compost (NPK+C) and inorganic fertilizer plus silica fertilizer as a soil amendment (NPK+S). Figure 1 shows the chronicle of fertilization schemes and practices along with rice cultivars being cultivated during 56 years. Three to seven samples were randomly obtained in a field and mixed for soil analysis. OM and available silica contents were determined by the Tyurin method (Tyurin 1931) and 1M NaOAc extraction method (NIAST 2000), respectively.

Results

OM and available silica contents in surface soils (0~15 cm) of paddy field were increased significantly by a long-term applications of rice straw compost and silica fertilizer, respectively (Figure 2). After 41 years, OM content in NPK+C treatment in surface soils (0-15 cm) reached at the highest (33 g/kg), followed by maintaining a plateau level for 8 years. This level was about 1.9 times higher than that (17 g/kg) of the first 4 years ('54-'57). The OM content in the control and NPK treatments increased steadily to 22 and 23 g/kg,

Year	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09
Rice cultivar	Paldael										Jinheoung										Milyang 23										Daechung										Samkwang															
N-P₂O₅-K₂O Kg ha⁻¹	75-75-75										100-75-75										150-86-86										110-70-80																									
N fertilizer	Ammonium sulphate																																																							
K fertilizer	Murate of potash																																																							
P fertilizer	Double superphosphate																				Super phosphate										Fused and superphosphate																									
Compost	Rice straw compost (7.5 Mg ha ⁻¹)																																																							
SiO₂ fertilizer	Calcium silicate(2 Mg ha ⁻¹)																				Silicate fertilizer(2 Mg ha ⁻¹)																																			

Figure 1. Chronicle of rice cultivation practices including fertilizer treatments in a long-term fertilization experiment from 1954 to the present.

respectively, which were about 1.3 and 1.4 times higher than those of the first 4 years. After 49 years, however, OM contents in all treatments tended to decrease and in 2009 reached 18 g/kg in control, 20 g/kg in NPK and 28 g/kg in NPK+C treatments. Currently, we are searching for the causes of these results.

Available silica contents in NPK+S treatment were in the ranges of 64~105 mg/kg until 1989 but thereafter increased rapidly to the level of 250 mg/kg (Figure 2). This result was attributed to replacement of silica fertilizer type from calcium silica to silica fertilizer which has a higher grade of silica. Among treatments without silica fertilization (Control, NPK and NPK+C), the differences in available silica contents were insignificant during 56 years. However, available silica contents in these treatments increased slightly.

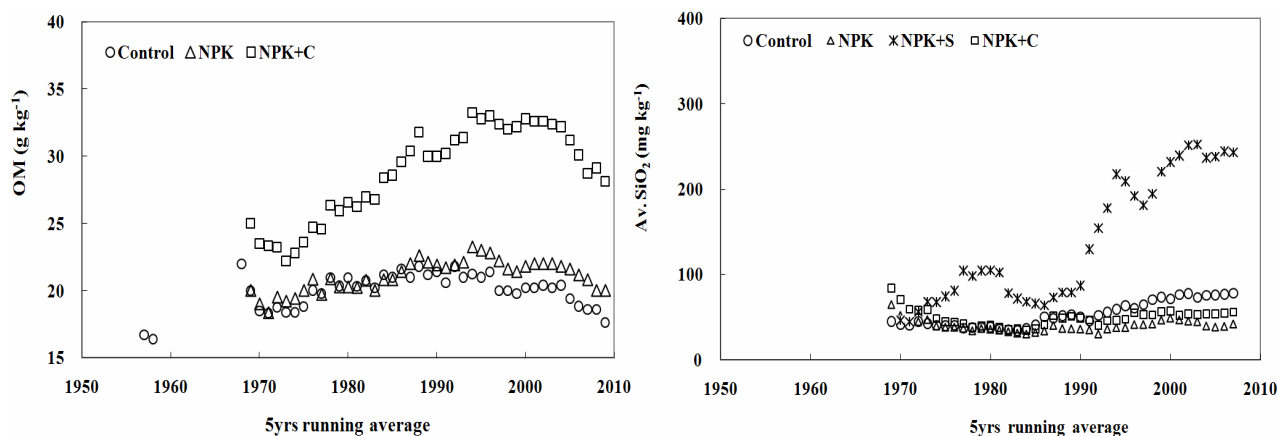


Figure 2. Changes of OM and Av. SiO₂ with continuous applications of four different fertilizer treatments for 56 years

Figure 3 shows the distribution of OM and av. silica contents in the soil profile. OM contents were higher in the surface soils (0-15cm) in all treatments than in subsurface soils (15-30cm). OM contents in NPK+C treatments in all profiles were higher than those in other fertilizer treatments. Available silica contents in NPK+S were higher than those in other fertilizer treatments in all profile. Contents of available silica in surface soil within to the plow layer (0-20cm) were significantly higher than those in subsurface soils (20-30 cm).

Conclusion

This long-term fertilization experiments since 1954 has been conducted to find the best fertilizer practice protocol in the continuous rice paddy cropping system. Since OM and available silica contents are crucial

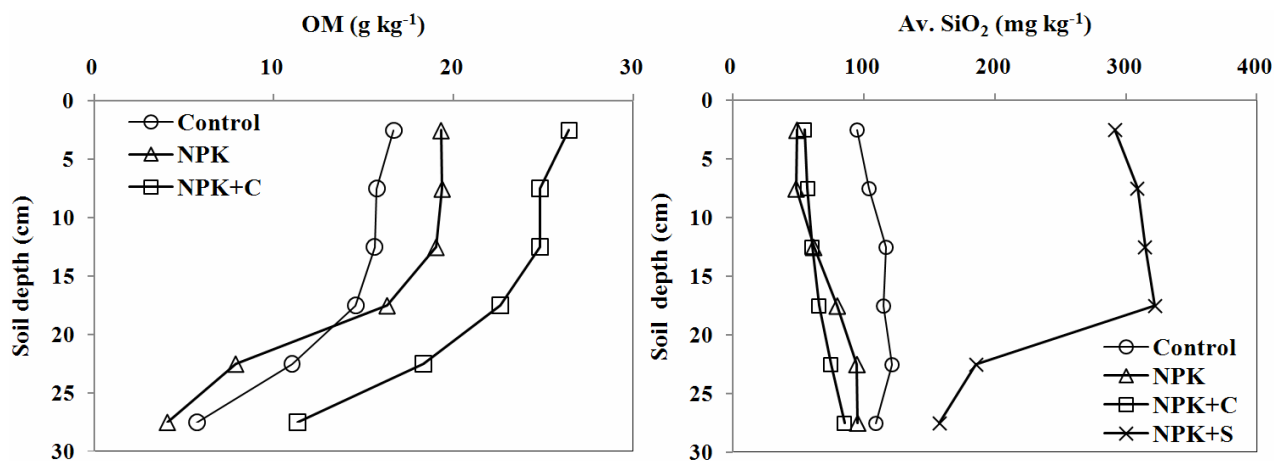


Figure 3. Distribution of OM and available SiO₂ in the soil profile after fifty-six years of the continuous fertilization experiments (2009).

parameters in rice production and quality, various efforts have been made to increase those levels in paddy soils in Korea. Rice straw has been used as livestock feed in many regions of Korea. Farmers have been avoiding of silica fertilization because of no visual response of rice to silica fertilizer even though government has subsidized the fertilizer cost. This fifty-six years of experiments shows that the continuous application of rice straw compost and silica fertilizer has revealed an significant impact on increasing OM and available silica contents in surface and subsurface soils. Therefore, combined application of inorganic fertilizers with organic compost and silica fertilizer as a soil amendment is considered to be the best fertilization practice in the continuous rice cropping system in terms of fertilizer use efficiency and enhancement of soil fertility.

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