Organic and Inorganic Cofertilization for Improved NPK Nutrition and Sustainable Production of Rice and Vegetable

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Name : Kyi Moe

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（イネや野菜の NPK 栄養の改善と持続可能な生産のための有機質と無機質肥料の共施用）

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Thesis Summary

Organic fertilizer plays a vital role in sustainable crop production systems. However, there is still a lack of appropriate application method. The general recommendation method (weight basis per unit area) cannot decide the amount of nutrient supply from organic fertilizer since it emphasizes on total weight and does not consider the nutrient composition. In the present study, we made a practical technique, the estimated mineralizable nitrogen (EMN) method, for the application of organic fertilizer. The idea of EMN method is the application of organic fertilizer based on the amount of mineralizable nitrogen (N), which is estimated from their total N content.

In two year pot experiments (2017 and 2018), three types of poultry manure (PM), Hakkou keifun (PMH), Keifun (PMK), and Ekono hakkou keifun (PME), and three types of cow manure (CM), Gyufun (CMG), Neobi-ru (CMN), and Hakkou gyufun taihi (CMH) were co-applied with two levels of chemical fertilizer (CF) to observe the continuous effects of organic manure as EMN on nutrients composition, quality and growth parameters of komatsuna (*Brassica rapa* L.), and compare with the sole CF. The results revealed that the CF + PMK (total N ≥4%) treatment showed higher N, phosphorus (P) and potassium (K) uptakes, and calcium (Ca) and magnesium (Mg) content, greater number of leaves, leaf length and soil-plant analysis development (SPAD) values and dry matter (DM) accumulation compared with the sole CF treatments, followed by CF + CMG (total 2%≤N<4%) treatments in both years. Another CF + PM (total 2%≤N<4%) or CM (total 2%≤N<4%) treatments achieved lower nutrient contents and uptakes, growth characters and DM in 2017, but these all parameters enhanced in 2018, compared with CF treatments. The nitrate content linearly increased when the CF application level increased. The plants of CF treatments obtained the highest nitrate content in both years. Compared with CF treatments, all CF + PM or CM treatments showed lower nitrate contents and obtained higher ascorbic acid contents. Particularly, the highest ascorbic acid contents were observed in CF + PMK (total N ≥4%) treatments followed by CF + CMG (total 2%≤N<4%) treatments. It is evident that the application of organic fertilizer as EMN plus CF was effective for enhancing nutrient content and uptake, quality and productivity of komatsuna, a short-growing vegetable.

In two year field experiments (2017 and 2018), the PM, CM and compost (CP) were co-applied with CF to observe the continuous effects of organic manure based on EMN method on N, P and K uptakes, growth character, yield components and yield of the Indica (Manawthukha) rice and the Japonica (Genkitsukushi) rice varieties as compared with the sole CF. The results indicated that the CF + PM (total N ≥ 4%) treatments synchronized the N supply and the N demand of both Indica and Japonica rice varieties, resulting in higher N, P and K uptake, SPAD value, plant height,

tiller number and DM at all growth stages. Compared with the sole CF treatment, the CF + PM (total N ≥ 4%) treatment provided higher yield and yield component for both rice varieties in both years. In 2017, the CF + CM (total 2%≤N<4%) or CP (total 2%≤N<4%) treatments provided the similar N, P and K uptakes, yields and DMs compared with the sole CF treatment. The continuous application of organic fertilizers increased the yields and DMs of both rice varieties in 2018, which were higher than those of the sole CF treatments. Nonetheless, the yields of both rice varieties were stagnant in the sole CF treatment in both years. As the variety effect, Indica rice obtained the greater N, P and K uptake, growth character and DM in both years. However, higher SPAD value was measured by Japonica rice throughout the crop growth period, resulting in a higher filled grain (%), greater harvest index and yield in both years. According to the results of this study, the CF + PM (total N≥4%) treatment showed the best performance in terms of NPK uptake, growth parameters and yields of Indica (Manawthukha) and Japonica (Genkitsukushi) rice varieties in both years. Moreover, the continuous application of CM (total 2%≤N<4%) and CP (total 2%≤N<4%) were also beneficial in 2018 as a residue effect.

The present study also evaluates the N, P, K recovery efficiency (N-RE, P-RE, K-RE) of komatsuna under upland condition, and N recovery efficiency (N-RE), N use efficiency (N-UE) and agronomic N use efficiency (A-UE) of Indica and Japonica rice varieties under lowland condition, applying organic fertilizers using EMN method. The results revealed that the CF + PMK (total N ≥4%) treatment exhibited the highest N-RE derived from manure (N-REdfM) value in Komatsuna. The ratio of N-REdfM to EMN was high and closed to 1. Consequently, the CF + PMK (total N ≥4%) treatment provided the higher N-RE, P-RE and K-RE values compared with the sole CF treatment. Other PM or CM (total 2%≤N<4%) had low N-REdfM and their treatments provided low N-RE values.

For Indica and Japonica rice varieties, the CF + PMK (total N ≥4%) treatment provided the highest N-REdfM value and the ratio of N-REdfM to EMN was high and greater than 1. Consequently, the N-RE, N-UE and A-UE values were high in both rice varieties. The CF + CM or CP (total 2%≤N<4%) had low N-REdfM and their treatments provided low N-RE values. However, the continuous application of CM or CP (total 2%≤N<4%) increased N-RE values in 2018.

The present study reveals that application of organic fertilizer based on EMN method is an effective technique that synchronized the N supply and the crop N demand, further supplying P and K. Specifically, application of organic fertilizer (total N ≥4%) based on EMN method co-applied with CF is beneficial for improving nutrient content, quality and production of vegetable, enhancing N, P, K uptakes, growth characters and yield of both Indica and Japonica rice varieties and increasing N recovery of crop under both upland and lowland condition.