

Rice Science

FOR DECISION- MAKERS

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Combining organic and inorganic fertilizers: recommended practice for sustaining rice yield

What are organic fertilizers?

Organic fertilizer is made of animal or plant biomass that has completely decomposed until the original material has become soil-like in texture. Biofertilizers, or microbial fertilizers, compost activators, inoculums are commonly classified as organic fertilizers, but they are either soil conditioners or growth enhancers.

Plants take nutrients from organic material this way: the organic material (OM) will decompose first (physical or chemical breakdown) before it can be used by the plants. The nutrients from the organic fertilizer are converted first into inorganic form before plants can absorb them, implying that plants do not directly use the nutrients found in organic material. Examples of organic material and manures are those from cattle or poultry manure, composted rice straw, or other crop residues. As they are decomposed by soil microorganisms, OM also serves as their food - for them to multiply and to be able to maintain the biological component of soil health.

KEY POINTS

- Combined application of organic and inorganic fertilizers makes soil nutrients available for rice plant use, enough to maintain soil productivity and increase yield potential of high-yielding rice varieties. Combined application is better than organic fertilizer alone.
- Continuous incorporation of rice straw increased soil potassium content while chicken manure increased phosphorus in the soils, although their accumulated concentration in the soil is still lower than the critical level (0.20 m.e/100) required by the rice plants to complete its growth and grain production.
- Neither the organic nor the inorganic fertilizer applied in flooded/paddy soils causes soil acidity.

What is the real score between organic and inorganic fertilizers?

A PhilRice study (1993-2012) on continuous application of organic and inorganic fertilizers on irrigated rice shows that achieving nutritional balance between these two inputs results in better soil productivity and functionality than using either of them singly. The study also looked at farmyard and household wastes as alternative source of fertilizer for rice crops.

Striving to better understand nutritional balance: PhilRice's long-term fertilizer management experiments

The first PhilRice experiment on the use of organic amendments, done in 1999-2001, investigated biological and chemical behavior of organic fertilizers on paddy rice. In that experiment, N from the organic fertilizer lasted only up to the maximum tillering stage thus the need to apply inorganic N.¹

The graph below illustrates the decline of nutrients N & K (as shown by the red arrow, see Fig. 2) within the growing season, which implies the need for additional elements for the rest of the season. The observed lower available soil N content from the organic fertilizers than that of the inorganic fertilizers still showed higher N supply from the latter than the former. This is expected as the total N content of the organic fertilizers applied are lower than the inorganic N fertilizer.

Review : 3-year experiment (1999-2001)

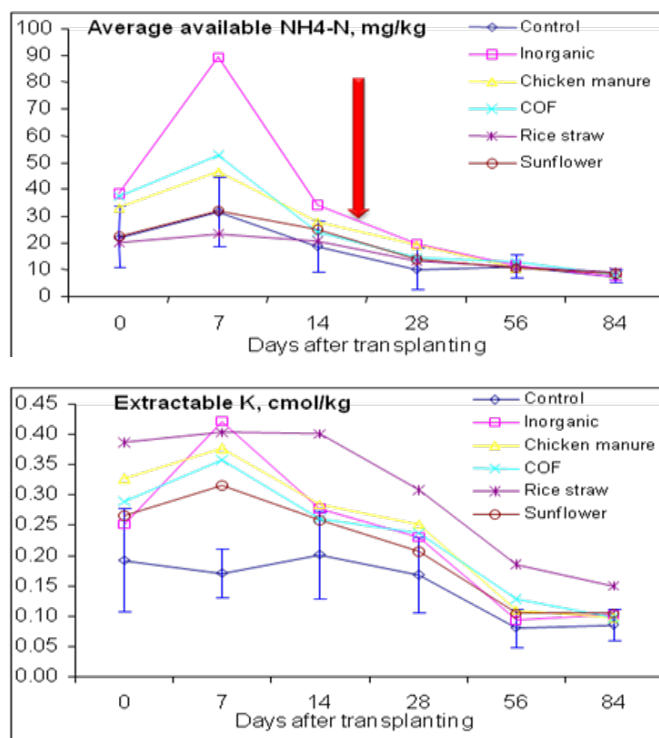


Figure 2. Available soil nitrogen and exchangeable soil K analyzed at different growth stages of the transplanted (irrigated) rice plant as affected by different organic materials/fertilizers. 1999-2001. Similar trend of nutrient elements was observed in the 2003-2006 experiment.

The 3-year experiment showed that rice straw is the better option compared to inorganic material as source of K, after a certain number of years of incorporation.

The experiment was re-established in 2003, but this time with the combination of inorganic NPK, full and half of the recommended rate. Highlights of the study (2003-2006 or six consecutive seasons) consistently showed that organic fertilizers are not enough to provide the nutrients

needed by the rice plant, and that inorganic or chemical fertilizers are still needed for higher yield. In fact, with or without organic fertilizer, application of inorganic fertilizer still produced better grain yield than organic fertilizer alone. However, plots applied with organic fertilizer+inorganic fertilizer produced more panicles.

It was found that chicken manure (CM), applied singly, produced comparative yield as did inorganic fertilizer. The reason for this is CM has narrower carbon:nitrogen (C:N) ratio thus mineralization is faster, understandably leading to quicker availability of nutrients. CM also contains more nutrients per unit weight of organic material compared to other organic sources.

Chicken manure, carbonized rice hull, and commercial organic fertilizer increased microbial biomass in the soil two weeks after application.

In the nutrient cycle, microbes transform applied chemical fertilizers into their available forms that can eventually be absorbed by plants. Chemical fertilizers lower decomposition rate particularly that of N as it is necessary to lower the C:N ratio of the organic fertilizers used. This process shows that chemical and organic fertilizers can actually co-exist and are complementary.

After 3 years of continuous reincorporation, rice straw was recommended in the rice-rice cropping system (irrigated lowland rice) to be an alternative nutrient source with half the rate of inorganic NPK fertilizer. During this time as well, accumulation of K in the soil started to build

Myths on organic and inorganic fertilizers

Myth: Inorganic fertilizer makes the soil acidic.

Fact: Neither organic nor inorganic fertilizer makes the soil acidic. It is the imbalance in the flooded/paddy soils (see Fig. 1). This eventually leads to decrease in yield.

There is no evidence to prove yet that imbalances would more likely occur with N without K results in lower yield; but with both, there is increase in yield even if the yield is observed. Hence, balanced application of N, P and K is needed to attain high yield present in the soil.

Myth: Inorganic fertilizer makes plants more susceptible to pests and diseases.

Fact: Susceptibility to pests and diseases occurs only when excessive fertilizer is applied. With too much fertilizer, leaves turn green and become succulent, making them more attractive to pests and diseases.

Myth: Inorganic fertilizer can contaminate bodies of water; while organic fertilizer cannot.

Fact: Contamination as well as deterioration in soil productivity can happen with the unwarranted use of fertilizers. As Mamaril (2004) mentioned, application of fertilizers has to be based mainly on the need of the crop and on the capacity of the soil to store and provide the essential nutrients. In fact, excessive use of N on aerated soils results in nitrate leaching that will contaminate ground water.

up in the 0 to 15-cm layer. This is attributed to the fact that rice straw contains most of the K that is absorbed by the rice crop. Therefore with rice straw continuously returned - plus the addition of K-containing inorganic fertilizers (try 14-14-14 or 17-0-17 or 0-0-60) - an increasing trend of K in the soil is expected.

Data also showed that continuous incorporation of rice straw increases soil potassium content while chicken manure increases phosphorus in the soils, although their accumulated concentration in the soil is still lower than the critical level (0.20 m.e/100) required by the rice plants to complete its growth and grain production (see Figure 3 below).

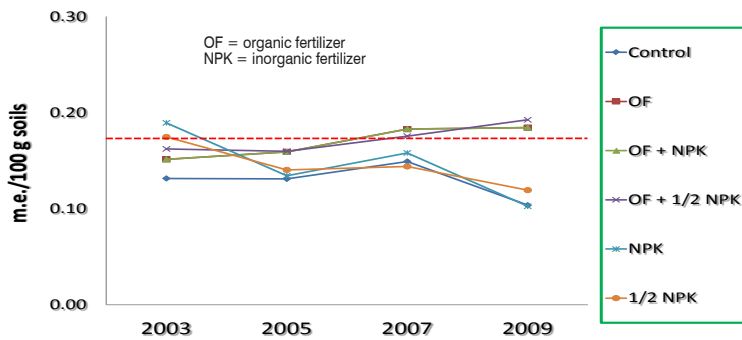


Figure 3. Soil exchangeable K across years

Overall, the long-term PhilRice study (2003-2011) revealed that constant incorporation of organic fertilizers sustainably increased rice yield than no applied fertilizer at all, although the rice yield was lower than with inorganic or chemical fertilizers, be it full or half rate.

Some scientific studies on nutrient availability in organic materials:

- Takahashi, Uenosono, and Ono (2003) investigated short- and long-term effects of rice straw application to paddy soils on crop growth, mineralization of straw N (nitrogen), and soil N supply under flooded and upland conditions. They found that gross rates of N mineralization under flooded conditions increased by continuous rice straw application. The application also contributed to the improvement of soil fertility and the promotion of growth and N uptake by paddy rice and upland crops, while short-term effects on dry matter production and N uptake by crops were little. To improve N uptake, it was recommended that continuous rice straw application be combined with mineral or inorganic fertilizer application, for short-term effectiveness. [in Plant and soil, 251 (2), 11 p.]
- Uenosono and his Japanese research team (2004) found that nitrogen in composted poultry and sawdust cattle manures remained available up to active tillering stage to panicle formation stage. [in Jpn. J. Soil Sci. Plant Nutr., 75, 313-319]
- A study by Buresh and Dobermann (2010) showed that the benefits of organic materials on soil physical, biological, and chemical properties are typically greater for aerobic soil than for submerged rice soil. The most probable benefit of organic materials for rice on submerged soil is as a source of essential nutrients. They also advised that when use of organic materials is financially attractive, the most effective way to supply a balanced amount of N, P, and K matching the needs of the rice crop for each nutrient is to include the use of some synthetic manufactured fertilizers. [in Revisiting the Organic Fertilizer Issue in Rice, Laguna, Phils: Asia Rice Foundation]
- Myint, Yamakawa, Kajihara, and Zenmyo (2010) conducted a study of soil incubation for 2 weeks to investigate the mineralized N of applied mineral and organic fertilizer. They found that plant growth characters, dry matter, yield and plant nutrient accumulations were higher in mineral fertilization than organic. Poultry manure as an organic matter provided comparatively higher nutrient accumulations which in turn enhanced the growth and yield of rice. Chicken manure and SU (rice straw + urea-mix application) gave lower plant growth, yield and nutrient accumulation. Organic matter with high carbon/nitrogen ratio provided very low mineralized N. [in Science World Journal 5 (2), 47-54]

ances of available soil nutrients that cause nutritional problem for rice plants

h inorganic than organic fertilizers. Collado (2012) explained that too much the N applied is reduced. Similarly, with just N and P applied without K, low gh yield potential. Results would still depend highly on the levels of nutrients

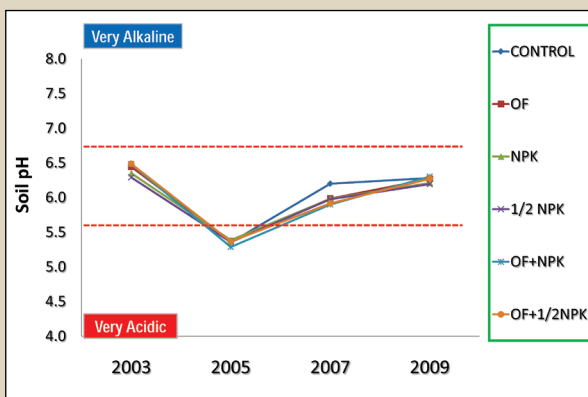


Figure 1. Soil pH due to fertilizer across the years in irrigated rice

Pure organic fertilizer application was still consistently lower than application with inorganic fertilizer alone or in combination with organic fertilizer.

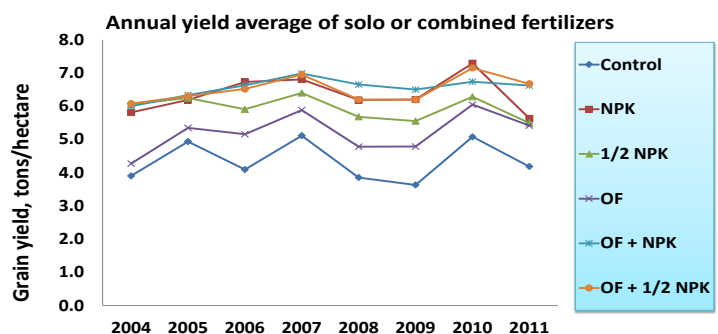


Figure 4. Average grain yield of irrigated PSB Rc82 per year as affected by organic fertilizer (OF) alone, inorganic fertilizer (NPK) alone, and/or combined organic/inorganic fertilizer (OF+NPK) application.

Opting for the practicable route toward sustaining rice yield

The long-term fertilizer management study attests that organic and inorganic fertilizers can complement to produce healthy soil and generate available nutrients to keep soil productive and functional as ultimately shown by the grain yield. The major role of organic material when combined with inorganic fertilizer is to increase the nutrient use efficiency of the inorganic fertilizer. Organic materials (including commercial products), by themselves, contain relatively low concentration of nutrients.

The findings of the long-term fertilizer experiments have shown how organic and inorganic fertilizers could work in synergy to produce good yield. Support toward this direction, when sustained, could aid us in our ultimate goal of achieving rice self-sufficiency in the near future.

Log on to www.philrice.gov.ph to view the online version of this article, with the complete list of references.

CALL FOR ACTION

- Encourage farmers to utilize farm wastes to sustain soil productivity. But judicious application of chemical fertilizers should be ensured if the objective is to sustain productivity at a higher level.
- Enjoin farming communities to maximize the use of indigenous sources, for instance rice straw, as organic material (in combination with half the rate of inorganic NPK fertilizer).
- Conduct learning sessions with farmers and technicians to clarify misconceptions about organic fertilizers' effects on soils (acidity, etc.) backed by scientific data and expert advice.
- Disseminate results of long-term studies on organic and inorganic fertilizers' effects on paddy rice.
- The benefits of organic materials on soil physical, biological, and chemical properties are typically greater for aerobic soil than for submerged soil. In irrigated and rainfed lowlands, complement chemical fertilizers with organic fertilizer use in order to improve nutrient-use efficiency. In these production environments where rice fields are prepared wet, the use of chemical fertilizers need not be abandoned in favor of pure organic fertilizer as this may lead to decline in yield.

ABOUT THE MATERIAL

Rice Science for Decision-Makers is published by the DA-Philippine Rice Research Institute (PhilRice). It synthesizes findings in rice science to help craft decisions relating to rice production and technology adoption and adaptation. It also provides recommendations that may offer policy triggers to relevant rice stakeholders in search of opportunities to share their knowledge on rice-related policies.

The articles featured here are grounded on solid basic and applied research in agronomy, biology, chemistry, and engineering; but it also underscores major contribution from the social sciences.

The theme for this quarter tackles a critical and timely issue on fertilizer management, particularly on the use and application of organic and inorganic fertilizers. It presents findings from a long-term fertilizer management study that sought to determine organic and inorganic fertilizers' effects on the growth and yield of irrigated lowland rice. Findings show that combined use of these organic and inorganic inputs can actually result in good yield. Call for policy action includes and underscores the need to erase some lingering misconceptions surrounding their application. Being informed of these concerns would lead to a heightened understanding and appreciation of the innovations we make in rice science. This dimension shall eventually take us a step closer to fulfilling our aspiration of achieving rice self-sufficiency by 2013.



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