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Organic Fertilizer Titonia Plus and Micro Nutrients Improved Rice (*Oryza sativa* L.) Production in Koto Panjang and Koto Tingga, Padang City, West Sumatera, Indonesia

Nalwida Rozen*, Gusnidar, and Nurhajati Hakim

Faculty of Agriculture, University of Andalas, Limau Manis, Padang, West Sumatera, Indonesia

*Corresponding author; e-mail: nalwida_rozen@yahoo.co.id

Abstract

A series of on-farm field experiments were conducted in two locations in Padang, Koto Panjang and Koto Tingga, West Sumatera, Indonesia in 2015. The purpose of the experiment was to establish the formula of organic fertilizer derived from Tithonia supplied with micro nutrients, Zn and Mn, on rice. The experiments were conducted using completely-randomized block design with six treatments and three replications. The treatments were P = Tithonia Organic Fertilizer Plus (TOFP) + 3.0 kg $Mn.ha^{-1}$, Q = TOFP + 3.0 kg $Mn.ha^{-1}$+ 3.0 kg $Zn.ha^{-1}$, R = TOFP + 4.5 kg $Mn.ha^{-1}$ + 6 kg $Zn.ha^{-1}$, S= TOFP + 4.5 kg $Mn.ha^{-1}$+ 9 kg $Zn.ha^{-1}$, T = TOFP only, U = 100% chemical fertilizer only. Treatment with micro nutrients as addition to TOFP (TOFP+ 3.0 kg $Mn.ha^{-1}$ and TOFP+ 3.0 kg $Mn.ha^{-1}$ +3.0 kg $Zn.ha^{-1}$) increased rice grain yield by 80 g per clump.

Keywords: micro nutrient, chemical fertilizer, rice culture

Introduction

One of main reasons of low yielding rice was due to the disruption of the nutrient balance in the soil as a consequence from using synthetic fertilizers which were limited to nitrogen (N), phosphorus (P) and potassium (K). Generally, there are 13 nutrients that plants need from the soil. Organic fertilizers contain all of the nutrients the plants need, not only N, P and K, but also Calsium (Ca), Magnesium (Mg) and Sulfur (S), but also micro elements which include iron (Fe), Zinc (Zn), Manganese (Mn), Copper (Cu), Boron (B), Chlorine (Cl), And Molybdenum (Mo). Besides unbalanced nutrient problem, synthetic fertilizers price has been increasing and become a major problem for rice growers. Therefore, the use of synthetic fertilizers should be reduced without compromising yield and one of the ways to deal with this problem is by using organic fertilizer.

Organic fertilizer is derived from natural sources and are rich in organic matter which can greatly benefit the soil upon use. One of the organic fertilizers is Tithonia Organic Fertilizer Plus (TOFP), which is made from Tithonia (*Tithonia diversifolia* Hemsl. A.Gray), with additional rice straw and/or manure, lime, fertilizer P, and microorganisms (biological agents). Tithonia is a fast growing perennial that has speedy recovery after cutting, and high yielding, between 30 and 70 $t.ha^{-1}$ of greens. Rutungga (1999) reported that Tithonia contains 0.59 % Ca, dan 0.27 % Mg, while Jamma et al. (2000) and Sanches and Jamma (2000) stated that Tithonia contains 3.5 %, 0.38 %, and 4.1 % of N, P, and K, respectively. A study conducted on Tithonia in West Sumatera reported similar results, i.e. 3.16% N, 0.38% P, and 3.45% K **(**Hakim and Agustian, 2003). Besides N, P, and K, Tithonia also contains 0.59% Ca and 0.27% Mg (Hakim and Agustian, 2003). Tithonia grows well along the rivers and lakes, and have grown to become a weed in tropical areas.

It has been reported that the use of TOFP in rice cultivation using System of Rice Intensification (SRI) method could reduce the use of synthetic N and K fertilizers for up to 50%, with a slightly higher yield compared to 100% synthetic fertilizers. The utilization of TOFP in rice cultivation using SRI method could produce grains up to 4.6 – 5.0 $ton.ha^{-1}$ in Air Pacah, the city of Padang, 3.6 - 4.6 $ton.ha^{-1}$ in Jawi-Jawi, Solok regency, and 6.8 to 7.0 $ton.ha^{-1}$ in Tanah Datar (Hakim et al., 2010). However, the results obtained with this trial is still below the expected rice yield of 8 $ton.ha^{-1}$. This may have been due to a lack of micro elements, which were indicated by brownish yellow spots (browning) symptoms on the paddy leaves (Hakim et al., 2010).

Report from the previous studies demonstrated that TOFP alone has not provided sufficient micro elements for the rice crops to produce optimal yield using SRI method. However, it is not known which among 7 micro elements (Fe, Mn, Zn, Cu, B, Cl and Mo) were deficient in the soil, hence warrant further research. The assessment of micro elements in the soil are rarely studies, whereas micro nutrients are essential for plant growth and development. Simultaneous field experiments were started on the farmers field and in the green house as pot trials. Hakim et al. studies (2014) added 6 micro elements, Fe, Mn, Cu, Zn, B and Mo on Tithonia organic fertilizer plus 50% of the recommended dose of the chemical fertilizer and compared this treatment with Tithonia alone, or chemical fertilizer alone. The results of Hakim et al. (2014) demonstrated that the addition of Mn to Tithonia increased rice grain yields by 21%, whereas Tithonia supplied with Zn increased it by 17% compared to without micro nutrient addition.

The objective of this study was to study the effects of TOFP supplied with both micro nutrients (Mn and Zn) and 50% recommended dose of the chemical fertilizers on rice yield using SRI method. The aim of the study is to improve rice grain yield to 8 tons.ha^{-1} with reduced uses of chemical fertilizer. The long-term goal was to reduce farmers dependence on chemical fertilizers and to accelerate the realization of rice self-sufficiency towards resilience and national food security.

The outcomes of this study is to patent the formula of micronutrient enriched TOFP and make it accessible to the farmers. Benefits for the Indonesian Ministry of Agriculture, the research partner, is the availability of technology package in the form of organic fertilizer made with locally sourced materials, i.e. Tithonia, straws, and lime. This technology can potentially reduce application of synthetic fertilizers by 50% while maintaining higher rice yield than conventional practice using 100% synthetic fertilizers. On the other hand fertilizer manufacturers will benefit from their access to the formula and method of manufacture of organic fertilizer plus (TOFP) once the technology has been patented.

Materials and Methods

The field experiment was conducted on farmers fields in Padang city, West Sumatera. Soil and plant analysis was conducted at the Soil Laboratory of the Agriculture Faculty and at the Laboratory of Environmental Engineering, Andalas University, from February to September 2015.

The experiment used a completely randomized block design consisting of six treatments and three blocks, with details as follows: P = Tithonia Organic Fertilizer Plus (TOFP) + 3.0 kg Mn.ha^{-1}, Q = TOFP + 3.0 kg Mn.ha^{-1}+ 3.0 kg Zn.ha^{-1}, R = TOFP + 4.5 kg Mn.ha^{-1} + 6 kg Zn.ha^{-1}, S= TOFP + 4.5 kg Mn.ha^{-1}+ 9 kg Zn.ha^{-1}, T = TOFP only, U = 100% chemical fertilizer only. All treatments received TOFP plus 50% of synthetic fertilizers for N (50 kg N.ha^{-1}) and K (50 kg K.ha^{-1}). Synthetic fertilizers used were Urea, SP36, KCl and Kieserite. Micro nutrients for the treatments were sourced from MnSO4 and ZnSO4. Rice cultivar used was IR-42. Materials for TOFP were Tithonia, rice straw, lime, and biological agents Stardec, *Trichoderma, Azotobacter, Azospirillum*, and phosphate solving bacteria.

Parameters for analysis were soil and TOFP nutrient contents, plant height, total number of tillers, number of productive tillers, dry weight of straw and grain, nutrient content and nutrient uptake of straw and grains.

Data were analysed with ANOVA using SAS 8.1. Significant differences between treatments were further analyzed using LSD at 5% level of significance.

Results and Discussion

Analysis of Soil Nutrient Levels

Soil P content in Koto Tingga was much higher than that in Koto Panjang (Table 1). This is due to the fact that rice field in Koto Tingga regularly received additional N, P, and K elements in the forms of Urea, TSP, and KCl. Therefore, P-potential of the soil was very high but it was bound strongly in the soil, hence was not available for the crops. While in Koto Panjang, rice growers had already started applying composted rice hay to their land so the soil P level was lower, but more readily available to the crops.

TOFP had high content of P (Table 2), so TOFP can contribute P for plant growth. In addition, TOFP can also help to release P from in the soil to be readily available to the crops.

Rice Height

Rice heights at both locations were significantly different, likely because of the different soil characteristics of the two sites, especially soil pore distribution (Figure 1). Based on our observation, the soil in Koto Panjang had less porosity than that in Koto Tingga, so more water is retained in the soil of Koto Panjang, whereas in Koto Panjang, the soil has high porosity, indicated by the fast drying of the

Table 1. Analysis of soil nutrients at Koto Tingga and Koto Panjang

Location	pH	N (%)	C-org (%)	P (ppm)	Ca (me/100g)	K (%)	Mg%	Mn (ppm)	Zn (ppm)
Koto Tingga	5.6	0.1	1.7	20.9	0.7	0.9	1.7	0.6	1.0
Koto Panjang	6.3	0.2	2.4	9.5	0.8	1.0	0.9	0.8	0.2

Table 2. Analysis of the nutrient content (%) of Tithonia Organic Fertilizer Plus (TOFP)

Na	N	P	C-org	Mg	K
0.2	0.95	1.5	0.68	0.35	0.35

soil after watering, which will also cause nutrients to leach out rapidly. Therefore, the application of TOFP into the soil may help in increasing the water holding capacity of the Koto Tingga soil.

Total Number of Tillers

Based on the analysis of variance, the total number of tillers among the treatments showed no significant difference in both pilot sites, as shown in Figure 2.

The number of rice tillers in Koto Tingga was higher than those in Koto Panjang (Figure 2), likely due to a higher levels of soil Mg and Zn in Koto Tingga. According to Boonchuay et al. (2013), Zinc improved rice seedling growth indicated by longer roots and coleoptiles, and increased up to ten-fold of the rice husks. In addition, Zinc in rice grains can be effectively raised by foliar Zn application after flowering (Boonchuay et al., 2013). Low availability of soil Mg might result in decreased transpiration, accumulation of sugars and starch in the leaves, and a decline in photosynthetic activity, hence lead to a decrease in yield (Tanoi and Kobayashi, 2015).

Number of Productive Tiller

The number of productive tillers showed no significant differences between the two pilot sites (Figure 3).

The number of productive tillers of rice IR42 at both locations was more than those with conventional method (synthetic fertilizer 100%).

Grain Dry Weight

Rice grain dry weight in Koto Panjang demonstrated different results with different treatments, whereas there were no significant differences amongst treatments in Koto Tingga (Figure 4).

It has been reported that high nutrient content in Tithonia depends on bioagent in their rhizosphere. In the rhizosphere of Tithonia nodulation was found due to symbiosis with nitrogen fixation bacteria such as *Azospirillum* and *Azotobacter,* phosphate solubilizing

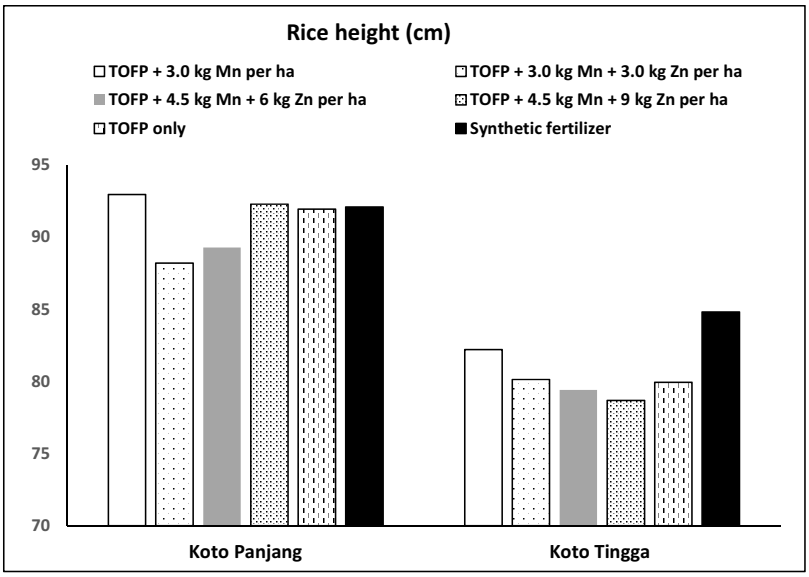

Figure 1. Height of rice treated with TOFP, TOFP + Mn, TOFP + Mn + Zn and synthetic fertilizer in Koto Panjang and Koto Tingga at 56 days after planting

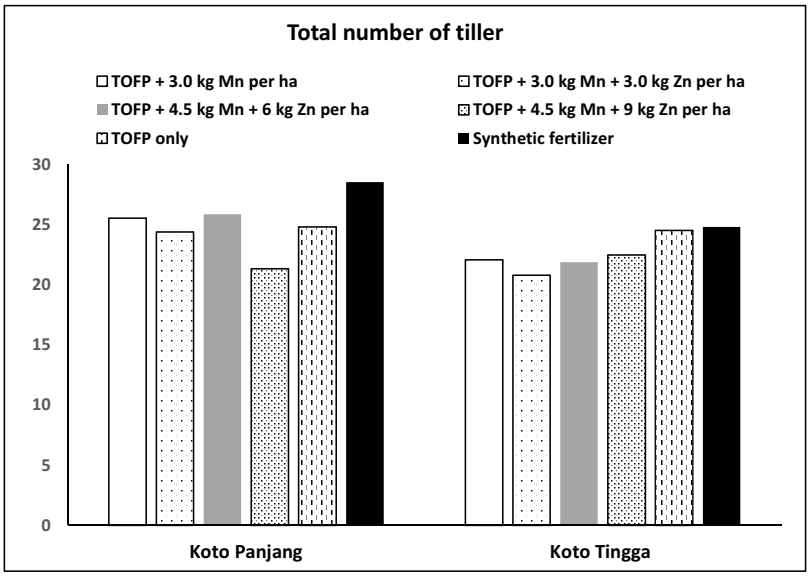

Figure 2. Total number of tiller of rice crops treated with TOFP, TOFP + Mn, TOFP + Mn + Zn and synthetic fertilizer in Koto Panjang and Koto Tingga at 56 days after transplanting.

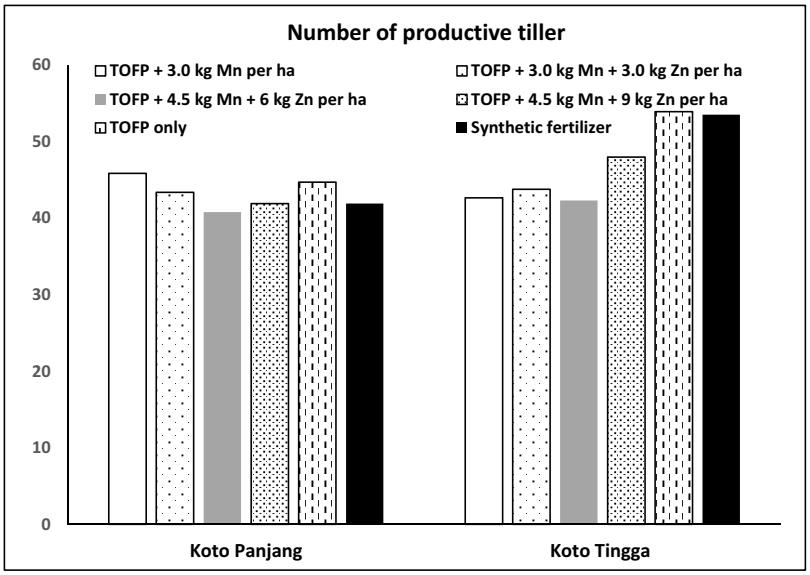

Figure 3. The number of productive tillers or rice treated with TOFP, TOFP + Mn, TOFP + Mn + Zn and synthetic fertilizer in Koto Panjang and Koto Tingga at 106 days after transplanting. There were no significant differences in the number of tillers between treatments

bacteria, and phosphate solubilizing fungi.

Straw Dry Weight

The straw dry weight of rice in Koto Panjang were significantly different among other treatments, whereas in Koto Tingga shows no significant difference. Data of straw dry weight of rice crops is presented in Figure 5.

The dry weight of rice straw was slightly higher in Koto Panjang than in Koto Tingga (Figure 5), and straw dry weight from synthetic fertilizer treatment was higher than those from the other treatments.

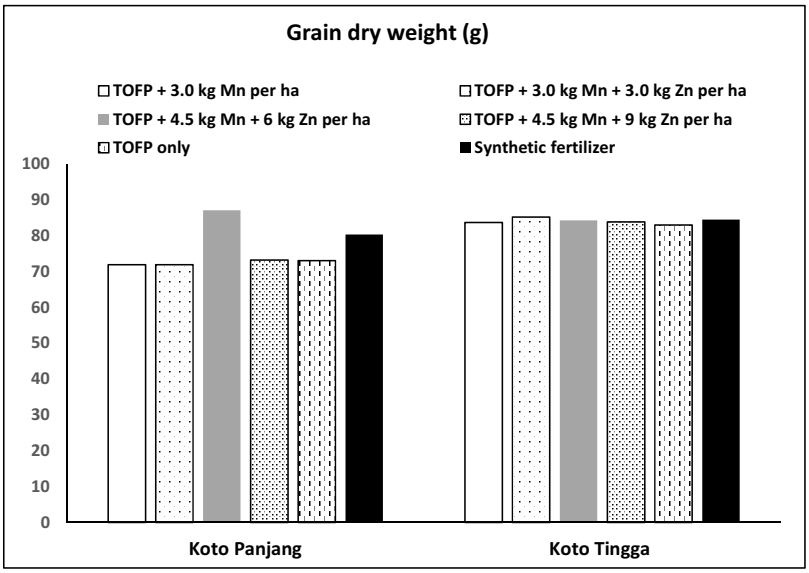

Figure 4. The grain dry weight of rice treated with TOFP, TOFP + Mn, TOFP + Mn + Zn and synthetic fertilizer in Koto Panjang and Koto Tingga at 105 days after transplanting. Significant differences between treatments in affecting in rice grain dry weight were noted in Koto Panjang only.

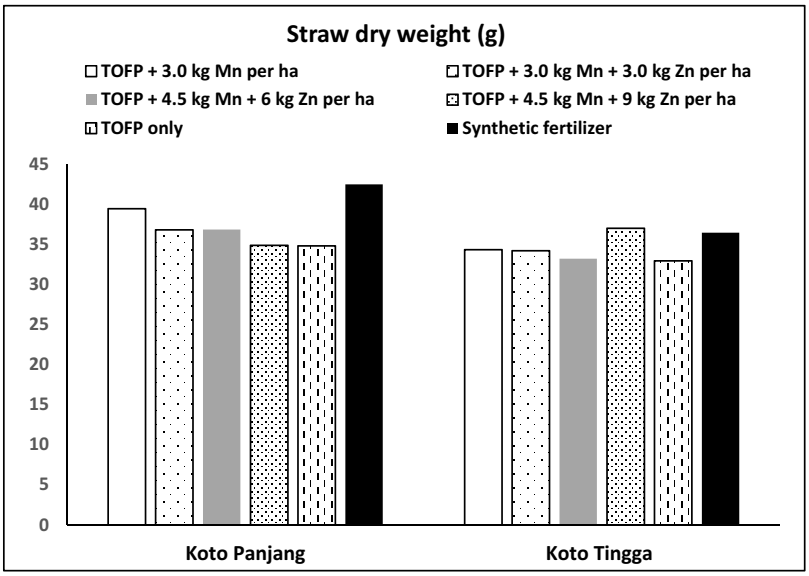

Figure 5. The straw dry weight of rice treated with TOFP, TOFP + Mn, TOFP + Mn + Zn and synthetic fertilizer in Koto Panjang and Koto Tingga at 105 days after transplanting. Straw dry weight at Koto Panjang was higher than those at Koto Tingga.

Conclusions

Treatment with micro nutrients added to TOFP was shown to increase rice grain yield.The best combination of TOFP and micro nutrients are TOFP + 3.0 kg $Mn.ha^{-1}$ and TOFP +3.0 kg $Mn.ha^{-1}$+ 3.0kg $Zn.ha^{-1}$, which had increased rice grain yield to 80 g per clump.

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