SUSANE – Sustainable, sanitary and efficient management of animal manure for plant nutrition

Fertilizer Value of Animal Manure Application on the Field

Introduction

If farmers are to improve their utilisation of animal manure for crop production, they need to know a realistic estimate of its fertilizer value. The plant nutritional effect from application of organic manure can be expressed as the mineral fertilizer equivalent (MFE) value, i.e. corresponding to the equivalent dose of mineral fertilizer producing the same yield. This makes it easier to calculate the appropriate fertilisation of a crop to achieve target yield, thereby avoiding over-fertilization

In this newsletter we would like to introduce the ways to estimate MFE from field experiments, as well as our research results for MFE of using animal manure for crops in Northern Vietnam, and the practical implications of these.

Mineral fertilizer equivalent estimation

In a field trial with manure and increasing levels of mineral fertilizer application (see Figure 1), the yield response curve can be used to estimate the agronomy efficiency (AE, increase in yield / kg nutrient input) of both fertilizer and manure.

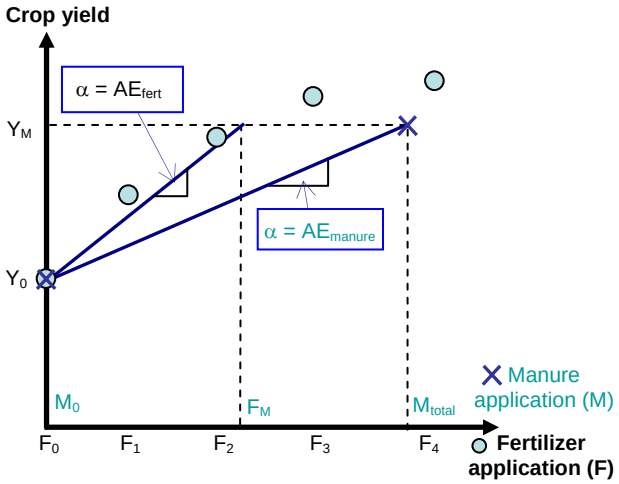

Figure 1. Estimation of mineral fertilizer equivalent (MFE) value of manure from crop yield response

The Mineral fertilizer equivalent (MFE) value of the manure can then be calculated by the following equations:

$$AE_{fert} = (Y_2 - Y_1) / (F_2 - F_1)$$

$$AE_{manure} = (Y_M - Y_0) / (M_{total} - M_0)$$

$$MFE = AE_{manure} / AE_{fert}$$

where Y_i is the crop yield at fertilizer (F) or manure (M) input level i of e.g. Nitrogen. In other words, the MFE expresses the relative efficiency of manure to mineral fertilizer nutrient value.

Instead of yield, the MFE value can also be estimated based on the nitrogen uptake of whole aboveground plant biomass, which has the advantage, that the N uptake response is more or less linearly related to $N_{fert\ (i)}$ over a wide range.

Fertilizer value of the fresh manure and various composts on the field

A crop field experiment was carried out in the Midland Centre of Soils and Fertilizers Research (Bac Giang, Vietnam) from September, 2007 to February, 2009 (Picture 2). Fresh manure or composts from field composting of pig manure with different additives (straw only or straw + lime, superphosphate, urea or micro-organism culture) or fresh pig manure were applied for a 1 year crop sequence maize-rice-rice (typical cropping system) on one of the main agricultural soils in Vietnam, degraded soil (Plinthic Acrisols/ Plinthaquults).

Figure 2. Manure application for the maize experiment (left) and the rice experiment (right)

The composts with Straw only and Lime were applied for maize 2007 and spring rice and then were replaced by Urea and Micro-org amended composts in the summer rice, respectively; whereas the Superphosphate amended compost was applied to all three crops. The two rates of the manure application (5 or 10 t/ha) was fixed for all crops in the crop sequence (maize 2007,

spring rice and summer rice). After the three-crop sequence, a last crop of maize 2008 was grown without manure application to investigate the residual effect of the previous three applications of fresh manure or compost. For all 4 crops MFE N value of the manures was estimated against increasing levels of mineral fertilizer Nitrogen treatments, with P and K supplied at non-limiting levels.

The results of the field experiment showed that:

- ☞ The mineral fertilizer equivalent (MFE) value of fresh manure or compost types for maize ranged (highest to lowest) from manure composted with superphosphate (SSP) > composted with Straw and fresh manure > composted with Lime. For rice MFE ranged from fresh manure > composted with SSP, with Micro-org and with Urea > composted with Lime and with Straw alone (Figure 3). Addition of Lime was therefore detrimental to fertilizer efficiency in all cases.
- ☞ The MFE value was generally higher for manure application rate of 5 tons ha^{-1} than for 10 tons ha^{-1} (Figure 3), indicating lower manure fertilizer efficiency at the higher rate.
- ☞ The residual MFE effect of composted manures was higher than of fresh manure (Figure 4), but in all cases quite substantial (15 - 24% of applied N).

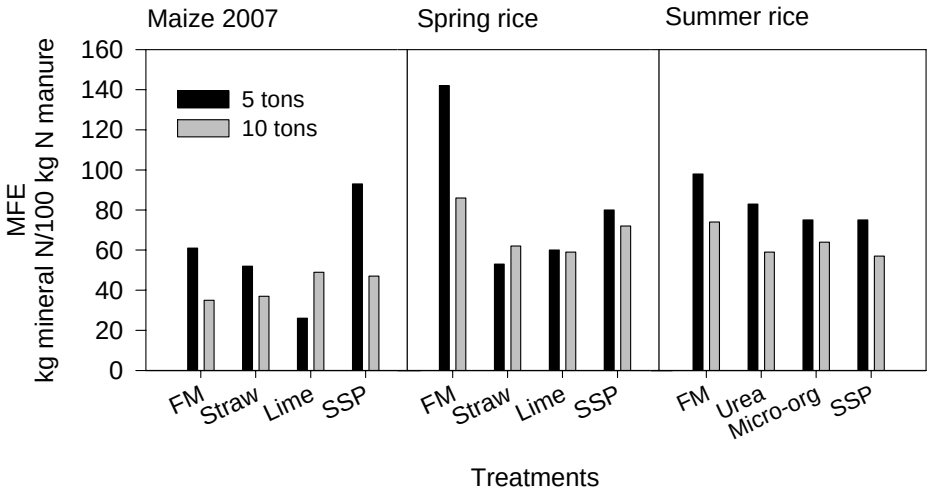

Figure 3 The effect of application rate on MFE of manure types during crop sequence

Practical implications

Fresh manure was more effective than composted manure to promote crop yield in the crop of application, probably because of a higher content of readily available ammonium N. However, applying composted manure could be more sanitary than fresh manure and thus reduce the health risk for farm workers spreading manure.

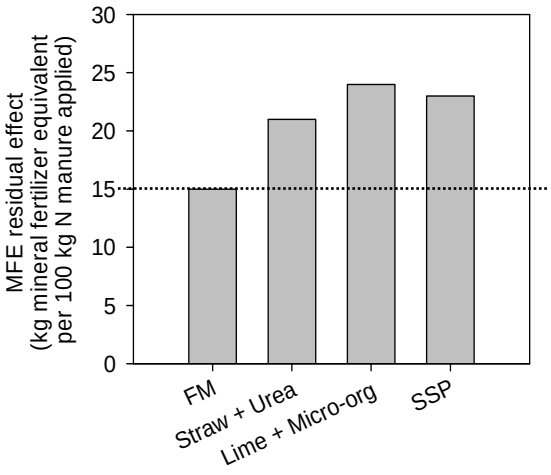

Figure 4. The residual MFE effect of different manure types after one year application (3 previous crops)

Furthermore, the residual effect of composted manure was somewhat higher than for fresh manure, and may to some extent compensate for the slightly lower immediate effect. Superphosphate (SSP) addition for pig manure composting increased crop yield and N uptake when SSP compost was applied to the field, because it increased available ammonium N. However, SSP additions to manure should not exceed that of crop P demand, in order to avoid overloading the soil with phosphorus, resulting in potential pollution of waterways.

Nutrient use efficiency of manure application for the typical maize-rice-rice crop sequence on degraded soil in Northern Vietnam could be improved if the manure application rates do not exceed 10 tons ha^{-1} $crop^{-1}$ and with repeated applications they should probably not exceed 5 tons ha^{-1} $crop^{-1}$, if the manure quality is similar to the composts quality in this study. It is of outmost importance that the mineral fertilizer application rate is adjusted according to MFE values expected for N, P and K, please see a couple of examples in the following.

Examples of mineral fertilizer calculations

Compared to crop nutrient demand, mineral fertilizer rate, has to be corrected for effective nutrient supply from applied manure. If we apply 5 tonnes of fresh pig manure per ha, we can calculate amount of applied total amounts nutrients (see Table 1). Based on MFE of the fresh manure (Fig 3 for N, assumed for P and K), the effective amounts of N, P and K from animal manure can be estimated, and the needed supplementary mineral fertilizer rate calculated as e.g. 180 – 27 = 153 for N.

Table 1 Calculation of mineral fertilizer application for maize applied 5 tons fresh manure

Parameters	Nutrients (kg per ha)	N	P	K
Recommended mineral fertilizers for maize		180	40	100
Nutrient content in 5 tonnes of fresh manure*		45	48	11
MFE value of fresh manure (from Fig. 3 for N)		60%	80%**	80%**
Nutrient effectiveness in 5 tonnes fresh manure		27	38	9
Need for supplementary mineral fertilizer application		**153**	**2**	**91**

*: Based on fresh manure used in field exp., 30 g N, 32 g P and 7.5 g K kg^{-1} dry matter; dry matter 30 % of fresh

**: MFE for P and K assumed from other experimental evidence

Repeated manure applications for every crop in a year will result in a considerable residual nutrient effect, and the fertilization of the next crop should be adjusted, or eventually not amended with manure, in order to use the residual effect of the manure better, and to avoid nutrient overload in soil, especially for phosphorous.

If we apply 5 tonnes of fresh manure for every crop in a year, as in the above example, the soil will have received totally 135 kg N, 144 kg P and 33 kg K per ha. Based on the MFE residual of fresh manure determined in our experiment (Fig 4), a similar calculation can be made for mineral fertilizers applied to the next crop of maize, if no manure is applied to this crop (Table 2).

Table 2 Mineral fertilizer need for maize based on the residual value of 3 previous manure applications, but no current application

Parameters	Nutrients (kg per ha)	N	P	K
Recommended mineral fertilizers for maize		180	40	100
Total manure nutrients applied to 3 previous crops in a year		135	144	33
MFE residual value (from Fig. 4 for N)		15 %	20 %*	20 %*
Nutrient residual effectiveness		20	29	6
Need for supplementary mineral fertilizer application		**160**	**11**	**93**

*: Assumed residual MFE for P and K

It can be seen that the residual fertilizer value of 3 previous applications almost corresponds to the immediate value of a single application (Table 2 vs. Table 1).

If manure is also supplied for the current crop (Table 1 + 2), the P supply from manure alone will be in surplus (38 + 29 = 67 > 40), so no need for fertilizer P and more than a quarter of crop N demand will be covered from manure (27 + 20 = 47). With continued manure application for more years, this will increase even further and should be taken into account when calculating fertilization plans.

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