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A CASE STUDY

Usage of FYM and its impact on rice productivity: Empirical evidence from Tamil Nadu

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ABSTRACT

This paper explores the usage of farmyard manure (FYM) and its impact on paddy yield under different soil conditions in Tamil Nadu, using farming households' three-year rotating panel data from 1993 to 2003. Estimated yield functions reveal that, direct impact of FYM application did not exists in paddy cultivation. Meanwhile, an indirect impact through an increase in the marginal product of chemical fertilizer is observed especially under low inherent soil fertility status. Reflecting the existence of the benefit of FYM application, our factor demand estimation showed that farmers react to FYM price change actively. This means that, reduction in FYM price contributed to the productivity improvement.

KEY WORDS : Rice, Farm yard manure (FYM), Productivity

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Attention to organic fertilizer has been increasing. Concern about the sustainability of food production has been leading to a revival in the use of organic inputs in modern agriculture as this is seen as an appropriate way to maintain soil health by providing soil organic matter and micronutrients (Rasmussen *et al.*, 1998). More recently, a steep rise in international prices for inorganic fertilizer has been further turning people's attention to organic fertilizer as a possible substitute. On top of that, growing concern about poverty and hunger in sub-Saharan Africa sheds light on the role of locally produced organic fertilizer for boosting crop productivity because expensive inorganic fertilizer on international markets becomes even more expensive at the farm gate in Africa due to poorly developed internal transportation systems (Otsuka and Yamano, 2005).

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Meanwhile, experiments in agronomy show that, for lowland rice cultivation, the use of organic fertilizer has little impact on its productivity, whereas it has a discernible impact on upland cereals (Hati *et al.*, 2007; Dawe *et al.*, 2003; Edmeades, 2003; Rasmussen *et al.*, 1998). They also show that the significance of organic fertilizer use varies considerably under different types of soil property (Dawe *et al.*, 2003). This means that organic fertilizer is effective but not a panacea. Therefore, in order to write a correct prescription for agricultural development, we need a better understanding of the potential and limitations of the use of organic fertilizer. However, evidence from farmers' field is limited.

The purpose of this study is to statistically explore differential impact of the use of FYM for paddy under different soil types, using the data set collected by Tamil Nadu Agricultural University under the cost of cultivation of principal crops from 1993 to 2003. The contributions of this study include not only the exploration of the potential and limitations but also policy implications on how to incorporate a dairy sector in a development strategy.

Field experiments show that FYM has little direct impact on paddy yield as the release of nitrogen from FYM is slow in flooded conditions and irrigation water helps to maintain soil health (Balwinder *et al.*, 2008; Pampolino *et al.*, 2008; Sahrawat, 2005; Dawe *et al.*, 2003). An exception is the case when soil quality is inherently very poor (Dawe *et al.*, 2003). Meanwhile, in most cases, the impact on upland crops, including upland cereals, is expected to be high, first because the release of nitrogen is fast under aerobic conditions, and second because the degradation of soil organic matter and the deficiency of micronutrients in soil are usually problematic under aerobic conditions (Hati *et al.*, 2007; Rangaraj, *et al.*, 2007; Yadav *et al.*, 2007; Mussgnug *et al.*, 2006 and Somasundaram *et al.*, 2004). Another group of studies shows that FYM or organic matters in soil indirectly increases yield by making external nutrient more absorbable to crops (Tiessen *et al.*, 1994). This sheds light on the role of FYM as a complement to inorganic fertilizer. At the same time, we should note that, as explained in existing studies in agronomy, the significance of the influence varies considerably under different agroecological conditions (Edmeades, 2003 and Yadav, 2003). Therefore, the empirical section of this study starts by confirming these established features by estimating yield functions by crop and by soil type.

Estimation models :

We define a yield function of farming household *i* in village *j* at time *t* as :

$$\mathbf{y_{ijt} = f\ (l_{ijt} n_{ijt} m_{ijt}; \text{¤}_{ij})}$$

where, *y* is the yield of either paddy per hectare, *l* is the hours of labor input per ha, n is the amount of NPK fertilizer applied per ha, *m* is the amount of FYM applied per ha, and ϕ is aggregated influence from technology, access to irrigation, soil condition, and agro-ecological environment, which is time-invariant at least in the short run (a household-level fixed effect). For econometric estimation, we consider a second-order local approximation to this general form. This gives a quadratic yield function defined as :

$$y_{ijt} = \alpha_0 + \alpha_1 l_{ijt} + \alpha_2 l_{ijt}^2 + \alpha_3 n_{ijt} + \alpha_4 n_{ijt}^2 + \alpha_5 m_{ijt} + \alpha_6 m_{ijt}^2 + \alpha_7 l_{ijt} n_{ijt} + \alpha_8 l_{ijt} m_{ijt} + \alpha_9 n_{ijt} m_{ijt} + \varphi_{ij} + \varepsilon_{ijt} \quad .....(1)$$

where, ε is the error term for random productivity shocks. Technical interdependencies are captured by the interaction terms, and α_9 becomes positive if FYM and NPK are complementary factors. One advantage of this functional form is that we can include observations with zero input values without any manipulation for log transformation. This is appealing to us as many farmers do not apply FYM at all. Econometrically, a self-selection bias due to the relationship between soil degradation and manure application is expressed as a possible negative correlation between m and ϕ. Estimation with household dummy variables (*i.e.* the household fixed effects model) purges the influence of ϕ.

ANALYSIS AND DISCUSSION

The findings of the present study as well as relevent discussion have been presented under following heads:

Table 1 : Estimation results of quadratic yield response functions for paddy by soil type using a household fixed effect model

Variables	Paddy yield (t ha^{-1})	
	All soil types	Poor soil type[a]
Labour (1000 hrs ha^{-1})	2.990 (3.34)***	3.654 (2.30)**
Labour^2	-0.301 (0.52)	-0.931 (0.91)
NPK (t ha^{-1})	10.759 (4.34)***	10.176 (2.50)**
NPK^2	-12.442 (2.02)**	-7.726 (0.70)
FYM (t ha^{-1})	-0.034 (0.81)	-0.082 (1.11)
FYM^2	-0.001 (0.89)	-0.002 (0.75)
Labour*NPK	-5.935 (2.69)***	-8.303 (2.17)**
Labour*FYM	0.009 (0.32)	-0.020 (0.34)
NPK*FYM	0.237 (1.88)*	0.637 (2.49)**
Constant	1.628 (3.62)***	1.697 (2.67)***
Time-varying dummies	Year*Village	Year*Village
Fixed effects	Household	Household
Observations	2445	1142

*,** and *** indicates significance of values at P = 0.01, P = 0.05 and P = 0.1, respectively; [a] Poor soil type is defined as the soil of non-black/-brown colour. The non-black/-brown soils include yellow, red, gray and mottled

Table 2 : Estimation results of linear FYM demand functions for paddy by soil type using a household fixed effect model

Variables	FYM for paddy (t ha^{-1})	
	All soil types	Poor soil type[a]
FYM price (p^{-m}/p^{y})	-679.697 (-1.89)*	-734.935 (1.17)
Number of ordinary cattle (c^{ord}/p^{y})	-54.226 (0.41)	-77.626 (0.33)
Number of improved cattle (c^{imp}/p^{y})	-121.245 (0.45)	198.736 (1.02)
NPK price (p^{-n}/p^{y})	658.315 (1.35)	959.319 (0.90)
Wage rate (p^{-l}/p^{y})	128.896 (0.27)	-444.148 (0.58)
Constant	2.193 (0.86)	3.620 (0.66)
Time-varying dummies	Year*Village	Year*Village
Fixed effects	Household	Household
Observations	1294	638

* and ** indicates significance of values at P = 0.01 and P = 0.05, respectively

[a] Poor soil type is defined as the soil of non-black/-brown colour. The non-black/-brown soils include yellow, red, gray and mottled.

Yield functions :

The summary statistics of the variables for paddy yield function was presented in Table 1. Since, many farmers do not apply FYM at all to either crop, the means of FYM input are low. However, if we restrict our sample to those who applied FYM, the means become 7.62 and 6.17 t ha^{-1}, respectively.

The results of the first model (all soil types) for paddy show that the co-efficients of labour, NPK, and the squared term of each have conventional signs, although only the squared term of labour is not statistically significant. Meanwhile, the co-efficients of FYM and FYM squared are not significant at any acceptable level of significance in any models, indicating that no direct impact exists, which is consistent with the findings from field experiments. However, it is worth noting that the interaction term between FYM and NPK (*n*m*) is positive and significant, and the magnitude of the impact becomes 2.7 times greater under the poor soil condition (the second model). Thus, our data indicate that although there is no direct productivity impact of FYM on paddy, FYM application still has an indirect impact, which becomes larger when soil quality is inherently poor. FYM can be effective as a complement to NPK for paddy.

Factor demand function :

To compute the village average FYM price, at least one farmer in a village must have record of FYM value. Hence, for this analysis, we excluded the observations in the villages where no one uses FYM at all for any purposes. An interesting result is that farmers apply more FYM to paddy than other crops and the reactions to the changes in FYM price is slightly greater for paddy which is contrary to our expectation based on the yield function analysis. Regarding the level of application, one possible reason is the lower real FYM price in paddy producing villages. In addition, FYM in paddy field has a lasting impact as the release of nitrogen is slow. Hence, although an immediate impact captured by yield function is not so large, expecting a long-term impact, farmers seem to actively increase FYM application when its real price goes down (Table 2).

Although we include the number of ordinary cattle and that of improved cattle, they are not statistically significant in any models. As we have noted in the previous section, this is probably due to small change in the number within a household in three years.

Once we restrict our sample to the poor soil observations Models (2), the co-efficients of real FYM price become larger, which is consistent with the fact that the benefit of FYM application is larger under poor soil condition. However, they are not highly significant, which may stem from the reduction in sample size as well as from the small variation in price in three years. We leave a further statistical analysis for our future issue when the latest and future rounds of CCPC data set will be merged for larger sample size. Similar work related to the present investigation was also carried out by Tambat and Shindedesai (2009), Darade and Bankar (2009), Uikey *et al.* (2010) and Prem *et al.* (2013)

Conclusion :

This paper analyzed the potential and limitations of the use of FYM for the improvement of crop productivity, using farming households' three-year rotating panel data from 1993 to 2003 in Tamil Nadu, India. Four main findings emerged from this analysis. First, the direct impact of FYM application did not exists in paddy. Second, an indirect impact through an increase in the marginal product of chemical fertilizer is observed in paddy, particularly when soil quality is inherently poor. Third, reflecting the existence of the benefit of FYM application, farmers react to FYM price changes actively. These findings reveal that moderate potential of FYM application exists in paddy cultivation under poor soil conditions. Since, the dairy sector development brings about the price reduction and then more FYM application, it contributes to productivity improvement.

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