Ex-Ante Analysis of Feasibility and Viability of selected options for demonstration/experimentation- Improved soil organic matter management, crop management and composting technologies for enhanced soil microbial function

Advent of new farm technologies in the 70s enabled farm sector in the country increase farm output tremendously. Consequently, the country transformed into a food surplus nation from being food deficit country. But this achievement is not without the cost. Due to continuous use of inorganic fertilizers and plant protection chemicals, the organic matter content in the soil declined alarmingly. This manifested in declining or stagnant crop yields in most of the states in the country, besides severely affecting soil ecology thereby fall in soil health.

Realising negative externalities created by modern agriculture on soils, concerted efforts have been initiated both in public and private sectors. One of the solutions suggested to remedy this problem is to enhance soil organic matter status which bestows a plethora of positive benefits including rise in crop productivity. But, a major problem in achieving this objective is non-availability of adequate organic mater from different sources. Exploitation of any sources to augment soil organic matter content beyond certain threshold level, will be uneconomical and may even affect sustainable supply of organic matter. Hence, there is a need to explore alternate sources of organic matter beyond traditional sources such as FYM, green manuring, leaf litter etc. In this direction, species of belowground biodiversity hold a lot of promise in enriching soil organic matter status, increase in nutrients supply to the crops, improvement in soil ecology and health and many other benefits.

Feasibility and viability of demonstration/experiments proposed:

The feasibility and viability of proposed demonstrations/experiments involving below ground biodiversity need to be looked in to the physical/technical and economic feasibility and viability. Only, when a particular option is technically/physically feasible then we have to analyse the economic feasibility of that option. As indicated by the results of the I phase of the project, inventory of belowground biodiversity, it is technically feasible to demonstrate and undertake the proposed experiments in the study region. Therefore, it is necessary to establish economic viability of the proposed/selected options in the study area.

The proposed options/experiments do not involve any large-scale investment of capital nature, which usually lasts for several years. Therefore, the economic viability of the proposed options needs to be analysed using simple economic measures. From cost side, costs of supplying organic matter or nutrients need to be examined as against likely economic benefits. Similarly, costs of creating (replacement cost approach) local environment as that of the proposed option again need to be analysed. From benefits side, we consider all types of benefits that could be obtained from the proposed options and translate benefits into rupee terms using appropriate methods provided in the environmental economics literature. Economic feasibility of some of the studies already carried are reviewed in the following sections to due inferences about ex-ante feasibility of the proposed experiments in the second phase of the project.

1. Experiments with vermicompost to increase organic matter as well as crop yields in the study area

Low cost technologies have been developed to convert farm, industrial, household and other wastes into useful organic matter. In this direction, vermicompost technology is a major one, in which organic wastes including household, industrial, crop residues and others can be transformed into vermicompost, which gives a plethora of benefits to farm sector and to the society. A great deal of benefits has been reported from vermicompost (VC) application to the crops. Improvement in soil physico-chemical and biological properties, improved rate of nutrient uptake by crops and the yield recovery in agricultural lands after the application of vermi-compost have been reported by several authors (Wilson and Carlile, 1989; Tomati and Galli, 1995; Thankamani *et al*, 1996; Szczech, 1999; Edwards and Burrows, 1988). A notable advantage of VC technology is that wastes can be transformed in to VC in a relatively shorter period of six to eight weeks depending on the type of feeding material used for the process. Further, secondary benefits such as higher moisture level, aeration, particle size, and finally the biomass of earthworms also improve soil ecological properties. Although, there will be negligible difference in the total nutrient levels between ordinary compost and vermi-compost, the magnitude of available nutrients will be more in VC than in other composts (Tomati *et al*, 1983; 1995; Springett and Syers, 1979; Kale,1994). Vermicompost possesses certain distinct advantages over organic manures as organic wastes that cannot be disposed off could be utilized for producing vermicompost (Edwards, 1988). The compost recovered is superior in terms of homogeneity and strong aggregate structure. Earthworm secretions and microbes harbored in the vermicompost are good growth stimulators and increased microbial activity takes place in the field receiving vermicompost (Kale *et al.*, 1992; Karuna *et al.*, 1999; Trimurthy, 2002; Buckerfield *et al.*, 1999). The compost recovered is homogenous and is characterized by strong aggregate structure. Therefore, vermicompost is superior to other forms of compost. Table 2 shows the nutrient content of VC and FYM. It is evident from the table that VC supplies higher level of N, P and K than conventional composting (FYM). In fact VC is the richest source of organic matter as well as organic source of nutrients as depicted in table 1. The nutrient status of VC was higher at 3 per cent of N, 1 per cent of P and 1.5 per cent of K as compared to other sources.

Table 1: Nutrient content of organic manures

A. Bulky organic manures	N	**P_2O_5**	**K_2O**
Cattle dung	0.40	0.20	0.17
Sheep & goat droppings	3.00	1.00	2.00
Horse dung	0.55	0.30	0.40
Pig dung	0.55	0.50	0.40
Poultry manure	3.03	0.63	1.40
FYM	0.75	0.20	0.50
Rural compost	0.75	0.20	0.50
Urban compost	1.75	1.00	1.50
Vermicompost	3.00	1.00	1.50
Coir dust	0.20	0.18	0.96

B. Concentrated organic manures			
Coconut cake	3.00	1.80	1.90
Neem cake	5.22	1.08	1.48
Ground cake	7.30	1.50	1.30
Blood meal	12.00	2.00	1.00
Meat meal	10.00	5.00	0.50
Bone meal	2.4	25.30	-

Source: Joshi, M. and Prabhakarasetty (2004),

A moot question is whether the application of vermicompost to enrich soil organic matter and crop yields is economically feasible. Excepting one study, there are no economic studies dealing with the feasibility of exploring vermicompost as a source of organic matter as well as nutrients to the soil and crops. A study by Reddy *et al.,* (2006) on the production impact and economics of vermicompost use in the selected crops reveals that application of vermicompost to the crops is economically feasible that there was perceptible increase in yields of crops that received vermicompost. Table 3 shows the increase in crop yields due to vermicompost in the selected crops of Karnataka state. It could be observed that VC applied fields reported higher yields to the extent of 2.17 q/ac and 3.42 t/ac respectively in the case of ginger and banana. But, in the case of coconut, reduction in yield in VC user farms was reported, but, as authors point out this could be due to non-application of other inputs at recommended levels for the crop. The net income that is obtained after deducting all costs from the gross income is an indicator of profitability or economic feasibility of VC use for crops (table 2). Interestingly all the three crops which received VC recorded increased net income to the extent of 23.40, 27.51 and 8.01per cent over the control farms which did not receive any vermicompost. These results strongly reiterate the economic viability of the use of VC in crop production.

Table 2: Change in yields and net income due to VC in the selected crops

	Ginger		Banana		Coconut	
	VC user	**Control**	**VC user**	**Control**	**VC user**	**Control**
Yield/ac	68.65(q)	66.48(q)	24.85 (t)	21.43 (t)	5.47 (q)	6.02 (q)
Change in Yield in VC	2.17		3.42		-0.55 (q)	
Per cent change in Y in VC over control	3.26		15.96		-9.14	
Cost of cultivation (Rs/ac)	62065.80	61445.7	27358.29	26611.4	8744.54	10194.46
Change in costs/ac	620.10		746.94		-1449.92	
Percent change in costs	0.18		2.81		-14.22	
Net income (Rs/ac)	25034.20	20287.3	83826.01	65741.25	36309.45	33615.57
Change in net income (Rs/ac)	4746.90		18084.8		2693.88	
Per cent change in net income	23.40		27.51		8.01	

Source: Reddy *et al.,* (2006)

2. Economic impact of bio-fertilisers

Use of microbes as a means to supply organic sources of nutrients to field crops especially to legumes and oil seeds is gaining popularity due to their positive impact not only on the crop yields but also on soil properties and ecology. It has been reported that under normal conditions, LNB can fix 24 to 584 kg of atmospheric nitrogen per ha per year in to the soil (Sindhu, 2004). A study by Sanjeev (1985) showed that rhizobium application in groundnut crop in Karnataka state increased yield by 20 per cent per acre. It has been reported that legume nodulating bacteria (LNB) besides enriching N status of soil through fixation of atmospheric nitrogen, also contribute many ecosystem services (ESS) such as improvement in moisture availability due to concentration of polysaccharides in the soil, soil aggregation, biomass accumulation and other beneficial impacts in the soil. Another study by Reddy et al (2005) on economic valuation of production of rhizobium on groundnut crop in Karnataka state revealed that yield of groundnut increased by 14.18 percent in farms which received rhizobium inoculation over non-users of rhizobium (table 3). Further, it was reported that farmers who used rhizobium for groundnut realised additional net income to the extent of Rs. 2482.54 per ha over non-users of rhizobium. This clearly shows that it is economically feasible to use rhizobium in groundnut as it not only increases yield and income but also improves soil organic matter, soil structure, increase in moisture regime and other ecological benefits. The economic value of direct benefit from *Rhizobium* in groundnut was estimated to be Rs. 1698/ha.

Table 3: Economics of Groundnut Production on User and Non-User Farms
(Rs. per ha)

	Groundnut	
	Rhizobium user	**Control**
Yield/ha	9.90	8.67
Change in Yield in rhizobium fields.	1.23	
Per cent change in Yield over control farms	14.18	
Cost of cultivation (Rs/ha)	9372.67	8672.22
Change in costs/ha	700.45	
Percent change in costs	8.08	
Net income (Rs/ha)	6918.96	4436.42
Change in net income (Rs/ha)	2482.54	
Per cent change in net income	55.96	
Economic value of direct benefits from rhizobium in groundnut	**Rs. 1698 /ha**	

Source: Reddy *et al.,* (2005)

3. Direct economic benefit/impact of VA mycorrhiza in crop production

Mycorrhizal fungi are known to enhance the uptake of diffusion-limited nutrients such as phosphorus and thus improve plant growth. Such fungi have a great economic potential (direct economic benefits to farmers) in terms of supply of natural source of nutrients to crops and soil thereby reduction in cost of cultivation and increased incomes to the farming community besides providing ecological services and functions. Several studies carried out in UAS have demonstrated the positive impact of mycorrhiza on farm economy. Studies (UAS) on the field response of mycorrhizal fungi on tomato, capsicum and chillies revealed that the fungi have direct farm level impact on the crop yields by enhancing uptake of available phosphorus in the soil (Mallesha and Bagyaraj, 1997; Bagyaraj and Sreeramulu, 1982). There was perceptible decline in the P usage (about 50 per cent over recommended dose of P) in these crops due to the fungi. The yields of these crops increased significantly due to VAM fungi and increased the availability of P.

Adopting the approach of “Effect on Production” (EOP), it was inferred that the potential economic benefits from mycorrhiza could be up to 50 per cent reduction in the cost of fertilisers due to decreased use of P fertiliser in the crop production. The mycorrhizal effect on crop growth may depend more on the interaction between fungal strains and soil than between the fungal strain and the crop. This clearly identifies the beneficial effect of fungi on the local ecology.

Results of a field experiment in Karnataka show that incremental yields in tomato ranged between 25 % and 46 % over control due to various strains of mycorrhizal inoculation. The incremental yields were obtained with use of only 50 % of recommended level of phosphorous, as mycorrhizal fungi enhanced availability of P nutrient in soil. The table 4 depicts likely economic benefits due to mycorrhizal fungi in tomato cultivation. The data furnished in the table shows that application of mycorrhizal fungi in field crops especially high value and commercial crops could be a viable proposition. However, a word of caution that these figures are estimated from small experimental plots which may have linear bias in either way when projected for a larger scale. Nevertheless, results are pointers towards economic feasibility of use of mycorrhizal fungi in crop production.

Table 4: Economics of use of mycorrizal fungi in tomato crop

(Projected per acre basis at 90% projected yields from the experimental data):

1	Additional yield at 50% P+***G. leptotichum*** **(kg/ac**):	766.00
2	Additional income @ Rs 3/kg (3*766)	Rs 2298.00
3	Savings in P fertilisers @ Rs 20/kg	Rs 440.00
4	Total incremental income	Rs 2738.00
5	Yield at control+100 % P, kg/ac	5861.00

1	Yield increase at 50% P+***G. intaradices***(kg/ac):	1855.00
2	Additional income @ Rs 3/kg (3*1855):	Rs 5565.00
3	Savings in P fertilisers @ Rs 20/kg	Rs 440.00
4	Total incremental income	Rs 6005.00
5	Yield at control+100 % P, kg/ac	5861.00

Rupee values were worked out for the results of Mallesha and Bagyaraj, (1997)

4. Effect of land use changes on the flux of nutrients through microbial mass in soils

Biomass stand on land surface influences greatly soil organic reserves and microbial biomass especially in tropical forest soils. This in turn influences the availability of nutrients to crops as well as the degree of flux of organic matter and nutrients. A study by Vidya *et al.*,(2001) in the Western ghats region of Chickamagalore district in Karnataka in different types of land uses namely natural forest, acacia plantations, grasslands, paddy fields and mined spoil revealed significant flux of N and P through microbial biomass in soil. The results revealed that microbial biomass added highest amount of nutrients in the natural forest to the extent of 858, and 152 kg of N and P respectively per ha per year. In the case of cultivated lands the addition of N and P was 388 and 177 kg respectively per ha per year. The addition of nutrients to the soil under cultivated ecosystem was lowest compared to other land use types. The economic value of these nutrients based on the opportunity cost/replacement cost (market prices) works out to Rs. 3880 and Rs 3540 for N and P for cultivated lands. This clearly suggests that microbial biomass significantly increased organic nutrient status of soil and it is likely that application of microbial inoculants to the soil would be economically feasible as they save considerable amount in the form of N and P.

Conclusion:

Ex-ante analysis of the proposed experiments in the second phase of the project will reveal whether such experiments would be beneficial to the farmers and society. Although, we do not have many studies pertaining to the proposed experiments, available studies especially with respect to vermi-compost and *Rhizobium* strongly suggest that these technologies are economically viable and give substantial economic benefits both in terms of reduction in cost and increase in yields to the farmers.

References:

Bhagyaraj, D.J.and K.R. Sreeramulu, 1982, Preincoulation with VA mycorrhiza improves growth and yield of chilli transplanted in the field and saves phosphotic fertilizer, *Plant and Soil*, **69** :375-381

Buckerfield, J. C; Flavel, T; Lee,K. E; and Webster, K. A., 1999. Vermicompost in solid and liquid form as a plant growth promoter. *Pedobiologia.* **43**: 753-759

Edwards, C. A., 1988. Breakdown of animal vegetable, and industrial organic wastes by earthworms. In. Earthworms in waste and Environmental Management. Eds. C. A. Edwards and E. F. Neuhauser. Publ. SPB publ, The hague, the Netherlands. Pp.21-23

Edwards, C. A.and Burrows, I., 1988, The potentials of earthworm compostsas plant growth media. In. Earthworms in waste and Environmental Management.Eds. C. A. Edwards and E. F. Neuhauser. Publ.SPB Academic press, The Hague, The Netherlands. Pp 21-32

Joshi, M. and Prabhakarasetty (2004), Sustainability through organic farming, Kalyani Publishers pp 194-195

Kale, R. D; B. C. Mallesh; K. Bano; and D. J. Bagyaraj., 1992. Influence of vermicompost application on the available macronutrients and selected microbial populations in a paddy field. *Soil Biol. Biochem.* **24**:1317-1320

Karuna, K; C. R. Patil; P. Narayanaswamy; and R. D. Kale., 1999. Stimulatory effect of earthworm bodyfluid (vermiwash) on crinkle red variety of*Anthurium andreanum* Lind. *Crop. Res*. **17**: 253-257

Mallesha, B.C. and Bagyaraj D.J., 1997, Field response of Tomato and Capsicum to inoculation with Arbuscular Mycorrhizal fungi, *J. Soil Biol. Ecol.***17** (1): 34-38

Reddy, B.V. Chinnappa, A. S. Venu Gopal and S. Shankar, 2005, Economic Valuation of Production impact of Legume Nodulating Bacteria on Groundnut production, Paper presented at *National Workshop on Conservation and Sustainable Management of Belowground Biodiversity,* KFRI, Peechi, Kerala

Reddy, B. V. Chinnappa, Radha D. Kale and G. Krishna Kumar, 2006, Economic Impact and production Efficiency of Vermicompost use in selected crops, Research Bulletin, University of Agricultural Sciences, Bangalore

Sanjeev, A.P., 1985, Economic Evaluation of Rhizobium-Gypsum Technology in groundnut production- A study in Bhadra Canal Region, Karnataka, Unpublished MSc (Ag) thesis, University of Agricultural Science, Bangalore.

Sindhu S.S, 2004, Biofertiliser technology and genetics of nitrogen fixation. Agriculture: Concepts and Strategy, CCSHAU, Hissar, 216-222

Springett, J. A; and J. K. Syers., 1979. The effect of earthworm casts on ryegrass seedlings. In. Proceedings Second Australian Conference Grass Invert. Ecol. Eds. T. K. Crosby and R.P. Pottinger. Publ. Government printer, Wellington, Australia. Pp.44-47

Szczech, M. M., 1999. Suppressiveness of vermicompost against *Fusarium* wilt of tomato. *J. Phytopathol.* **147**: 155-161

Thankamani, C. K; K. Sivaraman; and K. Kandiannan., 1996. Response of clove (*Syzygiu aomaticum*(L)Merr. And Perry) seedlings and black pepper (*Pipernigrum* L)cuttis to propagating media under nurseryondtion. *J.SpiesAromati Cps.* **5**: 99-104

Tomati,U; and E. Galli., 1995. Earthworms, soil fertility and plant productivity. *ActaZool. Fenn.* **196**: 11-14

Trimurthy, N., 2002. Dynamics of phosphate solubilizing Micro-organismsin organic waste decomposition and its impact on plant growth. Ph. D(Agri) thesis, University of Agricultural Sciences,Bangalore,India

Wilson, D. P. and W.R. Carlile., 1989. Plant growth in potting media containing worm-worked duck waste. *Acta Hortic.* **238**: 205-220

Vidya, K.R., Hareesh, H.R. Rajanna M.D., Sringeshwara, A.N., Balakrishna gowda and Balakrishna A.N., 2001, Changes in biomass, C, N and P as influenced by different land uses, *Myforest*, **38** (4): 561-568