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Technical, Allocative and Economic Efficiency of Organic Input Units in India

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I

INTRODUCTION

India had developed a vast and rich traditional agricultural knowledge since ancient times and is presently finding solutions to problems created by the over use of agrochemicals. Modern farming is not sustainable in consonance with economics, ecology, equity, energy and socio-cultural dimensions. The entire agricultural community is trying to find out an alternative sustainable farming system, which is ecologically sound, economically and socially acceptable. Sustainable agriculture is a unifying concept, which considers ecological, environmental, philosophical, ethical and social impacts, balanced with cost effectiveness. The answer to the problem probably lies in returning to our own roots. Traditional agricultural practices, which are, based on natural and organic methods of farming offer several effective, feasible and cost effective solutions to most of the basic problems being faced in a conventional farming system.

Further it has also proved that modern agriculture cannot be sustainable in the long run because of the adverse changes being caused to the environment and the ecosystem (Kaiser, 2004). These implications are being experienced by declining crop yields and instability in crop production (Chand and Raju, 2008). The necessity of having an alternative agricultural method which can function in an eco-friendly system while sustaining and increasing crop productivity is realised now. The rising input costs involved in modern farming and its unsustainability due to over-capitalisation has made organic farming a necessity in many agricultural regions (Singh, 2009). Organic farming has been found to be as or more viable than conventional farming in the USA and European countries due to higher yield or lower costs or higher market prices (Lampkin, 1994). Modern organic techniques have the potential to stabilise and even increase sustainable farm yields with increasing soil fertility, environmental sustainability and preserving biodiversity of the ecosystem (Haas *et al*., 2005). It will also increase the nutritional value of the produce and reduce the pesticide residues in it (Rekha *et al.,* 2006).

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An important event in the history of the modern nascent organic farming in India was the unveiling of the National Programme for Organic Production (NPOP) in 2000. Later, the Department of Agriculture and Cooperation and the Ministry of Agriculture had also launched a central sector scheme, i.e., the “National Project on Organic Farming (NPOF)” during 2004. It includes capacity building through service providers; financial support to different production units engaged in the production of bio-fertilisers, fruit and vegetable waste compost and vermi-hatchery units and human resource development through training on certification and inspection, production technology etc. The establishment of organic input production units under this scheme is being provided as credit-linked and back-ended subsidy by National Bank for Agriculture and Rural Development (NABARD) and National Cooperative Development Corporation (NCDC). The present paper focuses primarily on issues like capacity utilisation, the efficiency of organic input units sanctioned under this scheme and factors influencing the efficiency of these units. Section II of this paper presents a brief literature review and sampling strategy. Section III explains about the DEA model used in the study. Section IV summarises the results obtained from the analysis of data. Section V sums up the findings of the paper and suggests measures for strengthening the scheme.

II

LITERATURE REVIEW AND STUDY COVERAGE

Efficiency measures can be obtained through the use of a stochastic, parametric approach or a non-stochastic, non-parametric approach (Varian, 1984; Chavas and Cox, 1998; Chavas and Aliber, 1993; Featherstone *et al.,* 1997). In the parametric approaches, the functional form is assumed and econometric methods are used to estimate the flexible functional form. According to Varian (1984), the parametric form “must be taken on faith” since the real function form could never be tested. In addition, Bauer (1990) describes the parametric approach as being weak since the restrictions need to be imposed on technology and the distribution of inefficiency terms (Battese, 1992; Chavas and Aliber, 1993). In contrast, Fare *et al.* (1985) proposed the use of the non-parametric approach which can be used to estimate pure technical, allocative, scale and overall efficiencies. The non-parametric approach is independent of the functional form, which is considered a major advantage (Coelli, 1995). The disadvantage of the DEA approach is stochastic phenomena are ignored including the potential risk of contaminating efficiency estimates with measurement errors and the inability to include statistical inference in the analysis (Hallam, 1992). However, statistical information can be obtained using the bootstrapping method. Bravo-Ureta *et al.* (2007) believe that the major disadvantage of this approach is that it is deterministic; it is affected by extreme observations.

Sampling Strategy

Around 455 vermi-hatchery units, 31 bio-fertiliser units and 10 fruit and vegetable waste units were sanctioned across different states by NABARD till May, 2009. But, NCDC has so far sanctioned only two bio-fertiliser units in Maharashtra state. However, the present study focused mainly on vermi-hatchery units. A sample of 40 vermi-hatchery units were purposively selected from four states, namely, Gujarat, Maharashtra, Punjab and Uttar Pradesh based on their respective weights in the total population (Table 1). The sample vermi-hatchery units were chosen in two to three groups/clusters in each state in order to minimise the travel costs and time. A well structured and pre-tested questionnaire was administered to extract the quantitative data with utmost emphasis placed on qualitative issues through interaction with the promoters of the units.

TABLE 1. DETAILS OF SAMPLE UNITS SELECTED FOR THE STUDY

Unit type (1)	Punjab (2)	Uttar Pradesh (3)	Gujarat (4)	Maharashtra (5)	Total sample for study (6)
Districts covered	Ludhiana, Fatehgarh Sahib	Baghpath, Muzaffarnagar, Aligarh	Baroda, Ghandhinagar, Sabarkanta	Ahmednagar, Sangli	-
Vermiculture hatchery units	6 (42)	17 (115)	13 (86)	4 (29)	40 (272)

Note: Figures in parentheses indicate total number of units sanctioned in that state.

III

SPECIFICATION OF MODEL

The efficiency of a firm is measured in terms of its relative performance, that is, the efficiency of a firm relative to the efficiencies of firms in a sample. A formal econometric approach for estimating relative efficiency is with reference to the "best practice frontier". Best practice frontier, a term originally coined by Farrell (1957) denotes the maximum output that can be obtained with a given set of input quantities for a given set of firms in a sample. He also proposed that the efficiency of a firm consists of two components: technical efficiency, which reflects the ability of a firm to obtain maximum output from a given set of inputs, and allocative efficiency, which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and production technology. These two measures are then combined to provide a measure of total economic efficiency. The output and input perspective will coincide when measuring technical efficiency under Constant Returns to Scale (CRS). The allocative and economic efficiency measures however are completely different in nature and are not likely to coincide for other reasons than by chance.

Data Envelopment Analysis (DEA) involves the use of linear programming methods to construct a non-parametric piecewise surface (or frontier) over the data, so as to be able to calculate efficiencies relative to this surface. More detailed reviews of the DEA methodology were also presented by Seiford and Thrall (1990), Lovell (1993, 1994), Ali and Seiford (1993), Charnes *et al.* (1995) and Seiford (1996).

Consider 'n' firms producing 'm' different outputs using 'h' different inputs. Thus, Y is an m*n matrix of outputs and X is an h*n matrix of inputs. Both matrices contain data for all 'n' firms. The technical efficiency (TE) measure under the assumption of constant returns to scale (CRS) can be formulated as follows:

$$\text{Min } \theta, \lambda\ \theta$$

$$\begin{aligned} \text{Subject to } & -y_i + Y\lambda \geq 0, \\ & \theta x_i - X\lambda \geq 0, \\ & \lambda \geq 0 \\ & \theta\ \varepsilon\ (0,1) \end{aligned}$$

and solved for each firm in the sample. θ_i is firm i's index of technical efficiency relative to the other firms in the sample. y_i and x_i represents the output and input of firm 'i' respectively. $Y\lambda$ and $X\lambda$ are the efficient projections on the frontier. A measure of $\theta_i = 1$ indicates that the firm is completely technically efficient. Thus, $1 - \theta_i$ measures how much the firm i's inputs can be proportionally reduced without any loss in output.

However, the assumption of CRS is correct only as long as the firms are operating at an optimal scale (Coelli *et al.*, 2002). The various constraints on inputs like financing and the goals of the farmer may cause the firm to operate at a non-optimal scale. Using the CRS-DEA model when firms are not operating at their optimal scale will cause the TE-measures to be influenced by scale efficiencies and thus the measure of technical efficiency will be incorrect. By adding a convexity constraint to the model above, variable returns to scale (VRS) is assumed instead:

$$\text{Min } \theta, \lambda\ \theta$$

$$\begin{aligned} \text{Subject to } & -y_i + Y\lambda \geq 0, \\ & \theta x_i - X\lambda \geq 0, \\ & N1'\lambda = 1 \\ & \lambda \geq 0 \\ & \theta\ \varepsilon\ (0,1) \end{aligned}$$

The new constraint is $N1'\lambda = 1$ where N1 is a n*1 vector of ones. This constraint makes the comparison of firms of similar size possible, by forming a convex hull of intersecting planes, so that the data is enveloped more tightly. The technical efficiency measures under VRS (Pure TE) will always be at least as great as under the CRS assumption.

Many studies have decomposed the TE scores obtained from a CRS DEA into two components, one due to scale inefficiency and one due to "pure" technical efficiency. If there is a difference in the two TE scores for a particular DMU, then this indicates that the DMU has scale inefficiency and that the scale inefficiency can be calculated from the difference between the TE_{VRS} score and the TE_{CRS} score (Coelli, 1996).

$$TE_{CRS} = TE_{VRS} \times SE$$

If one has price information and is willing to consider a behavioural objective, such as cost minimisation and revenue maximisation, then one can measure both technical and allocative efficiencies. The cost minimisation vector of input quantities given the input prices is determined using:

$$\text{Min}_{\lambda, xi*} \; w_i' \, xi^*,$$

$$\begin{aligned} \text{Subject to} \quad & -yi + Y\lambda \geq 0, \\ & xi^* - X\lambda \geq 0, \\ & N1' \lambda = 1 \\ & \lambda \geq 0, \\ & \theta \, \varepsilon \, (0,1) \end{aligned}$$

Where w_i is a vector of input prices for the i-th DMU and xi* is the cost-minimising vector of input quantities for the i-th DMU, given the input prices w_i and the output levels y_i. The total cost efficiency (CE) or economic efficiency of the i-th DMU would be calculated as:

$$CE = w_i' \, xi^* / w_i' \, xi$$

That is, the ratio of minimum cost to observed cost. One can then calculate the allocative efficiency residually as AE = CE/TE. Each observation included two outputs, i.e., average vermi-compost production (Y_1) per unit per annum in tonnes and sale of worms (Y_2) per unit per annum in kg. In the input category, four variables were included. They were raw materials quantity (X_1) mainly dung in tonnes per annum, quantity of worms used per annum (X_2) in kg, units of labour used (both hired and own) per annum (X_3) and electricity/fuel charges (X_4) per annum. The unit prices of four input variables were also used in the calculation of cost-DEA functions. Under this approach, both CRS and VRS models were applied to data with input orientation. The DEA models were estimated using programme DEAP 2.1 algorithm (Coelli, 1996).

IV

EMPIRICAL RESULTS

Primary Details of Sample Units

The state-wise primary details of the sample units are presented in Table 2. Almost all the selected units were completed in the establishment of units. Nearly 97.5 per cent units have finished their construction within a stipulated period of six months. But, a lone unit in Uttar Pradesh has crossed this timeline. If the promoter could not able to construct the unit within a stipulated period of time or if the Joint Monitoring Committee (JMC) visits and feels that the standards are not meeting NABARD guidelines, then NABARD can recall the advance subsidy amount from the borrower/beneficiary. Overall, 8 out of 40 sample units repaid their advance subsidy to NABARD because of their poor construction standards. All these repaid units were located in Gujarat state. The average amount they paid back to NABARD was Rs.50,000 per unit. This indicates that the construction of units in Gujarat were of low standard when compared to those in the remaining states.

TABLE 2. PRIMARY DETAILS OF SAMPLE UNITS

(*Number*)

Item (1)	Gujarat (2)	Maharashtra (3)	Punjab (4)	Uttar Pradesh (5)	Overall (6)
Units construction					
(a) Completed	13	4	6	17	40
(b) Not completed	0	0	0	0	0
Construction completed within					
(a) Stipulated six months time	13	4	6	16	39
(b) Not completed	0	0	0	1	1
Any refund of advance subsidy					
(a) Yes	8	0	0	0	8
(b) Avg. amount (lakh)	0.50	N.A	N.A	N.A	0.50
Joint Monitoring committee (JMC) visited					
(a) Completed	8	3	6	11	28
(b) Not completed	5	1	0	6	12
Final subsidy received (Rs.)					
(a) Yes	1	3	4	11	19
(b) Avg. amount (lakh)	0.81	0.75	0.75	0.75	0.75

When the project is nearing completion, the promoter informs the bank by way of submission of a completion certificate. This will initiate action for a JMC visit. Almost 95 per cent of the sample promoters have submitted their completion certificates to the banks. One each from Gujarat and Maharashtra had not submitted till date due to lack of awareness. However, NABARD has so far conducted JMC visits only in 70 per cent of the sample units. Nearly, 30 per cent of sample units are still waiting for JMC visits and the final subsidy amount. This indicates a huge delay in the process of subsidy release. Among the four states, the delay was more pronounced in Gujarat (38 per cent) and Uttar Pradesh (35 per cent) states. Out of 28 units (who have completed JMC visits), only 19 units (67.8 per cent) have received the final subsidy amount. The average amount they received was Rs.75,000 per unit. Around 32 per cent of the units are still awaiting the release of the final subsidy amount from NABARD (after JMC visit). This is another bottleneck in the scheme where a lot of time is consumed for processing.

Financial Details of Sample Units

The financial information of sample units is presented in Table 3. On an average, Rs. 5.9 lakh per unit was the financial outlay. The outlay was the highest in the case of Maharashtra (Rs. 6.3 lakh) followed by Gujarat and Uttar Pradesh states (Rs. 5.9 lakh each). But, it was the lowest in the case of the Punjab state (5.7 lakh). The average promoters' contribution in the total outlay was Rs. 1.6 lakh. However, this amount was the highest in Maharasthra followed by Gujarat. The mean bankers' loan amount was Rs. 4.3 lakh per unit. It was the highest in Uttar Pradesh folllowed by Punjab state. Nevertheless, the eligible subsidy amount was uniform across states, i.e., Rs.1.5 lakh per unit. But, the actual mean subsidy received till date per unit was Rs.0.93 lakh. There was a gap of Rs. 0.57 lakh between these two figures. This gap was the highest in the case of Gujarat (Rs. 1.23 lakh) followed by Uttar Pradesh (Rs.0.27 lakh) and Punjab (Rs. 0.25 lakh). This difference was low in the case of the Maharashtra sample units (Rs. 0.19 lakh). The reasons for this difference were: not adhering to NABARD standards and guidelines in the construction of units and a lot of delay in the release of subsidy amounts. On an average, the actual amount invested by promoters for the establishment of each single unit was Rs. 5.4 lakh. Among the four states, the amount spent on each unit was the highest in Punjab (Rs. 8.2 lakh) followed by Maharashtra (Rs. 7.6 lakh) and Uttar Pradesh (Rs. 5.4 lakh). This amount was the lowest in the case of Gujarat (Rs. 3.5 lakh) which indicates the poor establishment of units. Nearly 78 per cent of the sample units were financed by commercial banks while the remaining 22 per cent were supported by district co-operative banks.

TABLE 3. FINANCIAL DETAILS OF SAMPLE UNITS

(Rs. lakh per unit)

Item (1)	Gujarat (2)	Maharashtra (3)	Punjab (4)	Uttar Pradesh (5)	Over all (6)
Total financial outlay (a + b)	5.9	6.3	5.7	5.9	5.9
Promoters contribution (a)	1.8	2.2	1.5	1.5	1.6
Bankers loan (b)	4.1	4.1	4.2	4.4	4.3
Subsidy eligible	1.5	1.5	1.5	1.5	1.5
Actual subsidy received till date	0.27	1.31	1.25	1.23	0.93
Actual amount spent	3.5	7.6	8.2	5.4	5.4
Sanctioned bank type					
(b) Commercial	13	1	2	15	31
(b) Co-operative	0	3	4	2	9

Capacity Utilisation of Sample Units

The details of capacity utilisation of sample units are presented in Table 4. Capacity utilisation is a concept which refers to the extent to which an enterprise actually uses its installed productive capacity. The results presented in the table referred to the capacity utilisation of organic input units in the last one year.

TABLE 4. CAPACITY UTILISATION OF SAMPLE UNITS

(tonnes per annum)

Item (1)	Gujarat (2)	Maharashtra (3)	Punjab (4)	Uttar Pradesh (5)	Overall (6)
Average installed capacity	150	150	150	150	150
Current capacity utilisation	24.2	187	33	105	76.2
Capacity utilisation rate (per cent)	16.1	124.6	22.0	70.0	50.8
Average recovery rate (per cent)†	48.0	52.5	33.3	39.7	42.7
Gestation period per cycle (days)†	46.5	35	60	50	48.8
Avg no. of cycles per year (range)†	5-7	10-15	3-5	6-8	7-9

†reviewed based on the farmers' past experiences.

The average installed capacity of the sample units was 150 tonnes per annum (TPA). On the whole, the average capacity utilisation was around 76.2 TPA. The average capacity utilisation rate was only 50.8 per cent which is nearly half of its full potential. Across different states, the average capacity utilisation was the highest in Maharashtra followed by Uttar Pradesh, Punjab and Gujarat. The actual production in Maharashtra units was more than its installed potential. The lowest capacity production was observed in Gujarat at the rate of 24.2 TPA. This capacity utilisation rate was one-sixth of the actual potential (16.1 per cent). The reasons for low capacity utilisation are lack of demand, poor production skills and insufficient infrastructure. Even though the units in Punjab were well equipped, their productivity levels were also low. This is because of the absence of market demand for vermi-compost. In the case of Uttar Pradesh, the average capacity utilisation rate was 70 per cent. However, the demand is slowly picking up due to its nearness to different export channels which exist in Delhi.

The average recovery rate per unit was 42.7 per cent. Across different states, the highest recovery rate was noticed in the case of Maharashtra (52.5 per cent) followed by Gujarat, Uttar Pradesh and Punjab. The high recovery rate in Maharashtra may be one of the reasons for its high productivity. Even though, the rate of recovery was high in Gujarat, the productivity was low because of lack of production skills and the influence of climatic parameters like high temperatures, heavy rains etc. The average gestation period per cycle for the entire sample was 48.8 days. It is dependent on various parameters like the number of worms per cubic meter, age of the worms, raw material type and production season etc. This period was the lowest in Maharashtra due their higher efficiency levels while it was the highest in Punjab. Overall, the average number of cycles per annum produced by the organic inputs was 7 to 9 cycles. This number was very low in the case of Punjab because of the high gestation period.

Economics of Vermi-Compost Production

The economics of vermi-compost production across different states has been summarised in Table 5. The results clearly proved that the production of vermi-compost was a profitable venture in India. The weighted average cost of production per quintal was Rs.286 and price realisation for the same was Rs.506. The net margin per quintal of vermi-compost production was Rs.220. This is quite a significant margin in the agri-business sector. Among the different states, the cost of production was the highest in Gujarat followed by Punjab, Uttar Pradesh and Maharashtra. Good production skills, higher market demand and the economies of scale of production may be the reasons for higher productivity and low cost of production in Maharashtra. Per quintal price realisation was the highest in Uttar Pradesh followed by Punjab, Maharashtra and Gujarat. Proximity to the Delhi Metropolitan and the presence of vermi-compost export channels have helped Uttar Pradesh state to realise a higher price per unit. Even though productivity and market demand was relatively lower in Punjab, the existence of green houses and nurseries in Chandigarh facilitated to reap a reasonable price for vermi-compost. The average net margin per quintal was the highest in Uttar Pradesh while it was the lowest and had a negative value in Gujarat state. Administering proper training to the promoters and providing technical know-how in vermi-compost production, would yield good results in Gujarat state as well.

TABLE 5. SUMMARY OF ECONOMICS OF VERMI-COMPOST PRODUCTION IN INDIA

(*Rs.*)

Item (1)	Gujarat (2)	Maharashtra (3)	Punjab (4)	Uttar Pradesh (5)	Weighted average (6)
Cost of production per quintal (Rs.)	453	218	433	324	286
Price realisation per quintal (Rs.)*	233	447	488	678	506
Net margin per quintal (Rs.)	-220	229	55	354	220

*Including the sale of worms.

Efficiency of Organic Inputs

The frequency distribution of technical, allocative and economic efficiencies of sample organic input units both under CRS and VRS models of DEA approach is presented in Table 6. The estimated mean technical, allocative and economic efficiencies under DEA-CRS model were 63.7, 50.95 and 32.95 per cent respectively. Similarly, these values under DEA-VRS model were 83.39, 59.42 and 50.24 per cent respectively. In terms of technical efficiency, about 45 per cent of the sample units have more than 90 per cent efficiency under the VRS model. Under the CRS model, only 20 per cent of the sample units have more than 90 per cent efficiency. In the case of allocative efficiency, majority of the sample units (40 per cent) fell under the less than 50 per cent category under the VRS model while 47.5 per cent of the same belonged to less than 50 per cent category under the CRS assumption; 85 per cent of sample units exhibited less than 50 per cent of economic efficiency under the CRS assumption. Correspondingly under the VRS model, a large share of the sample (57.5 per cent) also belonged to the same class.

TABLE 6. FREQUENCY DISTRIBUTION OF EFFICIENCY OF ORGANIC INPUT UNITS

(n=40)

	CRS			VRS		
Efficiency (per cent) (1)	TE (2)	AE (3)	EE (4)	TE (5)	AE (6)	EE (7)
1-50	47.5	47.5	85.0	12.5	40.0	57.5
51-60	5.0	17.5	2.5	2.5	7.5	10.0
61-70	5.0	10.0	0.0	5.0	20.0	10.0
71-80	12.5	7.5	5.0	10.0	2.5	2.5
81-90	10.0	10.0	2.5	25.0	20.0	10.0
91-100	20.0	7.5	5.0	45.0	10.0	10.0
Max (per cent)	100	100	100	100	100	100
Min (per cent)	25.4	12.8	8.8	44.6	16.3	13.4
Mean (per cent)	63.7	50.95	32.95	83.39	59.42	50.24
Standard deviation (per cent)	24.0	25.7	24.1	18.8	25.2	26.4

It is concluded from the table that majority of the sample organic units (47.5 per cent) showed less than 50 per cent technical efficiency under the CRS assumption, indicating that most of the organic production units were inefficient. In other words, the inputs under the CRS model (VRS) can be reduced by 36 per cent (16 per cent) to attain the same level of output. To supplement the above statement, the most frequent interval of allocative and economic efficiency was 1 to 50 per cent under both CRS and VRS assumptions. Further, it reveals that the organic production units were suffering from both technical inefficiency in using resources as well as inability to allocate inputs in the cost minimising way. The scale efficiency index among the sample varied from 32.7 per cent to 100 per cent, with a mean value of 77.7 per cent.

Efficiency Across Different States

The efficiency levels of the decision-making units in Gujarat state both under the CRS and VRS models are summarised in Table 7. The estimated mean technical efficiency of the sample units was 0.874 and 0.985 respectively under constant and variable returns to scale. The mean scale efficiency of the sample units was 0.888. The results showed that four DMUs were technically efficient under CRS assumption while twelve DMUs were on the efficient frontier when VRS was assumed. In other words, the inputs under CRS model can be reduced by 12.6 per cent (1.5 per cent under VRS) to attain the same level of output.

TABLE 7. EFFICIENCY OF ORGANIC INPUT UNITS IN GUJARAT

(n=13)

	CRS			VRS				
Unit No. (1)	TE (2)	AE (3)	EE (4)	TE (5)	AE (6)	EE (7)	SE (8)	(9)
G-1	0.926	0.192	0.177	1.000	0.397	0.397	0.926	irs
G-2	0.926	0.192	0.177	1.000	0.397	0.397	0.926	irs
G-3	0.926	0.192	0.177	1.000	0.397	0.397	0.926	irs
G-4	0.926	0.192	0.177	1.000	0.397	0.397	0.926	irs
G-5	1.000	0.629	0.629	1.000	1.000	1.000	1.000	-
G-6	1.000	0.629	0.629	1.000	1.000	1.000	1.000	-
G-7	0.799	0.348	0.278	1.000	0.757	0.757	0.799	irs
G-8	0.700	0.239	0.167	1.000	0.894	0.894	0.700	irs
G-9	0.709	0.709	0.502	1.000	1.000	1.000	0.709	irs
G-10	0.757	0.290	0.219	0.805	0.274	0.221	0.940	irs
G-11	1.000	0.586	0.586	1.000	0.968	0.968	1.000	-
G-12	0.700	0.630	0.441	1.000	0.767	0.767	0.700	irs
G-13	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-
Mean	0.874	0.448	0.397	0.985	0.711	0.707	0.888	-

The estimated TE, AE and EE of sample units in Uttar Pradesh both under the CRS and VRS models are given in Table 8. The mean efficiency values were 0.756, 0.526 and 0.396 and 0.940, 0.685 and 0.651 respectively for constant and variable returns to scale. The average scale efficiency was 0.809. Only four out of 17 sample units remained technically efficient under both the assumptions. 76.4 per cent of the sample DMUs showed increasing returns to the scale of economies.

TABLE 8. EFFICIENCY OF ORGANIC INPUT UNITS IN UTTAR PRADESH

(n=17)

	CRS			VRS				
Unit No. (1)	TE (2)	AE (3)	EE (4)	TE (5)	AE (6)	EE (7)	SE (8)	(9)
U-1	0.927	0.257	0.238	0.938	0.348	0.327	0.989	irs
U-2	1.000	0.467	0.467	1.000	1.000	1.000	1.000	-
U-3	0.890	0.236	0.210	0.907	0.273	0.248	0.981	irs
U-4	0.500	0.583	0.291	1.000	1.000	1.000	0.500	irs
U-5	0.937	0.497	0.466	0.948	0.516	0.489	0.988	irs
U-6	0.375	0.578	0.217	1.000	1.000	1.000	0.375	irs
U-7	0.596	0.490	0.292	1.000	0.861	0.861	0.596	irs
U-8	0.254	0.454	0.115	1.000	0.587	0.587	0.254	irs
U-9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-
U-10	0.441	0.825	0.364	0.886	0.925	0.820	0.498	irs
U-11	0.819	0.532	0.436	0.837	0.765	0.640	0.979	irs
U-12	0.807	0.495	0.399	0.847	0.521	0.442	0.952	irs
U-13	0.792	0.551	0.436	0.857	0.605	0.519	0.923	irs
U-14	0.796	0.533	0.424	0.851	0.567	0.483	0.936	irs
U-15	0.710	0.256	0.182	0.906	0.313	0.284	0.783	irs
U-16	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-
U-17	1.000	0.193	0.193	1.000	0.364	0.364	1.000	-
Mean	0.756	0.526	0.396	0.940	0.685	0.651	0.809	-

The relative efficiency levels of the organic input units in Punjab state are presented in Table 9. The estimated average technical efficiency of sample units was 0.980 and 1.000 respectively under the CRS and VRS models. Almost all the sample units have showed more than 90 per cent level of technical efficiency under the CRS assumption. However, all the units were on the efficient frontier under VRS model. Only two out of the six sample units exhibited increasing returns to scale of economies. The mean scale efficiency of the sample units was 0.980.

TABLE 9. EFFICIENCY OF ORGANIC INPUT UNITS IN PUNJAB

(n=6)

	CRS			VRS				
Unit No. (1)	TE (2)	AE (3)	EE (4)	TE (5)	AE (6)	EE (7)	SE (8)	(9)
P-1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-
P-2	0.952	1.000	0.952	1.000	1.000	1.000	0.952	irs
P-3	1.000	0.592	0.592	1.000	1.000	1.000	1.000	-
P-4	0.930	0.580	0.539	1.000	0.566	0.566	0.930	irs
P-5	1.000	0.263	0.263	1.000	0.613	0.613	1.000	-
P-6	1.000	0.251	0.251	1.000	0.613	0.613	1.000	-
Mean	0.980	0.614	0.599	1.000	0.799	0.799	0.980	-

The results of the DEA analysis of organic input units in Maharashtra are given in Table 10. Relatively, the estimated mean efficiency (TE, AE, EE and SE) levels were the highest in Maharashtra when compared to the remaining states. Three out of the four sample units remain technically efficient under CRS as well as VRS assumptions. Hence, the results conclude that the organic input units in Maharashtra state are relatively more efficient.

TABLE 10. EFFICIENCY OF ORGANIC INPUT UNITS IN MAHARASHTRA

(n=4)

	CRS			VRS				
Unit No. (1)	TE (2)	AE (3)	EE (4)	TE (5)	AE (6)	EE (7)	SE (8)	(9)
M-1	1.000	1.000	1.000	1.000	1.000	1.000	-	-
M-2	0.938	0.785	0.736	1.000	1.000	1.000	0.938	irs
M-3	1.000	0.838	0.838	1.000	0.850	0.850	1.000	-
M-4	1.000	0.838	0.838	1.000	0.850	0.850	1.000	-
Mean	0.984	0.865	0.853	1.000	0.925	0.925	0.984	-

Relationship Between Unit Size and Efficiency

The relationship between the unit size of organic input units and efficiency is summarised in Table 11. The sample units were classified into three categories based on their vermi-compost production per annum. Most of the sample units (65 per cent) fell under the category of small with a production of less than 50 TPA. Six and eight units were respectively grouped under the medium and large size categories. The results clearly indicate that there is a strong positive relationship between size of the unit and its efficiency. As the size of unit increases, all the three efficiency parameters increased significantly in almost all cases (except in medium VRS-AE) under both the CRS and VRS assumptions. These results clearly conclude that the large units are more efficient than the smaller units.

TABLE 11. EFFICIENCY BY SIZE GROUP

Size of the unit	Distribution of units	CRS			VRS		
		TE	AE	EE	TE	AE	EE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Small (1-50 tonnes)	26	0.51	0.44	0.21	0.80	0.56	0.45
Medium (51-100 tonnes)	6	0.81	0.54	0.45	0.82	0.55	0.46
Large (> 100 tonnes)	8	0.91	0.68	0.61	0.92	0.73	0.66

Factors Influencing Efficiency

The results of the regression analysis to identify the factors influencing efficiency (CRS-TE, VRS-TE and SE) are worked out in Table 12. Three efficiency parameters were regressed against different socio-economic characteristics of the promoters and with some policy related variables (like training and subsidy). A dummy variable

TABLE 12. DETERMINANTS OF EFFICIENCY IN ORGANIC PRODUCTION UNITS

Variable (1)	CRS- TE coefficient (2)	VRS – TE coefficient (3)	SE coefficient (4)
Constant	24.39	67.01*	48.37*
	(1.321)	(4.027)	(2.984)
Unit size	0.721*	0.056	0.759*
	(5.369)	(0.357)	(6.314)
Education	0.002	0.023	-0.016
	(0.020)	(0.183)	(-0.167)
Family labour	0.283**	0.148	0.207***
	(2.328)	(1.045)	(1.902)
Unit age	-0.221	0.127	-0.343*
	(-1.588)	(0.779)	(-2.756)
Own livestock	0.236	0.189	0.130
	(1.468)	(1.006)	(0.908)
Dummy-training	0.280***	0.228	0.187
	(1.905)	(1.324)	(1.420)
Dummy-subsidies	-0.167	0.063	-0.230***
	(-1.247)	(0.402)	(-1.921)
Dummy-Punjab state	0.050	- 0.536**	0.466*
	(0.284)	(-2.614)	(2.970)
Dummy – Uttar Pradesh state	0.133	-0.265	0.316
	(0.624)	(-1.061)	(1.657)
Dummy –Gujarat state	0.194	0.262	0.069
	(0.810)	(0.935)	(0.324)
No of observations (n)	46	46	46
R-square	0.638	0.505	0.710

Figures in parentheses are t –values.
***, ** and * Significant at 10, 5 and 1 per cent level.

(trained -1, untrained -0) was used to see the influence of the training component on efficiency. Similarly, to evaluate the impact of the subsidy on efficiency, six more private units (3 from Maharashtra and one each from the remaining three states) which were not subsidised by any means were added to the existing 40 sample units. So the total number of observations increased upto 46. For capturing the subsidy effect, another dummy was used (subsidised-1, not-0). To perceive state wise effects, three dummies (one each for Punjab, Uttar Pradesh and Gujarat) were used keeping Maharashtra as a control.

The best fit amongst the three regression equations was scale efficiency which exhibited the highest R-square of 0.710. Amongst the different factors, size of the unit was positive and significant at one per cent level. The contribution of family labour was also positive and significant at 10 per cent level. But, the age of the unit since its time of operation showed a negative and significant relation with scale efficiency. It indicates that as time progresses many units will become scale-inefficient. The dummy for the capital incentive subsidy from NABARD exhibited a negative relationship with efficiency. It concludes that with an increase in the subsidy amounts, the scale performance of the organic input units are decreasing. The dummy for Punjab state was positively statistically significant at 1 per cent level. This indicated that the scale-efficiency difference between Punjab and Maharashtra units was significant. However, the dummies for Uttar Pradesh and Gujarat were also positive but not statistically significant.

The R-square value of regression equation for CRS-technical efficiency was 0.638. Unit size and family labour variables were positive and statistically significant at 1 and 5 per cent level respectively. The dummy for the training component showed a positive relation with technical efficiency. It reveals that attending more number of training programmes will enhance the technical efficiency of the units. The dummy on subsidy also exhibited a negative sign with technical efficiency but it was not statistically significant. When the same independent variables regressed against VRS-TE, the R-square value was 0.505. Only the dummy for Punjab state showed a negative and statistical significance at 5 per cent level.

Overall, the size of the unit and contribution of family labour showed a positive relation with technical efficiency as well as on scale-efficiency. The promoters' participation in training programme also enhanced the technical efficiency of the units. The age of the unit and subsidies discouraged the scale-efficiencies. Among the four states, the efficiency differences were significant between the units in Punjab and Maharashtra states.

Impact of Training Programmes on Efficiency

The influence of training programmes on the efficiency of vermi-compost units is summarised in Table 13. Out of the total sample, 27 promoters had formal training in vermi-compost production either in the National Centre of Organic Farming (NCOF) or in other NGOs. The remaining 13 did not undergo any formal training. The results clearly indicated that there were significant differences in the mean capacity utilisation of units between the trained and untrained groups. The average cost of production per quintal of vermi-compost for trained promoters was Rs. 307 while the same for non-trained was Rs.340. Similarly, the mean CRS and VRS technical efficiency values were marginally higher under the trained promoter units than non-trained units. But, the mean allocative efficiency values were relatively higher in the non-trained units. However, the economic efficiency values showed a mix trend both under the CRS and VRS production technologies. In the case of scale efficiency, the results are conspicuous and higher for trained promoters. Overall, the results conclude that participation in training programmes will enhance the production skills of the promoter as well as the technical efficiency of the units.

TABLE 13. IMPACT OF TRAINING ON EFFICIENCY

Item (1)	Trained (n=27) (2)	Non-trained (n=13) (3)
Capacity utilisation (TPA)	82.4	68.6
Cost of production/qtl	307.0	340.0
Mean CRS-TE	64.9	61.2
Mean CRS-AE	49.8	53.3
Mean CRS-EE	33.0	32.9
Mean VRS-TE	83.7	82.8
Mean VRS-AE	57.9	62.6
Mean VRS-EE	48.3	54.3
Scale efficiency	79.0	75.0

V

SUMMARY AND CONCLUSIONS

Availability of quality organic inputs is critical for the success of organic farming in India. Setting up of the organic input units with a capital investment subsidy is one of major components under NPOF for encouraging the organic inputs production since 2004. The average capacity utilisation rate was 50.8 per cent which is nearly half of its full potential. Across different states, this value was the highest in Maharashtra (124.6 per cent) followed by Uttar Pradesh (70 per cent), Punjab (22 per cent) and Gujarat (16.1 per cent). The main reasons for low capacity utilisation are lack of demand, poor production skills and insufficient infrastructure. The estimated mean technical, allocative and economic efficiencies of sample vermi-hatchery units under the DEA-CRS model were 63.7, 50.95 and 32.95 per cent respectively. Correspondingly, the mean values for the DEA-VRS model were 83.39, 59.42 and 50.24 per cent. The results clearly indicate the low technical, allocative and economic efficiency of sample organic input units under the NPOF scheme in India. The regression results conclude that the size of the unit, contribution of family labour show a positive relation with technical as well as scale-efficiencies.

Prompt and timely visits by the Joint Monitoring Committee (JMC) and a quick disbursement of subsidy are the need of the hour for the promotion of this scheme. The organic input units established under various schemes in the country should be linked up with suitable market channels to improve their capacity utilisation or to make use of the entire installed capacities. The technical efficiency of organic input production should also be enhanced by imparting more production skills to the promoters. The economic and scale efficiency of the units should also be improved by providing more technical guidance, quality seed stock and training programmes. Finally, the quality of organic input production in the country should be further developed with the latest technologies and improved way of financial assistance.

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