A case study on resource-use efficiency in Onion cultivation in West Bengal, India

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ABSTRACT

This study focuses on the aspects of resource use efficiency of onion growers in the Indo-Gangetic Region of West Bengal, India. Data Envelopment Analysis (DEA) has been used in measuring efficiency level of stakeholders followed by K-means clustering for grouping them into homogeneous strata. The prime objective of this study is to explore the scope of increasing onion-yield as well as production using current resource base at the disposal of farmers. Additionally, characterization of growers in terms of several socio-economic indicators was made and studied. Finally, the study ends with advocating policy intervention measures in the gray fields. The study observed much potential for augmenting onion-yield with existing resource base of farmers with careful interventions.

Keywords: Onion, resource-use efficiency, data envelopment analysis, k-means clustering, policy

Onion represents one of the major vegetables in India. India has about 10 lakh hectares under onion cultivation constituting 10% of total acreage under vegetable. According to FAO statistics, India contributes 10% of global production (2010-11) and occupies second position after China in terms of onion production. However, India lags behind other onion growing countries in terms of yield parameter. During 2007-08 mean onion yield in India was recorded 12.97 MT/hectare and the figure was far off the global yield by more than 38%. Yield has not been uniform over time and it was recorded 12.97 MT/ha during 2007-08 and scaled up to 14.2 MT/ha in the year 2010-11. Thus this crop exhibits instability in yield eventually in production.

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West Bengal is deficit state in onion even it adds 2.1% of total onion production of India. Cultivation of onion is restricted to the Indo-Gangetic region and mainly confined to the low-lying areas, locally called *charlands.* Traditionally, jute based cropping pattern incorporating onion as a cash crop has been developed. Hooghly and Nadia districts of the state cover one third of onion production. According to National Survey Organization (1999-2000), the need of consumption is 0.56 kg per head per month in rural and 0.64 for urban. Thus the requirement for onion in West Bengal is 870 thousands MT per year, whereas West Bengal produces 258 Mt thousands which portrays a huge gap between production and consumption of onion.

In view of the above, an effort has been made in this study to explore the scope of increasing onion-yield as well as production using current resource base at the disposal of farmers. Emphasis has been made on studying resource-use efficiency of onion-farmers and characterization of growers in terms of several socio-economic indicators. Finally, based on the findings of the study suggestions have been made for policy measures in the gray fields.

Materials and Methods

This study is based on empirical survey on four sample villages in Nadia and Hooghly districts of West Bengal. These two districts were chosen purposively as they represent one third of entire onion area of the state. Thereafter, two onion dominated villages from each sample district were selected purposively. Finally, twenty-five onion farmers from each village were selected following Simple Random Sampling Without Replacement. The reference period of study is 2013-14.

Data Envelopment Analysis (DEA) technique has been employed to measure the technical as well as resource efficiency across sample respondents. DEA technique is a non-parametric measure showing performance or technical efficiency of an existing technology relative to an ideal "best practice" or frontier technology. Briefly, DEA uses mathematical programming to construct a production frontier comprising a set of linear segments. The Frontier relates to the best performance at a point of time and technical efficiency of a DMU (Decision Making Unit) is measured in terms of distance from the frontier. Mathematically the problem DEA is expressed as

$$\text{Max}_{\varphi'\lambda}\ \varphi,$$

Subject to

$$-\varphi\, y_i + Y\lambda \geq 0,$$

$$x_i - X\lambda \geq 0,$$

$$N1'\lambda = 1$$

$$\lambda \geq 0$$

In the above mathematical model, φ can take any value between one and infinity. The proportional increase in output that could be achieved by the i^{th} onion producing farm or decision making unit (DMU) with input quantities held constant is indicated by (φ-1). Y is (1 × N) the output matrix, λ is (N×1) vector of intensity variables, X is (K×N) the input matrix, Y1 is the output of i^{th} farm; N1′ is a vector of (N×1) and convexity restriction. The ratio of 1/φ defines a technical efficiency score between zero and one (Coelli *et al.*, 1996).

Using k-means cluster analysis onion growers were classified into four homogenous groups, viz.; efficient, semi efficient, moderate and poor in terms of technical efficiency scores. Thereafter, group characterization was made for studying distinctiveness of individual strata in terms of selected socio-economic indicators including both discrete and continuous variables.. Characterization of groups is based on the principle of comparing the values of a descriptive statistic indicator computed on the whole sample relative to the sub sample. For a continuous variable, the mean is compared and the test value is defined as follows:

$$t_c = (\mu_g - \mu)/\sqrt{\{(n-n_g)/(n-1)\times(\sigma^2/n_g)\}},$$

where the mean on the whole sample is μ, the empirical variance is σ^2, the mean computed into the group is μ_g, size of the data set is n, & size of the sub-sample is n_g. The indicator follows asymptotically Gaussian distribution, then for a 5% significance level, we consider that the difference is significant if the absolute value is greater than 2.

In case of discrete indicator, the proportion is evaluated with the test value statistic as

$$T_d = \{n_{jg} - (n_g \times n_j)/n\}/\ \sqrt{\ \{(n-n_g)/(n-1) \times (1- n_j/n) \times (n_g \times n_j)/n\}}$$

where nj is the number of instances corresponding to the category in the whole sample, n_{jg} is the number of instances corresponding to the sub-sample related to the group, the group size is n_g. Here, again the criterion is mainly used to highlight the category which characterizes the better the group of observations.

Results and Discussion

Sample stakeholders have shown diverse level of efficiency in onion cultivation. Distribution of onion growers according to four distinct groups has been shown in Table-1. The revealing scenario is that only less than one third of the sample members belong to the efficient group. It is also witnessed that 36% of sample units are having efficiency score in between 0.69 and 0.82. In other words, with appropriate intervention there is possibility of increasing output by 31% for 27% poor-category farmers and 18% for 9% moderate-category farmers, respectively. Similarly 34% farmers could scale up production by 10% with the existing level of resources.

Table 1: Distribution of sample DMUs according to level of technical efficiency

	Cluster i (Poor)	Cluster ii (Moderate)	Cluster iii (Semi-efficient)	Cluster iv (Efficient)
Technical Efficiency	0.69	0.82	0.9	0.99
No. DMUs	28	9	33	30

Table 2 shows group-wise average possibilities of critical input reduction without loss of current level of production.

Table 2: Group-wise average inputs used and possibilities of minimization

Group	Input used					Target reduction				
	Organic Manure	Fertilizer	Total labour	Onion land	Irrigation	Organic Manure	Fertilizer	Total labour	Onion land	Irrigation
Efficient	82	114.67	23.1	2.95	3.17	81.18	113.52	22.87	2.92	3.14
Semi efficient	56.42	90.61	20.79	3.21	2.52	50.78	81.55	18.71	2.89	2.26
Moderate	100.22	121.67	22.56	2.22	2.89	82.18	99.77	18.5	1.82	2.37
Poor	110.77	128.39	23.18	2.48	3.04	76.43	88.59	15.99	1.71	2.09

Table 3: Characterization of efficient category cluster

Cluster (Efficient Group)- (30%) 30		
Attributes	Test value	Mean (Std. Dev.)
Continuous attributes:		
No. of trainings taken	7.65	5.77 (1.28)
Cropping intensity	6.9	290.43 (17.57)
% of cash crops	6.2	86.74 (2.17)
Total land	-0.1	4.80 (1.56)
Discrete attributes:		
Strong institutional linkage	9.25	(93.5 %) 96.7 %
Medium institutional linkage	-5.22	(2.3 %) 3.3 %
Low institutional linkage	-3.86	(0.0 %) 0.0 %
Strong mobility	4.99	(47.6 %) 100.0 %
Medium mobility	-2.17	(0.0 %) 0.0 %

Low mobility	-3.96	(0.0 %) 0.0 %
Strong market linkage	4.46	(48.2 %) 90.0 %
Medium market linkage	-1.49	(15.8 %) 10.0 %
Low market linkage	-3.76	(0.0 %) 0.0 %
Loan=yes	3.71	(45.5 %) 83.3 %
Loan=no	-3.71	(11.1 %) 16.7 %

The semi-efficient group exhibits combination of characteristics of both efficient and in- efficient groups.

Table 4: Characterization of semi efficient category cluster

Cluster (Semi Efficient Group)- (33%) 33		
Attributes	Test value	Mean (Std. Dev.)
Continuous attributes:		
%of cash crops	3.48	75.91 (1.43)
Cropping intensity	2.67	259.39 (28.72)
Total land	1.69	5.29 (1.74)
No. of trainings taken	1.21	3.33 (0.54)
Discrete attributes:		
Strong institutional linkage	-3.77	(6.5 %) 6.1 %
Medium institutional linkage	7.18	(72.1 %) 93.9 %
Low institutional linkage	-4.14	(0.0 %) 0.0 %
Strong mobility	5.35	(52.4 %)100.0 %
Medium mobility	-2.33	(0.0 %) 0.0 %
Low mobility	-4.25	(0.0 %) 0.0 %
Strong market linkage	4.48	(51.8 %) 87.9 %
Medium market linkage	-1.22	(21.1 %) 12.1 %
Low market linkage	-4.03	(0.0 %) 0.0 %
Loan=yes	5.04	(54.5 %) 90.9 %
Loan=no	-5.04	(6.7 %) 9.1 %

In approaching to the summary results of group characterization, attempt has been made to examine the causes of variation in terms of selected statistical indicators such as quantum of labour use, organic mode of cultivation, critical input uses etc. of efficient group. It has been observed that efficient group represents a distinct entity and differs from the rest groups on several counts (Table 3). Evidently this group has received additional trainings comparing to the overall members. Thus, it is evidently proved that skill and knowledge play a critical role in efficiency level of onion growers. Another distinct characteristic of this group is of the entrepreneurship stance of the members as this group devotes a sizeable acreage under cash crops. Simultaneously, cropping intensity of this group is highest than that of other categories. Land-holding of this group is not different from the mean value of the sample growers witnessed by the test value. Members of efficient group are well linked with rural institutions specifically with financial institutions, market-information and having much communicative skills in comparison to the counter groups.

Table 5: Characterization of poor category cluster

Cluster(Poor Group)- (28%) 28		
Attributes	Test value	Mean (Std. Dev.)
Continuous attributes:		
Total land	-0.55	4.66 (2.21)
No. of trainings taken	-7.42	0.00 (0.00)
Cropping intensity	-8.38	103.07 (5.65)
% of cash crops	-9.05	29.15 (5.48)
Discrete attributes:		
Strong institutional linkage	-4.16	(0.0 %) 0.0 %
Medium institutional linkage	-3.6	(9.3 %) 14.3 %
Low institutional linkage	8.45	(92.3 %) 85.7 %
Strong mobility	-8.1	(0.0 %) 0.0 %
Medium mobility	-0.59	(20.0 %) 7.1 %
Low mobility	9.2	(96.3 %) 92.9 %
Strong market linkage	-7	(0.0 %) 0.0 %
Medium market linkage	-0.75	(21.1 %) 14.3 %
Low market linkage	8.7	(96.0 %) 85.7 %
Loan=yes	-6.86	(0.0 %) 0.0 %
Loan=no	6.86	(62.2 %) 100.0 %

Table 6: Characterization of moderate category cluster

Cluster (Moderate group)-(9%) 9		
Attributes	Test value	Mean (Std. Dev.)
Continuous attributes:		
%of cash crops	-1.45	52.94 (5.30)
Total land	-1.74	3.78 (2.24)
Cropping intensity	-2.29	158.89 (11.67)
No. of training taken	-2.6	0.89 (0.78)
Discrete attributes:		
Strong institutional linkage	-2.1	(0.0 %) 0.0 %
Medium institutional linkage	2.2	(16.3 %) 77.8 %
Low institutional linkage	-0.27	(7.7 %) 22.2 %
Strong mobility	-4.08	(0.0 %) 0.0 %
Medium mobility	8.23	(80.0 %) 88.9 %
Low mobility	-1.12	(3.7 %) 11.1 %
Strong market linkage	-3.53	(0.0 %) 0.0 %
Medium market linkage	5.57	(42.1 %) 88.9 %
Low market linkage	-1	(4.0 %) 11.1 %
Loan=yes	-3.46	(0.0 %) 0.0 %
Loan=no	3.46	(20.0 %)100.0 %

Table 7: Overall description of sample growers

Overall description of Sample Growers	
Attributes	Group mean
Continuous attributes:	
% of cash crops	64.00 (23.89)
total land	4.83 (1.90)
Cropping intensity	224.89 (90.18)
no. of trainings taken	2.91 (2.43)
Discrete attributes:	
Strong institutional linkage	32.00%
Medium institutional linkage	40.00%
Low institutional linkage	28.00%
Strong mobility	63.00%
Medium mobility	9.00%
Low mobility	28.00%
Strong market linkage	63.00%
Medium market linkage	9.00%
Low market linkage	28.00%
Loan=yes	63.00%
Loan=no	37.00%

In contrast to efficient group, the poor and moderate categories lack skills and knowledge. They are also risk prone farmers, having poor access to market, institutions and communication. Subsistence nature of farming is also predominant in this group. Characteristics of poor and medium category clusters are evident from Tables-5 and 6 respectively.

Conclusion

This study focuses some gray areas of onion cultivation and suggests policy intervention in some critical junctures for onion development in general well as the state in particular. It is suggested that imparting technology, developing skills and knowledge and accessibility to rural financial institutions are paramount for over all development of onion cultivation in West Bengal. Infrastructure facilities; like storage, go-downs and techniques of preservation of onion at household level are pre-requisites for increasing yield at achievable level.

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