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An Economic Analysis of Yield Gap and Sustainability of System of Rice Intensification (SRI) in Assam

Amvrin Baruah*, Rakesh Singh and Ravishankar Pardhi

Department of Agril. Economics, I.Ag.Sc., B.H.U., Varanasi, India

*Corresponding author: amvrin23@gmail.com

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ABSTRACT

Since green revolution wave didn't touch the state of Assam there is scope to increase production by 3-4 folds through implementation of improved technology with conservation of natural resources. Being a rice cultivating state, System of Rice Intensification (SRI) is a very good options for the farmers of Assam, as it provides higher yields with lesser inputs and intensive management practices. The study carried out to find the sources of yield gap between SRI and conventional method of rice cultivation in Assam. The study revealed that cultural practices contributed highest (32.63%) to the yield gap followed by FYM (10.76%) and human labour (7.46%). Seed (-33%) and irrigation (-2.24%) contributed negatively which implied that farmers growing SRI method paddy obtained higher output per hectare than that obtained by the farmers of Conventional method of paddy by spending less on those inputs. SRI was found to be sustainable with sustainability indices ranged from 78.09 to 129.5. It is estimated to be 56% that implies that SRI can thrive in the conditions of the study area and farmers can avail greater output and ultimately higher income by practicing this method of rice cultivation.

Highlights

- SRI is a very good options for the farmers of Assam.
- The SRI practices have been found to save inputs substantially and to increase returns. Higher return has been attributed to increase in production as well as substantial reduction in cost of cultivation.
- Cultural practices contributed highest (32.63%) to the yield gap
- SRI was found to be sustainable in Assam

Keywords: Yield gap, sustainability

India accounts for 20% of all world rice production. It is the second largest producer of rice in the world with a production of 106.65 million tonnes in the year 2013-14. Rice and wheat are the two crops are grown in rotation in almost 10 million hectares and are a source of food and nutrition (Paroda *et al.* 1994). The production of these crops was low and stagnant until early sixties in the last century. The population during the same period increased rapidly resulting in a decreased availability of food per person (Randhawa 1979). After green revolution major changes were witnessed in Indian agriculture. Undoubtedly by far, the most important among these changes is the introduction and widespread use of new technology such as high yielding varieties (HYV's) of seeds and fertilizers (Rao 1989). India became food secure in the last three decades, at gross level, because of increase in food production. The food security of India and other countries in South Asia is, however, now at risk due to increase in population. By 2050, India's population is expected to grow to 1.6 billion people from the current level of 1.1 billion. This implies a greater demand for food. Although, the world as a whole may have sufficient food for everyone, it would need to be produced in the region itself due to socio-economic and political compulsions (Rabbinge 1999). The cereal requirement of India by 2020 will be between 257 and 296 million tons (Mt) depending on income growth (Kumar 1998;

Bhalla *et al*. 1999). The demand for rice and wheat is expected to increase to 122 and 103 Mt, respectively, by 2020 assuming a medium income growth (Kumar 1998). There is no scope of enhancement of net sown are form the current level of 144 million ha. Therefore, this will have to be produced from the same or even shrinking land resource. The annual rate of growth of cereal production and yield showed a peak during the early years of the green revolution but since 1980s there has been a decline in it in several intensive farming districts of Punjab and Haryana (Sinha *et al.* 1998). As the post effect of Green Revolution the soil health is very much deteriorated, nutrition status is depleted which is a genuine concern for sustainability and resource conservation for future generation. As the land holding is declining and natural resources like land and water are being degraded, improved technologies for production are the need of the hour to meet the ever growing demand of rice.

Indian agriculture is dominated by small and marginal farmers (land holding of <2 ha) and constitute 82% of the total farmers' population. The proportion of total population engaged in agriculture is 49%. Due to unavailability of resources there exists a gap between actual yield in farmers' field and potential yield of the crop. The potential yield of rice in the tropics has not increased above 10 t ha^{-1} since IR8 was released 30 years ago, despite significant achievements in attaining yield stability, increasing per day productivity and improving grain quality (Aggarwal *et al.* 1996).

System of rice intensification (SRI) is emerging as an important technology for rice production as it helps in conservation of land, water and biodiversity and utilization of biological power of plant and energy. SRI is such a production method for rice invented in Madagascar, by Fr. Henri de Laulanié, S.J., is amalgamation of refined and intensive management practices with advantages of production enhancement and cost reduction.

Assam is the second largest state of the North Eastern region of India. It is famous for its scenic beauty and lush green tea gardens. The economy of Assam is mainly agrarian in nature. Rice is the major cereal crop that is being cultivated in the state. Since green revolution wave didn't touch the state of Assam there is scope to increase production by 3-4 folds through implementation of improved technology with conservation of natural resources. Being a rice cultivating state, SRI is a very good options for the farmers of Assam. SRI was first initiated in Assam by North East Social Trust (NEST) in Dighalipam village of in the year 2006 in the Ahu season. But greatest contribution to SRI in Assam has been offered by National Food Security Mission (NFSM). In 2007-2008, NSFM (rice) was launched in 13 Assam districts — Nagaon, Morigaon, Bongaigaon, Dhemaji, Sonitpur, Tinsukia, Karbi Anglong, Barpeta, Nalbari and Goalpara.

With the growing demand for food, an immense need has been realized for increasing the production of rice in Assam (Parasar *et al*. 2013). In this context, the technique of system of rice intensification (SRI) holds a promising position. Higher production and income has been reported in their study. The present study has been carried out with the objective of finding the sources of yield gap between SRI and conventional method of rice cultivation in Assam as well as to examine the sustainability of SRI in the state so that the improved technology can be adapted by farmers for higher gains.

Research methodology

Assam is the largest state in North- Eastern region in term of cropped area under rice hence selected purposively. Out of 27 districts of Assam, farmers of 10 districts practice SRI method of rice cultivation. Nagoan and Morigaon being the district having highest numbers of SRI farmers were selected purposively. Out 18 blocks of Nagaon district two blocks Raha and Batadrava were selected purposively as they have the highest numbers of SRI cultivators.

For the same reason Mayong block of Morigaon district was selected out of 5 blocks. A list of farmers practicing both SRI and conventionl from 2 villages from each block (total 6 villages) was prepared and 25 farmers from each village were selected randomly which led to the sample size of 150 farmers, out of which 75 were SRI farmers and 75 were conventional farmers.

Sources and period of data

The data was collected with help of pretested schedule by personal interview method for the crop year 2013-14. Secondary information was collected from published journal, bulletin and official records of districts and blocks.

Analytical tools

For the first objective that is the sources of yield gap analysis the output decomposition model as developed by Bisaliah (1977) was used for investigating the contribution of various constituent sources to the productivity difference between the SRI method and the conventional method of rice cultivation. For any two production functions, the total change in the productivity could be brought out by shifts in the production parameters that defined the production function itself and by the changes in the input use levels. Therefore, the production functions were considered as the convenient econometric tools for decomposing the productivity difference between the two methods of cultivation. Two separate production functions, one for SRI method of cultivation and another for traditional method were fitted as follows:

In logarithm form, Cobb-Douglas production function for SRI method of paddy is:

$$LnYs = lnbs_0 + bs_1\, lnXs_1 + bs_2\, lnXs_2 + bs_3\, lnXs_3 + bs_4\, lnXs_4 + bs_5\, lnXs_5 + bs_6\, lnXs_6 + Us \quad \ldots 1$$

Logarithm form of Cobb-Douglas production function for conventional method of paddy is:

$$lnYc = ln\, bc_0 + bc_1\, lnXc_1 + bc_2\, lnXc_2 + bc_3\, lnXc_3 + bc_4\, lnXc_4 + bc_5\, lnXc_5 + bc_6\, lnXc_6 + Uc \quad \ldots 2$$

Equation 1-equation 2=

$$ln\,(Ys/Yc) = \{ln\,[bs_0/\,bc_0)\} + \{(bs_1 - bc_1)\, lnXs_1 + (bs_2 - bc_2)\, lnXs_2 + (bs_3 - bc_3)\, lnXs_3 + (bs_4 - bc_4)\, lnXs_4 + (bs_5 - bc_5)\, lnXs_5 + (bs_6 - bc_6)\, lnXs_6\} + \{bs_1\, ln\,(Xs_1/Xc_1) + bs_2\, ln\,(Xs_2/Xc_2) + bs_3\, ln\,(Xs_3/Xc_3) + bs_4\, ln\,(Xs_4/Xc_4) + bs_5\, ln\,(Xs_5/Xc_5) + bs_6\, ln\,(Xs_6/Xc_6)\} + [(Us - Uc)]$$

This is the decomposition model for decomposing the productivity difference between the SRI method and the conventional method of rice cultivation. This equation involves decomposing the logarithm of ratio of per hectare productivity of SRI and traditional method of rice cultivations (LHS). This is approximately a measure of percentage change in per hectare output between the SRI cultivation and traditional cultivation. The summation of first and the second terms on the right hand side of the decomposition model together represented the productivity difference between the SRI method and conventional method, attributable to the difference in the cultural practices. The third term provided the productivity difference between the SRI cultivation and conventional cultivation.

To examine whether the parameters of the production function of SRI method were different from those of the conventional method Dummy variable technique was used. The following dummy variable model introducing intercept and slope dummy was specified.

$$Ln\, Q = lnb_0 + b_1 In\, X_1 + b_2 In\, X_2 + b_3 In\, X_3 + b_4 In\, X_4 + b_5 In\, X_5 + b_6\, ln\, X_6 + cD + d_1\,(DlnX_1) + d_2(DlnX_2) + d_3\,(DlnX_3) + d_4\,(DlnX_4) + d_5\,(DlnX_5) + d_6\,(D\, lnX_6) + lnu$$

Dummy values: D = 1 If it is SRI method

D = 0 if it is conventional method method

For the analysis of the second objective that is the sustainability index was estimated by the method suggested by Kiresur *et al*. (1996). The method explains that sustainability of SRI can be estimated by its proportional response to the existing conventional method of rice cultivation which in turn could be quantified by means of site specific index or site index. The various steps involved in estimation of sustainability index are stated below:

$Ei = (Xi-Xm)$, where, Ei = site index

Xi = Yield level of conventional in i^{th} field

Xm = Mean yield of conventional method

$Yi = a+\beta Ei$ where, Yi=Yield level of SRI for i^{th} filed

a = Regression constant

b = Regression co-efficient

S = symmetry of the site index

$Di = Yi+\beta S$ Di=Desirable yield level of SRI

$Ds = Ym+S$ Ds=Standard yield level of SRI

S.I. = S.I= Sustainability index

= Significantly greater than equal to

N= sample size

The significance of the difference between Di and Ds was tested using t-test with the following equation:

t_{n-2}= (Di-Ds)/ SE (Di), where SE (Di) is the standard error of Di.

RESULTS AND DISCUSSION

In the study area the average yield of SRI and conventional method of rice cultivation were found to be 9.5 t/ha and 6.4 t/ha respectively. To test the difference in structural relationship in the parameters defining the two production functions for the two methods SRI and conventional, the log liner production function for both intercept and dummies were estimated and presented in Table 1. The pooled R^2 is estimated to be .907 that explains 90.7% variation in paddy output due to variation in all resources put together. This shows a good fit to the model. The co-efficient of intercept dummy and slope were significant which means that the production parameters defining the SRI and conventional method were different and it justified for decomposition analysis. For decomposing the productivity difference between SRI and conventional method of paddy cultivation, the parameters of the per ha production functions and mean levels of input use for the two methods were essential.

Therefore, production functions of both the methods were estimated differently (Basavaraja *et al.* 2008). It was observed that for SRI and conventional method 84.54% and 90.02% variation respectively were explained by independent variables. Higher intercept (2.21) in case of SRI signified that there was upward shift in production function due to technological changes associated with SRI method. The paddy output of conventional method would increase by 25.4% and 14. 1% for every one per cent increase in use of labour and fertilizer. These two inputs provide major contribution to the output in conventional method. In case of SRI, the paddy output would increase by 41.4% and 22.2% for every percent increase of seeds and fertilizer.

The total yield difference between SRI and conventional method of rice cultivation is estimated to be 46.1%. Decomposition of yield gap of SRI and conventional method of rice cultivation has been presented in table 2. Cultural practices contributed highest difference with 32.63% followed by input usage (13.47%). Among the inputs, seeds (-33%) and irrigation (-2.24%) contributed negatively to the while human labour (7.46), FYM (10.76) PPC (1.9) and fertilizer (1.18) contributed positively to the yield difference.

The negative contribution implied that farmers growing SRI method paddy obtained higher output per hectare than that obtained by the farmers of

Table 1: Estimated production functions with intercept and slope dummies

Sl. No.	Particulars	Pooled	Conventional	SRI
1	Intercept	1.49 (1.087)	1.214 (0.335)	2.21 (0.359)
2	seed	0.100** (0.056)	0.100** (0.068)	0.414 ***(0.040)
3	Human labour	0.508** (.062)	0.254 ** (.065)	0.108 ***(.004)
4	Fertilizer	.0438** (.064)	0.141** (0.067)	0.222 ***(0.047)
5.	FYM	0.078*** (0.010)	0.078 ***(0.042)	0.156** (.013)
6	PPC	0.1947***(0.029)	0.1947*** (0.034)	0.0301***(.0329)
7	Dummy			
a.	Intercept	1.76** (.078)		
b	seed	0.214** (0.0508)		
c	Human labour	0.327**(0.0628)		
d	Fertilizer	1.45** (.00786)		
e	Fym	.0387 ***(0.0334)		
f.	PPC	0.195*** (.029)		
	R^2	90.75	84.54	90.12

Figures in parentheses are standard error

, and *** Significant at 5, 1 and 10% respectively.*

Conventional method of paddy by spending less on those inputs.

Table 2: Decomposition of yield gap between SRI and Conventional method of rice cultivation

Sl. No.	Sources of yield gap	Difference (%)
1	Yield	46.1
2.	Cultural practices	32.63
3.	Input Usage	13.47
a.	Seeds	-33
b	Human labour	7.46
c	fertilizer	1.81
d	fym	10.76
e	PPC	1.9
f.	Irrigation	-2.24

The results on computation of Sustainability index (S.I.) for farmers practicing SRI method of paddy cultivation along with the values of Di, yields of SRI and conventional method of paddy are presented in table 3 for 20 farmers out of 75 farmers taken for study. Positive symmetry index (1224.2) and positive regression co efficient (1.12) proves the fact that the yield levels SRI farmers were higher than those of traditional farmers. The desired yield levels Di's were higher than the actual level. The standard yield level (Ds) of the SRI method was estimated to be 10587 kg/ha. Out of 75 farmers 42 farmers show Di value significantly higher than Ds value thus sustainability index for SRI method has been worked out to be 56%. Rama Rao (2011) reported sustainability index value of SRI for North Coastal Zone of Andhra Pradesh as 46.7%.

Table 3: Actual yield and sustainability index of SRI method of Rice cultivation

Sl. No.	SRI yield	Conventional	Desired yield	Sustainability index
1	9250	6500	10620.88	100.3**
2	9600	6000	10970.88	103.6**
3	7000	6200	8370.88	79.06
4	6896.97	5500	8267.85	78.09
5	8950	4000	10320.88	97.4
6	8950	7000	10320.88	97.4
7	8990	6857.14	10360.88	97.8
8	9100	6498.18	10470.88	98.9
9	9639.19	6958.33	11010.07	103.9**
10	9500	6800	10870.88	102.6**
11	9650.85	6000	11021.73	104.1**
12	9909.091	5500	11279.97	106.5**
13	8939.02	5900	10309.9	97.3
14	7950	6500	9320.88	88.04
15	9240	6503.23	10610.88	100.2**
16	9140.50	6950	10511.39	99.2
17	8959.46	6839.66	10330.34	97.5
18	10010.32	6900	11381.2	107.5**
19	9459.95	3500	13731.9	129.5**
20	7450	6900	8820.88	83.3

Ds= 10587 kg/ha

β=1.12

, and *** Significant at 5, 1 and 10% respectively*

It is evident from the results of sustainability index that even though the yields of SRI farmers were higher than the conventional farmers, the sustainability indices of SRI method against conventional method from 78.09 to 129.5. Whenever the symmetry of the site indices was closer to zero, irrespective of the regression coefficients of SRI method yields on the site index, the mean yield of SRI was closer to the corresponding standard yield level (Ds), indicating that in cases, the mean yields of SRI could be used for assessing the sustainability of SRI.

CONCLUSION

The findings of above study showed that yield level of SRI is more than the conventional method of rice cultivation. There was 46.1% yield difference observed between the two methods of paddy cultivation. From the decomposition analysis of yield gap it was evident that cultural practices contributed maximum (32.63%) followed by FYM (10.76%) and human labour (7.46%). It is suggested that better understanding of cultural practices and its management may improve the yield and ultimately profit. Seed (-33%) and irrigation (-2.24%) contributed negatively which implied that farmers growing SRI method paddy obtained higher output per hectare than that obtained by the farmers of Conventional method of paddy by spending less on those inputs. SRI was found to be sustainable with sustainability indices ranged from 78.09 to 129.5. It is estimated to be 56% that implies that SRI can thrive in the conditions of the study area and farmers can avail greater output and employment and ultimately higher income by practicing this method of rice cultivation.

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