PRODUCTIVITY AND COST DIFFERENTIALS ACROSS ADOPTERS AND NON-ADOPTERS OF SYSTEM OF RICE (SRI) AND WHEAT INTENSIFICATION (SWI): A CASE STUDY OF GAYA DISTRICT BIHAR (INDIA)

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Abstract: In the fast growing Indian economy agriculture is not doing as well as it was expected, in fact not only agriculture is not doing well but widespread farmers distress are reported, leading to unnatural death by committing suicides. The government is introducing new reforms and measures like introducing new technologies system of rice and wheat intensification SRI/SWI, new institutional innovations such as participatory irrigation management, market reforms etc. to enhance farm productivity by reducing the cost and increasing farmers' income. This paper looks at one such reform, namely SRI/SWI, the technique of which is being applied to other crops as well. The main objective of this paper is to make a comparative study of the traditional green revolution method of cultivation of rice and wheat vis-à-vis the SRI/SWI method of cultivation in four villages of Gaya district in the state of Bihar (India). It is based on primary survey of 303 farmers from the selected four villages of Gaya district. The results show an increase in yield by almost double, reduction in use of seed but increase in labour use in case of SRI/SWI method of cultivation for both rice and wheat. Since the SRI technology is resource saving particularly those which requires cash expenses and it is also yield enhancing and requires only additional inputs of labour which is abundant with small farm house hold. It would be beneficial for viability and sustainability of small farms. The paper argues that introduction of such technological change would go long way in revitalizing Indian Agriculture.

Keywords: Technology, intensification, yield and cultivation

Introduction: India has come a long way from being a food scarce country to becoming food secure country. This could be possible only because of the green revolution technology. The growth rate of total crop production was calculated to be around 2.19 percent for the period 1967-68 to 1980-81 and 3.19 percent for the period 1980-81 to 1990-91 as a result of increase in yield (Venkateswarlu 2008). The main reason for the success of this technology was that it was completely divisible and therefore scales neutral. The technology was supported by public policies such as subsidies on fertiliser and irrigation and minimum support price (MSP) which created a favourable environment for their adoption. However, post liberalisation this is becoming a problem as subsidies are being withdrawn. Although green revolution technology increased the productivity of food grains, it also had serious repercussions on the ecology like excessive use of fertilisers degraded the soil quality, a decline in groundwater due to excessive use of tube wells and poor pest management. The focus of the agriculture policy makers at the time of green revolution was limited to only those areas which were suitable for the spread of green revolution, hence though agriculture as a whole was growing in the country there were areas which remained stagnant (Rao and Hiremath 2010).

Today the Indian Agriculture sector is going through a lot of structural changes. First, increase in number of small and marginal farmers. The number of smallholder farmers has increased from 66 million in 1980-81 to 117 million in 2010-11 i.e. an increase of 77 percent in the last three decades (Joshi 2015). Also the share of medium and large farmers has declined from 26 percent to 15 percent in the last three decades; however 56 percent of the operated area is still cultivated by medium and large farmers (Joshi 2015). Second, increase in cost of production due to intensive agriculture leading to excessive use of fertiliser, water and pesticides causing tremendous pressure on small farm household. The third structural change is commercialisation of Indian agriculture, earlier agriculture was carried out for subsistence, but today it is more for increase in income as peoples aspirations have gone up. Fourth is the breakdown of joint family system; whenever there is any loss in agriculture the farmer has to bear on his own and has no support from other family members, this has led to the distress of farmers leading to suicides in some cases and traditional joint risk bearing system is breaking down. Hence if the Indian agriculture has to sustain the issues concerning viability of small farmers is important because their number is increasing.

Therefore there is need for new technologies which are not only yield enhancing but also resource saving, and new institutional arrangements in market which promote participation of the farmers. One such technology which is said to be resource saving is System of Crop Intensification (SCI). This paper tries to examine the cost and production differential among adopters and non-adopters of this technology for two crops namely rice and wheat in Gaya district of Bihar. The paper has been divided into five

sections. After this brief introduction the next section discuss the main attributes of cultivation under crop intensification. The third section is about the research methodology used to conduct the study. Fourth section gives the results based on the study followed by a brief discussion on the results. Fifth and final section is concluding remarks and policy recommendation.

The Method of Crop Intensification: The method of crop intensification was developed in Madagascar in 1983 by father Henri de Laulanie for rice and it was known as the system of rice intensification (SRI). Today this technology is being adopted for various other crops. It has six main attributes namely, wide planting, less seed, transplanting young seedling, less water usage, turning back the weed into soil and use of organic manures. Wide spacing of plants help the roots grow healthier and absorb more nutrients as each plant gets more space, air and sunlight. Healthier roots result in more tillers, long panicles and more grain and grain weight, also reducing seed requirement. The seedling needs to be transplanted in 2 leaf stages i.e. when it is 8-12 days old, this helps the seedling to grow healthily and generate more tillers. It requires less water as water is not allowed to stagnate in the field. Providing water occasionally aerates the roots which result in its healthy growth. The weeds in the field are turned back into the field using a weeder leading to aeration of field which turn into organic matter (WWF-ICRISAT 2006). SRI is not possible in saline or alkali soils, it also requires levelled plots so that water spreads uniformly after irrigation across the field. Similar method is followed for wheat as well as other crops.

Research Methodology: This paper is a part of the larger study which was conducted in Gaya district of Bihar. However, briefly the research method used purposive random sampling. First two blocks from Gaya were selected after discussing with the agriculture personals at Gaya district and member of the PRAN (a Non-Government Organisation) which has been involved in the promotion of SCI in Gaya since 2006. The blocks selected were such that which had both adopters and non-adopters of this technology. Among these blocks we randomly selected two villages each which had both the adopters and non-adopters of the SRI and SWI technology. This is followed by, a detailed survey of the village through focus group discussion which comprised of one member of the Panchayat, ANM (Auxiliary Nurse Midwife) and ASHA (Accredited Social Health Activist) workers and a few village people old as well as young. For the village level study we divided the farmers into SRI, SWI, non-SRI and non-SWI farmers A total of 303 farmers were surveyed for the study, in which 212 farmers are adopters of SRI and/or SWI method and 91 farmers used traditional green revolution method of cultivation. They were treated as non-adopters of SRI/SWI technology. In this paper, we are presenting descriptive analysis. The analysis of data using more rigorous analytical technique is still being carried out.

Results and Discussion: On many counts there was similarity between the adopters and non- adopter of new technology. It can be seen from table 1 that from a total of 303 farmers selected 212 were adopters and 91 were non-adopters. The number of adopters is more as the study focuses on adopters. Among the adopters 80.66 percent are marginal farmers (having operated are less than 2.5 acres), 15.09 percent are small farmers (having operated area between 2.5-5 acres) and 4.25 percent are medium and large farmers (having operated above 5 acres). Similarly in case of non-adopters also 80.22 percent of the farmers belong to the marginal farmers category, 18.68 percent belong to small farmers category. The average no. of persons per household is almost same for both the adopters as well as the non-adopters of the two technologies, even across categories of farm household. The average operated area for the adopters is 1.8 acres per household and that for non-adopters is 1.65 acres (see table 1). Thus the sample of adopters and non-adopters are comparable on several counts like family size, average operational holding etc.

Table 1: Salient features of selected households (HH) under study

Particulars	No. of HH	Percentage	Avg. persons per HH	Avg. Operated area
Total	**303**	**100**	**8**	**1.75**
Adopters	**212 (100)**	**69.97**	**8**	**1.8**
M	171 (80.66)	56.43	7	1.21
S	32 (15.09)	10.56	9	3.53
M & L	9 (4.25)	2.97	19	6.91
Non-adopters	**91 (100)**	**30.03**	**8**	**1.65**
M	73 (80.22)	24.09	7	1.17
S	17 (18.68)	5.61	10	3.42
M & L	1 (1.10)	0.33	20	7.41

Source: Field survey

Note: Figure in brackets shows the percentage of farmers among adopters and non-adopters of SRI and/or SWI method of cultivation.

Table 2: Output per acre of SRI adopters and non-adopters (in Quintal per acre)

Category	Adopter		Non-adopter paddy	Overall	Difference in output between SRI paddy and non-adopter paddy	Difference in output between SRI paddy and non-SRI paddy	Difference in output between Non-SRI paddy and non-adopter paddy
	SRI Paddy	Non-SRI paddy					
Marginal	17	13.98	12.02	14.4	4.98 (7.44*)	3.02 (2.53*)	1.96 (1.28)
Small	21.09	13.73	12.16	14.38	8.93 (5.38*)	7.36 (3.94*)	1.57 (1.37)
Medium and large	21.38	13.25	10.98	13.99	10.4	8.13 (1.77***)	2.27
Total	18.15	13.76	12.01	14.34	6.14	4.39	1.75

Source: Field Survey

Note: Figures in bracket represents the "t" value for mean yield difference among adopters and non- adopters
*, **, *** represents level of significance at 1 percent, 5 percent and 10 percent respectively.

Table 2 given below shows the output per acre of SRI adopters and non-adopters. It can be seen from table 2 that the output per acre for SRI paddy (17 quintals) is much higher in comparison to non-SRI paddy (13.98 quintals) and non-adopter paddy (12.02 quintals) for marginal farmers. SRI paddy means paddy which has been cultivated using the SRI method either in full or partial land of the farmer, non-SRI paddy is the paddy cultivated by the adopters of SRI method using the traditional method in some portion of their land and non-adopter paddy is the paddy grown using the traditional method of cultivation. Similar is the case with wheat also. Similar trend can be seen for small and medium and large farmers also. This difference in output is statistically significant. An interesting thing to note is that the output for small and medium and large farmers is much higher than the marginal farmers Also their yield through SRI is much higher than the traditional method. But the area in which they are adopting this technology is quite less

Table 3: Output per acre of SWI adopters and non-adopters (in Quintal per acre)

Category	Adopter		Non-adopter wheat	Overall	Difference in output between SWI Wheat and non-adopter wheat	Difference in output between SWI wheat and non-SWI wheat	Difference in output between SWI wheat and non-SWI wheat
	SWI wheat	Non-SWI wheat					
Marginal	15.4	9.11	9.27	9.63	6.13 (8.12*)	6.29 (8.4*)	-0.16 (0.75)
Small	14.0	9.34	8.61	9.28	5.39 (3.75*)	4.66 (3.2*)	0.73 (0.83)
Medium and large	16.2	10.79	9.29	10.7	6.91	5.41 (2.3***)	1.5
Total	15.2	9.39	9.03	9.63	6.17	5.81	0.36

Source: Field Survey

Note: Figures in bracket represents the "t" value for mean yield difference among adopters and non- adopters
*, **, *** represents level of significance at 1 percent, 5 percent and 10 percent respectively.

It can be seen from table 3 that the output per acre for SWI wheat (15.4 quintals) is also much higher than the non-SWI wheat (9.11 quintals) and non-adopters wheat (9.27 quintals) for marginal farmers and a similar trend is seen for small and medium and large farmers, also this difference is significant. Hence SRI and SWI method of cultivating rice and wheat give a higher yield in comparison to traditional method. From the yield prospective there is enough evidence that system of rice and wheat intensification has higher yield in the Gaya district of Bihar. There are two questions first if the yield is higher why even then the adopters are using this technology only on a part of land allocated to rice and wheat. Second question is about the non-adopter and it need to be explained as to why the technology has not spread length and breadth of the village like it happened in the green revolution technology in late 1980's. Before these questions are addressed it needs to examine the cost of cultivation of SRI/SWI vis-à-vis traditional green revolution technology.

Table 4: Input quantity and Cost of cultivation of paddy using SRI and traditional method (per acre)

Particulars				Seed (in kg)	Manure (in Kg)	Fertiliser (in Kg)	Hours of Irrigation	No. of Labourer's
Marginal Farmers	Adopters	SRI Paddy	Qty	5.58	266.88	113.36	66.57	67.12 (18.94)
			Value (in ₹)	318.56	249.95	1492.34	2212.11	9579.87 (1948.06)
		Non-SRI Paddy	Qty	12.43	149.85	120.08	83.5	58.78 (22.06)
			Value (in ₹)	613.16	173.91	1543.24	1785.56	8944.2 (2804.24)
	Non-Adopter		Qty	15.56	124.57	119.4	63.09	60.35 (25.82)
			Value (in ₹)	595.94	131.78	1641.47	1601.65	9236.18 (3200.72)
Small Farmers	Adopters	SRI Paddy	Qty	5.29	200.99	113.79	96.86	60.14 (41.57)
			Value (in ₹)	278.14	413.46	1486.47	715.21	9153.2 (6090.19)
		Non-SRI Paddy	Qty	16.9	91.95	134.3	86.44	50 (43.22)
			Value (in ₹)	724.79	346.73	1920.58	1275.86	7477.65 (6404.17)
	Non-Adopter		Qty	14.9	94.73	124.52	43.83	54.36 (39.84)
			Value (in ₹)	518.89	119.74	1613.09	95.8	6701.95 (4809.53)
Medium and large Farmers	Adopters	SRI Paddy	Qty	4.09	172.95	153.46	69.18	53.14 (43.40)
			Value (in ₹)	495.28	511.01	2021.54	1108.49	8387.1 (6624.84)
		Non-SRI Paddy	Qty	14.86	62.97	148.32	45.31	43.38 (36.15)
			Value (in ₹)	561.78	244.33	1982.64	347.61	2079.29 (5550.93)
	Non-Adopter		Qty	9.29	16.89	101.35	40.54	35.81 (27.70)
			Value (in ₹)	253.38	0	1165.54	101.35	4606.75 (3662.16)

Source: Field Survey
Note: The figures in bracket are for hired labour

The requirement of seed and water is quite less in case of SRI method of cultivation as the quantity of seed and water used is much less when compared to traditional method (see table 4). However, the amount of labour used is much higher in case of SRI i.e. 67, 60 and 53 for marginal, small and medium and large farmers respectively and 60, 54, 36 for marginal, small and medium and large farmers who have not adopted SRI method. However, most of the labour in case of marginal farmers is family labour (see table 4). As the farm size increases the proportion of hired labour increases. This may be one of the reasons for slow and partial adoption of SRI technologies on the medium and large farms.

Table 5: Quantity and Cost of input for cultivation of wheat using SWI and traditional method

Particulars				Seed (in kg)	Manure (in Kg)	Fertiliser (in Kg)	Hours of Irrigation	No. of Labourer's
Marginal Farmers	Adopters	SWI Wheat	Qty	16.62	132.89	116.46	59.69	54.58 (14.22)
			Value (in ₹)	305.47	225.06	1472.57	3709.26	12044.57 (3981.14)
		Non-SWI Wheat	Qty	60.87	46.15	157.57	61.45	21.85 (10.68)
			Value (in ₹)	769.74	50.01	1445.49	1700.7	4631.21 (1969.70)
	Non-Adopter		Qty	63.49	65.59	118.85	46.73	19.52 (6.35)
			Value (in ₹)	859.89	73.82	1652.8	1501.04	4959.73 (2125.84)
Small Farmers	Adopters	SWI Wheat	Qty	15.67	110.79	220.61	78.32	43.35 (19.46)
			Value (in ₹)	201.73	28.9	2961.51	2207.13	9140.27 (4739.11)

		Non-SWI Wheat	Qty	55.35	35.15	116.93	47.86	14.73 (12.33)
			Value (in ₹)	604	5.41	1584.31	790.65	3986.6 (3506.91)
	Non-Adopter		Qty	59.38	19.38	134.44	40.89	18.30 (14.38)
			Value (in ₹)	795.53	0	1769.77	157.28	3829.77 (3170.28)
Medium and large Farmers	Adopters	SWI Wheat	Qty	11.8	22.47	148.32	28.65	37.08 (32.58)
			Value (in ₹)	258.43	0	1970.79	337.08	7919.95 (7077.25)
		Non-SWI Wheat	Qty	58.59	0	143.15	27.23	12.75 (11.15)
			Value (in ₹)	1003.3	0	2128.36	301.79	3455.6 (3096.44)
	Non-Adopter		Qty	43.92	0	101.35	40.54	14.19 (11.82)
			Value (in ₹)	405.41	0	1165.54	101.35	2466.22 (2145.27)

Source: Field Survey
Note: The figures in bracket are for hired labour

Similarly in case of wheat also the per acre requirement of seed is quite less when using the SWI method of cultivation i.e. 16.62 kg for marginal farmers, 15.67 kg for small farmers and 11.8 kg for medium and large farmers which in case of non-adopter wheat is 63.49 kg, 59.38 and 43.92 kg for marginal, small and medium and large farmers However, the requirement of labour (see table 5) is much higher in case of SWI method of cultivation since in the traditional method of cultivation the farmers make use of the broadcast method of sowing, which is much easier and less time taking. From the data of cost and inputs it could be inferred that the system of rice and wheat intensification technology is more labour intensive and land and water saving technologies. The amount of water saved is not very high in this region since only protective irrigation given when rain fails. But out of pocket expenses like on fertilizer and manure are higher with SRI/SWI than the traditional green revolution technology. Thus the adoption of SRI/SWI may be constrained by the availability of labour and its adoption may be further limited by availability of cash and credit availability with different farm house hold.

Conclusions: From the result and discussion presented in previous sections it can be clearly seen that Paddy and wheat grown using the SRI and SWI method have higher yield. Per acre output of both paddy and wheat was much more using SRI and SWI method than the traditional method across all categories of farmers However, the cost of cultivation is more in case of the SRI and/or SWI method of cultivation. This is due to the increase in number of labour required at the time of sowing and weeding for both paddy and wheat. The requirement of labour is much higher in case of SWI method since the traditional method of cultivating wheat uses broadcast method which can be done by one or two people depending upon the land size and also does not require more than a day or two in most of the cases. However, in case of SWI method the seed need to be sown at a particular distance and one at a time, this requires 3-4 labour at a time and also the time taken is more. Hence if low cost seed drills are made available to the farmers, the cost of labour will be reduced, leading to a reduction in cost of cultivation and increase in returns from SWI method. The method of rice and wheat intensification is more beneficial for the marginal farmers because most of the labour involved in cultivation of paddy and wheat is family labour or exchange labour (i.e. they work in others field in exchange of labour), 48 percent of the labour involved in growing paddy using SRI method is family labour and 19 percent is hired (see table 4), similarly in case of wheat also around 40 percent of labour is family labour and 14 percent is hired labour (see table 5). The requirement of seed is much less in case of SRI and SWI method of cultivation. Another important thing to note is that the farmers use more wormi compost and dung manure when using the SRI and SWI method of cultivation; this could have a positive effect on the output of crop as well. The increase in output could be due increased dedication and attention of the farmers towards the SRI and SWI crops in comparison to those grown by traditional method. We can also see that the output per acre of non-SWI wheat and non-SRI paddy is higher in case of adopters when compared to the non-adopters and also the cost of cultivation is more, this could be due to spillover effect and better management practices learned by these farmers in SRI/SWI cultivation. Finally, it may be concluded that SRI/SWI would go long way, if the technology is appropriately supported by the public policies such as credit and market support as it was done in case of green revolution technology.

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