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COST BENEFIT ANALYSIS OF SYSTEM OF WHEAT INTENSIFICATION METHOD OF CULTIVATION VIS-À-VIS THE TRADITIONAL METHOD: A CASE STUDY OF GAYA, BIHAR

Shikha Pandey[1]

Abstract

Wheat is one of the main cereal crops grown in Bihar, with more than 80 percent of the gross cropped area under it. Even then, the yield of wheat is quite low. With the declining land size per farmer, a decrease in area under agriculture and a continuous increase in population, it has become important to increase the productivity of wheat in order to maintain the food security. Keeping this in mind, the government of Bihar started promoting the System of Wheat Intensification (SWI) in the state in the year 2011. The main objective of this paper is to understand how beneficial is the SWI method of cultivation in comparison to the traditional method. The results of the study show that there is an increase in yield of wheat by 49 percent under SWI method, but also an increase in cost of production due to increase in use of labour. Overall, the net returns are higher under the SWI method of cultivation due to higher gross returns from increased yield of both main crop and by-product.

Key Words: Wheat, System of Wheat Intensification, Output and Net returns

Introduction

The state of Bihar along with Punjab, Haryana, Uttar Pradesh and West Bengal, is part of the Indo-Gangetic Plain of India, which is the source of food and livelihood security for millions of Indians (Aggrawal *et al,* 2004). The region has gently sloping fertile alluvial soil, which is very good for cultivation of crops. Rice-wheat cropping system has been practiced here from the 16th century, but the expansion of canal and tube well irrigation in the 1960's and 70's helped further spread of area under rice-wheat system (Pal *et al*, 2010). Even today, the state of Bihar is largely agrarian and rural, and around 88 percent of the total population of the state lives in rural areas and 77 percent of the total workforce is engaged in agriculture (Singh *et al*, 2015). Even though agriculture has been an integral part of Bihar's economy, it was one of the last states to adopt the High Yielding Varieties (HYV) or the green revolution technology. This was mainly due to lack of proper infrastructure support, mechanization and monetary support needed to cultivate using this method. Though the green revolution method of cultivation was scale neutral in nature, it was not resource-neutral and those who could not afford to purchase high yielding variety seed and did not have tube-well or canal irrigation facility were unable to cultivate using this technology and so the spread of the green revolution technology was very slow in the state of Bihar unlike in the states of Punjab, Haryana and Uttar Pradesh.

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Like the rest of the country, the economy of Bihar is also undergoing structural changes over the last two decades. The share of agriculture in the Gross State Domestic Product (GSDP) has declined from 35.8 per cent in 2001-02 to 19.7 per cent in 2017-18 due to increase in the share of tertiary sector. Even then, agriculture remains of great importance to the state of Bihar as it provides employment and livelihood to more than seventy per cent of the state's population, and it is a source of raw material for the industries, and is needed for the state's food self-sufficiency and security. Hence, in order to create both on-farm and off-farm employment opportunity to improve the income, especially for the poor, it is important to achieve high and sustained growth in the agriculture sector. This is also important for the overall economic growth of the state.

Another important issue pertaining to Bihar agriculture is the increase in number of marginal and small farmers. According to the Bihar Economic Survey 2019-20, around 91 per cent of the farming households in the state are marginal farmers, that is they operate in less than 1 hectare of land and 6 per cent are small farmers operating in less than 2 hectares of land. These 91 per cent of farming households cultivate only 58 per cent of the total land area under cultivation. The report also noted that in comparison to 2010-11 agriculture census year data, the number of marginal farmers has increased by 1.5 per cent in 2015-16. Therefore, most of the farming households in Bihar are marginal farmers, followed by small farmers. The percentage of large farmers is only 0.02 percent.

Hence, with the declining land size per farmer in Bihar and a decrease in area under agriculture, it has become important to bring in innovative technologies which will help increase the yield per hectare of land by sustaining the natural resources. To meet some of these challenges, the government of Bihar started promoting the method of crop intensification in the state in the year 2011. System of Rice Intensification (SRI) and System of Wheat Intensification (SWI) are the crop intensification techniques for paddy and wheat respectively. The main reason for promotion of this method of cultivation was its success in the states where it was being adopted and the success of this technology within Bihar, where it was being promoted by a NGO PRADAN (which is now being promoted by PRAN, an organisation carved out of PRADAN, focusing specifically on SRI (SWI)).

The main objective of this paper is to do a cost benefit analysis of SWI method of cultivation *vis-à-vis* the traditional method of wheat cultivation which is being followed in the study area in Gaya, Bihar. Since a lot of studies have already done the cost benefit analysis of the SRI method of cultivation, the focus of this paper is on SWI method of cultivation. In order to do so, the paper analyses the total cost of cultivation and the amount of input used for cultivating wheat using the SWI method and the traditional method. This paper is divided into five sections. After this brief introduction, the next section of the paper is review of literature, followed by the methodology section. The fourth section presents the results and discussion and finally it closes with the summary and conclusion and policy recommendations.

Review of Literature

Some community workers in India and Africa made use of the principles of rice intensification technique in wheat crop through an experiment, which gave them very encouraging results (Khadka and Raut, 2012). This technique of wheat cultivation then came to be known as the system of wheat

intensification. It is based on the techniques of SRI. However, in comparison to SRI, SWI is a newer concept. The SWI method of cultivation is developed on two principles of crop production: (1) the principle of root treatment and (2) principle of intensive care (Rana *et al*, 2017). Under the SWI method, one or two seeds are sown per hill at a distance of around 25*25 cm. The distance between the two crops helps in the proper growth of the roots.

There is not much difference in the method of wheat cultivation under SWI in comparison to the traditional method. But the SWI method of cultivation creates a beneficial environment for the crop by changing the sowing geometry, weed management and stressing on organic manuring (Raghavendra *et al*, 2019). The biggest advantage of this method of cultivation is that it is scale neutral, that is, it can be used by any category of farmer, be it marginal, small, medium or large. Also, it does not require any extra investment. The farmers do not need to invest in any new equipment or new variety of seed, and can cultivate the land using both the hybrid and non-hybrid varieties of seed. They only need to learn the technique of cultivation using this method, which is not difficult and can be mastered with some practice. In Bihar, the SWI method of cultivation was first experimented with in 2008 by the NGO PRAN. The positive results of the experiment led to the spread of this technology in the state. Today, this method of crop intensification is being used for various crops like sugarcane, rapeseed or mustard and vegetables like chilli, eggplant, tomato etc. in Bihar. Mentioned below are a few studies that have looked into the SWI method of cultivation.

Khadka and Raut (2012) compared the yield of wheat from traditional practice with that from SWI in Nepal. Participatory action research was conducted by Mercy Corps Nepal in collaboration with the district agriculture development offices in 16 sites of 3 working districts- 4 sites in Dadeldhura, 8 sites in Baitadi and 4 sites in Doti. They made use of high yielding WK-1204 variety of wheat with three treatments and local practices. The treatments were T1 (seed priming + line sowing), T2 (seed priming + broadcast method), T3 (without priming + local practice of sowing) and T4 control (local variety + local practice). The results of the study showed that plant height was same in all cases of treatment, but the number of tillers and length of the spikes differed significantly in case of T1 and T4 and there was a yield difference of 100% increase between T1 and T4. The wheat crops responded positively to seed priming and line sowing. The wheat variety WK-1204 was found to be highly productive, compared to the local variety. There was an increase in grain yield after treating the seeds organically before sowing them in the field. The spacing between the plants led to an increase in the number of tillers per plant, plant height and spike length and the number and size of grains, resulting in higher grain and biomass yield. The findings suggested that yield of wheat could be increased by 91.33% with the adoption of SWI technology compared to local practice.

Adhikari (2013), conducted a field experiment in at Bhimasthan –3, Kadame, Sindhuli, Nepal during December 2009 to 2012 in Integrated Crop and Water Management Program (ICWMP) Farmer Field School (FSS). The result of the study showed the number and plant height to be higher in SWI i.e. 25 and 61.4 as compared to the farmers' practice of broadcast method, which were only 2.6-3.4. The study observed that the average number of tillers was more in the case of SWI, 21.4 whereas the average number of tillers in conventional broadcast and line sown method were 1.7 and 2.3. The yield

under SWI method was found to be higher in comparison to conventional broadcast and line sown method.

Kumar *et al* (2015) conducted a field experiment in the Rabi seasons of 2011-12 and 2012-13 at the regional station of Indian Agricultural Research Institute (IARI), Pusa, Samastipur, Bihar. The study was aimed at comparing the system of wheat intensification with different plant geometry with conventional line sowing method of wheat under sandy loam soil. The study was conducted in Split Plot Design allocated 2 seed treatment (treated and untreated) method in main plot and 3 SWI spacing (10×10, 15×15 and 20×20 cm) and one conventional line sowing (22.5 cm) in sub plots and replicated thrice. The study observed higher effective but non-significant increase in tillers, grains spike^{-1} and 1000-grain weight of wheat in seed treated plots as compared to plots with untreated seed. The SWI method of wheat sowing at 10 cm × 10 cm spacing recorded significantly higher grain yield (6.6 and 5.1 t ha–1) during 2011-12 and 2012-13, respectively over other treatments. The straw yield was also observed to be higher for both the years. Based on the results of the study, they concluded that SWI method is slightly superior to conventional line sowing method with recommended practices and far superior to the usual farmers' practice. However, in economic terms, the study found the conventional line sowing practice more profitable as compared to cultivation under SWI method due to an increase in labour cost and not much increase in output. The study also observed that SWI method of cultivation leads to a saving of 17-18 per cent of irrigation water and improves irrigation water productivity to the tune of 7 percent.

Rakib *et al* (2016) assessed the effect of nutrient management and plant spacing on the performance of wheat under SWI and superior yield performance of wheat between SWI and the conventional system. The study was conducted from November 2011 to March 2012 at the Agronomy Field Laboratory, Bangladesh Agriculture University. It consisted of three factors: (1) Fertiliser doses, (2) line spacing and (3) plant spacing. A total of 57 plots were under experiment and they made use of high yielding wheat variety BARI GOM 24 (*Prodip*), developed by Bangladesh Agricultural Research Institute. Statistical tools like ANOVA (analysis of variance), computer package MSTATC and Ducan's Multiple Range Test (DMRT) were used. The results of the study showed that the full recommended fertiliser (RF) dose and closer line spacing increased grain yield by 50.5%. The SWI technique was found to increase 18 to 67% grain yield in wheat at farmers' field as compared to the broadcast method. They concluded that better yield attributes and grain yield of wheat were attained only when the full recommended fertiliser dose was applied and closer line and plant spacing ensured better utilisation of soil, water and above ground resources and increased grain yield.

Overall, the review of literature suggests that the SWI method of cultivation leads to an increase in the yield. The review also observes that this method of cultivation leads to reduction in the use of resources like seed and water. It also suggests that the SWI method of cultivation leads to an increase in the cost of production due to increase in labour requirement. However, all these studies that have been discussed above are experiments and do not look at the cost and benefit of using the SWI method from the farmer's field level. This study will help build the literature on SWI method of cultivation and give an understanding of the pros and cons of the method at the farmer's field level. Therefore, it is important to analyse the cost and benefit from SWI method of cultivation in detail.

These issues become important for small and marginal farmers in less developed areas like Gaya (Bihar), because the method of cultivation may be scale neutral but not resource neutral.

Methodology

Data used

This paper is part of a larger study titled, 'A study on system of rice and wheat intensification for sustainable agricultural development of Bihar'. It consists of data from four villages of Gaya district, namely Patthargatha, Dohari, Gohti and Pathara. These four villages were selected purposively after discussion with the agriculture officials at Gaya district and members of PRAN organisation. PRAN is a non-Government Organisation (NGO) working in Bihar towards the promotion of SRI and SWI methods of cultivation and had the data on farmers using these methods of cultivation in these villages. After deciding on the villages, the list of farmers using SWI method was collected from them and the adopters were randomly selected from the list. After this, the non-adopters were also randomly selected ensuring that they had the same socio-economic background and were from the same area. In the end, we had a total of 302 randomly selected farmers for study. However, this sample was for both adopters and non-adopters of SRI as well as SWI. Out of this total, around 299 farmers were cultivating wheat. Amongst the wheat growers, 92 were adopters of SWI method and 207 were non-adopters.The number of adopters represented 50 per cent of the population making use of this technology. The reason why there are more non-adopters is that the main study focuses on both SRI and SWI, but the focus of this paper is only on SWI. All of these 299 farmers were personally interviewed using a detailed interview schedule. The input output data for the plots where these households had adopted the SWI method of cultivation were considered to calculate the adopters' cost of cultivation for the SWI method. Similarly, the input output data for wheat cultivation for the traditional method were considered to calculate the cost of cultivation. The input output data from the households were collected using pre-tested questionnaire.

Analytical tools

In order to compare the cost of cultivation, the yield and returns of SWI and traditional method of cultivation, the study made use of descriptive statistics. The difference in mean output produced using the two methods is compared using statistical tools like t test. And finally, the net returns are calculated and compared.

Cost of Cultivation, Gross Returns and Net Returns

The cost of cultivation was calculated by adding up all the expenses incurred by the household for cultivation of wheat under SWI and non-SWI practice. The revenue earned was calculated by multiplying the total output produced with the average selling price of the crops as mentioned by the farmers during the survey. Then the cost of cultivation was subtracted from the gross returns and the net value arrived at was the net returns from cultivation of wheat using the SWI and traditional method of cultivation. In order to compare the cost of cultivation, the incremental cost of cultivation was estimated using the following method:

$\Delta_{CC} = \Phi_{SWI} - \Phi_{non\text{-}SWI}$

Where,

Δ_{CC} = The incremental cost of cultivation (Rs./acre)
Φ_{SWI} = Total input cost of SWI method (Rs./acre)
$\Phi_{non\text{-}SWI}$ = Total input cost of non-SWI method (Rs./acre)

Similarly, the incremental gross return was analysed using the following method:

$\Delta_{gr} = \delta_{SWI} - \delta_{non\text{-}SWI}$

Where,

Δ_{gr} = The incremental gross returns (Rs./acre)
δ_{SWI}= Gross returns from SWI method (Rs./acre)
$\delta_{non\text{-}SWI}$= Gross returns from non-SWI method (Rs./acre)
and net incremental returns from SWI method as:
$\Delta_{nr} = \theta_{SWI} - \theta_{non\text{-}SWI}$

Where,

Δ_{nr} = The net incremental returns (Rs./acre)
θ_{SWI} = The net returns earned from SWI method (Rs./acre)
$\theta_{non\text{-}SWI}$= The net returns from non-SWI method(Rs./acre)

Results and Discussion

Out of the total 302 farmers surveyed, 299 were cultivating wheat. Amongst these 299 farmers,only 92 (30.77 percent) had adopted the SWI method of cultivation (see Table 1). Also, most of the farmers among the adopters, around 83.70 per cent,as well as non-adopters, around 79.23 per cent,belong to the marginal farmer category, followed by the small and medium farmer categories as can be seen from Table 1. This clearly shows that the number of farmers who have adopted the SWI method of cultivation is quite low. This is because the SWI method of cultivation is a new technique and not all are willing to take risk.

Table 1: Number of Adopters and Non-adopters of SWI Method of Cultivation

Type of farmers	Adopters	Non-adopters	Total
Marginal farmers	77 (83.70) [31.95]	164 (79.23) [68.05]	241 (80.60) [100]
Small farmers	13 (14.13) [26.53]	36 (17.39) [73.47]	49 (16.39) [100]
Medium farmers	2 (2.17) [22.22]	7 (3.38) [77.78]	9 (3.01) [100]
All farmers	92 (100) [30.77]	207 (100) [69.23]	299 (100) [100]

Source: Authors calculation based on sample data

Figures in parentheses () are respective percentage of column total and in [] are respective percentage of row total

Productivity under SWI method of cultivation

Table 2 compares the per acre yield of wheat using the SWI and traditional methods of cultivation. It can be clearly seen from Table 2 that the yield for wheat is much higher under the SWI method of cultivation *vis-à-vis* the traditional method. The per acre yield was calculated to be 1475 kg/acre for marginal farmers, 1503 kg/acre for small farmers and 1465 kg/acre for medium farmers under the SWI method whereas it was only 993 kg/acre for marginal farmers, 979 kg/acre for small farmers and 1077 kg/acre for medium farmers under the non-SWI method of cultivation. This shows an increase in yield by 36 to 53 per cent across different categories of farmers. Overall, there is around 49 per cent increase in yield of wheat under the SWI method in general. The incremental yield is observed to be the highest for the small farmers, followed by marginal farmers.

Table 2: Per Acre Yield of Paddy and Wheat Using SRI and Non-SRI and SWI and Non-SWI Method of Cultivation (in kg per acre)

Type of farmers	SWI (3)	Non-SWI (4)	Incremental yield (3-4)
Marginal farmers	1475	993	482 (48.54)*
Small farmers	1503	979	524 (53.52)*
Medium farmers	1465	1077	388 (36.03)
All farmers	1479	993	486 (48.94)*

Source: *Authors calculation based on sample data*

*Represents 1 per cent level of significance

To check if this increase in yield is significant or not, T test was used. As can be seen from Table 2, the difference in yield of wheat was significant at 1 per cent level for all farmers taken together, marginal and small farmers. The difference in output was not found to be significant for medium farmers. There was a difference in yield of 388 kg per acre between the adopters and non-adopters of SWI method. It may be because of small size of adopters (only three) in medium farmers' category and high standard deviation in yield among non-adopters. Overall, thus the result is consistent with other studies on SWI (Makadia *et al*, 2014; Khadka and Raut, 2012 and Rana *et al*, 2017). Hence, from the above discussion, it can be concluded that SWI method of cultivation does lead to an increase in productivity in comparison to the traditional method of cultivation.

Input used

The average per acre inputs used by the farmers using SWI and non-SWI method in wheat crops is shown in Table 3. The standard deviation and range of inputs used is also provided here.

Table 3: Summary statistics of input used under SWI and non-SWI methods

Input (per acre)	Mean		Std. Dev.		Range	
	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI
Seed (in kg)	15	60	2	6	13-19	47-70
Manure (in kg)	155	50	159	86	0-545	0-421
Fertiliser (in kg)	115	114	21	21	27-172	28-164
Hrs. of Irrigation	22	24	4	0	5-41	23-27
Family Labour (in man days)	32	12	15	8	0-57	0-27
Hired Labour (in man days)	15	8	13	7	0-50	0-27
Total Labour (in man days)	46	19	11	4	32-100	12-28

Source: Author's calculation based on sample data

As can be observed from Table 3, the average amount of seed and water used in wheat cultivation declined under the SWI method. The mean quantity of seed is calculated to be 15 kg per acre for SWI method, whereas it is 60 kg per acre for non-SWI method. This decline is calculated to be around 74 percent. In the case of irrigation, the mean hours of irrigation for SWI method was calculated to be 22 hours per acre whereas that for non-SWI method was 24 hours per acre. There was a decline of 10 per cent in the use of water for irrigation. However, an increase in inputs was found in manure and labour which increased by 230 and 140 percent respectively. The reason for increase in manure is that in the traditional method of wheat cultivation, most of the farmers do not apply manure at the beginning. It is applied only in one season, that is at the time of cultivating paddy. But in the case of SWI practice, the farmers apply vermin compost, which is one of the steps and components of cultivation under SWI generally practiced by the farmers. A more detailed analysis of the input use by each category of farmers was also done. Appendix Table A1 presents the results. Here also it was found that the use of seed and hours of irrigation declined under the SWI method of cultivation. But the use of labour increased across all categories of farmers by around 130-164 per cent (see Appendix Table A1). However, the marginal and small farmers have more share of family labour than hired labour, unlike the medium farmers.

From this simple analysis, it is concluded that the SWI method of cultivation does lead to a decline in the use of seed and water for irrigation. Hence, it is a resource conserving technology at least in terms of seed and hours of irrigation. But there is an increase in the use of labour under the SWI method. This increase in labour is mostly due to increase in labour requirement at the time of sowing and weeding. Therefore, the total amount of labour required is more than for the non-SWI method of cultivation. However, this is also one of the reasons for the reduced requirement of seed. Hence, this method of cultivation is more beneficial for households which have more family labour, which will not lead to an increase in the cost of cultivation. This means it is more beneficial to marginal and small farmers.

Cost of Cultivation

After looking at the input use, let us now look at the cost of cultivation under the two methods. Table 4 makes a comparison of the cost of cultivation of SWI method of cultivation with the traditional method

of cultivating wheat. There is a vast difference in the cost of cultivation of both the methods. The total average cost of cultivation for non-SWI method is around Rs. 8288.48 when considering all the farmers together and the average cost of cultivation of SWI method was calculated to be Rs. 11800.49 for one acre of land. This means the cost of cultivating wheat using the SWI method is much higher in comparison to the traditional method. However, if the imputed value of family labour is excluded, there is not much difference in per acre cost of cultivation of SWI and non-SWI methods as can be seen from Table 4. If we look at total cost (b) in Table 4, which excludes the imputed cost of family labour, the total cost of cultivation under the SWI method is Rs. 6806.36 for marginal farmers and Rs. 6758.66 for small farmers in comparison to Rs. 12183.15 and Rs. 10214.12 respectively under total cost (a) which includes imputed cost of family labour. This reiterates the point that the SWI method of cultivation is more beneficial for households which have more family labour.

Table 4: Cost of cultivation of SWI and non-SWI wheat (in Rs. per acre)

Particulars	Marginal farmers		Small farmers		Medium farmers		All Farmers	
	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI
Seed	538.31 (4.42)	1732.05 (20.36)	634.92 (6.22)	1627.50 (21.77)	357.50 (4.84)	1846.86 (25.07)	548.03 (4.64)	1717.75 (20.72)
Manure	637.38 (5.23)	140.09 (1.65)	239.32 (2.34)	151.13 (2.02)	0.00	0.00	567.27 (4.81)	137.27 (1.66)
Pesticides	57.86 (0.47)	7.81 (0.09)	16.30 (0.16)	3.55 (0.05)	0.00	0.00	50.23 (0.43)	6.80 (0.08)
Fertiliser	1476.25 (12.12)	1511.28 (17.77)	1584.69 (15.51)	1480.31 (19.80)	1540.50 (20.88)	1567.00 (21.27)	1492.97 (12.65)	1507.78 (18.19)
Hrs. of Irrigation	1114.12 (9.14)	798.49 (9.39)	739.00 (7.24)	412.19 (5.51)	305.00 (4.13)	590.29 (8.01)	1043.52 (8.84)	724.27 (8.74)
Hired machinery	1272.48 (10.44)	1039.10 (12.22)	1329.03 (13.01)	960.71 (12.85)	202.70 (2.75)	918.38 (12.47)	1257.22 (10.65)	1021.38 (12.32)
Hired Labour	1710.07 (14.04)	824.65 (9.69)	2215.60 (21.69)	2320.96 (31.05)	3789.62 (51.35)	1943.31 (26.38)	1826.72 (15.48)	1122.71 (13.55)
Family Labour (imputed cost)	5376.68 (44.13)	2452.97 (28.84)	3455.26 (33.83)	518.58 (6.94)	1184.21 (16.05)	499.97 (6.79)	5014.04 (42.49)	2050.51 (24.74)
Total Labour	7086.76 (58.17)	3277.62 (38.53)	5670.85 (55.52)	2839.56 (37.99)	4974.00 (67.40)	2443.29 (33.17)	6840.76 (57.97)	3173.22 (38.28)
Total cost (a)	12183.15 (100)	8506.44 (100)	10214.12 (100)	7474.93 (100)	7379.53 (100)	7365.81 (100)	11800.49 (100)	8288.48 (100)
Total cost (b)*	6806.39	6053.44	6758.66	6956.37	6195.73	6865.83	6786.36	6237.94

Source: Authors calculation based on sample data

Figures in parentheses (..) are respective percentage of column total

*Total cost (b) represents the cost incurred by a family after excluding the imputed cost of family labour

Looking at the component-wise cost on each input, it is observed that for SWI practice, labour is the major cost incurred, followed by fertiliser and hired machinery. For non-SWI cultivation also, labour is the major cost followed by seed and fertiliser cost (see Table 4). The percentage share of labour cost in SWI method is around 58 percent, but in the case of non-SWI method, it is only 38 percent, showing a drastic increase in labour use under SWI practice. The cost of seed is only 5 per cent for SWI method whereas for non-SWI method, it is around 21 percent, which shows that there is a

marked decline in the cost of seed due to decline in use of seed under the SWI method. This is mainly because in SWI method, one needs to sow one or two seeds per hill at 20-25 cm at proper plant to plant and row distance. But the non-SWI cultivation followed in the study area makes use of broadcasting method at the time of sowing, leading to increase in seed requirement. Table 4 also points at the increase in manure cost under the SWI method of cultivation due to the use of vermin compost. This increase in cost of labour and manure is the main reason for increase in cost of SWI method of cultivation. The cost of labour can be reduced to some extent by introducing low-cost seed drills for sowing. Also, the government can provide free or subsidize the cost of vermin compost for marginal and small farmers to reduce the cost of cultivation.

Incremental Cost and Benefit Analysis

This section presents incremental cost and returns from the adoption of SWI method. Before the final results are presented, the difference in gross returns, cost of cultivation and net returns are calculated and T test results are presented on their differences for gross returns, cost of cultivation and net returns across various categories of farm size.

Table 5: Gross Returns from SWI Method (in Rs. per acre)

Type of farmers	Gross returns from SWI (4)	Gross returns from Non-SWI (5)	Incremental gross returns (6) (4-5)
Marginal farmers	25294.56	17096.05	8198.51* (47.96)
Small farmers	25226.88	16827.45	8399.43* (49.91)
Medium farmers	25379.8	18541.31	6838.49 (36.88)
All farmers	25286.85	17098.21	8188.64* (47.89)

Source: Author's Calculation based on sample data

*Represents 1 per cent level of significance

**Represents 5 per cent level of significance

Table 5 makes a comparison of the total value of output produced under the two methods of cultivation. The value of output is calculated by multiplying the total output of wheat and the output of its by-products with the respective market prices at that time. It can be seen from Table 5 that the total value of output in the case of SWI method is higher in comparison to the non-SWI method. The incremental value of output for SWI practice was found to be Rs. 8198.51, Rs. 8399.43 and Rs. 6838.49 per acre for marginal, small and medium farmers respectively. The percentage increase in value of output from SWI practice was in the range of 37-50 per cent across different category of farmers in comparison to traditional method. The increase was highest for the small farmers followed by the marginal and medium farmers. Overall, the increase in gross returns was calculated to be 48 per cent for all farmers taken together.

To examine if the difference in the value of the output from the two methods was significant, T test was conducted. The results of the study show that the difference was significant at 1 per cent level of significance for all the farmers taken together. Across different categories of farmers, the incremental difference in value of output was found to be significant at 1 per cent level for marginal and small

farmers. The incremental difference in value of output for medium farmers was not found to be significant due to lack of enough adopters under the SWI method of cultivation.

Table 6:Cost of Cultivation for SWI Method (in Rs. per acre)

Type of farmers	Cost incurred on SWI (4)	Cost incurred on Non-SWI (5)	Incremental cost (6) (4-5)
Marginal farmers	12183.07	8506.41	3676.66* (43.22)
Small farmers	10213.92	7474.95	2738.97* (36.64)
Medium farmers	7379.94	7365.8	14.14 (0.19)
All farmers	11800.4	8288.45	3511.95* (42.37)

Source: Author's Calculation based on sample data

*Represents 1 per cent level of significance

**Represents 5 per cent level of significance

Table 6 compares the incremental cost of cultivation for SWI and non-SWI methods of cultivation. It represents the average cost incurred by a household for cultivating wheat in one acre of land using the SWI and traditional methods. It can be seen from Table 6 that the cost of cultivation is higher for SWI method in comparison to the traditional method. This is because of imputed value of family labour in the cost of cultivation. Small and marginal farmers use a substantially higher amount of labour and most of these come from within the family. As already mentioned in the previous section, this increase in cost of SWI adopters is mainly from labour and manure. The percentage change in the cost of cultivation was calculated to be 43.22 for marginal farmers, 36.64 for small farmers and only 0.19 for medium farmers. The results of the T test show that the difference is significant at 1 per cent level of significance for marginal, small and all farmers taken together, that is the cost for SWI adoption is significantly high in comparison to the traditional method of cultivating wheat.

Table 7: Net Returns from SWI Method (in Rs. per acre)

Type of farmers	Net returns from SWI (4)	Net returns from Non-SWI (5)	Incremental net returns (6) (4-5)
Marginal farmers	13111.49	8589.63	4521.86*
Small farmers	15012.95	9352.51	5660.44*
Medium farmers	17999.86	11175.51	6824.35
All farmers	13486.45	8809.76	4676.69*

Source: Authors Calculation based on sample data

*Represents 1 per cent level of significance

Table 7 shows the net returns earned from SWI and non-SWI method of cultivation. Even though the cost of cultivation for the SWI method was found to be higher in comparison to the traditional method, the net returns earned are still higher for SWI adopters. This is mainly due to higher gross returns from increase in output of wheat under the SWI method of cultivation. Not only does the SWI method lead to a 45-50 per cent increase in grain output, there is also an increase in the quantity of by-products which is also important for the households as they use it for feeding the cattle or sell it if

they don't have cattle. It can be clearly seen from Table 7 that the incremental net return from SWI method of cultivation is around Rs. 4521.86 per acre for marginal farmers, Rs.5660.44 per acre for small farmers and Rs. 6824.35 for medium farmers and Rs. 4676.69 per acre for all farmers taken together. The overall percentage change in the case of SWI method was found to be 53 percent.

Again, to examine if this increase in net returns is significant, T test was used. The results of T test show that the incremental net return was found to be significant for marginal, small and all farmers taken together at 1 per cent level of significance. Hence, it can be concluded that the SWI method of cultivation is more profitable for the farmers, especially for those farmers who have more family labour as it will increase their profit even more by decreasing the cost of cultivation as labour is one of the main costs incurred by a household in the cultivation of wheat under the SWI method.

It can be inferred from the above discussion that the cost of cultivation for SWI method is more in comparison to non-SWI method and that increase in the use of labour is the main driving force for this. Therefore, from the above analysis, it may be concluded that there are significant differences in costs and returns in wheat cultivation for those adopting SWI and those not adopting the new cultivation method. Table 8 presents the results of the incremental cost and benefit analysis from the SWI method of cultivation.

Table 8: Incremental Cost and Benefits Analysis for SWI (in Rs.)

Type of farmers	Gross returns from SWI (1)	Gross returns from Non-SWI (2)	Incremental gross returns (3) (1-2)	Cost of cultivation for SWI (4)	Cost of cultivation for Non-SWI (5)	Incremental cost (6) (4-5)	Incremental net returns (3-6)
Marginal farmers	25294.56	17096.05	8198.51* (47.96)	12183.07	8506.41	3676.66* (43.22)	4521.86* (52.64)
Small farmers	25226.88	16827.45	8399.43* (49.91)	10213.92	7474.95	2738.97* (36.64)	5660.44* (60.52)
Medium farmers	25379.8	18541.31	6838.49 (36.88)	7379.94	7365.8	14.14 (0.19)	6824.35 (61.06)
All farmers	25286.85	17098.21	8188.64* (47.89)	11800.4	8288.45	3511.95* (42.37)	4676.69* (53.08)

Source: Author's Calculation based on sample data

*Represents 1 per cent level of significance

Finally, Table 8 presents the incremental cost and benefit analysis for using the SWI method of cultivation. It may be inferred from Table 8 that there is a substantial gain from the adoption of SWI technique. The net incremental returns from SWI method increased from Rs. 4521.86 per acre to Rs. 6824.35 per acre across different categories of farmers. The overall increase in net incremental returns was Rs. 4676.69 per acre for all farmers taken together. The maximum increase in net incremental returns was on medium farm households followed by small and marginal farm households. This is mainly due to imputed cost of family labour. Appendix table A2 shows the incremental net returns when imputed cost of family labour is not included. It can be seen from Table A2 that once the imputed cost of family labour is excluded from the total cost of cultivation, the net incremental returns increases for SWI adopters. The small farmers gain the most from this as their net incremental returns are around 87 per cent followed by marginal farmers with a gain of 67 percent.

Therefore, the fact that the small and marginal farmers use more family labour and that the SWI method of cultivation is more labour intensive, reflects that potentially those farm households are likely to gain more than their medium size farm households. It appears that the households who have surplus labour do not consider the market wage rate as the opportunity cost of working on their own farm. Further, it appears that in densely populated areas, like in the study villages, the labour market dualism continues to hold that the imputed price of labour to small and marginal farmers continues to be lower than for the medium farm households. It is, therefore, not a surprise that the adoption of SWI method is more by small and marginal farm households than their large counterparts.

Summary and Conclusion

In this paper, the productivity, incremental cost and benefits from the adoption of SWI method by farm households were analysed and it was found that SWI method of cultivation is economically beneficial, especially for small and marginal farmers. The SWI method of cultivation leads to an increase in output per acre of wheat by around 49 percent. Also, the SWI method of cultivation decreases the use of inputs like seed and irrigation water by 75 per cent and 8 per cent respectively. However, there is an increase in the use of labour by 2.5 times of that used in the traditional method of cultivating wheat. It is also observed from the study that the SWI method of cultivation increase the cost of cultivation in comparison to the traditional method, especially due to increase in labour resources. The yield, cost of production, gross and net returns were observed to be higher and statistically significant under the SWI method. Even though the SWI method increased the cost of production, the net returns from SWI practice were higher due to high gross returns from increased grain output and by-product output. It was observed that once the imputed value of family labour was excluded from the cost of cultivation, the incremental gain in net returns from the adoption of SWI method was higher for marginal and small farm households. Hence, from these findings, it can be concluded that the SWI method increases productivity, incremental net gains are substantial and it is a labour-intensive technique of production, and thus more beneficial for small and marginal size farms with availability of more family labour.

Policy Recommendations

Since the SWI method of cultivation increases the output of wheat by 49 per cent, its promotion will be highly beneficial for the farmers. Also, it is observed that this technique of cultivation is more profitable for small and marginal farmers who have more family labour. Though the technique is observed to be more labour intensive, the introduction of low cost seed drills by the government will be highly beneficial as it will reduce the cost of cultivation by reducing the labour requirement at the time of sowing. Also, the government needs to organise proper training programmes for the farmers to educate them about the method and show them the benefits of using the SWI method of cultivation.

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Appendix Tables

Table A1: Comparison of Inputs Used in the Cultivation of Wheat Using SWI and Non-SWI Methods by Farm Size

Inputs	Marginal farmers						Small farmers						Medium farmers					
	Mean		Std. Dev.		Range		Mean		Std. Dev.		Range		Mean		Std. Dev.		Range	
	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI	SWI	Non-SWI
Seed (kg/acre)	15	60	2	6	13-19	47-70	16	59	2	7	14-19	51-69	16	59	4	7	13-19	51-68
Manure (kg/acre)	165	54	157	89	0-541	0-421	122	43	167	74	0-545	0-270	0	0	0	0	0	0
Fertiliser (kg/acre)	113	115	22	19	27-172	67-164	125	111	17	27	93-149	28-160	127	122	7	19	122-132	101-149
Hrs. of Irrigation (per acre)	22	24	4	0	5-41	23-27	20	24	1	0	18-22	24-25	20	24	1	0	19-21	23-24
Family labour (man days/acre)	34	14	14	7	0-57	0-27	22	3	15	5	0-41	0-27	8	3	11	5	0-16	0-13
Hired Labour (man days/acre)	14	6	12	7	0-50	0-27	19	14	16	6	0-42	0-25	31	12	6	6	26-35	1-20
Total labour	48	20	11	4	35-100	12-28	40	17	4	4	32-47	12-28	39	15	5	3	35-42	12-20

Source: Author's Calculation based on sample data

Table A2: Incremental Cost and Benefits from SWI Excluding the Imputed Cost of Family Labour (in Rs. per acre)

Type of farmers	Gross returns from SWI (1)	Gross returns from Non-SWI (2)	Incremental gross returns (3) (1-2)	Cost of cultivation of SWI (4)	Cost of cultivation of Non-SWI (5)	Incremental cost (6)(4-5)	Incremental net returns (3-6)
Marginal farmers	25294.56	17096.05	8198.51 (47.96)	6806.39	6053.44	752.95 (12.44)	7445.56 (67.43)
Small farmers	25226.88	16827.45	8399.43 (49.91)	6758.66	6956.37	-197.71 (2.84)	8597.14 (87.09)
Medium farmers	25379.8	18541.31	6838.49 (36.88)	6195.73	6865.83	-670.1 (9.76)	7508.59 (64.31)
All farmers	25286.85	17098.21	8188.64 (47.89)	6786.36	6237.94	548.42 (8.79)	7640.22 (70.35)

Source: Author's Calculation based on sample data

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