International Journal of Agriculture, Environment and Biotechnology
Citation: *IJAEB*: **15**(04): 805-811, December 2022
DOI: 10.30954/0974-1712.04.2022.3

ASSOCIATION FOR AGRICULTURE ENVIRONMENT AND BIOTECHNOLOGY

RESEARCH ARTICLE

Economic and Environmental Sustainability of Surface Seeding Technology in Wheat

H.P. Singh[1], O.P. Singh[1], P.K. Singh[1], Yash Gautam[2], Jyoti Chaudhary[3], Amit Kumar Singh[1] and Anwesha Dey[1*]

[1]Department of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India
[2]Department of Agricultural Economics, College of Agriculture, Banda University of Agriculture and Technology, Banda, India
[3]Department of Social Sciences, College of Horticulture and Forestry, Dr Y.S. Parmar University of Horticulture and Forestry, Mandi, HP, India

*Corresponding author: anweshadey1993@gmail.com (**ORCID ID:** 0000-0001-9003-2580)

Paper No. 1058 **Received:** 2-08-2022 **Revised:** 30-11-2022 **Accepted:** 06-12-2022

ABSTRACT

With the advent of green revolution technology, Rice-wheat cropping system emerged as prominent system in the Indo-Gangetic plains. Conventional agriculture based on mechanized tillage system is responsible for increased crop production but same time deteriorating natural resource base. To address the sustainability issue, conservation agriculture was evolved. Various resource conservation technologies (RCTs) were adopted by the farming community in Indo-Gangetic plains, one of which was surface seeding technology (SST). In Eastern Uttar Pradesh this technology has been economically as well as environmentally beneficial to the farmers in wheat crop. SST-adopters earned net income of ₹ 30268.18 per hectare in comparison to non-adopters (₹ 17736.31 per hectare) in the study area. Adoption of SST benefits the environment also as it reduces the carbon emission by 22.46 kg/ha. The major constraint faced by the SST-adopters was inability to use mechanical harvesting for paddy crop which increases the cost of cultivation. The major issue that obstructs the non-adopters from adopting the technology was unsuitability of the soil type. Thus, SST proves to be an economic boon that maintains the sustainability.

HIGHLIGHTS

- The adopters of surface seeding technology earn ₹ 12531.87 more profit than non-adopters of the same.
- SST benefits the environment by reducing the carbon emission by 22.46 kg/ha.
- Resource use efficiency depicts that expenditure on seed is significant for both adopters and non-adopters.
- Adoption of the technology is majorly hindered by the farmers' inability to use mechanical harvesting in paddy crop (*kharif* crop).

Keywords: Surface seeding technique, wheat, conservation agriculture, Mirzapur, carbon emission

The global population is estimated to rise to 9.7 billion by 2050 (United Nations, 2019; Dey *et al.* 2022) to meet the growing exigency enhanced and sustainable agricultural food systems are a necessity. The use of conventional tillage no doubt has amplified the production levels but had very drastic effects on the natural resource base causing problems such as soil erosion, surface and underground water pollution (Chatterjee *et al.* 2020), climate change, water scarcity, decrease in soil organic matter and land degradation (Singh *et al.* 2013; Mandal *et al.* 2020; Rani *et al.* 2021) raising the concerns of the agriculture community to find an alternative path. Now-a-days, conservation

How to cite this article: Singh, H.P., Singh, O.P., Singh, P.K., Gautam, Y., Chaudhary, J., Singh, A.K. and Dey, A. (2022). Economic and Environmental Sustainability of Surface Seeding Technology in Wheat. *Int. J. Ag. Env. Biotech.*, **15**(04): 805-811.

Source of Support: None; **Conflict of Interest:** None

agriculture has emerged as the solution to the problems caused by conventional tillage system as it is majorly based on three basic principles of minimum tillage and soil disturbance; conservation of permanent soil covers with crop residues and live mulches; and by practicing crop rotation and intercropping (FAO, 2016). Another benefit that the conservation system has over the traditional system it protects the environment by causing minimum loss to the natural resource base; it prevents soil erosion, enhances quality of air and water, improves carbon sequestration, in long term it also aids in reduction of greenhouse effect and enriches our biodiversity. Conservation agriculture has the potential to provide food security, improve crop productivity, amplify farmer's income and protect the environment at the same time (Verhulst *et al.* 2010).

In India, conservation agriculture system is particularly practiced in the rice-wheat cropping system of the Indo-Gangetic region (Kumar *et al.* 2017). The resource conservation technologies (RCTs) promoted in Indo-Gangetic Plains are zero tillage, laser land levelling, bed planting, surface seeding, rotary tillage, use of leaf colour chart, mechanical rice transplanter etc. (Singh, 2011). Of them the resource conservation technology that is quite prevalent in wheat crop in this region is surface seeding technology. Under this practice the seeds of *rabi* cereal crops are broadcasted just before or after the standing *kharif* crop is harvested, this method is possible because of the wet soil surface which promotes the germination of *rabi* crop. Thus, this method is a boon for regions having moist, fine-textured, and poorly drained soils where tilling before planting is difficult. For resource poor marginal and small farmers this technology is a blessing as it saves machinery cost due to reduction in expenditure on land preparation, easily practiced on any size of field, advances sowing time, better grain quality and increases in cropping intensity where only paddy-wheat cropping system is followed.

Wheat is the second most consumed cereal as well as third most produced crop across the globe (World Economic Forum, 2022). India is the second largest wheat producing nation (PIB, 2022). Among the major wheat producing states Uttar Pradesh ranks first. In a developing nation like India where promotion of rapid economic development and rise in income among the poor population leads to increase the demand for wheat thus, rising the need for sustainable expansion of production. Keeping in view the above facts, this paper tends to focus on analysing how surface seeding technology is beneficial to adopters by having a comparison with the conventional tillage practiced by non-adopters.

METHODOLOGY

In Eastern U.P., Mirzapur district was selected purposively because SST has been adopted in Jamalpur block. For the comparison purpose Narayanpur block was selected where this technology (SST) has not been adopted which is adjacent to Jamalpur block. A list of adopting villages in Jamalpur block and non-adopting villages of Narayanpur block was prepared and four villages from each block were selected randomly. A list of farmers was prepared from each randomly selected village and 24 farmers from each village were selected randomly. Thus, 96 SST adopters and 96 non-adopters were selected. Primary data was collected through a pre-tested schedule.

Cost of Cultivation

Total cost was calculated by adding the variable and fixed costs. The variable costs consist of wages of human labour, charges of implements and machinery, costs incurred on seed, fertilizers and plant protection chemicals and irrigation charges, and interest on working capital. The fixed costs consist of rental value of owned land, land revenue, depreciation on farm equipments, farm buildings and interest on fixed capital assets excluding land.

Gross return

Gross return is the sum of the returns obtained from main product and by-product. The return is calculated by multiplying the quantity of produce with the market price of the same. Net return is the amount of money the producer receives from an investment after deducting all costs from gross return.

Resource Use Efficiency

Resource use efficiency for wheat production is examined by using Cobb Douglas production function. The function is as follows:

$$Y = aX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4}$$

Where,

Y = Income from yield (₹)

X_1 = Expenditure on seed (₹)

X_2 = Expenditure on fertilizers (₹)

X_3 = Expenditure on human labour (₹)

X_4 = Expenditure on plant protection chemicals (₹)

Statistical significance of estimates

To test statistical significance t-test was used. The t- value of regression coefficient (b_i) was worked out at (n–k) degree of freedom;

$$t = \frac{b_i}{S.E.(b_i)}$$

Where,

S.E. = Standard error

b_i = Regression coefficient

Environmental Benefit

The environmental benefit of adopting surface seeding technology was measured in terms of reduction in carbon emission. To find out the carbon emission following methodology was used:

1 litre diesel = 2.6 kg of CO_2 (Jat *et al*. 2006)

1 kg CO_2 = 0.27 kg of carbon (Paustian *et al*. 2006)

Garett's ranking

Garett's ranking technique was used to rank the constraints associated with the production of wheat by SST in Mirzapur area (Garett, 1969). In this method, respondents were asked to rank the particular problems encountered by them according to their perception. The assigned rank was transformed into a percentage position which was subsequently transferred into Garett score using Garrett's table (Rao *et al.* 2019).

$$\text{Percentage position} = \frac{100\left(R_{ij} - 0.5\right)}{N_j}$$

where,

R_{ij} = Rank given for the i^{th} item by the j^{th} respondent

N_j = Number of items ranked by the j^{th} respondent

RESULTS AND DISCUSSION

Socio-economic profile of respondents

Socio-economic status of the respondents in the study area for both adopters and non-adopters is represented in Table 1. It is clearly evident from the table that on an average the social status of the farmers/respondents were almost similar for both the categories which symbolises the uniformity of the respondents under both the categories. Average age of farmers was 54 years educated up to secondary level and agriculture being the

Table 1: Summary statistics for socio-economic status for sample households

Particulars	Units	SST Adopters (n = 96)		SST Non-adopters (n = 96)	
		Mean	SD	Mean	SD
Farmer's Age	Years	53.65	14.05	54.40	12.83
Education	Code	4.25	1.44	4.61	1.44
Occupation	Code	2.00	1.21	2.23	1.26
Family size	Number	7.01	3.63	7.28	2.96
Farming experience	Years	29.63	14.61	29.09	14.5
Operational landholding size	Hectare	1.52	1.65	1.49	2.01
Farm Income	INR/annum	257139.60	571519.30	195016.70	254440.70
Non-Farm Income	INR/annum	218031.30	243499.20	291304.70	344780.50
Consumption expenditure	INR/annum	185656.30	102024.10	192614.60	131794.70

SD = Standard Deviation.

Note: Code for Education: 1- Illiterate, 2- Upto Primary school, 3- Upto Middle School, 4- Secondary/10th, 5- Higher Secondary/12th, and 6- Graduation and above Code for occupation: 1- Agriculture + dairy, 2- agriculture, 3- Agriculture + service, and 4- Agriculture + business.

Table 2: Frequency of respondents based on landholding size

	Marginal farmers (< 1 ha)	Small farmers (1-2 ha)	Semi-Medium farmers (2-4 ha)	Medium farmers (4-10 ha)	Large farmers (> 10 ha)	Total
Adopters	58 (60)	15 (16)	17 (18)	6 (6)	0	96 (100)
Non-adopters	63 (66)	15 (16)	10 (10)	5 (5)	1 (1)	

Note: *Figures in parenthesis represents the percentage.*

major source of income. The average operational landholding size was about 1.5 hectare. Despite being similar in their social status the farmers of both categories vary in their economic status with major variation in their average farm income as well as non-farm income. The frequency of farmers categorised on basis of landholding size is tabulated in Table 2. In both categories majority of respondents were marginal farmers.

Economics of wheat cultivation in case of SST adopters and non-adopters technology

Farmers using surface seeding technology save the cost incurred on land preparation because the seeds were broadcasted in standing *kharif* crop before harvesting of paddy.

Table 3: Cost of wheat cultivation incurred by SST adopters and non-adopters (₹/Ha)

Particulars	Adopters	Non-adopters
(A) Operational Cost (in ₹)		
1. Land preparation	0.00	5048.50
2. Sowing	311.27	300.00
3. Fertilizer application	775.80	805.54
4. Plant protection*	1045.18	0.00
5. Irrigation	1834.00	1910.29
6. Harvesting	2850.66	3115.57
7. Threshing	7331.31	6694.32
Total operational cost	**14148.22**	**17874.22**
(B) Material cost (in ₹)		
1. Seed	7333.72	7253.24
2. Fertilizers (Total)	5311.51	5102.26
a. Urea	1433.59	1480.76
b. DAP	3398.83	3252.03
c. Zinc	479.0872	369.47
3. Irrigation charges	150.00	150.00
Total material cost	**12795.23**	**12505.5**
(C) Other costs		
1. Interest on working capital @3%	808.30	911.39
2. Depreciation	225.00	225.00
3. Land revenue	87.50	87.50
4. Rental value of owned land	9000.00	9000.00
5. Interest on fixed capital @10%	641.00	641.00
Total costs (₹) (A+B+C)	**37705.25**	**41244.61**

Table 3 represents the comparative cost of wheat cultivation by SST adopters and non-adopters. SST adopters in comparison to non-adopters encounter an additional cost on plant protection chemicals because of high weed incidence problem. Per hectare total cost accounted by adopters (₹ 37705.25) was less than that of non-adopters (₹ 41244.61). For better germination higher seed rate was applied by adopters which adds to the higher material cost.

The average yield of main product harvested by SST adopters was 30.35 quintals while it was only 26.95 quintals for the non-adopters, even the by-product harvested by adopters was slightly higher than non-adopters. Higher yield directly resulted into higher returns evident from Table 4, where the gross return earned by adopters was higher by ₹ 8992.51 as compared to non-adopters. Thus, low cost and high returns was experienced by adopters as per hectare net income earned by adopters was ₹ 30268.18, whereas that earned by non-adopters was ₹ 17736.31. The difference in net income of both categories definitely shows that surface seeding technology is an economically beneficial technology.

Table 4: Return from wheat cultivation by SST adopters and non-adopters

Particulars	Adopters	Non-adopters
Main product produced (Qt./ha)	30.35	26.95
By-product produced (Qt./ha)	20.26	18.07
Return from main product (₹/ha)	59933.45	53223.88
Return from by-product (₹/ha)	8039.985	5757.034
Gross returns (₹/ha)	67973.43	58980.92
Net return/Net income (₹/ha)	30268.18	17736.31

Resource Use Efficiency

Resource use efficiency was analysed and results are presented in Table 5 and 6 for adopter and non-adopter category, respectively. For the regression analysis in case of adopters gross return was considered as dependent variable and expenditure on seed, fertilizers, human labour and plant protection chemicals as independent variables. In case of non-adopter, expenditure on plant protection chemicals variable was not considered because unlike in adopters' case the weed incidence or pest incidence was very low enabling farmers to avoid usage of protection chemicals. For both the categories, adopters as well as non-adopters high value of coefficient of multiple determination (R^2) indicates that the fitted function seems to be a good fit; the value of R^2 indicates that in adopters 89 percent and in non-adopters 98 percent of the variation in dependent variable (i.e. gross return) was explained by the independent variables under study. In case of adopters, regression coefficients of expenditure on seed, fertilizer and human labour were found significant. The coefficient of expenditure on plant protection chemicals shows a negative value but not significant. In non-adopters, all the regression coefficients were found significant. Positive values of all coefficients state that increase in these inputs would increase the gross income.

Table 5: Regression coefficient in SST adopters in wheat

Variables	Coefficients	Standard Error	R^2
Expenditure on seed	0.449*	0.224	0.889
Expenditure on fertilizers	0.259*	0.118	
Expenditure on human labour	0.240*	0.112	
Expenditure on plant protection chemicals	-0.001	0.06	

**Significant at 5 percent level of probability .*

Table 6: Regression coefficient in SST non-adopters in wheat

Variables	Coefficients	Standard Error	R^2
Expenditure on seed	0.252**	0.072	0.979
Expenditure on fertilizers	0.404**	0.087	
Expenditure on human labour	0.339**	0.095	

***Significant at 1 percent level of probability.*

Environmental Benefit of Surface Seeding Technology

Surface seeding technology not only economically benefits the farmers but also protects the environment by reducing the carbon emission. Table 7 represents the environmental benefit of the technology. As the technology doesn't involve land preparation (ploughing and planking), it reduces diesel consumption. The reduction in diesel consumption in land preparation and sowing of wheat crop was 32 litres per ha and carbon emission reduced by 22.46 kg/ha. It is evident from the table that there is zero carbon emission in this technology making it an environment friendly technology to preserve the natural resource base.

Table 7: Environmental benefit of SST in wheat

Particulars	Wheat	
	Adopter	Non-adopter
Diesel consumption (lt/ha)	0	32
CO_2 emission (g/ha)	0	83.2
Carbon emission (Kg/ha)	0	22.46
Reduction in carbon emission (Kg/ha)	22.46	

Constraints in adoption of Surface Seeding Technology

The major constraint faced by the adopters was mechanical harvesting which can't be practiced in paddy crop and farmers were forced to do manual harvesting of the crop which directly increases the cost of harvesting of paddy crop as more labours were employed for manual harvesting. The labour availability is a problem in the study area. The prime constraint faced by the non-adopters was that the soil of the area is not suitable for adoption of the technology. The other problems that caused obstruction for farmers from adopting the technology were uncertainty of irrigation, low seed germination, lack of knowledge regarding the technology, lack of labour for manual paddy harvesting etc.

Table 8: Constraints faced by adopters

Constraints	Garrett Score	Ranking
Can't use mechanical harvesting for paddy	82.45	1
High cost of harvesting paddy (manually)	54.6	2
High wheat seed rate	46.3	3
Less seed germination	43.85	4
Others	32.8	5

Table 9: Constraints faced by non-adopters in adopting SST

Constraints	Garrett Score	Ranking
Soil type not suitable	65.29	1
Uncertainty of irrigation	64.74	2
Low seed germination	50.85	3
Lack of proper knowledge about SST	49.6	4
Less labour available for paddy harvesting	45.01	5
High cost of paddy harvesting	43.28	6
Others	26.34	7
Not sure of profits	40.25	8
Others	26.34	9

SUMMARY AND CONCLUSION

Surface seeding technology is one of the prominent Resource Conservation Technology, popular in Eastern Uttar Pradesh. From the study it was observed that surface seeding technology aided the increase in farmer's income by reducing the cost of inputs as well as by enhancing the wheat productivity. Higher net income was earned by the adopters in comparison to non-adopters of SST. From environment point of view, the technology has a positive impact as it helps to reduce the carbon emission which indeed saves fuel cost as well as protects the environment. The study states that SST is an economically beneficial as well as eco-friendly technology. The major constraint that needs to be addressed for better adoption of the technology is inability to use mechanical harvesting in paddy crop which increases the time as well as cost because farmers have to employ manual labours for the same. The major hindrance in adoption of SST by non-adopters was unsuitability of soil type.

ACKNOWLEDGEMENTS

Authors are thankful to Indian Council of Social Science Research (ICSSR), New Delhi for providing research grant to carryout research project on "Economic and Environmental Impact of Surface Seeding Technology (SST) in Wheat in Eastern Uttar Pradesh, India".

REFERENCES

Barmon, B.K. and Islam, M. 2017. Resource Use Efficiency and Factors Affecting Land Allocation for Wheat (*Triticum aestivum* L.) Production in Bangladesh. *The Agriculturists*, **15**(1): 28-39.

Chatterjee, S., Chakraborty, R. and Banerjee, H. 2020. Economic impact assessment of conservation agriculture on small and marginal farm households in eastern India. *Agril. Econ. Res. Rev.*, **33:** (347-2021-802).

Dey, A., Patel, S. and Singh, H.P. 2022. An Approach to Understand Conservation Agriculture. *Sustainable Agriculture Systems and Technologies*, pp. 201-223.

FAO 2016. Raised beds for improving crop water productivity and water efficiency in irrigated dryland agriculture, Egypt. http://www.fao.org/family-farming/detail/en/c/1040392/

Jat, M.L., Sharma, S.K. and Singh, K.K. 2006. Conservation agriculture for sustainable farming in India. *Winter School Training at Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, January*, **21**: 2006.

Kumar, A., Singh, R., Singh, S., Sendhil, R., Chand, R. and Pandey, J.K. 2017. Impact of resource conservation technologies in Haryana. *J. Community Mobilization and Sustainable Develop.*, **12**(2): 257-264.

Mandal, V.P., Rehman, S., Ahmed, R. *et al.* 2020. Land suitability assessment for optimal cropping sequences in Katihar district of Bihar, India using GIS and AHP. *Spatial Information Resear.*, **28**(5): 589–599.

Paustian, K., Antle, J.M., Sheehan, J. and Paul, E.A. 2006. Agriculture's role in greenhouse gas mitigation. *Food and Agriculture Organization*. https://agris.fao.org/agris-search/search.do?recordID=GB2013203398

Press Information Bureau, Government of India 2022, March 19. *Amidst a record surge in wheat exports in the current fiscal, APEDA organizes meet for boosting India's wheat exports*. https://www.pib.gov.in/PressReleseDetailm.aspx?PRID=1807305

Rani, M., Joshi, H., Kumar, K. *et al*. 2021. Climate change scenario of hydro-chemical analysis and mapping spatio-temporal changes in water chemistry of water springs in Kumaun Himalaya. *Environ., Development and Sustainability*, **23**: 4659–4674.

Singh, N.P., Singh, R.P., Kumar, R., Vashist, A.K., Khan, F., and Varghese, N. 2011. Adoption of resource conservation technologies in Indo-Gangetic Plains of India: scouting for profitability and efficiency. *Agricul. Econ. Res. Rev.*, **24**(1): 15-24.

Singh, K., Kumar, P. and Singh, B.K. 2013. An associative relational impact of water quality on crop yield: a comprehensive index analysis using LISS-III sensor. *IEEE Sensors J.*, **13**(12): 4912–4917.

Singh, O.P. 2016. Economic and Environmental Benefit of Zero-Tillage in Chandauli District of Uttar Pradesh, India. *Int. J. Innov. Res. and Adv. Stud.*, **3**(11): 97-101.

Singh, S.K., Patra, A., Chand, R., Jatav, H.S., Luo, Y., Rajput, V.D. ... and Adil, M.F. 2022. Surface seeding of wheat: A sustainable way towards climate resilience agriculture. *Sustainability*, **14**(12): 7460.

United Nations 2019. Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100. United Nations News.

Verhulst, N., Govaerts, B., Verachtert, E., Castellanos-Navarrete, A., Mezzalama, M., Wall, P., ... and Sayre, K. D. 2010. Conservation agriculture, improving soil quality for sustainable production systems. *Advances in soil science: Food security and soil quality. CRC Press, Boca Raton, FL, USA*, pp. 137-208.

World Economic Forum 2022, August 4. *These are the top 10 countries that produce the most wheat.* https://www.weforum.org/agenda/2022/08/top-10-countries-produce-most-wheat/