

Enhancing Agricultural Practices: Exploring the Benefits of Paddy Straw Management Technologies Adopted by Potato Growers in Jalandhar District, Punjab, India

ABSTRACT

This study was conducted in the Jalandhar district of Punjab in 2020-21, chosen purposefully due to its status as the region with the highest potato cultivation area. The list of potato growers was obtained from the District Horticulture Department in Jalandhar. Five blocks—Nakodar, Adampur, Bhogpur, Jalandhar East, and Jalandhar West—with the maximum potato cultivation area were selected from this list. A sample of 200 potato growers was then chosen using a proportionate cum random sampling method. Following the adoption of paddy straw management technologies, 52.5 % of potato growers reported a decrease in fertilization costs whereas 85 % of potato growers observed that increased in the cost of preparation of land during used of paddy straw management technologies by Rs. 3035 because of high rate of diesel consumption. Additionally, 37 % observed an improvement in soil health, while 40.5% noted an increase in potato yield. The majority of potato growers incorporated paddy straw into their potato fields. However, an equal percentage of growers (17%) either used paddy straw to make bales or burned it. Notably, the adoption of paddy straw chopper, mulcher, and mould board plough by potato growers led to a significant increase in potato yield. The results also indicated that for yield, the *t*-values for two tailed significance level of the difference between sample means for the response was 0.000 cost of production due to adoption of all the technologies by the potato growers. Therefore, statistically significant differences at level of 0.05 were observed in all five technologies used for paddy straw management in potato cultivation

Keywords: Benefits, Paddy Straw, Potato, soil health.

1. INTRODUCTION

“Potato (*Solanum tuberosum*) is a major vegetable crop which has 2.14 million hectares in India. Throughout the world, potato follows only rice and wheat as a food crop for human consumption. Cultivated potatoes have spread to 160 countries worldwide from the Andes of South America where they originated. When potato has become a staple in a rising number of people's diet, minor variations in potato nutritional composition can have significant impact on human health. It is a strong source of vitamin C, other vitamins and potassium. Many potato compounds contribute to antioxidant function, and growing interest in pigmented flesh cultivars” (Ellen et al., 2009). Paddy straw management is a key issue to paddy farming in northwestern India (Punjab, Haryana, and Uttar Pradesh). Paddy straw is used as animal bedding and for the production of biogas, fodder, power and compost in states such as West Bengal, Gujarat, Maharashtra, Assam, Bihar, Tamil Nadu, and Jammu & Kashmir (Lohan et al., 2018).

“In particular, the open burning of agricultural residues to clear cultivated fields of harvest by-

products is widely practiced in many developing countries in Africa, South Asia, and Southeast Asia. Deliberate open burning of crop residues is a major contributing factor to local and transboundary haze and air pollution” (Choudhary et al., 2024). “The impacts of open burning vary from region to region, depending on crop types, burning conditions, and seasons”(Elahi et al.,2024). “More than five billion metric tons of agricultural residues are produced annually worldwide. Despite having multiple uses and significant potential to augment crop and livestock production, a large share of crop residues is burned, especially in Asian countries. This unsustainable practice causes tremendous air pollution and health hazards while restricting soil nutrient recycling” (Krishna and Mkondiwa 2023).

In Punjab, cereal crops account for three-quarters of total residue output. According to research, 30-70 % of paddy residue is burned on fields (Lohan et al., 2018). “On a local, regional, and global scale, burning agricultural biomass pollutes land, air, and water. The heat generated by the burning of straw enters the soil, causing moisture loss and the death of beneficial bacteria. The loss of 5.5 kg, 2.3 kg, 25 kg, 1.2 kg nitrogen, phosphorus, potassium, and Sulphur, as well as organic carbon, is thought to occur when a tonne of stubble is ignited” (Gupta et al., 2004).

“The total stubble burnt on the Punjab region as of 15 May 2005 was found to be about 4,315.35 km². Among these, Amritsar had 673.99 km² of burnt area followed by Jalandhar, Ludhiana, Ferozpur and Patiala districts while Roopnagar had the least burnt area (41.36 km²)” (Ramesh et al.,2016). “According to reports, 51% of farmers burn paddy straw to save money, 48% for time savings and 48% for lack of machine availability, while 11% of farmers burn paddy straw for other reasons” (Sidhu and Beri 2009). Punjab's farmers have burned 13 % less crop residue this year compared to the paddy season last year (Sept to Nov), while Haryana and UP have burned 16 % and 23 % more paddy straw this year for the same period (Rai 2019). “Approximately 20 million tons of paddy straw was produced in Punjab alone which was not relished by animals because of high silica content, due to which 80 % of paddy straw was burnt on the fields for its management. It was considered as useful method for the management of paddy straw from the perspective of farmers. But with the burning of paddy straw on the fields, harmful gases were emitted which was one of the reasons for the environmental pollution. In addition to human and animal health hazards due to air pollution, it causes loss of vital components such as Nitrogen, Phosphorus, Sulphur and Potassium from the top soil layer, making the land less fertile and unviable for agriculture in the long run” (Kaur et al., 2021). “There has been a lack of significant practical effort to measure the economic effects (such as increased yields and resource depletion and conservation levels). Such a lack of knowledge is perhaps the key reason, the farmers for poor adoption of the technologies, seriously threaten the sustainability of natural resources and economic viability of farming”(Singh et al 2010). The industrial uses of crop residues such as biochar and biofuel production have the potential to augment farm income and cement inter-sectoral complementarities (Satpathy and Pradhan 2023), but an economically more relevant option is the use of residue as soil mulch.

To solve the problem of burning, there were various alternative ways to manage paddy straw which were eco-friendly and also manages paddy straw at proper time without delaying in sowing

operation of potato crop. Punjab Agricultural University recommended some alternate techniques such as Baler, Mulcher, Paddy straw chopper, Rotavator, Mould board plough. So it is crucial to study the economic and environmental benefits of paddy straw management technology in sixth largest Potato producing state in India *i.e.* Punjab. This study provides a significant impact in the scientific community since it delivers valuable information which contributes to attain agricultural sustainability. It also highlights the benefits of incorporating paddy straw waste utilization and potato cultivation, likewise this practice addresses the negative environmental effect of paddy straw burning and improves the soil health and increases potato crop productivity. This research can be a stepping stone and serve as a guide for farmers, agricultural scientists, and policy makers to adopt and promote an ecological friendly practice for the attainment of sustainable agriculture.

2. Material and methods

2.1 Study Area

The present study was conducted in Jalandhar district of Punjab. This district was selected purposively for the study as it has highest area (20438 ha) under potato cultivation.

2.2 Sampling and data collection

List of potato growers was obtained from the District Horticulture Department, Jalandhar. From that list five blocks Nakodar, Adampur, Bhogpur, Jalandhar East and Jalandhar West having maximum area under Potato cultivation were selected. From these five blocks a sample of 200 potato growers were selected by proportionate cum random sampling method.

2.3 Economic benefits

Benefit can be defined as something that produces good or helpful results or effects for paddy straw management in potato. Benefits can be classified in environmental and economic benefits. Paired t-test was used to find out whether the differences in cost of production and yield of potato due to adoption of paddy straw management technologies were significant at 5 % level. Satisfaction of sequence of technology obtained by dichotomous scale yes/no in terms of cost, performance, yield and quality. Expenditure was operationalized in term of total amount in Rs./acre spent on inputs after adoption of paddy straw management technologies in potato as compared to burning.

2.4 Environment benefits

Environment benefits were referred as less air pollution, more fertile soil and more survival of beneficial insects. For changes in soil and microclimate, the responses were obtained through open ended. Data collection was done personally by interviewing the respondents by visiting the study area and data analyzed with appropriate statistical tools. Frequency and percentage were used for analysis of data in environment benefits

3 Results and Discussion

3.1 Satisfaction of sequence of technology on the basis of cost, performance, yield and quality

SEQUENCE I

Table 1 revealed that the potato growers who were adopted sequence I as PAU super straw management system, paddy straw chopper, mould board plough and rotavator, 70.8 % potato growers satisfied in term of cost. All the potato growers were satisfied in term of the performance, yield and quality of produce with sequence 1 as this sequence is recommended by Punjab Agricultural University, Ludhiana.

SEQUENCE II

141 potato growers who were adopted sequence II with mulcher from managing paddy straw, 67.37 % of potato growers were satisfied with the cost of the sequence of technology and 97.87, 100, % of potato growers were satisfied in term of performance, yield respectively and on the basis of quality of produce 99.92 % of potato growers were satisfied. This sequence is recommended by Punjab Agricultural University.

SEQUENCE III

Thirty four potato growers who were adopted sequence III as combine harvester, stubble shaver, rake, baler, 70.58, 58.82, % of potato growers were satisfied in term of cost, performance respectively and 52.94 % were satisfied with the yield of potato, 88.23 % of potato growers were satisfied with the quality of produce respectively. This sequence is recommended by Punjab Agricultural University.

SEQUENCE IV

Thirty four potato growers who were adopted sequence IV as PAU super straw management system, stubble shaver, burning and rotavator, 38.23 % of potato growers were satisfied with cost, 35.29 % of potato growers were satisfied with performance 32.35 % of potato growers were satisfied with yield and quality of produce respectively. This sequence is not recommended by Punjab Agricultural University.

Table 1: Distribution of potato growers according to the satisfaction of sequence of technology on the basis of cost, performance, yield and quality

| S. no | Sequence | n | Satisfaction f*(%) | | | |
|------------------------|---|-----|--------------------|----------------|--------------|----------------|
| | | | Cost | Performance | Yield | Quality |
| PAU RECOMMENDED | | | | | | |
| 1 | PAU Super Straw Management System+ Paddy straw chopper + Mould Board plough + Rotavator | 24 | 17 (70.8) | 24 (100) | 24 (100) | 24 (100) |
| 2 | PAU super straw management system+ Mulcher + Mould board Plough + Rotavator | 141 | 95 (67.37) | 138 (97.87) | 141 (100) | 140 (99.92) |

| | | | | | | |
|------------------------|--|----|---------|---------|---------|---------|
| 3 | Combine harvester + Stubble shaver + Rake +Baler | 34 | 24 | 20 | 18 | 30 |
| | | | (70.58) | (58.82) | (52.94) | (88.23) |
| NON RECOMMENDED | | | | | | |
| 1 | PAU Super Straw Management System + stubble shaver + Burning + Rotavator | 34 | 13 | 12 | 11 | 11 |
| | | | (38.23) | (35.29) | (32.35) | (32.35) |

(*Multiple Response)

3.2 Change in cost of production and yield of potato after the adoption of paddy straw management technologies by Potato growers.

The result as shown in Table 2 indicated that the t-values for the two tailed significance levels of difference between sample means for the response was 0.000 cost of production due to adoption of all the technologies by the potato growers. It showed that after the adoption of paddy straw management technologies by potato growers results in significantly increased in the cost of production. The results also indicated that for yield, the t - values for two tailed significance level of the difference between sample means for the response was 0.015 for baler, 0.327 for Rotavator and 0.000 for Paddy straw chopper, Mulcher, Mould board plough. The result shown that there was a significant increase in yield of potato after the adoption of paddy straw chopper, mulcher and mould board plough by potato growers. Thus, there were statistically significant differences observed in all five technologies used for paddy strawmanagement in potato.

Table 2: Paired t-test on change in cost of production and yield of potato after the adoption of paddy straw management technologies by Potato growers.

| Paddy managing technology | straw | n* | Cost of production (Rs./ha) | | | | Yield (t/ha) | | | | | |
|---------------------------------|--------------|-----|-----------------------------|------------|--------|-----------------------|--------------|------------|--------|-----------------------|-------|-------|
| | | | Mean | Difference | t-test | Sig (2- tailed) | Mean | Difference | t-test | Sig (2- tailed) | | |
| Baler | | 34 | Before | 2.102 | 1.502 | 8.736 | .000 | Before | 5.023 | 3.683 | 2.565 | .015 |
| | | | After | 3.605 | | | | After | 8.707 | | | |
| Paddy chopper | Straw | 24 | Before | 1.126 | | 5.119 | .000 | Before | 1.068 | 1.583 | 6.612 | .000* |
| | | | After | 1.967 | 8.408 | | | After | 1.084 | | | |
| Mulcher | | 137 | Before | 6.359 | | 14.628 | .000 | Before | 1.060 | 1.005 | 6.019 | .000* |
| | | | After | 1.137 | 5.015 | | | After | 1.070 | | | |
| Rotavator | | 195 | Before | 1.00 | | 9.149 | .000 | Before | 1.083 | .074 | 1.000 | .327 |
| | | | After | 1.622 | 6.22 | | | After | 1.184 | | | |
| Mould board plough | | 163 | Before | 1.002 | | 9.914 | .000 | Before | 6.228 | 5.093 | 7.323 | .000* |
| | | | After | 2.070 | 1.068 | | | After | 1.135 | | | |

*Number of potato growers adopted particular technology

3.3 Change in expenditure on inputs used in Paddy straw management technologies in potato cultivation

Data in table 3 showed that the changed in expenditure used on inputs used in paddystraw management technologies in potato cultivation. 85 % of potato growers observed that increased in the cost of preparation of land during used of paddy straw management technologies by Rs. 3035 because of high rate of diesel consumption. 52.5 % of potato growers reported that there was decreased in the cost of fertilization by Rs. 1915. The dose of fertilizer after adoption of paddy straw management technologies was observed to decreased by one or two bags of DAP. Only 7 % of potato growers observed that there was decreased in number of irrigation by 1 unit. There was observed that there was no change in seed rate and pesticide application after adoption of paddy straw management technologies. Only 7.5 % of potato growers observed that there was increased in cost of herbicides by Rs. 183.

Table 3: Distribution of potato growers on the basis of change in expenditure on inputs used in Paddy straw management technologies in Potato cultivation

| S. no | Practices | n | Change in expenditure |
|-------|----------------------|-----|-----------------------|
| 1 | Land preparation | 170 | +3035 Rs. |
| 2 | Fertilization | 105 | -1915 Rs |
| 3 | Number of Irrigation | 14 | -1 (unit) |
| 4 | Seed rate | 0 | 0 |
| 5 | Herbicides | 15 | +183.3 Rs |
| 6 | Pesticides | 0 | 0 |

(n= Number of potato growers who observed change in their expenditure w.r.t. different practices)

3.4 Uses of paddy straw

Data in table 4 showed that the use of paddy straw taken by the potato growers. 75 % potato growers did the incorporation of paddy straw into the field of potato whereas equal percent of potato growers such as 17 % used paddy straw as making bales and burned the paddy straw. 6 %and 4% of potato growers used paddy straw as storage and packaging material. 3.5 % reveals that tribal people of that area picked the paddy straw from the field. 5 % of potato growers made Paralichar of paddy straw in the field. **The findings were contradicted with Kaur (2020) that 22.96 % are aware about biogas plant.**

Table 4: Distribution of potato growers on the basis of uses of paddy straw

n=200

| Sr. | Uses | f* (%) |
|-----|------|--------|
|-----|------|--------|

| | | |
|---|-------------------------|---------|
| 1 | Incorporation | 150(75) |
| 2 | Paralichar | 10(5) |
| 3 | Giving to tribal people | 7(3.5) |
| 4 | Burning | 34(17) |
| 5 | Bales | 34(17) |
| 6 | Storage | 12(6) |
| 7 | Packaging | 8(4) |

(*Multiple Response)

3.5 Changes in soil and microclimate observed after using paddy straw management technologies in potato cultivation

Table 5 showed that the changes that were observed by the potato growers in their soil and microclimate after using paddy straw management technologies in potato. The change in soil such as soil become fertile observed 37 percent potato growers. Only 5.5 % respondents found that the soil become leveled after using these technologies and decrease in air pollution after the adoption of paddy straw management technologies in the potato field observed by 26.5 % potato growers. With non-burning of paddy straw in the potato field, the 6 percent potato growers observed that the beneficial insects which are important for the soil are survived in large amount as compared to burning of paddy straw. Eight percent potato growers observed that after using paddy straw management technologies in the potato field, there was decrease in number of irrigation in succeeding crop. **These findings are in accordance to Singh (2020).**

Table 5: Distribution of potato growers according to changes in soil and microclimate observed after using paddy straw management technologies in potato cultivation

n=200

| S. no | Changes | f* | Percentage |
|-------|---------------------------|----|------------|
| 1 | More fertile soil | 74 | 37 |
| 2 | Leveled land | 11 | 5.5 |
| 3 | Decrease in air pollution | 53 | 26.5 |

| | | | |
|---|--|----|------|
| 4 | Lesser number of irrigation in succeeding crop | 16 | 8 |
| 5 | Increased potato yield | 81 | 40.5 |
| 6 | Increased in population of beneficial insects | 12 | 6 |

(*Multiple Response)

4 Conclusion

Based on study, 200 potato growers of Jalandhar district of Punjab. It can be concluded that 52.5 % of the potato growers reported there was decrease in the cost of fertilization after adoption of paddy straw management in potato. Nearly one third of the potato growers observed that there was improvement in soil health and 40.5 % of potato growers observed in increased in potato yield. Majority of the potato growers did the incorporation of paddy straw in the field. There was a significant increase in yield of potato after the adoption of paddy straw chopper, mulcher and mould board plough by potato growers. Thus, there were statistically significant differences observed in all five technologies used for paddy straw management in potato.

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AUTHOR'S CONTRIBUTION

Akshdeep Kaur performed the study, statistical analysis and wrote the draft of the manuscript, Dr. Kuldeep Singh designed the study, Dr. Lavleesh Grag managed the analyses of the study and Sunil Kumar helped in data collection and managed the literature searches.

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