Research Article

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Impact of integrating summer vegetables with major cropping systems for profitability and sustainability

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ABSTRACT

Punjab, contributing 35-40% of rice and 40-70% of wheat to the central pool, has a high cropping intensity (196-200%). This study evaluates the economic impact of integrating short-duration summer vegetables with major cropping systems. Survey data revealed that paddy-potato crop rotation recorded the highest net returns (Rs.1,18,467/acre), whereas paddy-wheat had the highest B:C (2.71). Inclusion of summer vegetables significantly increased economic indices like net returns and B:C in paddy-wheat by 84.87 and 4.06 per cent, and in paddy-mustard by 126.23 and 21.46 per cent, respectively. Cultivation of summer vegetables enhanced the land use efficiency from 71.23 to 95.89 per cent in case of paddy-wheat crop rotation. Summer vegetable cultivation increased land use efficiency from 68.49 to 93.15 per cent in paddy-mustard cropping system. Inclusion of summer vegetables significantly enhanced the system productivity of all the existing crop rotations. In paddy-wheat rotation an increase in system productivity by about 179.96 per cent was recorded due to cultivation of summer vegetables. Results of the study clearly show immense potential of short duration summer vegetables in enhancing the farm profitability and sustainability while justifying the objectives of crop diversification in Punjab state.

Introduction

Punjab occupies 1.54% of India's total geographical area (Pushkarna, 2017) and has played a crucial role in national food security, especially after the Green Revolution. The state boasts a well-organized irrigation system, access to quality seeds, efficient crop nutrient management, advanced mechanization, and a strong network of agricultural market centers. Punjab contributes approximately 35-40% of the rice and 40-70% of the wheat to the central food pool, reinforcing its significance in national grain production (Dhiman *et al.*, 2010). While the national average cropping intensity is around 150%, Punjab's cropping intensity stands at 196-200%. However, the introduction of short-duration crops, particularly improved varieties, can further enhance cropping intensity to ensure food and nutritional security for India's rapidly growing population.

With limited scope for horizontal expansion of agricultural land, increasing cropping system productivity must be prioritized (Choudhary *et al.*, 2024). Over time, the dominance of mono-cropping has highlighted the urgent need for crop diversification by integrating best-fit crops into existing cropping systems. Despite its small geographical area, Punjab features diverse agro-ecological zones, allowing farmers to cultivate a wide range of crops, including paddy, wheat, potato, maize, sugarcane, and mustard, through various crop rotations such as paddy-wheat, paddy-potato, and paddy-mustard. Additionally, short-season crops like

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summer green gram, spring maize, and mentha are cultivated after the *rabi* season.

In recent years, instead of cultivating crops themselves after the *rabi* harvest, many farmers have started leasing out their land to fellow farmers for short-term cultivation. During this period, farmers cultivate short-duration summer vegetables such as bottle gourd, ash gourd, pumpkin, cluster bean, longmelon, snap melon, and wanga, which fetch high market prices due to their seasonal scarcity. The inclusion of these vegetables provides a dual economic benefit, generating income for both landowners and tenant farmers while further increasing cropping intensity (Brar *et al.*, 2019; Krishna *et al.*, 2024). Punjab has a geographical advantage with the availability of resources to support vegetable production during the peak summer months before the onset of the monsoon. Since green vegetables are in high demand during this season in North Indian markets, Punjab has the potential to capitalize on this opportunity.

Keeping in the view of economic significance of short-duration summer vegetables, whether on leased or owned land, it appears to be a viable approach for increasing cropping intensity while promoting resource conservation farming. To assess the impact of these vegetables on the economics of different cropping systems and explore their future prospects, a survey-based study was conducted to evaluate their role in Punjab's prevailing agricultural landscape.

Material and Methods

This study focused on six cropping systems commonly practiced by farmers in Punjab. The selection of these cropping systems was based on their inclusion of paddy, wheat, mustard or potato in combination with summer vegetables (Table 1). During the summer season, farmers cultivated short-duration vegetables such as bottle gourd, ash gourd, pumpkin, wanga, cluster bean, longmelon, and snapmelon. After the summer crop, they proceeded with *kharif* crop cultivation. A survey was conducted during the agricultural year 2023-24 by randomly selecting 150 farmers from Punjab, as detailed of cropping systems in Table 1:

Table 1. Different cropping systems surveyed for the study

Cropping system	Number of farmers
Paddy-Wheat	25
Paddy-Potato	25
Paddy-Mustard	25
Paddy-Wheat-Summer vegetables	25
Paddy-Potato-Summer vegetables	25
Paddy-Mustard-Summer vegetables	25

The data were collected by using a pre-designed interview cum questionnaire schedule containing queries pertaining to type of crops, cropping system, date of sowing, method of sowing, seed rate, usage of fertilizers, herbicides, pesticides, fungicides, sale price, etc. The land use efficiency (LUE) was calculated by dividing the total duration of crops in given cropping system by 365 and was expressed as percentage. Production efficiency was computed to assess the yield output concerning crop duration with the formula as given below.

$$\text{Production efficiency (kg/ha/day)} = \frac{\text{Economic yield of the crops in cropping system}}{\text{Crop duration (days)}}$$

The economic viability of different cropping systems was evaluated based on the data collected from farmers. The benefit-cost ratio (B: C) was determined using the following formula:

$$\text{B:C} = \frac{\text{Net returns}}{\text{Total cost of cultivation}}$$

Data compilation of the survey was done using online OPSTAT software. All the parameters such as cost of cultivation, net returns, production efficiency etc. were compared by running basic statistical analysis in the software. The *p*-value at 5 per cent level of significance was calculated by randomly selecting 10 farmers in each cropping system as replications.

Results and Discussion

The survey data showed that in sole cropping systems other summer vegetables, highest net returns was recorded in paddy-potato cropping system but, on the contrary, highest B:C was observed in paddy-wheat rotation (Table 2). Even paddy-mustard cropping system also registered higher B:C than paddy-potato rotation. Paddy-potato crop rotation had lowest B:C although this system recorded highest net returns. The decrease in B:C of paddy-potato rotation can be attributed to increase in cost of cultivation, especially in case of potato crop. This increase in cost of cultivation of potato crop corresponds to those farmers who purchase the seed potato tubers either from government or private agencies. Generally, farmers cultivate potato crop for 3-4 years after purchasing the potato seed tubers. After harvesting of potato crop, they store the produce in cold store to be used as seed in next season. Therefore, use of self produced seed for 3-4 years decreases the cost of cultivation up to 60 per cent, which in turn makes the potato cultivation an economically viable option over the years. As compared to paddy-mustard rotation, high B:C in paddy-wheat cropping system can be attributed to better gross and net returns even under scenario

of high cost of cultivation. Further, inclusion of short duration summer vegetables in all the prevailing cropping systems positively affected the economic indices thereby increasing the net returns and B:C in comparison to sole crop rotation without vegetables. For instance, cultivation of summer vegetables in paddy wheat crop rotation enhanced the net returns and B:C ratio by 84.87 and 4.06 per cent, respectively. Similarly, inclusion of summer vegetables in paddy-mustard rotation registered increase in net returns and B:C ratio by 126.23 and 21.46 per cent, respectively. This enhancement in returns and B:C due to cultivation of summer vegetables can be attributed to better selling price of vegetables fetched by the farmers due to early arrival in the market which in turn provides avenues for having more returns per unit time and area. Due to better returns, farmers of the region opt for leasing out of their land for a period of 3-4 months to cultivate summer vegetables. While conducting the survey, it was also noted that availability of short duration varieties of paddy or basmati also provides sufficient time to the farmers to raise nursery and transplant.

Table 2. Economics of different cropping systems

Cropping systems	Cost of cultivation (Rs./ acre)	Gross returns (Rs./ acre)	Net returns (Rs./ acre)	B:C ratio
Paddy-Wheat	35500	131863	96363	2.71
Paddy-Potato	82833	201300	118467	1.43
Paddy-Mustard	30700	102300	71600	2.33
Pady-Wheat-Summer vegetables	63068	241812	178144	2.82
Paddy-Potato- Summer vegetables	110401	306926	196848	1.78
Paddy-Mustard- Summer vegetables	57268	218926	161981	2.83
p- value (0.05)	0.0001	0.0021	0.0003	0.0001
CV (%)	10.23	9.71	10.06	10.17

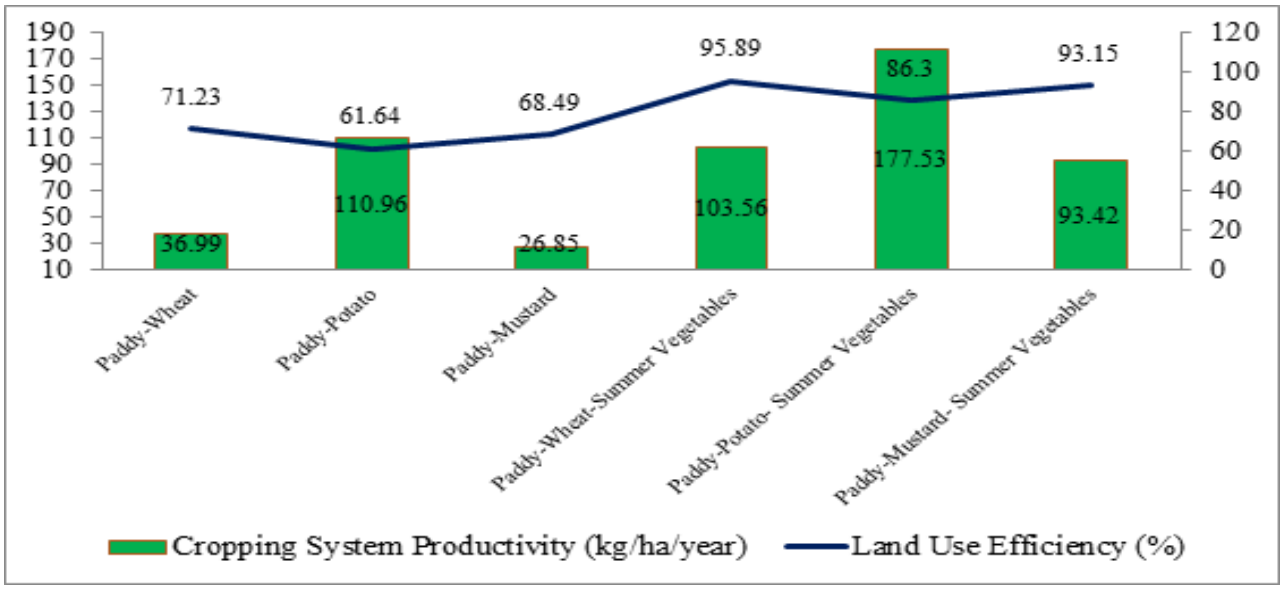

Fig. 1. Effect of summer vegetable cultivation on land use efficiency and cropping system productivity

As a result, it was observed that the inclusion of short-duration varieties and crops enhanced the sustainability of cropping intensity while optimizing input utilization in major cropping systems. This approach also provided farmers with an additional source of income during the gap months between major crop cycles. The cultivation of summer vegetables proved to be financially beneficial for both land-owning and lease-holding farmers. Moreover, some farmers generated income by leasing out their land for short-term vegetable cultivation during the three-month gap between major crop rotations, further maximizing land use efficiency (LUE) and profitability. Data regarding land

use efficiency (Fig. 1) depicted that cultivation of summer vegetables enhanced the LUE from 71.23 to 95.89 per cent in case of paddy-wheat crop rotation. Likewise, summer vegetable increased LUE from 68.49 to 93.15 per cent in paddy-mustard cropping system.

Under the changing scenario of urbanization and industrialization, this enhancement in LUE due to summer vegetables provide opportunities to the leading farmers to maximize their resource use efficiency as well as cropping intensity by multifold use of same piece of land in a given crop year. Furthermore, the integration of summer vegetables with existing crop rotations showed considerable increase in system productivity (Fig. 1). For instance, inclusion of summer vegetables in paddy-wheat rotation resulted in ~179.96 per cent increase in cropping system production efficiency. Enhancement in system efficiency creates avenues to yield more per unit area in a given period of time, which in turn can further be important to farmers who cultivate land on lease basis. Leasing land for summer vegetables provided additional income, while supply of produce during peak hot months of summer ensured better prices. Producing more per unit area along with fetching good price in the market certainly helps those farmers to repay their rental value on timely basis. Crop diversification though vegetable has been reported to enhance the productivity and profitability of traditional cropping systems (Kumar *et al.,* 2005; Upadhaya *et al.*, 2022).

Conclusion

From the study it can be concluded that cultivation of summer season vegetable is an economically viable option which not only increase cropping intensity with conservation technologies of the field but also improvise the returns and B:C in comparison to prevailing crop rotations without summer season vegetables. However, recent advances in various fronts of plant science such as natural resource conservation, crop diversification, and integration of artificial intelligence have made it possible to have sustainable growth in terms of farmer income and environment under rainfed as well as irrigated conditions. Furthermore, adoption of short duration field crops/vegetables/varieties would be more remunerative to the farming community of the Punjab state having an array weather conditions in a given calendar year. At the same time, cultivation of summer vegetables certainly proves propitious in achieving higher level of resource use efficiency, system productivity, dietary diversity, which no doubt remains the ultimate objective of the technological interventions taken in the agriculture production systems to address the food and nutritional security of the nation.

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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