Proceedings of the Pakistan Academy of Sciences:
B. Life and Environmental Sciences 58(2): 99-105 (2021)

ISSN (Print): 2518-4261; ISSN (Online): 2518-427X
http://doi.org/10.53560/PPASB(58-2)640

Pakistan Academy of Sciences

Research Article

Economic Evaluation of Tomato Sole and Tomato Onion Intercropping Systems of Smallholders in District Muzaffargarh, Pakistan

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Abstract: The objective of this research was to conduct an economic evaluation of smallholders' practices i.e tomato-onion intercropping (toi) and tomato sole cropping (ts). Primary farmer's field-level data was used in the study. Resource use efficiency and financial profitability indicators were calculated for comparison of two tomato cultivation systems. A financial model based on a modified Policy Analysis Matrix (PAM) approach was used as a method of research. The result indicates that 53 percent respondent adopts the tomato-onion intercropping system and remaining 47 percent respondents follows sole tomato system. Tomato-onion intercropping gave higher private profitability (US$. 1556/acre) with a benefit-cost ratio (BCR) of 2.35 compared to sole tomato with private profitability of US$.913 per acre with BCR 1.88. A higher BCR was found in tomato-onion intercropping than in the sole tomato cropping system. Tomato onion intercropping (toi) has more resource use efficiency with less Private Cost Ratio (PCR) value 0.30 as compared to tomato sole with PCR value 0.38. In conclusion, the tomato-onion intercropping system resulted in higher net income may be a viable option for smallholders to mitigate the economic risk of sole tomato cultivation. The result proved that the sole tomato cropping system is also economically viable however tomato-onion intercropping proved promising practice to minimize the economic risk of sole tomato crop. The findings have implicates that tomato-onion intercropping has the potential to increase the livelihoods of the smallholders in the study area.

Keywords: Smallholders, Tomato, onion, Intercropping, Economic comparison, Benefit-cost ratio, Punjab

1. INTRODUCTION

Pakistan has an agricultural-based economy with 18.5 percent share in the country's GDP and 4 percent horticulture area of the total cultivated area [1]. In vegetables, tomato ranked second after potato in the world. In Pakistan tomato is the third most important vegetable after potato and onion in terms of acreage and production. Pakistan is ranked 34th largest producer of tomatoes in the world. In Pakistan, Sindh produces 34.4 % followed by Balochistan 24.6 %, Khyber Pakhtunkhwa (KP) 22 %, and Punjab 18.6 % of total country produce. Muzaffargarh is the second largest district in terms of tomato production (15 120 tonnes) with the highest productivity of 14.2 tonnes per hectare in Punjab. Tomato and onion consumption is high in Punjab province as compared to other provinces of Pakistan. Tomato productivity of Muzaffargarh is higher as compared to other major producing districts of Punjab i.e., Sheikhpura (12.9) and Khushab (10.1) tonnes per hectare. The productivity is higher than the provincial average (12.8) and national average (9.5) tonnes per hectare [2]. In Pakistan, a farmer having up to 5-hectare land is classified as subsistence farmers. In the selected

Received: February 2021; Accepted: June 2021
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district Muzaffargarh there are 292,843 farms in which 93 % of farms are in the small category 12.5 acres or less; however, they account for 63 % of farm area in Muzaffargarh. With respect to 5 acres and fewer farms, 70 % of farmers in Muzaffargarh own 25 percent of land and the average farm size is 3.0 acres. A study revealed that in Pakistan 58 percent smallholder has less than 2 hectares of land and cultivate only 16 percent of total farm area, while large farmers with more than 10 hectares occupy 37 percent of the total farm area [3]. Worldwide, half a billion farmers are smaller than 2 hectares and these farms are getting smaller in many countries [4].

The present study is based on smallholders tomato growers of Muzaffargarh district which is the traditional tomato growing district of Pakistan. Muzaffargarh tomato growing pocket has a unique position in tomato production as a rabi season crop in Punjab. Smallholders are involved in production practices i.e sole and intercropped tomato. Overall, the average farm size is 4.4 acres in Muzaffargarh. Tenants and sharecroppers account for only 8 percent of rural families in the district indicating that the mode of agricultural production is no longer feudal and has been commercialized.

Tomato farming is a complex phenomenon due to its perishable nature, seasonality and bulkiness. All these well-known factors call for economic risk management to sustain the livelihood of smallholders. This fact is largely true in another part of the world. The study revealed that due to climate changes, pests and diseases, and market price variation tomato farmers face a huge economic risk in tomato production and marketing. The financial profitability of tomato cultivation is largely influenced by different risk factors and the management of these factors is largely influenced by farmers' attitudes towards risk management [5]. Due to weather conditions, diseases, and price uncertainties, many farmers live on the edge of extreme uncertainty. These factors are not under the control of farmers but some farmers have developed strategies of coping and managing economic risk. Intercropping is a form of crop diversification and income-generating activities from off-farm and non-farm can be used to manage price, yield, and income risk. Crops-livestock interaction is another common strategy by smallholder farmers around the world to reduce risk and improve the sustainability of the natural resource base [6]. Studies on tomato economic risk management in the study area are rare in the literature thus, this study analyses the smallholder's tomato cultivation systems under economic consideration in Muzaffargarh District of Punjab Pakistan. Intercropping is a system of growing crops in which two or more crops grow simultaneously in the same area for at least part of their cycles. To attain higher yield and value of the produce smallholders in developing countries commonly exercise intercropping to produce crops. In the past, only a few studies on the intercropping system have been performed in farmer's fields and many have been conducted under experimental conditions [7-9]. The present study is conducted in the farmer's field to address the issue in the study area which is not previously available in the literature. Further, more different studies outline the significance of the tomato crop in various ways. But the present research bridge the research gap between tomatoes in the intercropping and sole production system.

In the literature, the rewards of intercropping above single cropping are usually demonstrated by indexes that assess the area use efficiency. A study argued that intercropping can reduce the risk of crop damage or total crop failure as compared to sole cropping [15]. Tomato in the study area is considering their expensive production systems, intercropping might be an excellent alternative to optimize returns. Cost competitiveness by private cost ratio (PCR) was analyzed along with private profitability analysis at the farmer field level.

The research is a comparison of sole tomato and tomato onion intercropping practices by smallholders. This comparison will lead to new knowledge in the socioeconomic studies of tomato and onion crops. This methodology/comparison will add a new dimension of economic analysis to the existing knowledge. Compared with the previous work this study has some novelty by applying resource use efficiency and profitability indicators as tools for intercropping and sole tomato farms. The findings of the study would also be imperative to make informed decisions for risk reduction and ensure the livelihood of smallholders in the study area. The effects of the farmer's strategy on the profitability of tomato sole and tomato-onion intercropping have been evaluated.

2. MATERIALS AND METHODS

The study is based on primary data collected under a baseline survey from 45 small tomato growers out of the 60 registered farmers for the project interventions. The data was analyzed through the software SPSS-22 for descriptive statistics. Cost competitiveness and resource use efficiency, the benefit-cost ratio in the sole and intercropped tomato was determined by using selected indicators deduced from the Policy Analysis Matrix (PAM) framework as proposed by Monke and Pearson [10]. PAM is a recognized framework for measuring private profitability and efficiency in the use of domestic resources and is widely used in the comparative and competitiveness analysis of agricultural production systems. This study has used a modified PAM framework for the construction of farm budgets for tomato sole and tomato-onion intercropping systems. This approach is based on the estimation of farms' budgets using only financial prices, private profitability, private costs ratio, and benefit-cost ratios. The indicators were determined systematically as proposed by Indriyani et al. and Pilusa et al. [11-12]. In the recent past few studies in Pakistan have looked at resource use efficiency by using the PAM framework [13-14].

Mean and mean differences were calculated using the independent sample t-test to establish whether statistically significant differences exist between the practices under study (Tomato-onion intercropping and tomato sole cropping) in terms of the cost of production, gross return, and financial profitability.

2.1 Private Profitability (PP)

In the framework of PAM private profitability is a basic indicator and a positive value indicates that the system is adding to the income of the growers. PP= > 0 shows that farming business gains profits above normal which has implications that farming business can expand. PP ≤ 0 shows that the farming business receives profit under normal, which means that the farming business has not been able to expand.

$$PP_{ts,toi} = Q_k * pd_i - \sum_{j=1}^{k} a_{ij} pd_j + \sum_{j=1}^{k} a_{ij} pd_j$$

Where:

ts = Stands for tomato sole system

t*oi* = Stands for tomato-onion intercropping system

Q_k = Quantity of crop produced

pd_i = Market price of commodity under consideration

a_{ij} = jth traded inputs quantity required to produce a unit of commodity

j=1…k = directly traded and traded elements of non-traded inputs used in the production of commodity under consideration.

n=k+1...n = Primary inputs plus non-traded elements of non-traded inputs obtained after decomposing the non-traded items into non-tradable.

2.2 Private Cost Ratio (PCR)

Cost competitiveness at the farm level of any commodity can be measured by PCR. This ratio makes it possible to compare the private efficiency between two different production systems/practices It is a measure of resource use efficiency [16-17]. It indicates how much one can afford to pay domestic factor and remained competitive [18]. A value of PCR <1, showed that the system will be competitive and farming has a competitive advantage [17]. PCR ≥ 1 indicates that farming has no competitive advantage [18].

$$PCR_{ts,toi} = \frac{\sum_{j=1}^{k} a_{ij} pd_j}{pdi - \sum_{j=1}^{k} a_{ij} pd_j}$$

2.3 Benefit-Cost Ratio (BCR)

BCR is a relative measure that is used to compare benefits per unit of cost. BCR was estimated as a ratio of gross returns to total costs. The total revenue of a crop determines the benefits generated through the production of the crop. Total cost encompasses all the expenditures of inputs regarding cultivation. A greater than 1, Benefit-Cost Ratio indicates that the crop is suitable because the benefits measured by the present value of the total revenues (inflows) are greater than the costs, measured by the present value of the total outflows.

$$BCR_{ts,toi} = \frac{Q_k \; pd_i}{\sum_{j=1}^{k} a_{ij} pd_j + \sum_{j=k+1}^{n} a_{in} pd_n}$$

Table 1. Policy Analysis Matrix (PAM) Framework

	Revenue	Cost	
		Tradable inputs	Domestic factors
Private Prices	$Q_k\ pd_i$	$\sum_{j=1}^{k} a_{ij} pd_j$	$\sum_{j=k+1}^{n} a_{in} pd_n$
Social Prices	$Q_k\ pb_i$	$\sum_{j=1}^{k} a_{ij} pb_j$	$\sum_{j=k+1}^{n} a_{in} ps_n$

Source: Adopted from Monke and Pearson (1989)[10]

pd_n = non-tradable inputs n price used in the production of the commodity

3. RESULTS AND DISCUSSION

The result revealed that 53 percent of respondents replied that their tomato crop was intercropped with onion whereas 47 percent of respondents were growing tomato as the sole crop. the average cost per acre was calculated and compared for smallholders' practices i.e tomato-onion intercropping (toi) and tomato sole cropping (ts) by using a t-test. The result revealed that the total cost of production by the tomato-onion intercropping was US$. 1154.05/ acre and the total cost of production by the tomato sole cropping system was US$. 1036.48/acre. There is not a significant difference in the total cost of production between the two systems. However, FYM and plant protection costs have significant differences among the two practices (table 2).

Tomato yield was higher at 16924 Kg/acre for tomato-onion intercropping smallholders as compared to tomato sole smallholders 1 20 72 Kg/ acre. This result is consistent with the research which reports that intercropping tomato with other crops gives a high yield [19]. The results indicated that yields of tomato in the tomato-onion intercropping system were higher than the yield of the tomato sole system and have a significant difference. This finding is consistent with the studies of Huaasin et al. [19] which argued that tomatoes in okra, eggplant, and chilies gave more production and income as compared to grown alone. The result revealed that the tomato-onion intercropping provided the opportunity to secure a higher yield as compared to tomato sole crop by the respondent's farmers. Tomato prices received by smallholders of both systems did not have a significant difference.

Modified Policy Analysis Matrix (PAM) results presented in table 3 revealed that gross revenue attained by tomato-onion intercropping was estimated at US$. 2710/acre with private profitability US$. 1556/acre. The gross revenue attained by tomato sole cropping growers in the study area was estimated to be US$. 1950/acre with private profitability of US$.913/acre. The result revealed that the financial benefits of the intercropping system are higher than the sole cropping system. These results were in accord with the research studies [20-22]

Benefit-Cost Ratio (BCR) analyses were performed for farmers operating under the intercropping and sole tomato cropping system. The result revealed that tomato-onion intercropping gave a high BCR of 2.35 as compared to sole tomato with BCR 1.88 (table 3).

Tomato-onion intercropping (toi) has more resource use efficiency with less PCR 0.30 value as compared to tomato sole with PCR value 0.38. For attaining crop production, there is a need to increase resource use efficiency to make farming more remunerative and competitive [23]. Intercropping provides the opportunity for better utilization of domestic resources as compared to the sole cropping system [24].

A frequently cited benefit of intercropping is increased crop productivity and it is also adopted as a strategy to mitigate risk [25]. Because of small land ownership intercropping is a well-known practice in vegetable production in particular areas of Egypt [26]. To enhance the resource use efficiency in crop production knowledge and understanding of crop diversity are important [27]. Intercropping tomatoes with potato onion may be an effective strategy in tomato production by improving soil environment

Table 2. Cost of production and yield and prices of output under tomato-onion intercrop (toi) and tomato sole (ts) system (Cost, US$/acre, Yield Kgs/acre, Price US$/kg, %)

Variable/ Cropping system	Tomato- onion intercropping(toi)	Tomato sole(ts)	t-value
Agricultural Practices (%)	53	47	-
Land & Seed bed preparation	175.77	164.10	0.953
Seed cost	172.92	141.99	1.141
Farm Yard Manure(FYM)	40.80	20.50	2.106**
Chemical Fertilizer	145.77	130.65	0.918
Irrigation	105.93	91.87	1.276
crop protection measures	93.62	76.00	1.928*
Harvesting/Picking	183.55	165.72	1.209
Interest on variable cost	66.58	66.91	-0.042
Land rent for 6 months	169.11	178.74	-0.471
Total cost	1154.05	1036.48	1.185
Tomato Yield(kg)	16924	12072	3.226***
Tomato Price(US$./Kg)	0.15	0.16	-1.934**

Source: Authors calculation by using survey data, 2018, toi,=Tomato-onion intercropping, Ts= tomato sole cropping, 1US$=PKR 104.70., *, ** and *** indicate significant at 10%, 5% and 1% level of significance respectively.

Table 3. Resource use efficiency and profitability analysis of tomato onion intercropping and tomato sole by smallholders in the study area, Cost and Return (US$/acre)

Variable/cropping system	Tomato- onion intercropping (toi)	Tomato sole(ts)	t-value
Domestic factors cost	669	570	1.524
Tradable inputs cost	485	466	1.635
Total cost	1154	1036	1.125
Gross Revenues	2710	1950	2.854*
Private Profitability(PP)	1556	913	1.097
Benefit Cost Ratio(BCR)	2.35	1.88	0.951
Private Cost Ratio (PCR)	0.30	0.38	-0.449

Source: Authors calculation from the farm budget and table 2 above, toi,= Tomato- onion intercropping, ts= Tomato Sole cropping, PP=Private Profitability, PCR= Private Cost Ratio, *, ** and *** indicate significant at 10%, 5% and 1% level of significance respectively.

and phosphorus nutrition. Previous research also concluded that tomato yield has increased due to intercropping with potato and onion [28-30].

4. CONCLUSION

The current research found that both tomato cultivation systems are economically viable for smallholders in the study area. It was established that both tomato-onion intercropping and tomato sole cropping systems had higher returns than costs. However tomato-onion intercropping gave increased net returns over the sole cropping of tomato. The findings implicated that tomato-onion intercropping has the potential to reduce the risk of sole crop failure and provide partial shade. Tomato-onion intercropping has more resource use efficiency as compared to tomato sole at prevailing technology, prices of inputs and outputs, and policy environment. Tomato-onion intercropping could be recommended for adoption. This has also implications for the design of policy to educate farmers through the extension system about potential benefits due to tomato-onion intercropping in a similar environment. The finding of the research may help in informed policy decisions for promoting tomato-onion intercropping as a viable alternative to the sole tomato system to synthesize goals of higher productivity and increase the livelihood of smallholders tomato growers.

5. ACKNOWLEDGEMENTS

The authors greatly acknowledge the research support provided by the Australian Centre for International Agriculture Research (ACIAR) for the project entitled “Strengthing Vegetable Value Chains in Pakistan(SVVCP)”. The research project is being implemented by CAB International(CABI) Center, Regional Offices in Pakistan. The support of CABI in the baseline survey and this research output is highly acknowledged.

6. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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