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Socioeconomic impact of improved variety of Chinese potato in Tamil Nadu

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ABSTRACT

The socioeconomic impact was based on a farm household survey conducted in Tenkasi and Tirunelveli districts of Tamil Nadu among 200 Chinese potato producers during 2021/2022. A logistic regression model was employed to identify factors determining the adoption of 'SreeDhara', and the Inverse Probability Weighted Regression Adjustment (IPWRA) method was used to assess the impact of the adoption of 'SreeDhara' on yield and income. The cost of cultivation, gross income, and net income for 'SreeDhara' adopters were 7, 37, and 87% higher than for non-adopters. Years of schooling, farm income, access to extension services, and block dummies had significant, positive effects on adopting the variety. The IPWRA results indicated yield and income of 'SreeDhara' adopters were higher than non-adopters by 23.65 and 24.99 %, respectively. The most significant constraints to adopting Chinese potatoes were lack of awareness about 'SreeDhara,' inaccessibility to credit, and the non-availability of crop insurance. Thus, recognizing its higher nutritional value and potential farm income, institutional support in the form of better extension linkages, credit facilities, and crop insurance to Chinese potato growers needs to be strengthened.

Keywords: *Plectranthus rotundifolius*, Impact assessment, Logistic regression, Technology adoption.

INTRODUCTION

Adopting technology is vital to improve agricultural productivity (Evenson and Gollin, 4). Many farmers are not adopting promising technologies due to limited access to information through extension services and insufficient seed supply (Suri, 15; Asfaw *et al*., 3). The Chinese potato [*Plectranthus rotundifolius* (Poir.) Spreng] is a tropical tuber (Fig. 1) primarily intended for direct consumption and a lesser-known crop, rich in calories and essential nutrients (Kana *et al*., 5). It thrives in both tropical and sub-tropical conditions. The ICAR-Central Tuber Crops Research Institute, India has released a variety of Chinese potato cv. SreeDhara, with high yield, resistance to root-knot nematode, and good shelf life. Moreover, this variety is sold at a lucrative price on the market because of its aroma, flavour, and desired shape of the tubers. The Chinese potato is a monsoon crop in India grown under an irrigated and rainfed production system. Though Chinese potato tubers are slightly harder than Irish potato (*Solanum tuberosum* L.), their unique taste and aroma make the crop popular among farmers and consumers. Chinese potato is grown in India primarily in two states, namely Tamil Nadu and Kerala. It is known as *Siru Kizhangu* in Tamil Nadu and *Koorka* in Kerala. In Kerala, it is cultivated mainly in Thrissur, Malappuram, and Palakkad districts. In contrast, in Tamil Nadu, it is predominantly grown in the districts of Tenkasi, Tirunelveli, Tuticorin, and Virudhunagar. The ICAR-CTCRI launched an awareness-raising programme to promote the high-yielding Chinese potato 'SreeDhara' through demonstrations and seed villages from 2017 to 2022 in Tenkasi and Tirunelveli districts of Tamil Nadu as these districts have been the major growers of the crop for many decades. Planting materials of 'SreeDhara' and inputs were provided to farmers as part of the demonstrations. It is thus important to evaluate the impact of an improved variety of Chinese potato and their performance over the prevailing varieties. In this context, the present study was undertaken in the Tenkasi and Tirunelveli districts of Tamil Nadu with the objectives i) to assess the socioeconomic impact of the field intervention involving improved 'SreeDhara' and associated agro-techniques of Chinese potato and ii) to determine factors influencing adoption of 'SreeDhara' by farmers.

Fig. 1. Chinese potato

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MATERIALS AND METHODS

This study is based on a survey of farm households using a well-structured schedule of interviews, focus groups, and interviews with key informants from the Chinese potato growers during 2021-2022 in Tenkasi and Tirunelveli districts of Tamil Nadu, India (Fig.2). These districts were purposively chosen because (i) the field intervention involving improved variety and technologies implemented; (ii) these districts have more than 50% of the area under Chinese potato. Multi-stage random sampling has been used to select blocks, villages, and farmers. First, in each district, two blocks were selected. Then, from each block, two clusters comprising 2 to 3 villages were selected based on the concentration of Chinese potato cultivation. Finally, 25 households were randomly selected for the survey from each selected cluster of villages based on the household listing. Thus, the survey included 200 households of 124 farmers who adopted local varieties and 76 farmers who adopted improved varieties from eight clusters of villages (~20 villages) in two districts of Tamil Nadu. In addition, the information on respondents' characteristics, varietal adoption, cost of cultivation, household employment, marketing of Chinese potatoes, socioeconomic benefits, and constraints in adopting Chinese potato cultivation were collected.

Most studies of decisions made by farmers to adopt a single technology have employed binary logit or probit models because these models are seen as the most appropriate approaches for providing comprehensive details on adopters and non-adopters (Mariano *et al*., 7; Sunny *et al*., 14). In this study, the logit model was employed to determine the factors influencing the adoption of improved variety, namely SreeDhara. The model for estimating the logit model is written as

$$Z_i = log \frac{pi}{1 - pi} = \propto + \beta Xi + \varepsilon ij$$

Xi is the independent variable and the logarithm of the odds of farm households' decision to adopt the improved variety' SreeDhara' (Zi = 1) versus not adopting (Zi = 0).

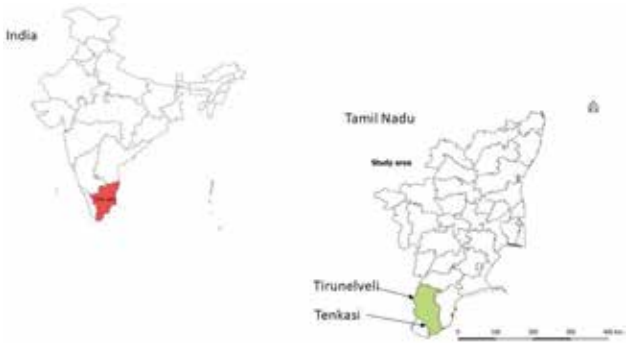

Fig. 2. Locations of the study area

Since the field intervention treatments were not randomly assigned to the beneficiaries, the impact has confounding effects due to selection bias. The inverse probability weighted regression adjustment (IPWRA) method was used to determine the impact of the field interventions to manage the confounding effects (Tambo and Mockshell, 16). IPWRA approach first estimates the sample selection to treatment, predicts treatment for all observations, assigns the inverse of the probability of treatment for treated individuals along with the inverse probability of not being treated for control individuals, and finally re-estimates the outcome model using these new weights (Rahman *et al*., 9). The IPWRA is considered a double robustness estimator, i.e., even if one of the models (treatment or outcome) is misspecified, the estimator is still consistent (Zheng and Ma, 17). IPWRA estimator uses a three steps approach to assess the Average Treatment effect on Treated (Manda *et al*., 6). Compared to the RA estimator, the IPWRA uses weighted regression coefficients to compute ATT, where the weights are the estimated inverse treatment of probabilities. The Logistic and Inverse probability weighted regression adjustment models were estimated using STATA Software V. 15.1.

RESULTS AND DISCUSSION

The SreeDhara variety disseminated by ICAR-CTCRI is grown in large areas and is popular amongst Tamil Nadu and Kerala farming communities. Chinese potato is grown in the Tenkasi and Tirunelveli districts of Tamil Nadu as both an irrigated and rainfed crop. It is propagated by stem cuttings 10-15 cm long through the tubers. The nursery raising is done two and a half months prior to planting. First, farmers raise nurseries using seed tubers to multiply stem cuttings. Then, it is transplanted from June to August by ridge and furrow method. Farmers did two to three weedings and one earthing-up the second month after planting. It is a labour-intensive crop, which demands more labour during transplanting, harvesting, and grading. In addition, the root-knot nematode is a significant pest in the study area. Chinese potato takes four to five months to attain maturity, with an estimated yield of 13.56 tons per hectare. Around 38% of the farmers used SreeDhara, and 62% used local varieties. Farmers keep minimum tubers for next season's planting and sell the remaining tubers.

The average difference between family size and farm size between adopters (SreeDhara) and non-adopters (local varieties) is insignificant, as the average family size and family size of the respondents in both categories are almost the same (Table 1).

Table 1. Socioeconomic characteristics of adopters and non-adopters.

Variables	Adopters	Non adopters	Mean difference	Total mean
Age (years)	44.08 (8.71)	45.86 (10.65)	-1.78^{ns}	45.19 (9.98)
Education (years of formal education)	9.01 (2.80)	6.81 (4.22)	2.21***	7.65 (3.89)
Family size (number of people)	4.38 (1.70)	4.34 (1.61)	0.043^{ns}	4.36 (1.64)
Farm size (ha)	1.51 (1.20)	1.52 (1.38)	-0.01^{ns}	1.52 (1.31)
Area under Chinese potato (%)	43.01 (27.60)	50.18 (29.46)	-7.17*	47.46 (28.91)
Chinese potato yield (tons/ha)	15.53 (4.05)	12.35 (4.17)	3.19***	13.56 (4.40)
Societal membership (1/0)	1.55 (0.50)	1.65 (0.47)	-0.10^{ns}	1.62 (0.49)
Access to extension services (1/0)	0.45 (0.50)	0.24 (0.42)	0.21***	0.32 (0.47)
Sample size	124	76		200

Figures in parenthesis indicate the standard deviation; *** and * denote the significance of mean difference at 1% and 10%, respectively; ns=not significant; Difference in means of societal membership and access to extension services were tested using chi-square (χ^2), t-tests were used for all other comparisons.

Average years of education were higher among adopters (nine years) than non-adopters (around seven years), which was statistically significant. Nikan *et al.* (8) also reported that adopters had a significantly higher level of education than non-adopters. As far as yield is concerned, the results showed that adopters had more yields than non-adopters, which was statistically significant. The mean yield of adopters was 15.53 tons/ha, while it was 12.35 tons/ha for non-adopters. The adopters had an average age of 44 years, while non-adopters had 46 years, and the difference was non-significant. Non-adopters had more areas than adopters, and the difference was significant. The area shares for adopters were 43% and 50% for non-adopters. Adopters had more access to extension services than non-adopters, and the difference was significant. Similar results were reported by Acheampong *et al*. (2), who reported that adopters had more access to extension contacts than non-adopters.

The total cost for cultivating Chinese potatoes between adopters (SreeDhara) and non-adopters (local varieties) varied (Table 2). Adopters incurred Rs. 1.89 lakh/ha while Rs. 1.77 lakh/ha for non-adopters. The SreeDhara variety (25%) showed significant yield gains compared to the local varieties. Higher yields of the SreeDhara variety have reduced the unit cost of production and therefore increased profitability. Gross and net returns for SreeDhara were 37% and 87% higher than that of local varieties. The unit cost of production due to the adoption of SreeDhara over local varieties declined by 17% (Rs. 2123 per ton). The Chinese potato tubers of SreeDhara fetched a higher price (10%) than local varieties. Chinese potato cultivation required 521.17 labour days/ha for SreeDhara and 468.31 labour days for local varieties. The employment resulting from adopting SreeDhara generated 11.28% more than the local varieties due to increased yield, which requires more labour for harvesting, grading, and packaging. The estimated benefit-cost ratio was high for SreeDhara (2.07:1) than for the local varieties (1.61:1).

The socioeconomic impact of Chinese potato cultivation revealed that higher income enabled Chinese potato farmers not only to spend more on reinvestment into agriculture (55%) but also spend more on education (12%) and health (10%) (Fig. 2). Sudha *et al*. (13) also confirmed that with the adoption of commercial vegetable seed production, the socioeconomic impact on increased income was more followed by reinvestment in agriculture and repayment of loans.

All sampled farmers sold their production immediately after harvest. *Mandi* played a significant role in channelizing Chinese potatoes, accounting for 71.50%, followed by aggregators (25.25%), wholesalers (2.25%), and consumers (1%) (Table 3). Most farmers got payments immediately after the sale (91.25%), and very few (6.1%) got advance payments from buyers. Chinese potato is a seasonal crop, and it is harvested mainly during November, December,

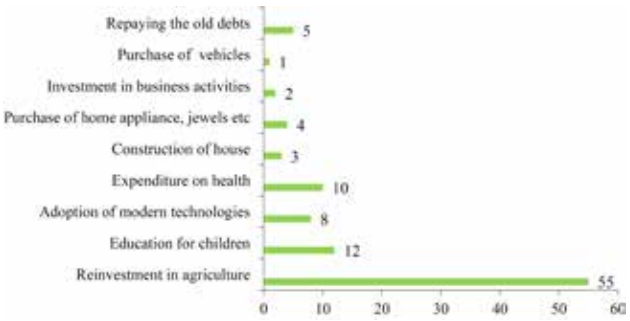

Fig. 2. Pattern of investment of farm income (%).

Table 2. Costs[$] and returns in Chinese potato production in Tamil Nadu.

Particulars	Adopters		Non-adopters		Total mean	
	Amount (Rs)	%	Amount (Rs)	%	Amount (Rs)	%
Nursery raising cost[#]	8617	4.54	8401	4.73	8827	4.78
Machinery charges for land preparation	7660	4.04	7825	4.41	7739	4.20
Ridge and furrow making	15650	8.25	15526	8.75	15582	8.45
Transplanting charges	6425	3.38	6589	3.71	6504	3.53
Intercultural operations	29158	15.36	28005	15.77	28570	15.49
Fertilizers/manures	14389	7.58	14455	8.14	14614	7.92
Plant protection measures	1853	0.98	4077	2.30	3335	1.81
Harvesting	77013	40.58	68158	38.39	72556	39.33
Grading and packing	29034	15.30	24504	13.80	26758	14.50
Total input cost	189799	100	177541	100	184485	100
Yield (t/ha)	15.49	(25%)	12.35		13.56	
Price/kg of tubers	25.54	(10%)	23.19		24.09	
Gross returns (Rs)	393446	(37%)	286273		326660	
Net returns (Rs)	203647	(87%)	108732		142176	
Cost of production (Rs/tons)	12253	(17%)	14376		13605	
Gross labour days (per ha)	521.17		468.31		494.74	
Benefit Cost Ratio (BCR)	2.07		1.61		1.77	

Figures in parenthesis indicate percentage increase over the local varieties; #included machine labour cost, ridge and furrow making charges, planting cost, weeding cost, seed materials cost, fertilizers/manures cost, and its application charges; $ included both family and hired labours.

Table 3. Marketing behaviour of Chinese potato farmers in Tamil Nadu.

Particulars	Value
Average price (Rs/q)	2409
Time of sales (%)	
Immediate sales	100
Month of sales	
November (%)	13.34
December (%)	33.25
January (%)	26.56
February (%)	17.2
March (%)	9.65
Type of buyers	
Aggregators (%)	25.25
Wholesale markets (%)	71.50
Wholesalers (%)	2.25
Consumers	1.00
Payment types	
Immediate payment (%)	91.25
Late payment (%)	2.65
Advance payment (%)	6.1

January, February, and March. December and January are the peak months of Chinese potato production in Tamil Nadu.

Adopting an improved variety was influenced by many factors identified through binary logit regression (Table 4). The logit regression model revealed that the farmer's decision to adopt improved variety was positively influenced by their age, education, family size, access to extension services, farm income, and block dummies. In contrast, farm size negatively influenced the adoption of improved variety. Variables viz., years of education, farm income, access to extension services, and block dummies were significant factors for adopting improved varieties. Shiyani *et al*. (12) found positive effects of education on adopting improved crop varieties. Sharma *et al*. (11) confirm that household income was positively linked to adopting new varieties. Ransom *et al*. (10) confirm that access to extension services was positively associated with adopting new crop varieties. All other variables included in the model were not significant. Analysis of marginal effects has shown that the likelihood of adopting SreeDhara increases by 2.5 % for every year of an increase in formal schooling. The estimated marginal effects of farm income suggest that a 1% increase in farm income

Table 4. Logit model explaining factors affecting adoption of SreeDhara.

Variables	Binary logit model		Marginal effects	
	Coefficients	Z	(dy/dx)	Z
Dependent variable: (1: if farmer adopted the improved variety, 0: otherwise)				
Age (years)	0.001	0.07	0.000	0.07
Education (years)	0.142***	2.68	0.025***	2.85
Family size (number of people)	0.012	0.12	0.002	0.12
Farm size (ha)	-0.076	-0.55	-0.013	-0.55
Access to extension service (1/0)	0.675*	1.84	0.118*	1.90
Ln_farm income (Lakh/ha)	2.432***	4.69	0.425***	5.94
Block dummies				
Block 2 (1=Pappakudi, 0=otherwise)	1.533***	2.12	0.270***	2.19
Block 3 (1=Ambasamudram, 0=otherwise)	0.962*	1.68	0.164*	1.79
Block 4 (1=Kadayam, 0=otherwise)	0.570	1.04	0.094	1.09
Constant	-33.399	-4.95		
LR chi^2 (11)	56.970			
Pseudo R^2	0.215			
Prob> chi^2	0.000			
Observations (n)	200			

***and * denote significance at 1%and 10% respectively

is expected to increase the likelihood of moving to SreeDhara by 42.5%. The estimated marginal effects of the dummy variable have shown that the availability of extension services increases the likelihood of adoption by 11.8%. Block dummies were significant, suggesting that soil types, rainfall, and cropping models influenced the decision to adopt them.

The results showed that Chinese potato yield and income were significantly higher among adopters than non-adopters. The Chinese potato yield was higher by 2.97 t/ha and income by Rs. 78600 /ha for adopters than the non-adopters, indicating that adoption of SreeDhara increases yield by 23.65% and income by 24.69% (Table 5). Abdulai and Huffman (1) also confirm that adopting improved agriculture technologies improves yields and incomes.

Table 5. IPWRA estimates the impact of the adoption of SreeDhara on yield and income.

Outcome variable	The mean value of outcome variables		ATET
	Adopters	Non-adopters	
Yield (t/ha)	15.53	12.56	2.975*** (1.187)
Income (lakh/ha)	3.99	3.20	0.786*** (0.342)

ATET = Average treatment effect of the treated; Figures in the parentheses are standard error;*** denote significance at a 1% level

All the respondents (100%) indicated that the SreeDhara variety offers many advantages over local varieties, such as higher tuber yield (69%), less incidence of nematode (58%), employment generation (53%), good shape and size of tubers (42%), early maturing (36%), fetches remunerative price (28%) and tuber rotting is less during water stagnation (21%) (Table 6). However, about 23% of farmers reported difficulty getting seed tubers. In addition, lack of awareness and knowledge of SreeDhara (55%), availability of local varieties (31%), and no accessibility to seed tubers and planting materials (14%) of SreeDhara were reported as reasons by non-adopters.

The study concludes that the improved variety of Chinese potatoes gave a higher yield (15.53 tons/ha) than the local varieties (12.35 tons/ha). Local varieties were adopted by 62% while improved variety was adopted by 38% of farmers. But the net return from improved variety was almost 87% higher than local varieties. Farmers with more education, higher farm income, and extension contact are likelier to adopt the technology. The IPWRA results showed that the impact of adopting SreeDhara increases yield by 23.65% and income by 24.69%. Constraints analysis showed that lack of awareness about the improved varieties and inaccessibility to credit and insurance coverage are the most important

Table 6. Farmer's perceptions about improved variety of Chinese potato

Reasons	Farmers (%)
'SreeDhara' variety has advantages over local varieties (n=76)	100
Higher tuber yield	69
Less incidence of nematode	58
Employment generation	53
Market-preferred shape and size off tubers	42
Early maturing	36
Fetches remunerative price	28
Tuber rotting is less during water stagnation	21
High demand among traders and consumers	19
Good keeping quality	8
'SreeDhara' variety has disadvantages compared to local varieties (n=76)	26
Difficulty in getting seed tubers	23
Never tried cultivating the 'SreeDhara' variety (n=124)	63
Lack of awareness and knowledge of the SreeDhara variety	55
No access to seed tubers/planting materials	14
Local varieties meet our needs	31

factors hindering technology adoption. Therefore, recognizing its higher nutritional value and potential farm income, institutional support in the form of better extension linkages, credit facilities, and crop insurance for Chinese potato growers needs to be strengthened.

AUTHORS' CONTRIBUTIONS

Conceptualization of research (PP, DJ, SI); Methodology, validation, and data collection (PP, DJ, RM); Statistical analysis and interpretation of results (PP, DJ, PSS); Preparation of the manuscript (PP, DJ, SI, RM, PSS). All the authors reviewed the results and approved the final version of the manuscript.

DECLARATION

The authors declare that there is no conflict of interest.

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