



Groundwater Saving in Punjab: Role of Short Duration Paddy Varieties in Agricultural Sustainability

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Abstract: There are two types of varieties of paddy grown in the state i.e. long duration and short duration. To compare the economic viability of paddy varieties, most preferred long duration variety, Pusa 44 and short duration varieties, PR121 and PR126 were chosen for the study. A random sample of sixty farmers was taken from two blocks of Ludhiana and Barnala districts. The analysis revealed that expenses on fertilizers, plant protection measures, human labour use, and expenses on diesel for irrigation was considerably higher in Pusa 44 variety vis-a-vis short duration varieties. Total variable cost incurred while growing Pusa 44 variety was Rs. 39956 per hectare whereas it was Rs. 37056 and Rs 34724, respectively in case of PR 121 and PR 126 varieties. Although gross returns and returns over variable costs (ROVC) were higher in case of Pusa 44 than short duration varieties, but it requires more number of irrigations and input usage. Pusa 44 being long duration variety, results in delayed harvesting due to late maturity of crop leading to paddy straw burning due to shortage of window between paddy harvesting and wheat sowing affecting timely sowing of the wheat crop in *rabi* season. The benefits of short duration paddy varieties in terms of saving ground water and judicious input usage should be weighed in terms of agricultural sustainability perspective for Punjab vis-à-vis higher returns from long duration paddy varieties.

Keywords: Economic analysis, Sustainability, Input use, Gross returns

India produces 107 million tonnes of rice (*Oryza sativa* L.) in an area of 44 million hectare which constitutes about 35 per cent of area and 40 per cent of food grains production in the country. About 90 per cent world's rice is grown and consumed in Asian countries. It is the major source of protein and calories for the masses (Job and Nandamohan 2004). Despite having stagnant area of rice in India during the last decade, the rice production has registered an increase of 18 per cent (Kumar et al 2018). Paddy production generates employment of about 3.5 billion man days and contributes about 10 per cent to Agricultural GDP in the country. However, paddy is considered 'water guzzler' and the unfavourable monsoon adversely affects its area, production and productivity in the country (Bouman 2009). Even it requires large quantities of inputs, particularly water, fertilizer and pesticides, contributing to high cost of cultivation (Narayanamoorthy 2013). Punjab has 1.53 per cent geographical area of India and contributed 31 per cent rice to the central pool during the year 2017-18. With the exponential increase in population, the need for increase in food grain production is becoming a great challenge. Punjab has a huge area under paddy crop though it's not staple food of the state. A sustainable production of rice in Punjab is crucial for the food security of India. Currently, out of 20 million tube wells in the country, almost 1.3 million are in

Punjab, contributing to fast-paced groundwater extraction and its depletion (Satvir and Vatta 2015). The state is facing many challenges like depletion of water table, environmental issues and problem of crop diversification etc. owing to paddy cultivation. But the farmers are growing this crop due to low risk involvement and assured minimum support price and efficient marketing system in the state. To sustain paddy production, there is a need to adopt the efficient and economically viable production strategies and water saving technologies in the state (Dhillon et al 2018).

Two types of varieties of paddy are grown in the state-long duration and short duration. Under long duration varieties, Pusa 44 is sown in some districts of the state, however, this variety has not been recommended by the PAU for cultivation. Similarly, PR 121 and PR 126 are the short duration varieties sown by the farmers and recommended by PAU. These varieties are high yielding and mature nearly 20 to 37 days earlier than Pusa 44. Farmers preferred to grow short duration varieties compared to long duration in order to grow three crops in a year (Manan et al 2018). The foremost challenge to Punjab agriculture is posed by the depletion of groundwater in Central districts and its poor quality in South-Western region, requiring technological innovations besides strong policy measures. Punjab farmers deserve appreciation for adopting short duration rice varieties, which

during 2017 season came to occupy about 69 per cent of paddy rice acreage. On account of short duration and low biomass, these varieties save irrigation water and lower cost incurred on pesticide usage, are suitable for transplanting after June 20, besides being amenable to residue management (Dhillon and Bains 2018). In this paper, an attempt has been made to compare the returns from long and short duration varieties of paddy grown in the state.

MATERIAL AND METHODS

Three paddy varieties namely; Pusa 44, PR 121 and PR 126 were taken under the study. Two clusters were purposely selected, one from Samrala block of Ludhiana district and another from Barnala block of Barnala district. Each cluster consisted of two to three villages and after preparing a list of farmers growing the above mentioned varieties during the year 2018-19, twenty farmers for each variety from both the clusters were randomly chosen. Hence, a total sample of 60 farmers was selected and data were collected through a well-structured schedule having details of socio-economic pattern, land holding details, input usage, cost-return structure and problems faced by farmers in raising different paddy varieties. The data were analyzed by using simple tools such as averages, percentages etc. In order to evaluate the farmer's perception with respect to constraints and advantages of different varieties, Garrett Ranking technique

was used. The farmers were asked to rank the given problem according to the magnitude of the problem faced. The orders of merit given by the respondents were converted into ranks by using the following formula:

$$\text{Percentage Position} = \frac{100(R_{ij} - 0.5)}{N}$$

Where,

R_j = Rank given for the i^{th} item by the j^{th} individual

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

The percentage position of each rank thus obtained was converted into scores by referring to Garrett and Woodworth (1971). Then for each factor, the scores of individual sample farmers were added together and divided by the total respondents for whom scores were added. Thus, mean score for each problem was ranked by arranging them in the descending order.

RESULTS AND DISCUSSION

Socio-economic profile and land holding status: The socio-economic profile of the sample households is given in Table 1. Land holding pattern on sample farms (Table 2) showed that farmers growing short duration varieties have less owned land as compared to their counterparts. The operational holding on sample farms was 8.50 hectares in an overall scenario. The average operational holding size was 9.68 hectares in case of farms growing short duration

Table 1. Socio-economic profile of sample farmers growing paddy, Punjab, 2018-19

Particulars	Farmers growing paddy varieties		
	Pusa 44	PR 121	PR 126
Average age (Years)	50	44	43
Average schooling years	9	11	11
Agricultural experience (Years)	21	19	18
Family size (No.)	5.53	5.21	5.11
Family members engaged in agriculture (No.)	1.60	1.50	1.50

Relatively young farmers preferred short duration paddy varieties while having less experience in undertaking farming

Table 2. Land holding pattern on the sample farms, Punjab, 2018-19

Particulars	Farmers growing paddy varieties			(ha)
	Long duration variety (Pusa 44)	Short duration varieties (PR 121 & PR126)	Overall	
Owned land	4.30 (73.19)	3.60 (37.19)	3.82 (44.94)	
Leased-in land	2.52 (42.78)	6.08 (62.81)	4.97 (58.47)	
Leased-out land	0.94 (15.98)	-	0.29 (3.41)	
Operational holding	5.88	9.68	8.50	
Land value (Rs. lakhs ha ⁻¹)	59.55	62.52	61.62	
Land rent (Rs. lakhs ha ⁻¹)	1.21	1.00	1.07	

Figures in parentheses indicate the per cent share in the operational area

varieties while it was 5.88 hectares for the farms growing long duration variety. The value of land for the farms growing short duration varieties was higher as compared to the farms growing long duration variety while on the other hand in case of land rent reverse was true although the average land rent was Rs 1.07 lakh per hectare on the sample farms.

Input-output coefficients: There was not much difference in seed rate for long duration variety Pusa44 and short duration varieties PR 121 and PR126. In case of fertilizer application, higher dose of urea was applied to long duration variety than short duration varieties. The extra cost of urea accounted to Rs. 452 and Rs. 492 per hectare in case of long duration variety Pusa 44 vis-a-vis short duration varieties. In case of di-ammonium phosphate (DAP) usage, more quantity was used in Pusa 44 than short duration varieties. Similar pattern was observed in the use of zinc sulphate ($ZnSO_4$) fertilizer as higher dose was applied in long duration variety in comparison to short duration varieties. Muriate of potash (MOP) was applied only in case of short duration varieties. Total expenses on fertilizer use was higher in case of Pusa 44 (Rs. 3819 ha^{-1}) than short duration varieties where it ranged between Rs. 3029 to Rs. 3292 per hectare. The expenditure incurred on plant protection measures was also higher in case of Pusa 44 than short duration varieties PR 121 and PR 126, respectively. Long duration variety require higher doses of fertilizers and plant protection measures to control pest and diseases during its period of growth in comparison to short duration varieties. Human labour requirement was also higher in long duration variety, however, use of tractor for various field operations during the

crop season showed not much difference in all the varieties. Irrigation hours were considerably higher in case of Pusa 44 than short duration varieties which show its higher water requirement due to longer crop duration. Diesel usage for running diesel engine/ generator for irrigation was more than double in Pusa 44 than PR 121 while in PR 126, none of the sample farmers used diesel for irrigation purpose. The per hectare yield of paddy was 74.12 qtls for long duration variety Pusa 44 which was higher than short duration varieties PR 121 (69.87 qtls ha^{-1}) and PR 126 (67.77 qtls ha^{-1}). Thus, it can be inferred that though the productivity was comparatively lower in case of short duration varieties but these varieties require lesser quantity of inputs and saved irrigation water and time due to shorter crop period.

Number of irrigations applied to Pusa 44 variety was higher vis-à-vis PR 121 and PR 126 varieties. Consequently, farmers using submersible pump resulted in saving 16.42 and 21.50 per cent irrigation hours, respectively while irrigating PR 121 and PR 126 varieties as compared to Pusa-44 variety (Table 4). The, farmers using mono-block pumps saved 19.14 and 21.53 per cent irrigation hours in case of above cited varieties. This shows enormous saving of irrigation water while growing short duration paddy varieties and thus can play vital role in agricultural sustainability of the state.

Cost-return structure: The cost-return structure of different varieties of paddy showed that per hectare total variable cost (TVC) incurred was higher in case of Pusa 44 in comparison to PR 121 and PR 126 varieties (Table 5). Major components of variable cost are human labour and machine use in various

Table 3. Input-output status of different paddy varieties on sample farms, Punjab, 2018-19

Particulars	Pusa 44		PR 121		PR 126	
	Quantity	Value (Rs.)	Quantity	Value (Rs.)	Quantity	Value (Rs.)
Seed (Kg)	10.97	295	12.55	375	12.42	435
Fertilizer use (Kg)						
Urea	380	2287	305	1835	300	1795
Di-ammonium phosphate (D.A.P)	35	770	25	570	30	685
Zinc Sulphate ($ZnSO_4$)	12.5	762	6.57	442	10	555
Muriate of Potash (M.O.P)	—	—	3.03	182	3.47	262
Plant protection measures (Rs.)	—	4475	—	4107	—	3902
Human labour (Hrs)	327	14880	305	14122	285	13295
Irrigation (Hrs)	359	2400	306	1180	292	—
Value (Cost of diesel use)						
Combine harvesting + S.M.S (Hrs)	1.27	3757	1.35	4185	1.30	4160
Tractor use (Hrs)	12.77	9450	12.97	9243	11.95	8870
Main product (Qtl)	74.12	131187	69.87	123667	67.77	119967

crop operations. These together constitute about 70 to 75 per cent of the input cost incurred on the sample farms. Similarly, fertilizer usage and plant protection measures form about 20 per cent of the total variable cost. Although electricity supply to agricultural sector is free in Punjab, the major difference in cost incurred for irrigation was diesel used for running tube wells through diesel engine/ generator set which was about 6 per cent in Pusa 44 and 3 per cent was in PR 121 variety. Gross returns (GR) as well as returns over variable costs (ROVC) were higher in case of Pusa 44 vis-à-vis short duration varieties. But, higher water usage accompanied by fertilizer and plant protection expenses for raising long duration paddy variety is an immediate threat to Punjab agriculture for agricultural sustainability in the long run.

Constraints/problems: Garret's Rank showed that short crop period was the strength of short duration varieties PR 121 and PR 126 being 120 and 136 days, respectively as compared to long duration varieties (157 days). The, short cropping period gave ease to the farmers in terms of less irrigation requirement and lower cost of cultivation, hence ranked at II and III place. Pesticide usage being lower was ranked IV by the farmers. In spite of the fact that short duration varieties require low irrigation and input usage but at the same time the yield was slightly lower than long duration

varieties, hence ranked at V spot by the sampled farmers.

In case of long duration variety, the window of time for sowing wheat crop after paddy harvesting is short. So, long crop period was the major demerit reported by the farmers and hence ranked at first spot. Because of long crop period,

Table 6. Garret's rank for merits of short duration paddy varieties, Punjab, 2018-19

Merits	Short duration varieties (PR 121 & PR 126)	
	Mean score	Rank
Short crop period	6.70	I
Lower irrigation requirement	6.05	II
Low cost of cultivation	5.08	III
Lower use of pesticide	3.98	IV
Yield	3.55	V
Demerits	Long duration variety (Pusa 44)	
Long crop period	6.43	I
High cost of cultivation	6.03	II
High irrigation requirement	5.68	III
Difficult to manage paddy residue	3.78	IV
High use of pesticide/weedicide	3.18	V

Table 4. Variety-wise irrigation hours per hectare in Paddy on sample farms, Punjab, 2018-19

Particulars (Varieties & crop duration)	Submersible pump usage				Mono-block pump usage			
	No. of farmers	Average (H.P)	Irrigation (no.)	Hrs. ha ⁻¹	No. of farmers	Average(H.P)	Irrigation (no.)	Hrs. ha ⁻¹
Pusa-44 (157 days)	14	15	33	335	6	5	32	418
PR-121 (136 days)	11	14.5	28	280 (16.42)*	9	6	26	338 (19.14)*
PR-126 (120 days)	12	14	26	263 (21.50)*	8	6.5	25	328 (21.53)*

*Figures in brackets shows the relative difference in irrigation hours for PR-121, PR-126 vis-à-vis Pusa-44

Table 5. Cost-return structure of different varieties of paddy on sample farms, Punjab, 2018-19

Particulars	(Rs. ha ⁻¹)						
	Pusa 44	% Share in TVC	PR 121	% Share in TVC	PR 126	% Share in TVC	
Human labour	14880	37.24	14122	38.11	13295	38.29	
Machine use	13207	33.05	13427	36.23	13030	37.52	
Cost of seed	295	0.74	375	1.01	435	1.25	
Cost of fertilizer usage	3820	9.56	3030	8.18	3297	9.49	
Plant protection expenses	4475	11.20	4107	11.08	3902	11.24	
Irrigation charges(diesel use)	2400	6.01	1180	3.18	-	-	
Interest on variable cost @ 9% p.a. for half crop season	879	2.20	815	2.20	765	2.20	
Total variable cost (TVC)	39956	100.00	37056	100.00	34724	100.00	
Gross returns (GR)	131187	-	123667	-	119967	-	
Returns over variable cost (ROVC)	91231	-	86611	-	85243	-	

cost of cultivation and irrigation requirement becomes high hence ranked II and III, respectively. Managing paddy straw is a major issue in Punjab but straw produced by long duration variety is higher in quantity and weighs heavy which cause hindrance in its proper chopping for incorporation in soil. Therefore, difficult to manage paddy straw was ranked IV by the farmers. Pesticide usage to control various pests was ranked V as major demerit of the long duration variety on the sample farms.

CONCLUSIONS

This study presents the economic returns for growing major long and short duration paddy varieties in Punjab. It was found that long duration variety was more input intensive as compared to short duration varieties. On account of short duration and low biomass, these varieties save irrigation water and cost incurred on input usage is lower. In long duration variety, irrigation need is comparatively higher, fertilizer usage, pest control measures are more. Also, the window of time for sowing wheat after harvesting paddy is short hence; crop growing period is long which are major issues vis-à-vis short duration paddy varieties. Though the returns over variable costs were slightly lower on the farms growing short duration varieties, but the savings in terms of lesser ground water extraction and lower input usage is higher. Therefore, these short duration varieties fulfil the major three requisites i.e. water saving, low input cost and

short time span for crop establishment. Hence, to give paddy cultivation a sustainable pathway, the proportion of area under the short duration varieties should be increased in the state keeping in view the overall interest of Punjab in general and farming community in particular whose major share in income comes from agriculture.

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