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Resource Use Pattern and Efficiency of Non-Basmati Paddy Production in Punjab

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ABSTRACT

The study evaluated the resource-use pattern and efficiency in non-basmati paddy production in Punjab. The unit/farm level data collected under centrally sponsored scheme Comprehensive Scheme for Studying the Cost of Cultivation of Principal Crops in Punjab has been analyzed for this purpose. The total variable cost incurred on paddy cultivation showed an inverse relationship with the farm size as variable cost decreased with the increase in farm size category with Rs 49033/-ha on small, Rs 42107/-ha on medium and Rs 38989/-ha on large farms. The estimated returns in percentage terms turn out to be 66.25 per cent over and above the total variable cost of paddy cultivation on overall farms. Returns over variable cost had direct relation with farm size, both in percentage as well as in absolute terms. The results of Cobb-Douglas production function revealed that human labour, irrigation, farm yard manure and plant protection were found to be significantly affecting productivity in paddy cultivation in the State.

Key Words: Allocative efficiency, Crop production, Efficiency, Production function, Profitability.

INTRODUCTION

Punjab holds place of pride among the Indian States for its commendable strides in agricultural development. The state has witnessed tremendous increase in the agricultural production during the green revolution period, mainly due to healthy mix of institutional and technological factors. Agrarian economy, consolidation of landholdings, reclamation of new agricultural lands, development of irrigation network, use of biochemical inputs comprising high yielding variety seeds, chemical fertilizers, insecticides and mechanical inputs, development of credit and marketing infrastructure along with effective implementation of agricultural price policy for wheat and paddy played significant role in agriculture and rural development of state (Grover *et al,* 2017). Consequently, the Punjab state comprising only 1.5 per cent of the total geographical area of country now contributes 13-14 per cent towards the total food grain production of the country. State has earned a name of granary of India and contributed about 22 to 33 per cent of rice and 33 to 75 per cent of wheat to the central pool during the past two decades (Anonymous, 2019).

However, Punjab agriculture now days faces some serious concerns. Traditionally, Punjab has been predominantly a wheat growing area. Rice stormed in the cropping pattern since mid 1970's as a commercial crop and made a major impact on the Punjab agriculture (Singh, 2021). Despite being unsuitable to the ecological health of the state the role pf paddy in improving economic health of farmers has been duly reported (Singh *et al*, 2022). Area, production and yield of paddy during 2019-20 was 3141 thousand hectares, 18912 thousand tonnes and 6021 kg/ha respectively (Anonymous, 2020). The wheat-rice dominated cropping pattern is causing a serious damage to the state's natural resource base. Rice in particular, a water-intensive crop is blamed for water-table depletion in tube-well irrigated areas and water-logging in canal irrigated areas (Kalia and Dhindsa, 2021; Singh, 2021). Increased electricity consumption on account of paddy cultivation is also putting serious strain on

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State Exchequer to meet the cost of free power supply to the farm sector. Productivity level of paddy has also been plateaued and the farmers are using higher quantities of modern inputs in order to maintain the productivity level. Decrease in area under non-basmati paddy has been suggested as a corrective measure by various expert committees from time to time. In this backdrop, the present study has been aimed to examine the resource use pattern and efficiency of non-basmati paddy production in Punjab

MATERIALS AND METHODS

To achieve the objectives of study the farm level data of paddy cultivation collected under centrally sponsored scheme Comprehensive Scheme for Studying the Cost of Cultivation of Principal Crops in Punjab for agricultural year 2018-19 has been analyzed. The sampling design for this scheme being run in the Department of Economics and Sociology, PAU, Ludhiana consists of the three-stage stratified random sampling technique. For the purpose of providing representation to all the areas in the state, the state has been divided into homogenous agro-climatic zones depending on cropping patterns, soil type, rainfall, irrigation etc. The first stage of the sampling units is the tehsils, the second stage is cluster of villages and the third and final stage of the sampling units is the operational holding within a cluster of villages. The sample size covered under the scheme in state is 300 farm holdings distributed among 30 tehsils representing the above said agro climatic regions *viz.,* 12, 8 and 10 from zone-I, zone-II and zone-III, respectively. From each cluster, a sample of 10 operational holdings, two each from the five size classes viz. category I (<1 ha), category II (1-2 ha), category III (2-4 ha), category IV (4-6 ha) and category V (>6 ha) were selected. Cost accounting method has been adopted for collection of household data, which is in very detailed form covering all the inputs and outputs of all the crops grown as well as other agriculture related activities along with income from other sources on the selected holding. To know the regional effect in present study, the agro-climatic zones were reframed according to the classification provided by National Remote Sensing Centre. Five categories of farmers has been re-arranged into three farm size classes viz. small (<2 ha), medium (2-6 ha) and large (>6 ha). Out of total sample of 300 farm households, paddy crop was cultivated by 248 farm households and the same has been analyzed to achieve the objectives of study.

The extent of use of inputs affects the level of paddy production and profitability has been worked out. Equally important, the cost structure indicated by the share of various input factors in the cost of cultivation paddy has also been evaluated. For determining the profitability of paddy, the cost structure of various size categories of farms along with total variable costs, cost A1, cost A2 and cost A2+FL has been worked out. The input prices were reported according to the information provided by the farm households.

To study the resource productivity and resource use efficiency production function analysis was used. Based on the value of coefficient of multiple determination ($R^{2)}$ and sign and significance of the coefficients following Cobb-Douglas production function has been finalized to identify the determinants of paddy productivity.

$$\ln Y_i = \ln\beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots\ldots\ldots\beta_i \ln X_i + \ln u_i \quad \text{(Where i = 1,2,3}\ldots\ldots\text{n)}$$

The variables defined in the model are as follows

Y = Main product in terms of paddy (Qtls/ha)

ln = Natural logarithm

β_o = Constant

β_i = Estimated coefficient

u_i = Random error term

X1 = Crop area (Ha)

X2 = Human labour (Man hours/ha)

X3 = Tractor use (Hours/ha)

X4 = Combine use (Hours/ha)

X5 = Irrigation machine use (Hours/ha)

X6 = Seed (Kg/ha)

X7 = Nitrogen (Nutrient Kg/ha)

X8 = Phosphorous (Nutrient Kg/ha)

X9 = Potash (Nutrient Kg/ha)

X10 = Farm yard manure (Qtls/ha)

X11 = Other fertilizers (Kg/ha)

X12 = Insecticides/Pesticides (Rs/ha)

Z1 = Dummy variable for Zone I

Z2 = Dummy variable for Zone III

C2 = Dummy variable for medium farmers

C3 = Dummy variable for large farmers

Input use efficiency (Allocative Efficiency)

Efficiency is relative and can be defined in terms of producing a higher amount of output, given a set of inputs; or producing a given level of output using a lower level of inputs; or a combination of both. The allocative efficiency (AE) of each input was calculated from the β s obtained from multiple regressions as following:

$AE=MVP_i/MFC_i$

Where,

MVP_i= Marginal value productivity of the i^{th} input

MFC_i= Marginal factor cost of the i^{th} input

Where,

β_i = Estimated coefficient or elasticity of the i^{th} input

= Geometric mean of output

= Geometric mean of i^{th} input

P_y = Price of output

RESULTS AND DISCUSSIONS

Resource use pattern

This section provides the information regarding the resource use pattern in the cultivation of paddy crop in Punjab. Paddy is the most important kharif crop of the state and accounted for 37.88 per cent of the gross cropped area on the sample households. The resource use pattern in paddy cultivation during the year 2018-19 has been presented in Table 1. On overall farms, quantity of seedling used in transplanting of paddy was 227.76 kg/ha. In case of fertilizers the quantity of nitrogen applied was 153.10 kg/ha which was significantly higher than the recommended dose of 105 kg/ha (PAU, 2021). Higher use of N fertilization in rice crops in Punjab has also been reported by other studies such as Sharma *et al* (2020). The quantity of phosphorous, potash, other fertilizers & micronutrients and plant protection chemicals in paddy cultivation worked out to be 11.70, 4.36, 17.47 and 17.82 kg/ha, respectively. The application of farm yard manure was observed to the tune of 13.22 q/ha. A look into the farm size category-wise application of these material inputs revealed that the quantitative use of farm yard manure, other fertilizers & micronutrients and plant protection chemicals had a clear inverse relationship with farm size *i.e.,* per hectare use of these inputs declined with the increase in the farm size. However, no clear relationship is observed in the size of farm and the per hectare use of seedlings, nitrogen, phosphorus and potash.

On the overall farms, the human labour requirement was 321.41 man hours/ha which constituted about 36 and 64 per cent of family and hired labour respectively. The reason for higher hired labour use is due to the fact that, the labour intensive operation of paddy transplanting is almost entirely done by the hired labour in Punjab. Further, per hectare use of total human labour hours had a clear inverse relationship with the farm size. Similar results on the trends of human labour use in paddy cultivation were reported by Bhoi (2017). The use of animal labour for transport of inputs at farms was negligible with 0.21 hr/ha on overall farms.

Table 1. Resource use pattern in paddy cultivation, Punjab, 2018-19 (Per hectare)

Sr. No.	Particulars	Small	Medium	Large	Overall
A	Inputs				
1	Seedlings (Kg)	226.22	225.12	230.49	227.76
2	Fertilizers and manures				
	Nitrogen (Kg)	152.33	149.11	156.90	153.10
	Phosphorous (Kg)	14.20	8.33	14.22	11.70
	Potash (Kg)	4.05	2.76	5.89	4.36
	Other fertilizers and micronutrients (Kg)	31.61	20.77	11.36	17.47
	Farm yard manure (q)	16.66	13.39	12.31	13.22
3	Plant protection chemicals (Kg)	20.92	17.03	17.86	17.82
4	Human labour (Man hours)	360.21	331.61	303.59	321.41
	i) Family	185.97	128.35	86.82	114.80
	ii) Hired	174.24	203.26	216.77	206.61
5	Animal labour (hr)	0.39	0.32	0.07	0.21
6	Tractor (Hours)	12.01	12.37	11.89	12.11
	i) Owned	6.58	11.01	10.81	10.46
	ii) Hired	5.43	1.36	1.08	1.65
7	Combine harvester (hr)	1.75	1.75	1.70	1.73
	i) Owned	0.04	0.04	0.09	0.06
	ii) Hired	1.71	1.71	1.61	1.66
8	Power sprayer (hr)	2.18	3.13	3.07	3.00
	i) Owned	0.65	1.66	1.69	1.57
	ii) Hired	1.53	1.47	1.38	1.43
9	Irrigation machinery (hr)	231.95	213.28	189.54	204.07
B	Output				
1	Main product (q)	68.67	68.77	69.83	68.97
2	By-product (q)	6.72	5.28	5.63	5.87

Land preparation is an important determinant of paddy productivity (Mehta *et al*, 2021) and tractor use is highly crucial in this particular activity. The tractor use in paddy cultivation in the study area was 12.11 hr/ha with 10.46 owned and 1.65 hired tractor. The use of owned tractor increased with increase in farm size while that of hired decreased with the increase in farm size. This was due to the reason that with increase in farm size the ownership of this important machinery increases and almost all large farms owned the tractor while a significant proportion of the small farmers have to hire this machinery for various agronomic practices on farms. Combine harvester was usually used on hired basis and out of its total 1.73 hr/ha usage nearly 96 per cent (1.66 hr) constituted the hired ones. Use of power sprayer for spraying of various chemicals in paddy cultivation was 3 hr/ha. Paddy being known as water guzzling crop, pumping of underground water plays a very crucial role in its cultivation and thus, use of irrigation machinery was 204.07 hr/ha. Further, per hectare use of irrigation machinery had a clear inverse relationship with the farm size, the reason being that area coverage per pump was less

Table 2. Cost structure of paddy crop, Punjab, 2018-19 (Rs/hectare)

Sr. No.	Particular	Small	Medium	Large	Overall
1	Seed	1622.42 (3.31)	1626.46 (3.86)	1581.29 (4.06)	1604.85 (3.88)
2	Fertilizers and manures	4281.72 (8.73)	3520.36 (8.36)	3777.08 (9.69)	3719.25 (8.99)
	NPK	2670.09 (5.45)	2270.85 (5.39)	2777.58 (7.12)	2549.72 (6.16)
	Other fertilizers and micronutrients	1005.33 (2.05)	854.81 (2.03)	764.29 (1.96)	827.85 (2.00)
	Farm yard manure	606.3 (1.24)	394.70 (0.94)	235.21 (0.60)	341.67 (0.83)
3	Plant protection chemicals	4539.39 (9.26)	4757.13 (11.30)	5167.55 (13.25)	4927.25 (11.91)
4	Human labour	17229.56 (35.14)	16439.44 (39.04)	14484.99 (37.15)	15535.83 (37.56)
	i) Family	8538.79 (17.42)	6261.60 (14.87)	4046.07 (10.38)	5414.27 (13.08)
	ii) Hired	8690.77 (17.72)	10177.84 (24.17)	10438.91 (26.77)	10121.55 (24.47)
5	Animal labour	46.66 (0.10)	38.94 (0.09)	8.78 (0.02)	25.59 (0.06)
6	Machine labour	11270.60 (22.99)	9895.59 (23.50)	9285.83 (23.82)	9789.93 (23.67)
	i) Owned	3740.14 (7.63)	5637.76 (13.39)	5240.94 (13.44)	5294.84 (12.80)
	ii) Hired	7530.46 (15.36)	4257.83 (10.11)	4044.89 (10.37)	4495.09 (10.87)
7	Irrigation	8523.94 (17.38)	4531.03 (10.76)	3488.42 (8.95)	4490.97 (10.86)
8	Miscellaneous expenses	33.33 (0.07)	22.43 (0.05)	13.54 (0.03)	19.38 (0.05)
9	Interest on working capital	1485.86 (3.03)	1275.98 (3.03)	1181.48 (3.03)	1253.53 (3.03)
	Total variable cost	49033.48 (100.00)	42107.37 (100.00)	38988.97 (100.00)	41366.57 (100.00)
	Cost A1	41199.70	36634.31	35561.00	36668.05
	Rental value of leased-in land	3917.00	5098.00	6288.00	5535.00
	Cost A2	45116.70	41732.31	41849.00	42203.05
	Cost A2 + FL	53655.49	47993.91	45895.08	47617.32

Table 3. Returns of paddy crop cultivation, Punjab, 2018-19 (Rs/hectare)

Particulars	Small	Medium	Large	Overall
Main-product	121518	121696	123656	122068
By-product	676	413	442	511
Gross returns	122194	122108	124098	122580
Returns over variable cost	73161	80001	85109	81213
Percent returns over variable cost	59.87	65.52	68.58	66.25
Returns over cost A2+FL	68539	74114	78203	74962
Percent returns over cost A2+FL	56.09	60.70	63.02	61.15

on small farms as compared to medium and large farms. Paddy productivity on overall farms was 68.97 q/ha and it did not vary much among small and medium farm size categories both of which had marginally lower yield in comparison to their large counterpart.

Structure of cost of cultivation

The cost structure of paddy cultivation on sample households in Punjab has been displayed in Table 2. Human labour expenditure at Rs 15,536/ha and 37.56 per cent share in total variable cost was the major component of the variable costs and nearly 65 per cent (Rs 10,122/ha) of total human labour cost was on account of the hired component of it. As most of the operations in paddy cultivation (except for transplanting) are mechanized, on overall farms, the machine charges accounted for about 23.67 per cent (Rs 9,790/ha) of total variable cost of paddy cultivation (Rs 41,367/ha) and out of total machine expenditure 54 per cent (Rs 5,295/ha) was constituted by the owned machinery while rest (Rs 4,495/ha) being contributed by the hired machinery. The other components of cost viz. plant protection chemicals (Rs 4,927/ha), irrigation charges (Rs 4,491/ha) and NPK and other fertilizers (Rs 3,378/ha) accounted for 11.91, 10.86 and 8.16 per cent of the total variable cost of cultivation of paddy, respectively. In terms of variable cost, cost A1, cost A2 and cost A2+Fl, of paddy cultivation on overall farms worked out to be Rs 41367/-, 36668/-, 42203/- and 47617/- ha, respectively.

Figures in parentheses are percentage to total variable cost

The farm size category-wise analysis represented that cost on plant protection chemicals showed direct relation with the farm size both in absolute and percentage terms. While overall machinery charges revealed direct relationship with the farm size in percentage terms; component of hired machinery do not revealed any relationship in this regard. Total human labour charges, though in absolute terms had a clear inverse relationship with the farm size, its share in total variable cost did not vary much on various farm size categories of farms. However, component-wise expenditure on human labour *i.e.,* the family labour showed decreasing trend while the hired labour increased with the increase in farm size both in absolute as well as in percentage terms. Similarly, the expenditure on farm yard manure, irrigation charges and other fertilizers & micronutrients decreased with the increase in size of farm both in absolute and percentage terms. The expenditure on account of NPK fertilizers did not show any clear trend in relation to the farm size. The total variable cost incurred on paddy cultivation on small, medium and large farms was Rs 49,033/-, Rs 42,107/- and Rs 38,989/-ha, respectively. It showed a clear inverse relationship with the farm size as variable cost decreased with the increase in farm size category. Similarly, cost A1 and cost A2+FL of paddy cultivation had shown a strong inverse relationship with the farm size categories. Cost A2 was also observed to be significantly higher on

Table 4. The coefficients of production function (Cobb-Douglas) for paddy crop, Punjab, 2018-19

Variable	Coefficient	Standard error
Intercept	2.374***	0.199
Area under paddy (ha)	-0.027*	0.015
Human labour (Man hours/ha)	-0.286***	0.043
Tractor use (hr/ha)	0.022	0.023
Irrigation machine (hr/ha)	0.062***	0.023
Seedlings (Rs/ha)	-0.047	0.044
Nitrogen (Nutrient Kg/ha)	-0.039	0.037
Farm yard manure (q/ha)	0.006***	0.002
Plant protection chemicals (Rs/ha)	0.075***	0.012
Z1 (Dummy for zone I)	-0.043***	0.009
Z3 (Dummy for zone III)	0.006	0.007
C2 (Dummy for medium category)	0.003	0.010
C3 (Dummy for large category)	0.011	0.015
R^2	0.47	
Adjusted R^2	0.44	
Number of observations	248	

Note: ***,** and * denotes significance level at 1 per cent, 5 per cent and 10 per cent, respectively

small farms as compared to their medium and large size counterparts. The explanation of this point lies in relatively higher costs on smaller size farms particularly on account of higher human labour use and irrigation expenses.

Returns

The information regarding returns from paddy cultivation depicted in Table 3 revealed that the value of the main product in paddy turns out to be Rs 1,22,068/-ha on the overall farms. Value of main product was relatively high in case of large farms due to slightly higher yield on these farms in comparison to their small and medium counterparts.

The by-product of paddy being not palatable for livestock on account of high silica content and low calorific value is generally not harvested (Anonymous, 2018). The gross returns in paddy came out to be Rs 1,22,194/- on small farms, Rs 1,22,108/- on medium and Rs 1,24,098/- on large farms and for the overall farms it was Rs 1,22,580/-ha.

The estimated returns over variable cost and cost A2+ FL at Rs 81,213/- and Rs 74,962/-ha turn out to be 66.25 and 61.15 per cent over and above the respective costs in case of overall farms. Due to inverse relationship of per hectare costs and farm size, category-wise returns over costs, both in absolute as well as in percentage terms showed the direct relationship with farm size *i.e,.* per hectare returns over variable cost and cost A2+FL of paddy cultivation increased with the increase in the farm size.

Production function analysis of major crops in Punjab

The cost-return analysis provides only general indication of cost structure and provides only the basic insight into the sufficient light on the efficiency of resource allocation. However, one of the main objectives in production activity is to coordinate and utilize the resources in optimal way to maximize the returns/yields. Thus, production function analysis was used to determine the functional relationship of

Table 5. Resource use efficiency (Allocative efficiency) in production of crops (individual and overall), Punjab, 2018-19

Variable	Coefficient	MVP	MFC	Allocative Efficiency MVP/MFC	Remarks
Human labour (Man hours/ha)	-0.286	-101.00	47.16	-2.14	Over-utilization
Irrigation machine (hr/ha)	0.062	35.51	58.85	0.60	Over-utilization
Farm yard manure (q/ha)	0.006	10.62	19.55	0.54	Over-utilization
Plant protection chemicals (Rs/ha)	0.075	2.20	1	2.20	Under-utilization

NS: Non-significant

various inputs used with the output level of paddy. The Cobb-Douglas production function was used to estimate the elasticities of paddy productivity with respect to different inputs and the relevant data in respect of the coefficients of production function (Cobb-Douglas) for paddy crop is presented in Table 4. The value of coefficient of multiple determination (R^2) was 0.47 hence, the selected production function collectively explained about 47 per cent of the variation in the yield of paddy. The coefficient of human labour was negative and significant at 1 per cent level of significance which indicated that there was excessive use of this input in paddy production. The coefficient for irrigation machinery use, farm yard manure and plant protection chemicals were positive and significant at 1 per cent level of significance with magnitude of 0.062, 0.006 and 0.075, respectively. This indicated that with one per cent increase in the use of these inputs the yield of paddy would have increased by 0.062, 0.006 and 0.075 per cent, respectively. The response of paddy productivity to land area under paddy was negative and significant at 5 per cent level of significance. The coefficient of tractor use, seedlings and nitrogen were found to be non-significant. Similar results for fertilizers in rice cultivation were observed by Rao *et al* (2003) while measuring the technical efficiency.

The coefficient of dummy variable for zone I was negative and significant at one per cent level of significance. This indicated that due to regional differences the paddy productivity in zone I was less as compared to zone II. The non significant dummy variables for the farm size categories indicated towards neutrality in farm size and paddy productivity relation.

Resource use efficiency

The resource use efficiency in paddy production has been presented in the Table 5. The use level of different resources which played significant role in determination of paddy productivity in State viz. human labour, irrigation machine use, farm yard manure and plant protection chemicals was evaluated through working out efficiency ratios. The ratio of MVP and MFC in human labour, irrigation and farm yard manure was -2.14, 0.60 and 0.54 which were significantly less than unity indicated towards over-utilization of these inputs in paddy crop and the returns would have increased by reduction of expenditure on these resources. On the other hand the ratio with respect to plant protection chemicals was significantly above unity, indicating the under-utilization of this resource. The results showed that with one rupee additional expenditure on this resource returns would have appreciated by Rs 2.20.

CONCLUSION

In paddy the key resources were human labour, machine use and plant protection chemicals that accounted for about 73 per cent of the total variable cost (Rs 41,367/ha). Variable cost of paddy cultivation had shown a strong inverse relationship with the farm size categories. The gross returns

in paddy came out to be Rs. 1,22,580/ha and the estimated returns over variable cost and cost A2+ FL were Rs 81,213/- (66.25%) and Rs 74,962/- (61.15%) per hectare. The profitability had direct relation with the increase in farm size. The production function analysis revealed that human labour use was over-utilized in paddy. Irrigation was over-utilized in paddy. Plant protection expenditure in paddy was observed to be under-used. The technological and policy interventions aimed at economising the use of human labour and machinery will have a significant impact to arrest the escalating cost of cultivation of crops in state. Determining the optimal combinations of human labour and type/size of machinery and its promotion is the need of hour. The results suggest the need for policies aimed to bring down the cultivation costs on smaller size farms. The government should develop the PACS as Agro-Service Centres for such services and take steps like fixing the reasonable custom hiring rates along with priority availability for small farmers. This would be helpful to small farmers in lowering their machinery and labour costs and increasing the net incomes. The irrational use of important resources in paddy cultivation identified by the study needs to be addressed seriously. This calls for strengthening of the extension infrastructure to sanitize the farmers to make the judicious use of vital resources and bring down the cost of cultivation. Policy of subsidization of vital inputs (like irrigation) needs to be revisited in order to promote the optimal utilization.

REFERENCES

Anonymous (2018). *Action plan for biomass management*. Confederation of Indian Industry (CII), New Delhi, India.

Anonymous (2019). *Agricultural Statistics at a Glance.* Department of Agriculture, Cooperation and Farmers Welfare, Government of India.

Anonymous (2020). *Statistical Abstract of Punjab*. Economic and Statistical Organization, Punjab.

PAU [Punjab Agricultural University] (2021). *Package of Practices Recommendations, (Vol 39),* Punjab Agricultural University.

Bhoi P B (2017). *Dynamics of input use efficiency and profitability in Punjab Agriculture*. Ph.D (Ag Economics) Dissertation. Punjab Agricultural University, Ludhiana, 161p.

Grover D K, Singh J M, Kaur A and Kumar S (2017). *State Agricultural Profile-Punjab*. Agro Economic Research Centre, Punjab Agricultural University, Ludhiana.

Kalia P and Dhindsa P K (2021). Factors effecting shift from paddy to maize cultivation in Punjab. *Indian J Econ Dev* **17** (1): 170-175.

Mehta B K, Kumari M and Jha A K (2021). Impact of field preparation equipment on productivity of rice. *J Krishi Vigyan* **9** (2):82-85.

Rao, C A R, Chowdry K R, Reddy Y V R and Rao G V K (2003). Measuring and explaining technical efficiency in crop production in Andhra Pradesh. *Indian J Agric Econ* **58** (4):768-780.

Sharma K, Dhaliwal N S and Tiwari D (2020). Adoption status of improved rice varieties and fertilizer use in Sri Muktsar Sahib District of Punjab. *J Krishi Vigyan* **8** (2): 1-7

Singh K (2021). Agricultural sustainability in Punjab: Issues and challenges. *Indian J Econ Dev* **17** (1):136-142.

Singh J, Kingra H S, Saini R, Kaur M and Mavi H K (2022). Economic status of farming in border districts of Punjab. *J Krishi Vigyan* **10** (2):68-77

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