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Resource Use Efficiency (RUE) of Lentil Cultivation in Sultanpur District of Uttar Pradesh

Divyanshi Mishra, K. K. Singh, Harshit Mishra, Aditya Bhooshan Srivastava

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ABSTRACT

A study was carried out to estimate and analyze the profitability and resource use efficiency of lentil production in Sultanpur district of Uttar Pradesh. Using a pre-tested questionnaire, primary data and information were collected from 100 lentil producing farmers, categorized in 68 marginal, 20 small and 12 medium farmers were chosen from the five villages in the Kurebhar block of the Sultanpur district. The study revealed that the B:C ratio in lentil production was higher in medium farmer (1.19) due to increased production. Return to scale was found to be increasing in lentil production and Marginal Value Product were more than one in all the cases except few which indicate the further chance of investment on variable inputs to get the additional income. To get the maximum profit from lentil production using improved seed, input use in land preparation, threshing, and post-harvest should be increased while decreasing the amount of other inputs.

Divyanshi Mishra[1], K.K. Singh[2], Harshit Mishra[3]*, Aditya Bhooshan Srivastava[4]
[1]Young Professional-II, [2]Assistant Professor, [3,4]Ph.D. Research Scholar
Department of Agricultural Economics, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya UP 224229, India

Email: wehars@gmail.com
*Corresponding author

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INTRODUCTION

India has long promoted a cereal-based diet centered on basic staples like rice and wheat because the country has a sizable population of the poor and malnourished. On the other hand, dietary practices are evolving today. Researchers, policymakers, and health activists are looking into ways to tackle malnutrition in the nation as well as hunger. Pulses, which are the dried, edible seeds of legumes, are growing in popularity as people pay more attention to nutrition rather than calories. Three types of hunger exist : Calorie inadequacy, protein malnutrition and micronutrient malnutrition (Panda *et al.* 2019).

One of the most important food crops in the world is the pulse and India is the country where they generate the highest revenue. The most often cultivated pulses include chickpeas, pigeon peas, moong beans, black beans, lentils, peas, and a range of other legumes (Sarkar *et al.* 2020). India produces the majority of the world's pulses, making up 25% of the total production. With 27% of the world's consumption, it also consumes the most pulses. According to the FAO, dry beans made up 32.98% of the 92.28 million tonnes of total pulse production in 2018. Chickpeas made up 18.63%, peas 13.53%, cowpeas 7.83%, lentils 6.86% and pigeon peas 6.45% (Srivastava *et al*. 2010).

Despite being the highest producer of pulses in the world (23020 tonnes in 2019), India must import

3 to 5 million tonnes of pulses annually to meet domestic demand, making it the world's largest pulse importer (15% of worldwide imports) (Suresh and Reddy 2016). Lentil is the third most significant crop grown for pulses, behind gram and arhar.

One of the earliest crops to be domesticated and grown by humans is believed to be lentils. The vegetarian population of the world continues to value this crop similarly. Global production of lentils exceeded 5.0 million tonnes in 2014. Lentil is India's second most popular *rabi* pulse, behind chickpea. 90% of the nation's total lentil production in 2017–18, according to the Indian government was produced in Madhya Pradesh (45.09%), Uttar Pradesh (29.69%), Bihar (9.47%) and West Bengal (6.59%). Lentils were previously produced in large quantities by India, but Canada has lately surpassed India to occupy the top spot. It has been claimed that there is potential for growing lentil area during the *rabi* season, as the crop has a lower cost per hectare and a greater net return than competitive crops such as gram and mustard when water is scarce and resources are few. Furthermore, the lentil-based cropping system is lucrative and has a very high yield, making it suited for largely untapped rice-fallows in water-stressed areas (Ahmad *et al.*2018).

Lentil (*Lens culinaris* L.) is an edible pulse. It is known by at least 30 common names in various parts of the world viz., Massour dal, Mangu/Margu, Masura, Renuka, Mangalaya or split peas and considered an important source of protein (Guntukula 2018). Cultivated lentil, an annual crop has been grown as an important food source for over 8000 years. It comes in two varieties, i.e., macrosperma (with large seeds and little pigmentation) and microsperma (with small seeds pigmentation). The comparative economics of winter season crops were worked out taking net returns into consideration. It was observed that the cultivation of lentil is more profitable than other crops under rain-fed conditions (Yadav *et al*. 2007).

Mostly consumed as dried seeds, lentil is an essential human food that is rich in protein, carbs, vitamins, minerals, and other nutrients. Nutritional studies show that lentil is an excellent feed for cattle. Husk, dried leaves, stems, fruit walls, and bran can all be fed to livestock. Lentil residue is composed of about 10.2% moisture, 1.8% fat, 4.4% protein, 50% carbohydrate, 21.4% fiber and 12.2% bran (Kaur and Gupta 2018).

Sultanpur district enjoys sufficient area under lentil crop. No scientific study has been so far conducted in this district. Lentil is an important crop of this district. This crop is helpful in doubling the income of the farmers of the study area. Seeing the above facts under due consideration, this paper has been specifically undertaken with following specific objectives :

To work out cost of cultivation and various profit measure of lentil production on sample farms and

To work out resource use efficiency of lentil on sample farms.

MATERIALS AND METHODS

Data collection

This present study of resource use efficiency has made extensive use of primary data. The primary data were collected from selected farmers through personal interview by survey method using pretested interview schedules. The population sample was drawn using a multi-stage stratified random sampling technique. The study was conducted in the year 2021-22 and confined to Sultanpur district of Uttar Pradesh. The Sultanpur district comprises fourteen blocks. Out of these 14 blocks Kurebhar block was selected purposively for the study having highest area under lentil. Five villages from Kurebhar block were selected randomly. The farmers were category into three size groups based on their size of holdings viz., marginal (up to 1 ha), small (1 to 2 ha) and medium (2 to 4 ha). Total 100 respondents (i.e., 68 marginal, 20 small and 12 medium) were selected randomly through proportionate allocation to the population for detail investigation.

Cost concept

Cost A_1: This cost includes actual expenditure incurred in cash and kind.

Table 1. Average size of holding on different size of sample farms.

Sl. No.	Size group of farms	No. of farmers	Net cultivated area (ha)	Average size of holding
1.	Marginal	68	27.34 (29.11)	**0.402**
2.	Small	20	30.95 (32.95)	**1.547**
3.	Medium	12	35.63 (37.93)	**2.969**
	Grand total	100	93.92 (100.00)	**0.9392**

1. Value of hired human labor and machinery labor.
2. Value of seed (both forms produced and purchased).
3. Value of manure (owned and purchased).
4. Value of insecticides, pesticides and chemical fertilizer.
5. Deprecation on implements, farm machinery and farm buildings.
6. Irrigation charges.
7. Land revenue, and other taxes.
8. Interest on working capital.
9. Miscellaneous expenses.

Cost A_2: Cost A_1 + rent paid for leased in land.
Cost B_1: Cost A_2 + interest on value of owned fixed capital assets (including land).
Cost B_2: Cost B_1 + rental value of owned land.
Cost C_1: Cost B_1 + imputed value of family labor.
Cost C_2: Cost B_2 + imputed value of family labor.
Cost C_3: Cost C_2 + 10 % of C_2 (managerial cost).

Measures of farm profit

Gross income: Yield in quintal × Price per tonne
Net income: Gross Income – Cost C
Farm business income: Gross Income - Cost A_2 or Net income + imputed value of family labor
Family labor income: Gross income - Cost C
Farm investment income: Net income + Rental value of owned land+ Interest on fixed capital
Benefit-cost ratio: Cost C / Gross income

Regression analysis

A production function analysis was conducted to assess the productivity and effectiveness of several sample farms' resources. To investigate the cost-benefit relationship and agricultural productivity, multiple regression analysis was used. Various pro-

Table 2. Cropping pattern under different size group of sample farms (ha).

Sl. No.	Crop grown under different seasons	Size group of farms: Marginal	Small	Medium	Overall average
A.	***Kharif***	**0.40 (46.51)**	**1.52 (46.91)**	**2.59 (43.17)**	**0.89 (45.41)**
1	Paddy	0.18 (20.93)	0.68 (20.99)	1.15 (19.17)	0.40 (20.30)
2	Pigeon pea	0.05 (5.81)	0.17 (5.25)	0.28 (4.67)	0.10 (5.20)
3	Maize	0.05 (5.81)	0.16 (4.94)	0.25 (4.17)	0.10 (4.92)
4	Vegetables	0.04 (4.65)	0.15 (4.63)	0.30 (5.00)	0.09 (4.77)
5	Sugarcane	0.03 (3.49)	0.12 (3.70)	0.19 (3.17)	0.07 (3.44)
6	Urd	0.02 (2.33)	0.10 (3.09)	0.17 (2.83)	0.05 (2.77)
7	Moong	0.02 (2.33)	0.09 (2.78)	0.15 (2.50)	0.05 (2.54)
8	Bajra	0.01 (1.16)	0.05 (1.54)	0.10 (1.67)	0.03 (1.47)
B.	***Rabi***	**0.32 (37.21)**	**1.23 (37.96)**	**2.12 (35.33)**	**0.72 (36.77)**
1	Wheat	0.17 (19.77)	0.66 (20.37)	1.11 (18.50)	0.38 (19.50)
2	Lentil	0.09 (10.47)	0.38 (11.73)	0.69 (11.50)	0.22 (11.27)
3	Mustard	0.03 (3.49)	0.12 (3.70)	0.18 (3.00)	0.07 (3.38)
4	Potato	0.02 (2.33)	0.04 (1.23)	0.08 (1.33)	0.03 (1.60)
5	Pea	0.01 (1.16)	0.03 (0.93)	0.06 (1.00)	0.02 (1.02)
C.	***Zaid***	**0.14 (16.28)**	**0.49 (15.12)**	**1.29 (21.50)**	**0.35 (17.82)**
1	Okra	0.05 (5.81)	0.15 (4.63)	0.46 (7.67)	0.12 (6.10)
2	Mentha	0.04 (4.65)	0.13 (4.01)	0.39 (6.50)	0.10 (5.12)
3	Cucumber	0.03 (3.49)	0.10 (3.09)	0.19 (3.17)	0.06 (3.24)
4	Bitter gourd	0.01 (1.16)	0.08 (2.47)	0.13 (2.17)	0.04 (1.97)
5	Chari	0.01 (1.16)	0.03 (0.93)	0.12 (2.00)	0.03 (1.39)
Grand total (A+B+C)		**0.86 (100.00)**	**3.24 (100.00)**	**6.00 (100.00)**	**1.95 (100.00)**

duction function types were investigated, but only the Cobb-Douglas production function was shown to be the greatest fit for analysis (Chavan *et al.* 2020).

The mathematical form of Cobb- Douglas production function is given below :

$$Y = a\, X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} \ldots\ldots X_n^{bn} e^{\mu}$$

Where,
Y = Per hectare output (Rs/ha)
X_1 = Human labor (Rs/ha)
X_2 = Machinery charges (Rs/ha)
X_3 = Seed (Rs/ha)
X_4 = Manure and fertilizers (Rs/ha)
X_5 = Irrigation charges (Rs/ha)

b*i* (*i* = 1, 2, 3, 4, 5) = Elasticity coefficient of the respective input variables
e = Error term or disturbance term
μ = Random variables

The value of the constant (a) and coefficient (bi) in respect of the independent variables in the function have been estimated by using the method of least squares.

Estimation of marginal value product

The marginal value product of input was estimated by taking partial derivatives of returns with respect to the input concerned, at the geometric mean level of inputs (Gavali *et al.* 2015 and Kumar *et al.* 2021).

$$(MVP)\ b_i = \frac{b_i y}{x_i y}$$

Where,

Table 3. Cropping Intensity of different size group of farms.

Sl. No.	Size group of farms	No. of far-mers	Net culti-vated area (ha)	Gross crop-ped area (ha)	Cropping intensity (%)
1	Marginal	68	0.40	0.86	**215.00**
2	Small	20	1.55	3.24	**209.03**
3	Medium	12	2.97	6.00	**202.02**
	Over all	100	0.94	1.95	**207.93**

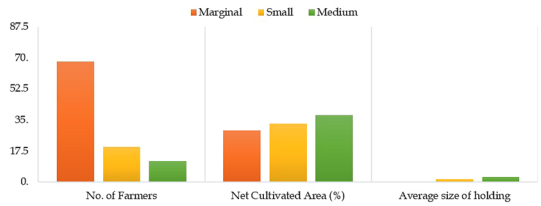

Fig. 1. Average size of holding on different size of sample farms.

bi = Production elasticity with respect to Xi

y = Geometric mean of y (output values in Rs/ha)

Xi= Geometric mean of Xi

(MVP) = Marginal value product of i^{th} impact

RESULTS AND DISCUSSION

Average holding size on sample farms

The description of land holding under different size group of sample farms are given in Table 1 and indicated in Fig. 1. The average size of holding of marginal, small and medium, farms were found 0.402, 1.547 and 2.969 respectively and overall land holding size is 0.939 hectare. The distribution of cultivated land owned by different size groups of sample farms found that 29.11% of the cultivated area was owned by marginal size of farms. Whereas 32.95 and 37.93% of that were owned by small and medium size group of farms, respectively.

Cropping pattern

The cropping pattern presents the area devoted to the various crop during the given period, conventionally in a single year. It indicates the yearly sequence and arrangement of crops grown by farmer in a particular area. The cropping patterns followed by the sample farms are presented in Table 2. It is depicted from the table that on an average the highest area was covered under paddy 20.30% followed by wheat 19.50%, lentil 11.27%, pigeon pea 5.20%, maize 4.92%, sug-arcane 3.44%, mustard 3.38%, urd 2.77%, moong 2.54% of the total cropped area on sample farm.

Table 4. Cost of cultivation of lentil on different size of sample farms (Rs/ha).

Sl. No.	Particulars	Size group of farms: Marginal		Small		Medium		Overall average	
1	Human labor	12836.87	(28.81)	13138.99	(28.20)	13463.16	(27.44)	12972.45	(28.51)
	a. Family labor	9249.53	(20.76)	3541.79	(7.60)	2664.64	(5.43)	7317.80	(16.08)
	b. Hired labor	3587.34	(8.05)	9597.20	(20.60)	10798.52	(22.01)	5654.65	(12.43)
2	Machinery charges/ Tractor charges	8248.57	(18.51)	8542.12	(18.33)	8938.25	(18.22)	8390.04	(18.44)
3	Seed cost	4050.36	(9.09)	4725.98	(10.14)	5175.81	(10.55)	4320.54	(9.50)
4	Manures and fertilizers	3854.92	(8.65)	4063.47	(8.72)	4841.55	(9.87)	4015.03	(8.82)
5	Irrigation	3879.31	(8.71)	3921.65	(8.42)	4079.11	(8.31)	3911.75	(8.60)
6	**Total working capital**	**23620.50**	**(53.02)**	**30850.42**	**(66.21)**	**33833.24**	**(68.96)**	**26292.01**	**(57.78)**
7	Interest on working capital	944.82	(2.12)	1234.02	(2.65)	1353.33	(2.76)	1051.68	(2.31)
8	Rental value of owned land	6000.00	(13.47)	6000.00	(12.88)	6000.00	(12.23)	6000.00	(13.19)
9	Interest on fixed capital	686.92	(1.54)	733.67	(1.57)	752.49	(1.53)	704.14	(1.55)
10	**Sub-total**	**40501.77**	**(90.91)**	**42359.89**	**(90.91)**	**44603.70**	**(90.91)**	**41365.63**	**(90.91)**
11	Managerial cost @ 10% of sub-total	4050.18	(9.09)	4235.99	(9.09)	4460.37	(9.09)	4136.56	(9.09)
	Grand total	**44551.95**	**(100.00)**	**46595.88**	**(100.00)**	**49064.07**	**(100.00)**	**45502.19**	**(100.00)**

Cropping intensity on sample farms

The details of cropping intensity are given in Table 3 indicated that the overall average cropping intensity on sample farms was 207.93% which was found highest on marginal farms 215.00% followed by small 209.03%, and medium 202.02% respectively. Cropping intensity was inversely related to the size of farms. The value of cropping intensity reflects the better utilization of cultivated land on marginal size

Table 5. Per hectare costs and income measures from lentil production on various costs concepts (Rs/ha).

Sl. No.	Particulars	Size group of farms: Marginal	Small	Medium	Overall average
1	Cost A_1/A_2	24565.32	32084.44	35186.57	27343.69
2	Cost B_1	25252.24	32818.10	35939.06	28047.83
3	Cost B_2	31252.24	38818.10	41939.06	34047.83
4	Cost C_1	34501.77	36359.89	38603.70	35365.63
5	Cost C_2	40501.77	42359.89	44603.70	41365.63
6	Cost C_3	44551.95	46595.88	49064.07	45502.19
7	Yield (qtl/ha)				
a	Main product	16.64	17.59	18.65	17.07
b	By product	25.81	25.96	26.52	25.93
8	Gross income	95655.92	101031.46	107477.46	98149.62
a	Main product	92860.19	98369.26	104680.40	95380.43
b	By product	2795.74	2662.20	2797.06	2769.19
9	Net income	51103.98	54435.57	58413.39	52647.43
10	Family labor income	64403.68	62213.35	65538.40	64101.78
11	Farm business income	71090.60	68947.02	72290.89	70805.92
12	Farm investment income	61841.07	65405.23	69626.25	63488.13
13	Cost of production (Rs/Qtl)	2677.40	2649.00	2630.78	2666.13
14	Input - Output ratio				
a	On the basis of cost A_1	1:3.89	1:3.15	1:3.05	1:3.64
b	On the basis of cost B_1	1:3.79	1:3.08	1:2.99	1:3.55
c	On the basis of cost B_2	1:3.06	1:2.60	1:2.56	1:2.91
d	On the basis of cost C_1	1:2.77	1:2.78	1:2.78	1:2.78
e	On the basis of cost C_2	1:2.36	1:2.39	1:2.41	1:2.37
f	On the basis of cost C_3	1:2.15	1:2.17	1:2.19	1:2.16
15	B:C ratio	1:1.15	1:1.17	1:1.19	1:1.16

Table 6. Production elasticity of lentil on different size group of farms. *Significant at 1% level of probability. ** Significant at 5% level of probability.

Size group of sample farms	Production of elasticity					Return to scale	R^2
	X_1	X_2	X_3	X_4	X_5		
Marginal (68)	0.438**	0.215	0.181*	0.050	0.040	**0.92**	**0.85**
	(0.07)	(0.06)	(0.05)	(0.05)	(0.04)		
Small (20)	0.071	0.253*	0.061	0.302**	0.195	**0.88**	**0.87**
	(0.24)	(0.36)	(0.19)	(0.20)	(0.16)		
Medium (12)	0.207**	0.189	0.270*	0.082	0.103	**0.85**	**0.89**
	(0.09)	(0.08)	(0.11)	(0.06)	(0.07)		

group of farms.

Costs and returns and resource use efficiency

Cost and return

The cost and return have been summarized in this part on the sample farms. Beside the estimate of total costs, on the basis of six cost concepts i.e., cost A_1/A_2, cost B_1, cost B_2, cost C_1, C_2 and cost C_3, have been worked out for estimation of cost. Similarly, the various measures of farm profits, such as net income, family labor income, farm investment income, farm business income, input-output ratio and resource use efficiency for lentil crop have also been worked out.

Per hectare costs of cultivation of lentil crop

Per hectare costs incurred on the various input factor in lentil production was worked out and are given in Table 4. The Table indicates that costs of cultivation were highest on farms medium (Rs 49064.07), followed by small farms (Rs 46595.88) and marginal farms (Rs 44551.95), respectively. The overall average cost of cultivation was observed (Rs 45502.19) on sample farms. The major component of the cost was human labor (28.51%), tractor and machinery charge (18.44%), seed cost (9.50%), rental value of owned land (13.19%), manure and fertilizers (8.82%) and irrigation charge (8.60%), respectively of the total costs of cultivation.

Table 7. Marginal value productivity (MVP) of included factors in the production process of lentil cultivation.

Size group of farms	Marginal value productivity of input/factors				
	X_1	X_2	X_3	X_4	X_5
Marginal	3.18	2.33	3.82	1.16	0.89
Small	0.51	2.81	1.22	6.83	4.73
Medium	1.52	2.00	4.76	1.68	2.42

Per hectare costs and income from the production of lentil crop

Table 5 revealed that on an average cost A_1/A_2, cost B_1, cost B_2, cost C_1, cost C_2 and cost C_3 came to Rs 27343.69, Rs 28047.83, Rs 34047.8, Rs 35365.63, Rs 41365.63 and Rs 45502.19 respectively. On an average, gross income was recorded Rs. 98149.62 and net income came to Rs 52647.43. On medium farms, gross income was highest, which was recorded Rs 107477.46, followed by small farms Rs 101031.46 and lowest on marginal farms i.e., Rs 95655.92 respectively. The net income was highest on medium farms Rs 58413.39, followed by small farms Rs 54435.57 and medium farms Rs 51103.98. On an average family labor income, farm business income and farm investment income were obtained to Rs 64101.78, Rs 70805.92 and Rs 63488.13, respectively. Family labor income was highest on medium farms followed by marginal and small farms and farm investment income was highest on medium farms followed by small farms and marginal farms and farm business income was highest on medium farms, followed by marginal farms and small farms. On an average, the cost of production per quintal and yield per hectare was estimated to Rs 2666.13 per quintal and 17.07 quintal, respectively. On an average input-output ratio regarding costs C_3, C_2, C_1, B_2, B_1 and A_2/A_1 were recorded 1:2.16, 1:2.37, 1:2.78, 1:2.91, 1:3.55 and 1:364, respectively. On the basis of cost C_3 input-output ratio was highest on medium farms (1:2.19), followed by small (1:2.17) and medium (1:2.15), respectively. Benefit-cost ratio was highest on medium farms 1:1.19 followed by small

farms 1:1.17 and marginal farms 1:1.15. Whereas the average benefit-cost ratio on overall farms comes to 1:1.16 and thus, it is concluded the costs of cultivation on different size group of farm increases with an increase in farm size. But net return per hectare was found of a negative trend with farm size. It was because of less increase in yield against the increased input factors at increasing size of farm.

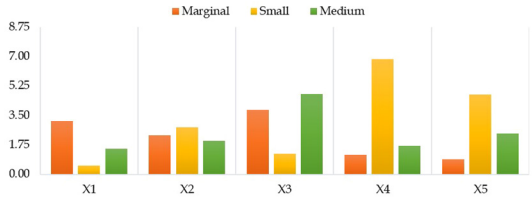

Fig. 2. Marginal value productivity (MVP) of included factors in the production process of lentil cultivation.

Resource use efficiency in lentil crop

Resource use efficiency, the elasticity of production, return to scale and other qualities of interest in lentil crop at different size group of farms are displayed in Table 6. High value of R^2 of the fitted function indicates that sufficient and maximum proportion of the total variation in the dependent variable was explained by the included factors in the production process. The five variables viz., human labor, tractor and machinery charges, seed, manure and fertilizers and irrigation explained 0.85, 0.87 and 0.89% variation of the dependent variable on marginal, small and medium farms, respectively. In the case of marginal farms human labor and seed were found statistically significant at 5% and 1% probability level, respectively while other factor viz. tractor and machinery charges, manure and fertilizer and irrigation were found statistically non-significant.

In the case of small farms tractor and machinery charges and manure and fertilizer were found statistically significant at 1% and 5% probability level, respectively while other factor viz., human labor, seed and irrigation were found statistically non-significant.

In the case of medium farms human labor and seed were found statistically significant at 5% and 1% probability level, respectively while tractor and machinery charges, manure and fertilizer and irrigation were found statistically non-significant.

Return to scale on marginal, small and medium farms were found 0.92, 0.88 and 0.85 respectively which are less than unity. It is therefore, concluded that the cultivation of lentil crop is characterized by decreasing return to scale on marginal, small and medium size group of farms.

Marginal value productivity (MVP) of lentil crop

Marginal value productivity (MVP) of lentil crop is clear from Table 7 as well as Fig. 2 that the MVP of all the included factor were found more than unity except X_5 on marginal farms and X_1 on small farms observed less than unity. On most of the factors, there is further scope of investment to realize an optimum return. Less than unity value of MVP reflects the excessive investment of those factors was made the farmers in the study area.

CONCLUSION

From the above discussion we highlight the fact that the average size of holding of marginal, small, and medium, farms were found 0.402, 1.547 and 2.969, respectively and overall land holding size was 0.939 hectare. The highest area was covered under paddy 20.30% followed by wheat 19.50%, lentil 11.27%, pigeon pea 5.20%, maize 4.92%, sugarcane 3.44%, mustard 3.38%, urd 2.77%, moong 2.54% of total cropped area on sample farm.

Cobb-Douglas production function was fitted to find out resource use efficiency in lentil crop. Per hectare gross income was taken as a dependent variable and costs of five inputs i.e., human labor, machinery charge, seed, manure and fertilizer and irrigation were considered independent factors in lentil production. The test of significance was examined by "t" test for testing various input factors and "F" test was applied for testing the regression as a whole. The coefficient of multiple determination (R^2) was used to express the variation of output by including factors in the production process. Most of the input factors included in the study were found of significant association with the dependent variable at 5% level and 1% level of

probability. The marginal value productivity (MVP) of each input factor were more than unity in the case of all three categories of farms revealed that there is further scope for investment in these factors to obtain optimum production from lentil crop in the study area. Lastly, we concluded that lentil is most suitable crop from all points of view for the farmers of Sultanpur district.

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