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An Economic Appraisal and Resource Use Efficiency of Spring Maize Cultivation in Haryana

Mandeep Kumar[1,3], R.S. Pannu[2,3], D.P. Malik[3]

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ABSTRACT

Background: Maize [*Zea mays* (L.)] is one of the most versatile crop thriving well in a myriad of agro-climatic environments. In Haryana, it is grown over an area of 0.07 lakh ha with production of 0.20 lakh tonnes having productivity of 3026 kg ha^{-1} in 2020-21. Traditionally, maize is cultivated in *kharif* season in Haryana but in recent years, the area under spring maize is also picking up in eastern part of the State owing to assured irrigation facilities. So, the present study evaluated cost and returns structure of spring maize and resource use efficiency in its cultivation in irrigated tract of Haryana during 2020-21.

Methods: The study was based on primary data collected through face to face approach from 80 spring maize farmers using multi-stage purposive sampling technique. Simple budgeting technique was done for determining the cost and return structure of spring maize. In order to work out the resource use efficiency, production function analysis *i.e.* Cobb-Douglas production function was employed.

Result: The findings exposed that, based on 2020-21 market prices, the average total cost of cultivation was ` 83350 ha$^{-1}$ and gross returns realized were ` 108029 ha^{-1} reflecting net returns of ` 24679 ha^{-1}. Moreover, the value of B-C ratio (1.29) reflected the profitability of spring maize cultivation in the study area. Further, the Cobb-Douglas production function analysis revealed that value of R^2 was more than 0.80 in both districts and efficiency of resource use in spring maize exhibited decreasing returns to scale in both Karnal (0.91) and Kurukshetra (0.70) districts. Over-utilization of farm resources in cultivation of spring maize was observed in the study area.

Key words: Cost of cultivation, Gross returns, Production function, Resource use efficiency, Spring maize.

INTRODUCTION

Agriculture is an important sector of Indian economy which helps in ensuring food security, lowering poverty and sustaining economic growth. It provides income to more than 60 per cent of rural household. The food grains production in India has increased from 50.83 million tonnes in 1950-51 to 310.74 million tonnes in 2020-21 showing an increase of about 511 per cent over a span of 70 years. Due to this rapid growth in agricultural production, Indian agriculture has marked its existence at the global level. Maize [*Zea mays* (L.)] is one of the world's most vital food crops grown over an area of 197 million ha covering more than 130 nations with total production of 1148 million tonnes globally (FAO, 2020). India backed about 4.8 per cent to total maize area and 2.5 per cent to total production in the world in 2020-21. Approximately 28 per cent of total maize produced in India is used directly as food in processed forms like popcorn, baby corn, sweet corn, flour and corn flakes. Animal feed constituted for 11 per cent of maize consumption, poultry feed for 48 per cent, starch for 11 per cent, brewing and seed for 1.0 per cent each, of maize consumption (Murdia *et al*., 2016). Nearly one million tonne of maize is consumed in processed food industry for preparing bread, muffins, doughnuts, pancake mixtures, infant foods, biscuits, wafers, breakfast cereals and pet foods.

Maize is one of the most versatile crop which can thrive well in a myriad of agro-climatic environments (Ram *et al*., 2021). It has the greatest genetic yield potential among all the cereals. It is largely utilized for three purposes *i.e*. as a human staple meal, livestock feed and industrial raw material (Devi and Suhasini, 2016). With potential growth rate in various maize-based industries such as feed sector (8%), starch industry (5.1%), ethanol industry (12.5%), processed food industry (11.5%) and dairy sector (4.5%), the cumulative demand for maize will reach to 43 million tonnes by 2030 (Rakshit *et al*., 2021). This humongous demand can be met by enhancing its cultivation in both time and space dimensions. Moreover, the increased domestic production of maize will provide India a strategic advantage in catering to the international demand for maize and helps in earning foreign exchequer. Maize is cultivated in all seasons *viz. kharif, rabi* and spring in India (Parkash and Peshin, 2020).

[1]Division of Dairy Economics, Statistics and Management, ICAR-National Dairy Research Institute, Karnal-132 001, Haryana, India.
[2]Department of Agricultural Economics, Maharishi Markandeshwar Deemed University, Mullana, Ambala-133 203, Haryana, India.
[3]Department of Agricultural Economics, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.

Corresponding Author: Mandeep Kumar, Division of Dairy Economics, Statistics and Management, ICAR-National Dairy Research Institute, Karnal-132 001, Haryana, India.
Email: mbedwal527@gmail.com

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The maximum area of maize is under *kharif season* (7.75 million ha) followed by *rabi season* (2.13 million ha) and least under *spring season* in India.

In Haryana, maize is grown over an area of 0.07 lakh ha with production of 0.20 lakh tonnes having productivity of 3026 kg ha^{-1} in 2020-21 (GoH, 2022). Traditionally, maize is cultivated in *kharif* season in Haryana but in recent years, the area under spring maize is also picking up in eastern part of the State owing to assured irrigation facilities. By inclusion of spring maize in the existing cropping system, the farmers will fetch more income from their farms with the available farm resources. Very few studies were being conducted pertaining to economic aspects of spring maize. Hence, an attempt has been made to work out critically the returns and resource use efficiency of spring maize in the study area. The detailed investigation will certainly help the farmers, research scholars and policy makers in assessing the profitability of the crop and further to take appropriate decision for enhancing cultivation of spring maize in the area and adoption of resource conservation technologies.

MATERIALS AND METHODS

The study was conducted at Chaudhary Charan Singh Haryana Agricultural University of Hisar, Haryana during 2020-21. Multi-stage purposive sampling technique was employed for selection of farmers. The selection of two districts, namely Karnal and Kurukshetra on the basis of area under spring maize cultivation, was the first stage and selection of two blocks from each district and two villages from each block was second and third stage of sampling adopting the same criterion. At last stage of sampling, 10 farmers from each village were selected purposively cultivating spring maize on large area of their operational holding. Finally, 80 farmers were interacted to extract the relevant information using well-structured and pre-tested interview schedule.

Descriptive statistical tools such as average, percentage, *etc*. were used for tabular analysis in order to determine the cost and return structure of spring maize. The cost of cultivation was intended using various owned and acquired inputs at market prices in 2020-21. The rate of interest levied by financial institutions for crop loan at 7 per cent per annum was used to work out the interest on working capital. The transportation cost was the cost incurred for carrying produce from the farm to the nearby purchase centre or regulated market. The rental value of land was calculated based on prevailing leasing prices in the study area for similar types of land and apportioned on the basis of crop period. The gross returns were obtained by multiplying produce of the crop with its prevailing selling price. Further, return over variable cost was computed by subtracting the total variable cost from gross returns obtained from the crop produce. Moreover, the net returns were calculated by subtracting the total cost incurred in cultivation of crop from gross returns obtained from the sale of produce. Benefit-cost ratio (B-C ratio) was calculated by dividing gross returns with total cost of cultivation.

In order to work out the resource use efficiency, production function analysis *i.e.* Cobb-Douglas production function was used. Best fit of this production function was obtained based on significance level of explanatory variables, coefficient of multiple determination (R^2 value) and signs of independent variables used in the model. Cobb-Douglas production function was employed with six explanatory variables in monetary terms. The production function of the following form was used in the present study:

$$Y = A\Pi_{i=1}^{n} X_i^{bi} e^u$$

$$i.e.\ Y = A.X_1^{b1}.X_2^{b2}.X_3^{b3}.X_4^{b4}.X_5^{b5}.X_6^{b6}.u$$

The non-linear form of Cobb-Douglas production function was transformed into linear production function using logarithmic operation. So, the estimated form of the equation was found to be:

$$\text{Log } Y = \text{Log } A + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + b_5\log X_5 + b_6\log X_6 + u$$

Where,

Y = Output value (` ha^{-1}).

A = Constant.

X_1 = Seed (` ha^{-1}).

X_2 = Chemical fertilizers (` ha^{-1}).

X_3 = Plant protection chemicals (` ha^{-1}).

X_4 = Human labour (` ha^{-1}).

X_5 = Machine labour (` ha^{-1}).

X_6 = Irrigation (` ha^{-1}).

b_i = Regression coefficient of respective variable X_i.

u = Random error term.

To test the significance of production elasticities, t-value of the estimates was calculated at (n-k) degree of freedom using the following formula:

$$t_{(n-k)} = \frac{bi}{S.E.\ (bi)}$$

Where,

b_i = Regression coefficient of input X_i.

S.E. (b_i) = Standard error of b_i.

The resource use efficiency was worked out using the concept of marginal value productivity (MVP), which shows an increase in the value of output due to a unit addition in a given input, *ceteris paribus*. In Cobb-Douglas production function, the marginal value productivity (MVP) of i^{th} input was calculated using the following formula:

$$\text{MVP of } X_i = b_i \left(\frac{\overline{Y}}{\overline{X}}\right) P_i$$

Where,

b_i = regression coefficient of i^{th} input.

$\overline{Y}_i$ = Geometric mean of yield.

$\overline{X}_i$ = Geometric mean of input X_i.

P_i = Price of input X_i.

The resource use efficiency can be determined by finding the difference between marginal value productivity

(MVP) of each resource and its marginal factor cost (MFC) or marginal input cost (MIC) where MFC or MIC is the price of additional unit of input which is same as P_i in the above mentioned formula. Under MVP-MFC method, the decision rules regarding level of resource use are as follows:

If MVP-MFC > 0 then it represents underutilization of farm resources.

If MVP-MFC = 0 then it represents efficient utilization of farm resources.

If MVP-MFC < 0 then it represents over utilization of farm resources.

Further, any deviation of MVP of input X_i from its unit price (P_i) may be defined as inefficiency of resource use. The significance difference between MVP of input and its acquisition cost (or price of input) was tested using following t-test:

$$t = \frac{MVPi - Pi}{S.E.\ of\ MVPi}$$

Where,

$$S.E.\ of\ MVP_i = S.E.\ b_i\left(\frac{Y}{Xi}\right)$$

RESULTS AND DISCUSSION

The relevant information regarding various inputs used, output obtained and their prevailing market prices during 2020-21 was gathered from sampled farmers of Karnal and Kurukshetra districts in order to compute the cost and returns of spring maize. The distribution of cost of spring maize cultivation in the study area is depicted in Table 1. The table shows that total cost incurred in cultivating spring maize was ` 83035 $ha^{-1}$ in Karnal, out of which, 52.48 per cent was variable cost (` 43574 ha^{-1}) and 47.52 per cent was fixed cost (` 39461 ha^{-1}). The distribution pattern of variable cost revealed that highest expenses were incurred in harvesting operation (12.16%) trailed by seed (10.73%), preparatory operation (10.14%) and chemical fertilizers (8.71%). Among the fixed cost, rental value of land alone constituted 35.04 per cent (` 29096 $ha^{-1}$) of the total cost of cultivation in Karnal district. On the other hand, the total cost of cultivation in Kurukshetra was found to be ` 83664 ha^{-1}, out of which, 54.90 per cent was variable cost (` 45937 $ha^{-1}$) and 45.10 per cent was fixed cost (` 37727 ha^{-1}). Among variable cost, expenses incurred largely in harvesting operation (12.74%) followed by seed (10.65%), chemical fertilizers (10.53%) and preparatory operation (9.99%).

Among the fixed cost, rental value of land alone constituted 31.93 per cent (` 26719 $ha^{-1}$) of the total cost of cultivation in Kurukshetra district. Furthermore, the overall total cost incurred in cultivation of spring maize in the study area came out to be (` 83350 ha^{-1}) of which 53.69 per cent was variable cost (` 44755 $ha^{-1}$) and 46.31 per cent was fixed cost (` 38595 ha^{-1}). Overall, the highest share of variable cost was in harvesting operation *i.e.* ` 10381 ha^{-1}, constituting 12.45 per cent of the total cost of spring maize cultivation, followed by seed (10.69%), preparatory operation (10.07%) and chemical fertilizers (9.63%).

Per hectare cost and returns attained from spring maize cultivation in the study area is shown in Table 2. The gross returns obtained from spring maize cultivation in Karnal and Kurukshetra districts were found to be (` 108241 $ha^{-1}$) and (` 107816 ha^{-1}), respectively. The yield obtained from main product was 73.16 quintals ha^{-1} and 74.96 quintals ha^{-1} with monetary values of ` 103345 $ha^{-1}$ and ` 102864 ha^{-1} in both

Table 1: Cost of cultivation of spring maize in the study area. (` ha^{-1})

Particulars	Karnal		Kurukshetra		Overall	
	No./Qty.	Value	No./Qty.	Value	No./Qty.	Value
Preparatory operation	4.8	8423 (10.14)	5	8362 (9.99)	4.9	8393 (10.07)
Sowing		2431 (2.92)		2446 (2.92)		2438 (2.92)
Seed (kg)	20.03	8912 (10.73)	19.93	8918 (10.65)	19.98	8915 (10.69)
Chemical fertilizers	482.71	7233 (8.71)	547.69	8815 (10.53)	515.2	8024 (9.63)
Irrigation	4.35	2076 (2.50)	4.1	1982 (2.36)	4.225	2029 (2.43)
Inter-cultural operation		1285 (1.54)		1289 (1.54)		1287 (1.54)
Plant protection chemical		1992 (2.39)		2298 (2.74)		2145 (2.57)
Harvesting operation		10100 (12.16)		10661 (12.74)		10381 (12.45)
Miscellaneous		142 (0.17)		133 (0.16)		137 (0.16)
Total (1 to 9)		42594 (51.29)		44904 (53.67)		43749 (52.49)
Interest on working capital @ 7% p.a		980 (1.17)		1033 (1.23)		1006 (1.2)
Total variable cost		43574 (52.48)		45937 (54.90)		44755 (53.69)
Transportation cost		1649 (1.98)		1820 (2.17)		1735 (2.08)
Rental value of land		29096 (35.04)		26719 (31.93)		27908 (33.50)
Management charges @ 10%		4358 (5.24)		4594 (5.49)		4476 (5.37)
Risk charges @ 10%		4358 (5.24)		4594 (5.49)		4476 (5.37)
Total fixed cost		39461 (47.52)		37727 (45.10)		38595 (46.31)
Total cost (A+B)		83035 (100.00)		83664 (100.00)		83350 (100.00)

Figures within parentheses indicates percentage to their respective total cost.

districts, respectively. As the total cost of cultivation was ` 83035 ha$^{-1}$ in Karnal and ` 83664 ha^{-1} in Kurukshetra while net returns realized were ` 25206 ha$^{-1}$ and ` 24152 ha^{-1}, respectively. Further, it was worth to mention that the B-C ratio of value around 1.29 indicated the economic viability of spring maize cultivation. Overall, the average production of spring maize was found to be 74.06 quintals ha^{-1} of worth ` 103104. Moreover, by-product of worth ` 4925 ha^{-1} was also attained from its cultivation. So, overall gross returns came out to be ` 108029 ha$^{-1}$. As the overall cost of spring maize cultivation was ` 83350 ha^{-1}, the net returns derived out to be ` 24679 ha^{-1} in the study area. Similar results of spring maize profitability were narrated by Devi and Suhasini, (2016); Singh *et al*. (2018); Saeed *et al*. (2018) and Choudhri *et al*. (2018) in their studies. Further, similar findings were also reported by Ghimire *et al*. (2016) while conducting a field experiment on ‘Rajkumar’ variety of spring maize cultivated using improved practices in Bardiya district of Nepal.

Resource use efficiency of spring maize cultivation

The production function analysis offers a powerful tool in allocation of scarce resource at farm. The resource use efficiency in spring maize cultivation was understood using the Cobb-Douglas type production function as described in the methodology. The production elasticity or regression coefficient (bi) of the production function along with its standard errors, t-value and coefficient of multiple determination is exposed in Table 3.

The Cobb-Douglas production function was employed with six explanatory variables i.e. seed (X_1), chemical fertilizers (X_2), plant protection chemicals (X_3), human labour (X_4), machine labour (X_5) and irrigation (X_6) in monetary terms for determining the efficiency level of individual resource used in the cultivation of spring maize. The perusal of Table 3 shows that, in Karnal district, the coefficient of multiple determination (R^2) was 0.80 which indicated that 80 per cent of the total variation in the spring maize gross returns was explained by the explanatory variables included in the model and the rest 20 per cent remained unexplained. This unexplained variation might be attributed to a number of factors such as variety selected, sowing time, weather and varied soil fertility of different farms. Further, the production function analysis indicated that the regression coefficients of irrigation, machine labour and chemical fertilizers were found to be positive and significant at different levels (1%, 5% and 10%), indicating their importance in spring maize cultivation. However, seed, plant protection

Table 2: Cost and returns from spring maize in the study area. (` ha^{-1})

Particulars	Karnal		Kurukshetra		Overall	
	No./Qty.	Value	No./Qty.	Value	No./Qty.	Value
Total variable cost		43574		45937		44755
Total fixed cost		39461		37727		38595
Total cost		83035		83664		83350
Gross returns		108241		107816		108029
(a) Main product (Qtl.)	73.16	103345	74.96	102864	74.06	103104
(b) By product		4896		4952		4925
Return over variable cost		64667		61879		63274
Net return		25206		24152		24679
Cost of production (`/Qtl.)		1135		1116		1125
B:C ratio		1.30		1.29		1.29

Table 3: Production elasticity of input factors in spring maize production.

Variables	Karnal			Kurukshetra		
	Production elasticity (bi)	Standard error (SE)	t-value	Production elasticity (bi)	Standard error (SE)	t-value
Intercept	2.94	3.31	0.89	4.35	3.67	1.18
Seed	0.08^{NS}	0.40	0.46	0.01 ^{NS}	0.30	0.04
Chemical fertilizers	0.07*	0.04	1.79	0.47***	0.05	4.90
Plant protection chemicals	0.03^{NS}	0.04	0.64	0.04 ^{NS}	0.04	1.07
Human labour	0.04^{NS}	0.17	0.23	0.02 ^{NS}	0.16	0.13
Machine labour	0.35**	0.14	2.61	-0.03 ^{NS}	0.05	-0.49
Irrigation	0.34***	0.05	6.96	0.19***	0.06	2.82
Returns to scale	0.91			0.70		
R^2	0.80			0.87		

***Significant at 1% level, **Significant at 5% level, *Significant at 10% level.

NS: Non-significant.

Table 4: Resource use efficiency of spring maize in the study area.

Inputs	Seed	Chemical fertilizers	Plant protection chemicals	Human labour	Machine labour	Irrigation
Karnal						
MVP	2.09	1.12	1.36	0.23	5.00**	19.26***
MFC or Price	1.00	1.00	1.00	1.00	1.00	1.00
Difference	1.09	0.12[@]	0.36	-0.77	4.00	18.26[#]
S.E. of MVP	4.52	0.56	2.10	1.00	1.92	2.77
t-value	0.24	0.01	0.17	-0.76	2.09	6.60
Kurukshetra						
MVP	0.16	4.06***	2.15	0.13	-0.43	10.23***
MFC or Price	1.00	1.00	1.00	1.00	1.00	1.00
Difference	-0.84[@]	3.06	1.15	-0.87	-1.43	9.23[#]
S.E. of MVP	3.44	0.43	2.15	1.04	0.87	3.23
t-value	0.24	7.11	0.53	-0.83	-1.64	2.85

***Significant at 1% level, **Significant at 5% level, *Significant at 10% level.

[#]Least resource use efficiency [@] Highest resource use efficiency.

Minus sign in the row 'Difference' shows over utilization and positive value shows under utilization.

chemicals and human labour had positive but non-significant impact on returns from spring maize. Furthermore, the returns to scale *i.e*. sum of all the production elasticities of explanatory variables included in the model was 0.91 which implied that if all the variable inputs were increased by 100 per cent simultaneously, the returns from spring maize would increase by 91 per cent. This indicated that the production function exhibited decreasing returns to scale in Karnal.

In case of Kurukshetra district, the value of R^2 (0.87) reflected that 87 per cent of the total variation in the gross returns was due to the explanatory variables specified in the model. Further, the regression coefficients of chemical fertilizers and irrigation were found to be positive and significant at 1 per cent level. However, seed, plant protection chemicals and human labour had positive but non-significant impact whereas machine labour had negative and non-significant impact on spring maize returns. Furthermore, the returns to scale was 0.70 which indicated that the production function exhibited decreasing returns. These results were in conformity with the findings of Hasan (2008); Mukherjee *et al*. (2015) and Choudhri *et al*. (2019). As far as returns to scale was concerned, Paul *et al*. (2012) reported increasing returns whereas the present study reported decreasing returns. This might be due to location of study, varied agro-climatic conditions, different management practices adopted, dissimilar variety/hybrid cultivation, *etc.*

For resource use efficiency, the difference between marginal value product (MVP) and marginal factor cost (MFC) was worked out and significance test were applied. The perusal of Table 4 shows that, in Karnal district, the difference between MVP and MFC was found to be positive for inputs namely, seed, chemical fertilizers, plant protection chemicals, machine labour and irrigation thus indicating underutilization of such inputs, which reflects that there is an ample scope for increasing the returns from spring maize cultivation by enhancing the usage of these resources. However, the difference was found to be negative for human labour thus indicated that the resource was over utilized. Further, chemical fertilizers exhibited the highest resource use efficiency while irrigation was found to be least resource use efficient in Karnal. On the other hand, in Kurukshetra district, the difference between MVP and MFC was found to be positive for inputs namely, chemical fertilizers, plant protection chemicals and irrigation thus indicating that such inputs were underutilized and the usage of such resources can be increased in order to fetch better returns. The difference was found to be negative for seed, human labour and machine labour showing over utilization, therefore, it would be better to reduce their usage in order to curtail cultivation cost by optimal use of these resources. Further, seed exhibited the highest resource use efficiency while irrigation was found to be least efficient input. Similar kind of results has also been described in the studies carried out by Anupama *et al*. (2005); Gani and Omonona (2009) and Mukherjee *et al*. (2015). The results are also at par with findings of the study conducted by Choudhri *et al*. (2019) in Uttar Pradesh regarding the resource use efficiency of maize using same production function and MVP concept.

CONCLUSION

The average total cost of cultivation of spring maize was observed to be ` 83350 $ha^{-1}$ and gross returns were ` 108029 ha^{-1} with net returns of ` 24679 ha^{-1}. The B-C ratio of 1.29 reflected the profitability of spring maize cultivation in the study area. The production function analysis indicated that, in both the districts, disguised unemployment situation has prevailed as regression coefficient of human labour was found to be non-significant. Further, chemical fertilizers and seed were the most efficiently utilized resources in Karnal and Kurukshetra districts, respectively whereas irrigation was found to be least efficiently utilized resource in the study area. Furthermore, decreasing returns to scale has been observed in both districts. To sum up, it can be concluded that by adopting various spring maize based cropping systems (Paddy-potato-spring maize, paddy-toria-spring maize *etc*.), farmers will be able to cultivate more than two crops in one agricultural year and fetch greater returns from their farms. Moreover, there is an ample scope to increase productivity of spring maize through adoption of improved and novel technologies along with optimum resource allocation and better management practices.

Conflict of interest: None.

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