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Resource productivity and resource use efficiency of soybean production in Maharashtra

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ABSTRACT: *Soybean [*Glycine max*] is the world's natural source of protein. Soybean is the most important oilseed crop of the world. It is grown successfully in various agro-climatic conditions. Investigation was carried out for the year 2013-14 in order to study the marginal productivity and economic efficiency in soybean production in all regions of Maharashtra. The data were collected from 144 soybean growers from all three regions of Maharashtra state. Cobb-Douglas production function was fitted to the data of soybean production. Results revealed that, regression coefficients of human labour (0.083) and irrigation (0.023) were positive and significant at 10 per cent level of significance. Similarly regression coefficients of manures (0.016) and Technology Adoption Index (0.112) were positive and significant at 1 per cent level of significance. It could be inferred that, if one per cent increased in use of human labour, irrigation, manures and Technology Adoption Index, it would lead to increase the soybean production by 0.083, 0.023, 0.016 and 0.112 per cent, respectively. Thus, it implied that, there was scope to increase these resources in soybean production. The value of coefficient of multiple determination (R^2) was turned out to 0.65.*

The ratios of MVP to MC for soybean in case of human labour were found to be (1.11), for manure (1.80) and for irrigation (8.20) which was greater than unity. These ratio indicated that, too little of these inputs are being used in relation to the prevailing market conditions. Hence, the farmers are seems to be inefficient in allocating crucial inputs vis., human labour, manure and irrigation. This implies that, there are ample opportunities for the farmers to increase production by allocating these inputs and using them efficiently.

Key words: *Soybean, Resource productivity, Resource use efficiency, TAI, etc.*

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is the world's natural source of protein. Soybean is grown successfully in various agro-climatic conditions. It is grown well in sub-tropical and tropical regions. Though, soybean is a legume crop, yet it is widely used as oilseed crop. Due to very poor cook ability on account of inherent presence of trysin inhibitor, it cannot be utilized as pulse crop. In India, farm business is the basic business but due to lack of management, it is not much profitable. Farm business management has assumed greater importance not only in developed and commercial agriculture all around the world but also in developing and subsistence type of agriculture. A farm manager must not only understand different methods of agriculture production, but he must allocate scarce production resources in the farm business. Farm management is concerned with resource allocation. Farmer has set of farm resources such as land, labour, seed, fertilizers, irrigation and so on that are relatively scarce. By managing these scarce resources farmer can achieve the maximum production.

The soybean production is no exception to this, as in most of the regions of Maharashtra state, the farmers are growing crop in kharif season. The present exercise was thus carried out for knowing the fact in utilization of crucial inputs.

METHODOLOGY

The state of Maharashtra comprises of four regions *viz.*, Konkan, Western Maharashtra, Marathwada and Vidarbha. As there is no production of soybean due unsuitable weather conditions in Konkan region, hence, only three regions *viz.*, Western Maharashtra, Marathwada and Vidarbha were selected for the study of soybean where the area under the crop was concentrated. **One district from each region** *viz.*,

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Ahmednagar (Western Maharashtra), Latur (Marathwada) and Amravati (Vidarbha) and two tahsils from each district were selected on the basis of maximum area under soybean. Based on availability of samples, two villages from each tahsil were selected. In all, twelve villages for soybean were selected for the study. The list of cultivators growing the crop from the selected villages was prepared from revenue records at village level. For the study, 12 farmers were randomly selected from each village, thus total 144 farmers were selected for the present study. Appropriate schedule were prepared keeping in view the objectives of the study. The formulated schedules were covering all the important aspects regarding the soybean crop. The survey method was used for the collection of primary data. The individual soybean sample growers were interviewed and detail information was collected for the year 2013-14 with the help of prepared schedules.

Functional analysis

The empirical evidences from previous studies suggested that amongst the many mathematical functions, the Cobb-Douglas type production function is the appropriate one for the studies of resources productivities because it gives specific diminishing, Increasing or constant returns. The variables *i.e.,* human labour, bullock labour, machine labour, manure (FYM), fertilizers and irrigation expenditure were taken as an independent variables. The data were subjected to functional analysis by using the following Cobb-Douglas type of production function,

$$Y = aX_1^{b1}\ X_2^{b2}\ X_3^{b3}\ X_4^{b4} \ldots\ldots.. X_n^{bn}\ e^u$$

Where,

Y = Output (Dependent variable)

a = Constant or Intercept

b_1, b_2, ...,bn = Regression coefficients

X_1, X_2, X_3 . . . .Xn = Initial factors (Independent variables)

u = Error term.

When expressed in logarithmic terms, this function get transferred into a linear function of the following form,

$$\text{Log } Y = \text{Log } a + b_1 \text{ Log } X_1 + b_2 \text{ Log } X_2 + \ldots\ldots\ldots + b_n \text{ Log } X_n + u \text{ Log } e$$

Estimation of marginal value product

The marginal value products (MVP's) of the individual resources were estimated and compared with the marginal cost (MC). The MVP's of individual resources were estimated by using the following formula,

$$Marginal\,Value\,Product\,(MVP)\,of\;\; X_i = b_i \frac{\overline{Y}}{\overline{X}} P_y$$

Where,

bi = Elasticity of production of i[th] input

Y = Geometric mean of output

Xi = Geometric mean of i[th] input

Py = Per unit price of output

Economic efficiency of resources

In order to evaluate the economic efficiency of resources, the MVP of input factor resources were compared with their respective acquisition costs, i.e. input price. The ratio of MVP's of different resources to their acquisition costs (MVP/input price) were calculated. A ratio, that is equal to unity (MVP = input price or MVP/input price= 1) indicates the optimum use of the resources. A ratio more than unity indicate the under use of resources and the returns could be increased by using more of that resource and ratio less than unity indicates excess use of resources, which should be decreased to maximize the profit.

RESULTS AND DISCUSSION

Resource use productivity of soybean has been estimated by Cobb-Douglas type of production function. An efficiency of resource use in soybean production on the sample farms was judged with the help of MVP/MC ratio. The results of resource use productivity and resource use efficiency are presented in Tables below.

Estimates of Cobb-Douglas production function and resource use efficiencies for soybean in Western Maharashtra

It is revealed from Table 1 that, human labour (X_1), manure (X_4), irrigation (X_7) and technology adoption index (X_8) have significantly influenced the production of soybean in the study area as indicated by their significant regression coefficients. Manure positively influenced the production of soybean whereas chemical fertilizer and machinery works had negative influence. Other inputs like seeds, plant protection chemicals, human labour and bullock labour were positively associated with the production of soybean even though their influence was not significant. At the overall level, coefficient of multiple determination (R^2) turned out to be 0.66 indicating that 66 per cent variation in output is jointly explained by the above considered independent factors.

It was also observed in Table 2 that, the ratio of MVP to MC was positive and more than one for human labour, manure and irrigation indicating that resources were used advantageously. Whereas, it was less than one in case of bullock labour, machine labour, nitrogen and phosphorus indicating over utilization of inputs in soybean cultivation.

Estimates of Cobb-Douglas production function and resource use efficiencies for soybean in Marathwada

Regression coefficients with relation to various explanatory variables, geometric mean of inputs, marginal products, marginal value product, price of input, MVP to price ratio and optimum resource use were calculated and presented in Table 3. Coefficient of multiple determination (R^2) was 0.68 which indicated that 68 per cent variation in soybean production explained due to variation in all independent variables. Further, regression coefficient with respect to human labour, manure, potassium and technology adoption index was 0.336, 0.365, 0.313 and 0.256 which was positive and significant at 10 per cent level. It was clear that, when increase the use of labour, manure, potassium and technology adoption index by 1 per cent over its geometric mean it would lead to increase soybean production by 0.336, 0.365, 0.313 and 0.256 per cent, respectively. On the contrary, the regression coefficient of phosphorus were negative and non-significant. It inferred that, phosphorus were over utilized in soybean production. Thus, there was need to reduce such non-significant variables in soybean production.

Marginal product with respect various explanatory variables were estimated as given in the Table 4. It was observed from the table that marginal product of human labour, manure and potassium were 1.00, 4.26 and 1.56 quintals, in other words addition of one human labour, one quintal manure

Table 1
Result of Cobb-Douglas production function for soybean in Western Maharashtra region

Sr.No.	*Particulars*		*Regression coefficients*
1	Constant	(a)	1.57
2	Human labour (Man days/ha)	X_1	0.2135***
			(0.0733)
3	Bullock labour (Pair days/ha)	X_2	-0.0110
			(0.0069)
4	Machine labour (hr)	X_3	0.0056
			(0.0073)
5	Manures (q)	X_4	0.0118***
			(0.0043)
	Fertilizers (kg/ha)		
	N	X_5	-0.0994
			(0.1199)
	P	X_6	0.0673
			(0.0663)
6	Irrigation (')	X_7	0.0214***
			(0.0072)
7	Technology Adoption Index (%)	X_8	0.1307***
			(0.0371)
8	Coefficient of Multiple Determination	R^2	0.66
9	Number of observations		48
10	Degrees of freedom		39

(Figures in parentheses are standard errors of respective regression coefficient)
*,** and *** indicates significance at 10,5 and 1 per cent level

Table 2
Resource use efficiencies for soybean in Western Maharashtra region

Sr.No	*Particulars*	*bi Value*	*MP*	*MVP*	*MC*	*MVP/ MC*
1	Human labour	0.2135	6.97	137.26	135.00	1.02
2	Bullock labour	0.0100	0.19	3.73	440.00	0.01
3	Machine labour	0.0056	0.04	0.84	120.00	0.01
4	Manure	0.0118	6.54	128.90	100.00	1.29
5	N	0.0994	0.08	1.57	16.90	0.09
6	P	0.0673	0.74	14.51	18.20	0.80
7	Irrigation	0.0214	0.34	6.73	1.00	6.73

and one kg potassium could cause to give 1.00, 4.26 and 1.56 quintals of yield, respectively.

Estimates of Cobb-Douglas production function and resource use efficiencies for soybean in Vidarbha

Resource use productivity and resource use productivity for soybean production in Vidarbha region is given in Table 5. The coefficients of multiple determination (R^2) was estimated 0.61. This indicates that, the above nine independent variable have jointly explained nearly 61 per cent variations in the total value of crop output.

At the overall level, human labour (X_1), manure (X_3), plant protection (X_7), Irrigation (X_8) and technology adoption index (X_9) were turn out to be positive and significant. Out of these five variables human labour and technology adoption index were highly significant at 1 per cent level of significance indicating that, these are the important variables for which the output was highly responsive.

At overall level, the production elasticities for technology adoption index was 0.17. It indicates that, if we increase the technology adoption index by 1 per cent the output will increase by 0.17 per cent. The use of fertilizer was non significant which indicates that, the farmers were not used the recommended and balance use of fertilizer in all the adopter groups.

An efficiency of resource use in soybean production on the sample farms was judged with the help of MVP/MC ratio and results of resource use efficiency are presented in Table 6.

It is noticed from the table that, marginal value product to factor cost ratio (MVP/MC) was greater than unity in case of human labour (X_1), manures (X_3)

Table 3
Result of Cobb-Douglas production function for soybean in Marathwada region

Sr.No.	*Particulars*		*Regression coefficients*
1	Constant	(a)	1.29
2	Human labour (Man days/ha)	X_1	0.3368* (0.1515)
3	Bullock labour (Pair days/ha)	X_2	0.0484 (0.0379)
4	Machine labour (hr)	X_3	0.0045 (0.0199)
5	Manures (q)	X_4	0.0365* (0.0179)
6	Fertilizers (kg/ha)		
	N	X_5	0.3432 (0.3669)
	P	X_6	-0.2290 (0.1406)
	K	X_7	0.3133** (0.1589)
7	Irrigation (‘)	X_8	0.0073 (0.0235)
8	Technology Adoption Index (%)	X_9	0.2563* (0.1024)
9	Coefficient of Multiple Determination	R^2	0.68
10	Number of observations		48
11	Degrees of freedom		38

(Figures in parentheses are standard errors of respective regression coefficient)
*,** and *** indicates significance at 10,5 and 1 per cent level

Table 4
Resource use efficiencies for soybean in Marathwada region

Sr.No	*Particulars*	*bi Value*	*MP*	*MVP*	*MC*	*MVP/ MC*
1	Human labour	0.3368	0.07	135.51	135.00	1.00
2	Bullock labour	0.0484	0.22	433.00	440.00	0.98
3	Machine labour	0.0045	0.08	158.97	120.00	1.32
4	Manure	0.0365	0.21	425.88	100.00	4.26
5	N	0.0343	0.01	10.70	16.90	0.63
6	P	0.0229	0.01	17.87	18.20	0.98
7	K	0.3133	0.01	15.25	9.80	1.56
8	Irrigation	0.0073	0.00	2.23	1.00	2.23

Table 5
Result of Cobb-Douglas production function for soybean in Vidarbha region

Sr.No.	*Particulars*		*Regression coefficients*
1	Constant	(a)	0.33
2	Human labour (Man days/ha)	X_1	0.2864* (0.1359)
3	Bullock labour (Pair days/ha)	X_2	0.1808 (0.1041)
4	Machine labour (hr)	X_3	0.0571 (0.0492)
5	Manures (q)	X_4	0.0155** (0.0078)
6	Fertilizers (kg/ha)		
	N	X_5	0.1322 (0.1083)
	P	X_6	-0.0028 (0.0531)
7	Irrigation (')	X_7	0.0675** (0.0352)
8	Technology Adoption Index (%)	X_8	0.1731* (0.0790)
9	Coefficient of Multiple Determination	R^2	0.61
10	Number of observations		48
11	Degrees of freedom		39

(Figures in parentheses are standard errors of respective regression coefficient)
*,** and *** indicates significance at 10,5 and 1 per cent level

Table 6
Resource use efficiencies for soybean in Vidarbha region

Sr.No	*Particulars*	*bi Value*	*MP*	*MVP*	*MC*	*MVP/ MC*
1	Human labour	0.2864	0.09	192.90	135.00	1.43
2	Bullock labour	0.1808	0.29	652.67	450.00	1.45
3	Machine labour	0.0571	0.01	25.92	120.00	0.22
4	Manure	0.0156	0.04	101.89	100.00	1.02
5	N	0.1322	0.00	8.60	16.90	0.51
6	P	0.0028	0.00	6.29	22.20	0.28
7	Irrigation	0.0675	0.00	7.82	1.00	7.82

Table 7
Result of Cobb-Douglas production function for soybean in Maharashtra

Sr.No.	*Particulars*		*Regression coefficients*
1	Constant	(a)	1.44
2	Human labour (Man days/ha)	X_1	0.0837* (0.0409)
3	Bullock labour (Pair days/ha)	X_2	0.0127 (0.0126)
4	Machine labour (hr)	X_3	0.0096 (0.0089)
5	Manures (q)	X_4	0.0167*** (0.0062)
	Fertilizers (kg/ha)		
	N	X_5	0.0002 (0.1046)
	P	X_6	0.0749 (0.0520)
	K	X_7	-0.0109 (0.0205)
6	Irrigation (')	X_8	0.0231* (0.0093)
7	Technology Adoption Index (%)	X_9	0.1126*** (0.0364)
8	Coefficient of Multiple Determination	R^2	0.65
9	Number of observations		144
10	Degrees of freedom		134

(Figures in parentheses are standard errors of respective regression coefficient)
*,** and *** indicates significance at 10,5 and 1 per cent level

Table 8
Resource use efficiencies for soybean in Maharashtra

Sr.No	*Particulars*	*bi Value*	*MP*	*MVP*	*MC*	*MVP/ MC*
1	Human labour	0.0837	0.03	150.00	135.00	1.11
2	Bullock labour	0.0127	0.06	440.00	440.00	1.00
3	Machine labour	0.0096	0.20	120.00	120.00	1.00
4	Manures	0.0167	0.23	180.00	100.00	1.80
5	N	0.0002	0.00	16.19	16.90	0.96
6	P	0.0749	0.06	22.20	18.20	1.22
7	K	0.0109	0.04	22.20	9.80	2.27
8	Irrigation	0.0231	0.00	8.20	1.00	8.20

and irrigation (X_8). This implied that, higher resource use efficiency was achieved in case of these variables. The MVP/MC ratio for bullock labour (X_2), nitrogen (X_4) and phosphorus (X_5) were found to be less than unity depicting the inefficient use of these resources. The foregoing analysis revealed that, profitability of soybean production at the overall level could be maximized by increasing the use of bullock labour, nitrogen and phosphorus fertilizer.

Estimates of Cobb-Douglas production function and resource use efficiencies for soybean in Maharashtra

The variables taken into consideration were human labour (X_1), bullock labour (X_2), machine labour (X_3), manures (X_4), nitrogen (X_5), phosphorus (X_6), potassium (X_7),irrigation (X_8), Technology adoption index (X_9). The results of functional analysis are presented in Table 7.

At the overall level, coefficient of multiple determination (R^2) turned out to be 0.65 indicating that 65 per cent variation in output was jointly explained by these independent factors. The manure (X_4) and technology adoption index (X_9) were turned out statistically significant at 1 per cent level of significance while human labour (X_1), and irrigation (X_8) at 10 per cent level of significance. This indicated that, one unit increase in the manures, technology adoption index, human labour and irrigation would result into 0.01, 0.11, 0.08 and 0.02 per cent increase in the output, respectively. The other resources like bullock labour (X_2), machine labour (X_3), nitrogen (X_5), phosphorus (X_6) and potassium fertilizers (X_7) were seem non-significant. In case of soybean at the overall level, individual elasticity of production for every resource found less than the unity indicating thereby diminishing marginal returns for the individual resource.

The findings of the resources use efficiency in production of soybean depicted in the Table 8. It is noticed from the table that, marginal value product to factor cost ratio (MVP/MC) was greater than unity in case of human labour (X_1), manures (X_4) and irrigation (X_8). This implied that, higher resource use efficiency was achieved in case of these variables. The MVP/MC ratio for bullock labour (X_2), machine labour (X_3), nitrogen (X_5), phosphorus (X_6) and potassium (X_7) were found to be less than unity depicting the inefficient use of these resources. The foregoing analysis revealed that, profitability of soybean production at the overall level could be maximized by increasing the use of these variables.

CONCLUSIONS

The findings of this study indicate that, if soybean growers need to increase their soybean productivity, they should allocate more land to the crop and make sure that they use capital intensive inputs such as fertilizers and pesticides. The success of this operation is possible if farmers are convinced of its benefits by a well designed and implemented soybean resource-to consumption chain development program.

Human labour, manure and irrigation have significantly influenced the production of soybean in the study area as indicated by their significant regression coefficients. The ratio of MVP to MC was positive and more than one for human labour, manure and irrigation indicating that resources were used advantageously. Whereas, it was less than one in case of bullock labour, machine labour and chemical fertilizers indicating over utilization of inputs in soybean cultivation. The agencies working in this area should plan their future course of action regarding soybean cultivation technology for enhanced production.

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