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Resource productivity and resource use efficiency of soybean in Marathwada region of Maharashtra

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Abstract
Soybean (*Glycine max* L.) is known as 'golden bean' and grown in India for dual purpose that is oil seed as well as pulse crop. About 120 soybean growers were selected from two districts (Nanded and Parbhani) in Marathwada region of Maharashtra for study. Cross sectional data were collected from soybean growers with the help of pretested schedule by personal interview method. The data pertains for the year of 2015-16. The result revealed that marginal value product (MVP) to price ratio with respect to area, hired human labour, family human labour, machine, seed, manure, bullock pair and potassium was greater than unity while MVP to price ratio of Nitrogen, Phosphorus, and plant protection was negative. The results inferred that there was greater chance to increase seed, Potassium, manure and hired human labour utilization.

Keywords: Soybean, resource productivity, resource use efficiency

Introduction

Soybean (*Glycine max* L.) is known as 'golden bean' and grown in India for dual purpose that is oil seed as well as pulse crop. It is important natural source of protein with number of amino acids essential for good health. *Glycine* is derived from Greek word 'Glykus' and probably refers as 'sweet tuber.' The genus Glycine is wild and member of family leguminoceae, sub-family tribe phaseolae and native of China. The phaseolae is the most economically important tribe of leguminoceae family. It is a major oilseeds crop of the world. In USA, it is called as 'Cinderella crop', 'a king without a crown', 'a marvel bean'. In China, it is known as 'Yellow Jewell', great treasurer 'Chinese cow' and 'vegetable meat'. The Yellow river region in China is generally considered as origin center of soybean and the earliest record of soybean in China. Soybean was introduced to several nearby countries with the development of sea and land trades, probably in the 7th century and land races development in Japan, Indonesia, Philippines, Vietnam, Thialand, Malysia, Burma, Nepal and North India. These regions comprise the secondary gene centre. The soybean was first introduced to North America in 1765 and then spread to Canada and Latin America. The earliest known date for introduction into Brazil is 1882. Soybean is known as the "miracle crop" because of its several uses. It is an excellent source of protein and oil. It contains about 21 percent carbohydrates, 5 percent minerals, 20 percent fat, 4 percent fiber and reasonable amounts of vitamins. Besides utilization of soybean as vegetable, it is also used in oil industry where it occupies first place in the world oil production. It containing 43 percent protein and 18-20 percent oil has tremendous potential to meet the protein-calorie malnutrition of the ever increasing Indian population. It supplies most of the nutritional constituent's essentional for human growth because of its richness in protein, deoiled soya cakes as greater importance in manufacturing human food and livestock feeds. The soybean milk is prepared from soybean flour. It has man fold industrial uses like preparation of butter, fats, paints, varnishes, soap, glycerin, printing ink, etc.

In Maharashtra during 2014-15 area under soybean cultivation was 36.40 lakh hectares with annual production of 18.21 lakh tons with an average productivity of 500 kg/ha.I n Marathwada region during 2014-15 area under soybean cultivation was 12.22 lakh hectare with an annual production of 5.16 lakh tons with an average productivity of 401.50 kg/ha (Source: www.mahaagri.gov.in). In Parbhani district during 2014-2015 area under soybean cultivation was 1.88 lakh hectares with annual production of 0.584 lakh tons with an average productivity of 1255 kg/ha. In Nanded district during 2014-2015 area under soybean cultivation was 2.61 lakh hectares with annual production of 0.690 lakh tons with an average productivity of 1287 kg/ha (Source: www.mahaagri.gov.in).

Materials and Methods
Resource use efficiency
The production function approach was used to examine the productivity of resources used in soybean cultivation. For this purpose, the Cobb-Douglas production function was employed. The single most advantage of this production function has been that the input coefficients constituted the respective elasticity.

The Cobb-Douglas type of Production Function was used and is usually defined as follows.

$$Y = a X_1^{b1} X_2^{b2} X_3^{b3} \text{-----------------} X_n^{bn} e^u \qquad (1)$$

Where,

Y = Output of soybean crop including main produce and by products (qts./ha).

a = Intercept.

X_1, X_2, X_3,-----------X_n

Different variables used or independent variables.

e^u = Error term.

b_n = regression coefficient of the respective resource variables.

The function given in equation (1) can be expressed as,

$$\text{Log } \hat{Y} = \text{Log } a + b_1 \text{ Log } X_1 + b_2 \text{ Log } X_2 \ldots b_n \text{ Log } X_n + u \text{ log } e \ \ldots. (2)$$

For fitting the production function in soybean crop, eleven input variables were considered as important factors by considering the problem of multicollinearity in estimating production function. Multicollinearity refers to situation where because of storing interrelationship among the independent variables, it becomes difficult to disentangle their separate effects on the dependent variables. Some of the independent variables are not important just because the standard errors are high. It might be due to the presence of multicollinearity.

The main consequences of multicollinearity are (a) the sampling variances of the estimate coefficients increase as the degree of collinearity increase between the explanatory variables, (b) estimated coefficients may become very sensitive to small changes in some of the estimates of the coefficients. This result in non-significance of regression coefficients. Sometimes it is happens that more of the regression coefficients are significant but the value of R^2 is very high.

The equation fitted was of the following formula.

$$\hat{Y} = a.\ X_1^{b1}.\ X_2^{b2}.\ X_3^{b3}.\ X_4^{b4}.\ X_5^{b5}.\ X_6^{b6}.X_7^{b7}.\ X_8^{b8}.\ X_9^{b9}.\ X_{10}^{b10}.\ X_{11}^{b11}.\ e^u$$

Where,

Y = Yield of the crop in quintal per hectare

a = Intercept of production function

bi = Partial regression coefficients of the respective resource variable

(i = 1, 2, 3, ..., 11)

X_1 = Area of the crop in hectare

X_2 = Hired human labour in man day per farm

X_3 = Family human labour in man day per farm

X_4 = Bullock labour in pair day per farm

X_5 = Machine labour in hours per farm

X_6 = Seed in kg per farm

X_7 = Manures in quintal per farm

X_8 = Nitrogen in kg per farm

X_9 = Phosphorus in kg per farm

X_{10} = Potassium in quintal per farm

X_{11} = Plant protection in litre per farm

e^u = Error term

Elasticity of production (EP)
The elasticities of the respective variables are equal to the regression coefficient of the resource in Cobb-Douglas production function. The elasticity of production can be calculated as follows.

$$EP = \{baX^{b-1}\} \frac{X}{Y} = \frac{baX^b}{X} . \frac{X}{Y} = \frac{bY}{X} . \frac{X}{Y} = b$$

Testing of regression coefficient
Partial regression coefficients are tested for significance by applying ‘t’ test at n-k-1 degree of freedom as under:

$$t_{(n-k-1)} = \frac{bi}{SE(bi)}$$

Where,

bi = Partial regression coefficient of particular variable

SE = Standard error of bi

n = No. of observations

k = Dependent variables

Marginal product (MP)
Cobb-Douglas production function allows either constant, increase or decrease marginal productivity. In other words, resource productivity refers to marginal product with respect to added unit of input. The marginal product equation is as:

$$MP = \frac{dy}{dx} = bia\ X^{b-1} = \frac{biaX^b}{\bar{X}} = b\frac{\bar{X}}{\bar{Y}}$$

Where,

bi = Elasticity of production

$\bar{Y}$ = Geometric mean of output and

$\bar{X}$ = Geometric mean of respective input

Marginal value product (MVP)
It refers to the product of MP and Py, where MP is marginal productivity and Py is the price of soybean per quintal. The MVP with respect to input factor is worked out by the following formulae

$$MVP = bi\frac{\bar{Y}}{\bar{X}} Py$$

Where,

bi = Partial regression coefficient of particular independent variable

$\bar{X}$ = Geometric mean of particular independent variable

$\bar{Y}$ = Geometric mean of dependent variable

Py = Price of dependent variable

Optimum resource use efficiency
Optimum resource use efficiency was calculated by following formula

$$\text{Optimum resource use} = \frac{bi.\bar{Y}.Py}{Px}$$

Where,
bi = Partial regression coefficient of particular independent variable
$\bar{Y}$ = Geometric mean of dependent variable
Py = Price of dependent variable
Px = Price of independent variable

Returns to Scale
It refers to summation of bi values.
Return to scale = ∑bi
If ∑bi = 1, constant return to scale
If ∑bi < 1, decreasing return to scale
If ∑bi > 1 increasing return to scale

Its significance is tested by 'F' test as

$$F = \frac{(\sum bi - 1)(n-k)}{[\sum var\ (bi)](k-1)}$$

Analysis and interpretation
Resource productivity and resource use efficiency in soybean crop
Cobb-Douglas production function was used and on the basis of goodness of fit (R^2) proper function was selected. The independent variables used in the production function, correlation matrix for soybean crop was developed. On the basis of non-significant correlation coefficients, some of the variables were dropped. Similarly in order to solve problem of which had less than the value of multiple determinations was taken in to consideration and one of the variables was dropped. Thus, remaining independent variables were used in specific production. Mostly Cobb-Douglas production function was used whereas, the regression coefficient are the elasticities of production and easy to determine the returns to scale in production function.

Estimates of Cobb-Douglas production function in soybean production
Estimates of Cobb-Douglas production function in soybean production were obtained and are presented in Table 1. The findings with respect to elasticity of production, marginal productivity, resource use efficiency and optimum resource use are presented as follows.

Elasticity of production
The results revealed that coefficient of multiple determination (R^2) was 0.809 which indicated 80.90 percent effect of all independent variables together in soybean production. F-value was 19.58 which were highly significant. Return to scale was 1.0710 which indicated increasing return to scale. Among the individual independent variables, partial regression coefficient of area under soybean was 0.3771 which was positive and highly significant at one percent level of significance. Similarly, partial regression coefficient of bullock labour, manure and plant protection was 0.0992, 0.0300 and 0.0034 respectively which also positive and highly significant. On the contrary the partial regression coefficient of Nitrogen and Phosphorus was -0.0004 and -0.0158 respectively having negative and non-significant.

Marginal productivity
It was observed that marginal product with respect to area under soybean was 24.0535 quintals which means that in addition of one hectare of land to geometric mean which caused to give production of soybean by 24.0535 quintals. The marginal product of bullock labour was 0.9060 quintals it indicated that when there was addition use of one pair day of bullock labour which caused to give additional product of soybean by 0.9060 quintals. Similarly the marginal product of hired human labour, family human labour and machine was 0.6713 quintals, 0.7273 quintals and 0.1972 quintals respectively which means that when there was addition of one man day of hired and human labour and one hour of machine it give additional product of 0.6713 quintals, 0.7273 quintals and 0.1972 quintals respectively. As regards to marginal product of seed, manure and Potassium was 1.7199 quintals, 0.5279 quintals and 0.1616 quintals respectively it indicated that when there was addition use of one kg of seed, one quintal of manure and one kg of Potassium which caused to give additional product of soybean by 1.7199 quintals, 0.5279 quintals and 0.1616 quintals respectively. On the contrary the marginal product of Nitrogen was -0.0028 quintals which indicated that due to the addition of one kilogram of Nitrogen caused to reduce the product of soybean up to 0.0028 quintals. Similarly, the marginal product of Phosphorus and plant protection was -0.0942 quintals and -0.0569 quintals respectively it inferred that due to the addition of one kg of Phosphorus and one litre of plant protection caused to reduce the product up to 0.0942 quintals and 0.0569 quintals respectively. It can be included that Nitrogen, Phosphorus and plant protection was excess use in soybean production.

Resource use efficiency
Results revealed that marginal value product (MVP) due to area under soybean were found to be Rs. 89879.95 and price of input of land under soybean was Rs. 9342.96 hence MVP to price ratio was 9.62. MVP to price ratio of seed was found to be 94.56 followed by Potassium (21.82), manure (17.18) and family human labour (12.54). The MVP to price ratio of Nitrogen, Phosphorus and plant protection was found to be negative. It was cleared that higher the MVP to price ratio there was greater chance to increase this resources. So the results inferred that there was greater chance to increase seed, Potassium, manure and hired human labour utilization.

Optimum resource use
The results showed that optimum resource use of area under soybean was found to be 3.55 hectares which inferred that there was good chance to increase the area under soybean up to 3.55 hectares. With respect to area there was chance to increase the seed to 431.02 kg, Potassium to 72.17 kg, hired human labour to 45.91 man days and family human labour to 35.36 man days. On the contrary optimum resource use of Nitrogen and Phosphorus was negative i.e. -2.78 kg and -35.58 kg respectively which indicated that there was need to reduce Nitrogen to 2.78 kg and Phosphorus to 35.58 kg.

Table 1: Estimates of Cobb Douglas production function in soybean production

Sr. No.	Variables	Partial Regression Coefficient (bi)	Standard Error (SE)	't' value	Geometric mean (Xi)	Marginal Product (MP) q	Marginal Value Product (MVP)	Price of Input (Rs)	MVP to price ratio	Optimum Resource Use
1	Area under Soybean (ha/farm)	0.3771	0.1485	2.5399*	0.3686	24.0535	89879.95	9342.96	9.62	3.55
2	Hired Human Labour (manday/farm)	0.1132	0.1661	0.6820	3.9657	0.6713	2508.58	216.67	11.58	45.91
3	Family Human Labour (manday/farm)	0.0872	0.0985	0.8852	2.8194	0.7273	2717.67	216.67	12.54	35.36
4	Bullock Labour (pairday/farm)	0.0992	0.0322	3.0859**	2.5751	0.9060	3385.39	500.00	6.77	17.44
5	Machine (hours/farm)	0.0210	0.0508	0.4132	2.5017	0.1972	736.79	516.67	1.43	3.57
6	Seed (kg/farm)	0.3334	0.1849	1.8035	4..5579	1.7199	6426.61	67.96	94.56	431.02
7	Manure (qtl/farm)	0.0300	0.0111	2.7003**	1.3351	0.5279	1972.45	114.83	17.18	22.93
8	N (kg/farm)	-0.0004	0.0050	-0.0824	3.4782	-0.0028	-10.41	13.04	-0.80	-2.78
9	P (kg/farm)	-0.0158	0.0423	-0.3739	3.9486	-0.0942	-351.96	39.06	-9.01	-35.58
10	K (kg/farm)	0.0227	0.0440	0.5171	3.3076	0.1616	603.72	27.67	21.82	72.17
11	Plant protection (liter/farm)	0.0034	0.0012	2.7554**	-1.3894	-0.0569	-212.60	1756.41	-0.12	0.17

Intercept (log a) ------------ 1.2324
Note: Geometric mean ($\bar{Y}$) of soybean production was
F value ----------------------- 19.58**
23.51 qtls/farm and price was Rs. 3736.67/qtl
R^2 ----------------------------- 0.809
Return to scale (∑bi) ------ 1.0710
* Significant at 5 percent level
** Significant at 1 percent level

Conclusions

In case of soybean production the value of coefficient of multiple determinations (R^2) was 0.809 which indicated 80.90 percent effect of all independent variables together in soybean production. The partial regression coefficient of area under soybean (0.3771) which was positive and highly significant at one percent level of significance. The marginal product with respect to area under soybean was 24.0535, hired human labour, family human labour, bullock labour, machine, seed, manure and Potassium was 0.6713, 0.7273, 0.9060, 0.1972, 1.7199, 0.5279 and 0.1616 quintals respectively which mean that when there was addition of these resources the production of soybean was increases of their quantity. MVP to price ratio with respect to area, hired human labour, family human labour, machine, seed, manure, bullock pair and potassium was greater than unity while MVP to price ratio of Nitrogen, Phosphorus, and plant protection was negative. The results inferred that there was greater chance to increase seed, Potassium, manure and hired human labour utilization.

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