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Technologies adoption, resource use and technical efficiency in Alphonso mango production

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ABSTRACT : The average adoption index of low, medium and high adopters group was 45.14 per cent, 64.73 per cent and 90.22 per cent, respectively. Whereas, at overall level it was 66.69 per cent. Among the different technologies, the adoption index was higher in application of nitrogen (98.42), organic manure (95.64) and use of Nutan mango harvester (88.33) whereas, it was low in use of Amar loranthus cutter (14.17) and measures for control of spongy tissue (17.50). The co-efficient of multiple determinations (R^2) indicated 96.20 per cent variation in mango production, explained by the independent variables included in the function. The ratio of MVP/MFC was more than unity in case of phosphorus, manures indicating the scope of expanding the use of these inputs. The expenditure on other variables *i.e.*, human labour, nitrogen, potassium, insecticides and cultar need to be curtailed. Technical efficiency at overall level was 58.58 per cent. Among the groups such as low, medium and high adopters it was 59.29 per cent, 57.49 per cent and 62.80 per cent, respectively. Farmers having small land holding (< 2.0 ha) area had technical efficiency 54.11 per cent. Large farmers, who hold area more than 4.0 ha, had technical efficiency 59.38 per cent and the medium farmers it was 56.56 per cent. The farm size and technical efficiency had exhibited positive relationship in mango production.

KEY WORDS : Technology adoption index, Resource use efficiency, Allocative efficiency, Technical efficiency

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Mango (*Mangifera indica*) is an important fruit crop of India which day by day acquiring more demand which has encouraged the mango growers to undertake new plantations as well as to adopt improved technologies to increase yield of mango. India is largest producer of mango, accounts for about 40.9 per cent of the total world production. In the year 2009-10 it was cultivated on an area of 2.36 million ha with the production of 13.56 million tonnes in India. Improved technology include use of variety (Alphonso), use of recommended dose of nitrogenous, phosphorus, potash fertilizers, organic manures, recommended schedule for insect-pest control, use of recommended dose of cultar, control measure for spongy tissue and fruit drop etc. The present study was an attempt to analyze the impact of modern technologies on mango production in south Konkan region of Maharashtra.

RESEARCH METHODS

A cross sectional sample of 120 mango growers was selected randomly from south Konkan region of Maharashtra. The information for the agricultural year 2009-10 was obtained through personal interview with

the sample farmers. The sample farmers were grouped into different categories on the basis of adoption of technology in mango production to study the impact of technology out of all the technologies recommended by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli as given below :

- Proportion of area under Alphonso mango in total mango plantation
- Use of nitrogen (N), phosphorus (P) and potassium (K)
- Use of organic manure
- Schedule for control of insect-pest and disease
- Use of cultar
- Amar loranthus cutter
- Measures for control of fruit drop
- Measure for control of spongy tissue.

$$TAI_i = \frac{1}{K}\left(\frac{AX_1}{RX_1} + \frac{AX_2}{RX_2} + \ldots\ldots + \frac{AX_K}{AX_K}\right) \times 100$$

where,

TAI_i = Technology adoption index

AX_i = Actual use of selected technology.

RX_i = Recommended use of selected technology.

The technology adoption index (TAI) for each sample farmer was worked out for all technologies and then the selected sample farmers were classified into three groups as low adopters, medium adopters and high adopters. The classification was carried out with the help of mean and standard deviation criteria, such as :

- Category I (low adopters) = less than AM – SD.
- Category II (moderate adopters) = (AM - SD) to (AM + SD)
- Category III (high adopters) = greater than AM + SD.

where,

AM – Arithmetic mean of technology adoption index of all the farmers.

SD – Standard deviation of technology adoption index.

Functional analysis :

The production function analysis approach was used to identify the factors influencing the yield of mango.

$$Y = f(X_1, X_2, X_3, \ldots, X_n)$$

where,

The Cobb-Douglas type of production function specified below was used for the present analysis.

$$Y = a x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5} x_6^{b_6} x_7^{b_7} x_8^{b_8} x_9^{b_9} x_{10}^{b_{10}} U$$

where,

Y = Production of mango crop (q)

a = Intercept, a scale parameter

X_1 = Area under mango (ha)

X_2 = Human labour (days)

X_3 = Quantity of nitrogen (kg)

X_4 = Quantity of phosphorus (kg)

X_5 = Quantity of potassium (kg)

X_6 = Quantity of FYM (t)

X_7 = Quantity of plant protection (kg)

X_8 = Quantity of cultar (l)

X_8 = Use of amar loranthus cutter

X_9 = Measures for control of fruit drop

X_{10} = Measures for control of spongy tissue

b_1 to b_{10} = Regression co-efficient of respective variables

U = Error term.

The technical efficiency in production was estimated using the stochastic frontier production function (Job and George, 2002). The stochastic frontier production function of the Cobb-Douglas type was specified for this study and was defined as follow :

$$\ln Y = \beta_0 \ln X_i + U_i$$

where, $U_i \leq 0$.

Timmer measure of technical efficiency :

Timmer measure of technical efficiency of a farm is the ratio of the actual output to the potential output given the level of input use on farm 'i'. It thus, indicates how much extra output could be obtained if farm 'ith' were to be on the frontier.

Timmer measure of technical efficiency,

$$TE = \frac{Y}{Y^*}$$

where,

Y* = The maximum attainable output at given levels of the input (frontier output).

Y = Actual output.

Efficiency of resource use :

To see whether the existing resources allocation was at optimum level or otherwise, the ratio of marginal value productivity of resource to its unit cost (factor price) was calculated by using following procedure.

Marginal physical productivity (MPP) :

The MPP of particular resource was estimated by

taking first order partial derivative of output with respect to each input by using the following method.

$$\frac{Dy}{Dx_i} Z\ bi \frac{\overline{Y}}{\overline{X_i}}$$

$$\frac{dy}{dx_i} Z \text{ MPP of } X_i$$

where,

bi = Production elasticity of Xi

$\overline{X_i}$ = Geometric mean of Xi

$\overline{Y}$ = Geometric mean of Y

Likewise MPP of ith input was estimated.

Marginal value product (MVP):

The marginal value product of each input was calculated by multiplying the marginal physical product (MPP) of input by price per unit of output (MFC).

MVP of Xi = (MPP of Xi) × (per unit price of Y)

To know resource use efficiency, MVP of resource was then compared with per unit cost of resource (MFC) *i.e.*, ratio of MVP to MFC (Marginal factor cost).

MVP/MFC = 1- Optimum use of resources

MVP/MFC < 1- Excess utilization of resources

MVP/MFC > 1- Under utilization of resources.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Distribution of sample of mango growers :

The distribution of sample of mango growers was done according to Technology Adoption Index (TAI). The technology adoption index (Table 1) for all the selected mango growers was measured as per methodology explained above and they were classified into three categories.

Extent of adoption of selected technologies for mango production :

The technologies selected for study were use of Alphonso variety, dose of nitrogen, phosphorus, potassium, manure and insecticides/fungicides, use of nutan mango harvester, Amar loranthus cutter, cultar, control measures for fruit drop and spongy tissue. The extent of adoption of selected technologies for mango production is given in Table 2.

It was observed from Table 2, the average adoption index of low, medium and high adopters group was 45.14

Table 1 : Classification of sample farmers on the basis of technology adoption index (TAI)

Sr. No.	TAI range (%)	Number of farmers	Adoption level
1.	Up to 53.82	14	Low
2.	53.83 to 79.57	86	Medium
3.	Above 79.58	20	High
	Total	120	
	Arithmetic mean (TAI)	66.69	
	Standard deviation (TAI)	12.875	

Table 2 : Extent of adoption of selected technologies for mango production **(Figures in %)**

Sr. No.	Name of technology	Level of adoption			
		Low (n=14)	Medium (n=86)	High (n=20)	Overall (n=120)
1.	Area under alphonso mango	100.00	100.00	100.00	100.00
2.	Application of nitrogen	84.16	99.98	98.49	98.42
3.	Application of phosphorus	71.81	88.24	96.03	87.62
4.	Application of potassium	61.21	72.19	86.34	73.26
5.	Use of organic manure	75.25	96.97	95.78	95.64
6.	Use of insecticides/ fungicides	51.92	71.42	77.90	70.22
7.	Use of Nutan mango harvester	21.43	96.51	100.00	88.33
8.	Use of Amar loranthus cutter	0.00	1.16	80.00	14.17
9.	Use of Cultar	4.63	71.18	81.17	65.08
10.	Control measures for fruit drop	2.38	44.96	75.00	45.00
11.	Control measures for spongy tissue	0.00	1.16	100.00	17.50
	Average adoption index	45.14	64.73	90.22	66.69

per cent, 64.73 per cent and 90.22 per cent, respectively. Whereas, at overall level it was 66.69 per cent. Among the technologies, the adoption index was higher in application of nitrogen (98.42), organic manure (95.64) and use of Nutan mango harvester (88.33) whereas, it was low in use of Amar loranthus cutter (14.17) and measures for control of spongy tissue (17.50).

Production of mango :

The information about the per farm and per hectare number of trees, production and per tree production of the farmers in low, medium and high adopters group is given in the Table 3.

It is observed from the Table 3 that at the overall level per farm area of mango orchard was 3.08 ha, whereas, it was 0.91 ha, 2.94 ha and 5.16 ha on the farms belong to low, medium and high adopters group, respectively. At the overall level, numbers of trees were 300. Per farm production of mango fruits was 104.98 q, at the overall level. The per hectare analysis showed that, there were 98, 98 and 97 mango trees, respectively with low, medium and high adopters group and at overall level average number of trees were 98. Per hectare overall mango production was 33.28 q fruits, which were 28.93 q, 33.01 q and 37.49 q in low, medium and high adopters groups, respectively. This indicated that size of orchard, number of trees per farm as well as per hectare, production of fruits, per farm and per hectare was comparatively better on farms in high adopters group than the farms in low and medium adopters group. This may be the result of better utilization of important inputs by the growers in high adopters group. The results are in conformity with Naik (2005) in his study entitled an economic analysis of mango production, processing and export in South Konkan Region of Maharashtra.

Functional analysis :

The information on the estimated parameters is

Table 3 : Per farm and per hectare productivity of mango

Sr. No.	Particulars	Low adopters (n=14)	Medium adopters (n=86)	High adopters (n=20)	Overall (n=120)
1.	**Per farm**				
	Area of orchard (ha)	0.91	2.94	5.16	3.08
	Number of trees	89.64	288.05	501.50	300.48
	Production (q)	26.14	97.47	192.5	104.98
2.	**Per hectare**				
	Number of trees	98.11	97.95	97.11	97.83
	Production (q)	28.93	33.01	37.49	33.28

Table 4 : Production function estimates in mango cultivation

Sr. No.	Resource	Regression co-efficients	Standard error
1.	Intercept	2.0655	
2.	X_1 – Area (ha)	1.53*	0.4436
3.	X_2 – Number of trees	0.83	0.9854
4.	X_3 – Age (years)	0.35*	0.0392
5.	X_4 – Human labour (days)	-0.13	0.1853
6.	X_5 – Nitrogen (kg)	-0.56***	0.3283
7.	X_6 – Phosphorus (kg)	0.20	0.2108
8.	X_7 – Potassium (kg)	-0.31***	0.1677
9.	X_8 – Manures (t)	0.37***	0.2219
10.	X_9 – Insecticides (kg)	-0.085	0.1311
11.	X_{10} – Cultar (lt)	0.016	0.0121
12.	R^2	0.962*	
13.	Adjusted R^2	0.958*	
14.	Number of observations	120	
15.	Returns to scale (Σbi)	2.2	
16.	F value	272.36	

* and *** indicate significance of values at P=0.01 and P=0.1, respectively

given in Table 4. Various forms of production functions were tried to find out the effect of various inputs on productivity of mango, however, log linear form of production function (CD type) was found to be best fit as co-efficient of determination (R^2) was 0.962 explaining 96.20 per cent of variation on dependent variable (yield) was explained by the independent variables in the model and model was best fit as R^2 was also statistically significant at one per cent level, which was observed from the significant F value (272.36).

It is seen from the Table 4 that, the elasticity co-efficients of area (X_1) and age of orchard (X_3) were positively significant at one per cent level of probability at overall level. The elasticity co-efficient of nitrogen (X_5) was negatively significant (-0.56) at ten per cent level of probability indicating negative effect of nitrogen on the productivity of mango. The similar type of results was obtained for potassium (X_7) with elasticity co-efficient -0.31. The elasticity co-efficient of manures (X_8) was positive and significant at ten per cent level of probability indicating positive effect on the productivity of mango. In case of area, age and manures one per cent increase would result 1.53 per cent, 0.35 per cent and 0.37 per cent increase in yield, respectively. However, as regards to nitrogen and potassium one per cent increase would affect adversely on productivity by 0.56 and 0.31 per cent, respectively. Similar, results were also observed by Naik (2005) in his study.

In CD function, the sum of production elasticities directly gave return to the scale. The sum of production elasticities (Σ bi) was 2.2, indicating increasing returns to scale.

Efficiency of resource use :

Details of allocative efficiency of inputs used in mango cultivation at overall level are given in Table 5.

It is seen from the Table 5 that, the ratio of MVP to MFC in case of human labour (X_4) was -0.90. Ratio

Table 5 : Allocative efficiency of inputs used in mango cultivation

Sr. No.	Resource	Ratio of MVP/MFC	Level of resource use
1.	Human labour (X_4)	- 0.90	Excess utilization
2.	Nitrogen (X_5)	- 34.92	Excess utilization
3.	Phosphorus (X_6)	27.87	Under utilization
4.	Potassium (X_7)	- 15.02	Excess utilization
5.	Manures (X_8)	7.07	Under utilization
6.	Insecticides (X_9)	- 0.81	Excess utilization
7.	Cultar (X_{10})	0.36	Excess utilization

Table 6 : Technical efficiency of sample mango orchards as per technology adoption level

Sr. No.	Particulars	Low adopters (n=14)	Medium adopters (n=86)	High adopters (n=20)	Overall (n=120)
1.	Average technical efficiency (%)	59.29	57.49	62.80	58.58
2.	Efficiency level (No. of farms)				
	High efficiency (TE > 67.44%)	2 (1.67)	9 (7.50)	5 (4.17)	16 (13.33)
	Medium efficiency (TE 49.73% to 67.44%)	9 (7.50)	59 (49.17)	13 (10.83)	81 (67.50)
	Low efficiency (TE <49.73%)	3 (2.50)	18 (15.00)	2 (1.67)	23 (19.17)
	Total farms	14 (11.67)	86 (71.67)	20 (16.66)	120 (100.00)
3.	Minimum efficiency (%)		39.39		
	Maximum efficiency (%)		100.00		

(Figures in parentheses are percentages to total farms)

Table 7 : Technical efficiency according to farm size of sample mango growers

Sr. No.	Particulars	Efficiency level (%)
1.	Small farmers (≤ 2.0 ha)	54.11
2.	Medium farmers (2.0 – 4.0 ha)	56.56
3.	Large farmers (≥ 4.0 ha)	59.38
	Overall	58.58

was less than unity indicating excess utilization of the labour resource. This ratio for fertilizers *i.e.*, for nitrogen (X_5), phosphorus (X_6) and potassium (X_7) was -34.92, 27.87 and -15.02. The ratio was less than unity for nitrogen and for potassium, indicating excess use of these fertilizers also. Whereas, ratio was more than unity for phosphorus indicating further scope to increase the level of this fertilizer resource for maximization of profit. In case of manure (X_8) this ratio was more than one (*i.e.*, 7.07) which indicated under utilization of this resource and hence, scope for increasing utilization of manure.

The ratio of MVP to MFC for insecticides (X_9) and cultar (X_{10}) were also less than unity (*i.e.*, -0.81 and 0.36, respectively), which indicated excess utilization of these resources. However, the use of insecticides (X_9) and cultar (X_{10}) should be curtailed for maximization of profit.

The analysis of resource use efficiency indicated that in the production of mango, farmers were found to have used excess quantity of labour, nitrogenous and potassium fertilizers, insecticides, cultar and under utilization of phosphorus fertilizers, manures. As these are the costly and important inputs in mango production, the mango growers should have to use recommended doses of these inputs to increase the profit.

Technical efficiency :

The technical efficiency of an individual farm is defined as the ratio of the observed output to the corresponding frontier output, conditioned on the levels of inputs used on farm. The technical efficiency of each farm was calculated and later on the basis of technical efficiency of all farms were classified into three categories as high, medium and low efficient on the basis of mean and standard deviation criteria which is explained in methodology. Details of farm specific technical efficiencies in different adopters group are given in Table 6.

Table 6 revealed that farm specific technical efficiencies varied between 39.39 per cent and 100.00 per cent. Average per cent of technical efficiency at overall level was 58.58 per cent. Among the groups such as low, medium and high adopters it was 59.29 per cent, 57.49 per cent and 62.80 per cent, respectively. At overall level about 16 farms had high technical efficiency *i.e.*, more than 67.44 per cent, 81 farms had medium technical efficiency (49.73 to 67.44 %) and about 23 farms had low technical efficiency (less than 49.73 %). The results are contrary to Karale (2010) in her study on impact of modern technologies on rice production in Ratnagiri district (M.S.).

The technical efficiency according to farm size of sample mango growers is given in Table 7.

Farmers having small land holding (< 2.0 ha) area had technical efficiency 54.11 per cent. Large farmers, who hold area more than 4.0 ha, had technical efficiency 59.38 per cent and the medium farmers it was 56.56 per cent. The farm size and technical efficiency has exhibited positive relationship in mango production. However, there was comparatively less difference in technical efficiency of farms of different size of holding. However, it is revealed from the study of technical efficiency in mango production, there is further scope for increasing the mango production with present level of resource use.

Conclusion :

Area, age, organic manures, these variables showed positive significant influence on yield, while nitrogen and potassium were having negative significant influence. In mango cultivation, excess used inputs were human labour, nitrogen, potassium, insecticides and cultar while under used inputs were phosphorus and organic manures. Overall technical efficiency of sample mango orchard was 58.58 per cent; however, 71.67 per cent farms were operating with medium efficiency while 11.67 per cent and 16.67 per cent had low and high efficiency level. Increase in farm size indicated increase in efficiency level, however, the difference in efficiency level over different farm size was less. Average technical efficiency of low, medium and high adoption group was 59.29 per cent, 57.49 per cent and 62.80 per cent, respectively. With the present level of use of resources with proper allocation and use of inputs the technical efficiency can be increased by 25 to 30 per cent.

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