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Technological change in rice production in north Konkan region (M.S.)

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Abstract
The present study is an attempt to analyze the impact of improved technologies on rice production in North Konkan regions of Maharashtra. The studies undertaken so far had mostly focused on the favorable effects of technological change. The study is based on primary data collected from 270 rice growers from North Konkan region. The data were collected through personal interview method. At the overall level, technology adoption index score in study area was 66.37 percent. The lower of technology adoption index were found in use of FYM/green manuring, Urea briquette, P and K. The per hectare total cost of cultivation (Cost-C2) of low adopters, medium adopters, high adopters and overall level was ₹ 96221.52, 93393.95, 82464.22 and ₹ 91591.80 respectively. per hectare yield was increased 29.98 q in low adopters to 35.98 q in high adopters with an overall average of 34.21 q. Per hectare gross returns, it was highest in high adopter (₹65080.60) followed by medium adopter (61388.70) and low adopter (53958.10). The benefit cost ratio at cost C1 (0.76) and cost C2 (0.67) was negative at overall level, but it was increased from low to high adopters. Net incremental benefits was found for medium group (10258.17), high level of adoption group (24879.81) and (12395.32) at overall level of adoption.

Keywords: Rice growers, production, technology, adoption, rice cultivation, yield gap

Introduction
India is the second leading producer of rice in the world after China. Rice is grown extensively in India on 43.86 million ha followed by China (30.16 million ha) However, highest production of rice is in China (144.85 million tonnes) followed by India (104.80 million tonnes). This is due to higher productivity of rice in China (6.86 t ha^{-1}) than India (3.77 t ha^{-1}) (Anon. 2017). In technology breakthrough in the field of agriculture has resulted in the spectacular performance in rice production in the country, but concerning average productivity, such a phenomenon forth coming, as compared to other Asian countries, the production of rice per unit of land (productivity) is low in India. In the year 2016 – 2017, the area under rice crop in India was maximum in Uttar Pradesh (5.87 million hectares) followed by West Bengal (5.39 million hectares), Andra Pradesh (3.81 million hectares) and Orissa (4.17 million hectares). In terms of production of rice, West Bengal ranked first (14.71 million tonnes) followed by Uttar Pradesh (12.22 million tonnes), Andra Pradesh (11.57 million tonnes), Punjab (11.11 million tonnes) and Orissa (8.29 million tonnes). In Maharashtra, rice is grown on area of about 1.55 million hectares with a production of about 2.93 million tonnes. In Maharashtra, rice is cultivated on 15.56 lakh ha area in all four regions *viz.* Vidarbha (8.15 lakh ha), Konkan (3.69 lakh ha), Western Maharashtra (3.55 lakh ha) and Marathwada (0.156 lakh ha). The highest productivity of rough rice was in Konkan region (4.25 tha^{-1}) followed by Western Maharashtra (3.5 tha^{-1}) and Vidarbha (3.4 tha^{-1}) (Anon. 2017). In Konkan region of Maharashtra has 5 districts *viz.* Thane, Palghar, Raigad, Ratnagiri and Sindhudurg. Highest productivity in Konkan is in Sindhudurg district (4.89 t ha^{-1}) followed by Ratnagiri (4.66 tha^{-1}), Palghar (4.1 tha^{-1}), Raigad (3.99 tha^{-1}) and Thane (3.88 tha^{-1}). In *Konkan* region, rice occupies an area of about 3.69 lakh hectares with annual production of nearly 15.69 lakh tonnes. The area under rice in Konkan is about 23.71 percent of total cultivated area in Maharashtra and productivity of Konkan region is 2.9 tonnes per hectare.
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli has developed approximately 25 high yielding varieties of rice with improved architecture and 5 excellent rice hybrids of various durations. In addition to development of varieties, University has recommended

several modern rice technologies for benefit of farmers. The average yield in tonnes/ha must be increased basically through improved cultivation practices and new techniques. This study focused on the economics of technological change in rice production. Specifically, the study examined the nature and magnitude of change in technology of rice production from traditional to improved rice varieties and the effect of such change on the productivity differences among farmers. The findings of the study will further be helpful to identify impact of adoption of technological change in rice production thus, this study will help to form the base for improvement in rice cultivation. More ever, it will also be helpful to formulate some strategies for the rice growers.

Objectives
1. To study the extent of adoption of technologies in rice production.
2. To study the economics of rice cultivation across different level of technology adoption.

Methodology
North Konkan region has 240100 ha area under rice cultivation with a productivity 8310 metric tons considerily. In the Konkan region 369000 ha area is under rice cultivation of which North Konkan region shares 65.07 percent and South Konkan region shares 34.93 percent hence the North Konkan region selected purposively for the study. Thus, final sample were consisting of 3 district, 9 tahsils, 27 villages and 270 rice growers from North Konkan region (M. S.). The data were collected through personal interview method.

Analysis of data
There are more than 40 technologies recommended by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for rice growers in Konkan region for rice production. However, out of these 21 technologies were selected and they were grouped into 9 technology components (groups).

Table 1: Technologies Selected for present study

S. No.	Name of technology		Recommendation	
1.	Varieties according to soil type	a) Kharland	Panvel – 1, 2, 3, MK- 47-22, Damodar, MR 3.9	
		b) Other land	All other recommended varieties (approximately 25)	
2.	Tillage operations	a) Ploughing	1st (After rainy season) 2nd (After 1st shower)	
3.	F.Y.M. / Green manure	a)7.5 tones/ha F.Y.M. or compost before 2^{nd}ploughing		
		b) 5 tones/ha green manure (Glyricidia-puddling)		
4.	Seed technology	a) Varieties - 1) Seed (Quantity)	Coarse varieties – 50 to 60 kg/ha Fine varieties – 35 to 40 kg/ha Hybrid – 20 kg/ha	
5.	Transplanting	a) Age of seedling	Kharif 22 to 25 days	
		b) Spacing	i. HYV 20 x 15 cm or 25 x 15 cm ii. Hybrid 20 x 15 cm	
		c) No. of seedling per hill	i. HYV – 2 to 3 ii. Hybrid – one	
6.	Fertilizers	a) Quantity (NPK)	i. HYV 100-50-50 ii. Hybrid 120-50-50 iii. Scented varieties 80-50-50	
		b) Method of application	HYV – 1) 40-50-50 (Puddling) 2) 40-0-0 (Sprouting) 30 to 40 days after planting 3) 20-0-0 (flowering) 70 to 80 days after transplanting	
7.	Urea briquettes	On the same day after transplanting		
		Depth – 7 to 10 cm		
		Weight – 2.7 gm		
		Place – At centre at 4 plants		
8.	Intercultural operation	a) Hoeing	30 to 35 days after transplanting	
		b) Weeding		
		c) Weedicide	Butachlor 1.5 kg 4 days after transplanting	
9.	Harvesting	a) At 90% of grains maturity		
		b) Use of Vaibhav sickle		

Actual level of adoption of each item of technology on rice growers' field were identified. On the basis of this information the 'Technology Adoption Index" of each rice growers were estimated by using following formula. [Anupama *et al.* (2005)].

$$A) \quad TAI = 1/n\{(AX_1/RX_1)+(AX_2/RX_2)+\ldots\ldots(AX_n/RX_n)\} X100\ldots..(1)$$
Where,

n = No. of technologies
AX_i = Actual use of selected technology
RX_i = Recommended use of selected technology
Excess use was observed in case of seed and nitrogen. The following formula was used to calculate adoption index for those input and for particular sample farm. [Torane *et al.* (2015)].

A) Excess use up to 200 percent
For calculating the adoption index for excess input use upto 200 percent more than the recommended input level for individual input (technology) following formula was used.

Single Technology Adoption Index (STAI)
$$STAI = 2- (AX_i / RX_i) X 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$
Where, 2 = constant

The STAI index was calculated for seed and nitrogen and it was used in equation – (1) as mentioned earlier.

B) Excess use upto 300 percent
Single Technology Adoption Index (STAI)
$$STAI = [3- (AX_i / RX_i)] / 2 X100$$
Where, 3 = constant (a) & 2 is constant (b).

In the present study after calculating the total adoption index for inputs for each rice growers the sample rice growers were grouped into three categories of adoption level. The classification were carried out with the help of mean, and standard deviation criteria, such as
1. Group I (Low adopters) = Less than AM − SD
2. Group II (Medium adopters) = (AM − SD) to (AM + SD)
3. Group III (High adopters) = Greater than AM + SD

Where,
AM − Arithmetic Mean of Technology Adoption Index of all the rice growers and all the technologies.
SD − Standard Deviation of Technology Adoption Index.

Different cost concepts used in working out cost of cultivation
For estimating cost of production of rice, the standard cost concept followed by CACP was used. Appropriate statistical tools were used. [Nirmala and Muthuraman, (2009)].

Cast A1 = Actual cost paid by rice growers in the form of cash and lands.
Cost A2 = Cost A1 + Rent paid for leased-in land
Cost B1 = Cost A1 + +Interest on fixed capital.
Cost B2 = Cost B1 + Rental value of owned land + Rental paid for lease-in land
Cost C1 = Cost B1 + family labour.

Cost C2 = Cost B2 + family labour
Cost C2*= Per quintal cost C2 + marketing charges /quintal
Cost C3= Cost C2* + 10% of C2

iv) Benefit Cost Ratio
As the rice is annual crop a Benefit Cost Ratio or Input Output Ratio was calculated by using following formula.

$$\text{Benefit Cost Ratio} = \frac{\text{Gross Returns ()}}{\text{Total cost ()}}$$

v) Per quintal cost of production
Per quintal cost of production was worked out by using following formula

$$\text{Per quintal cost of production} = \frac{\text{Total cost} - \text{Value of by produce}}{\text{Grain yield in quintal}}$$

Results and discussion
The results of the study were analyzed with the use of basic data collected for this investigation.

Distribution of sample rice growers as per level of adoption
The selected rice growers for *kharif* rice were classified into three groups as per level of adoption and presented in Table No. 2.

Table 2: Distribution of sample rice growers as per level of adoption

Sr. No.	Category of technology adoption	Technology adoption index	Range of technology adoption index (%)	No. of sample rice growers	Percentage
1	Low	below 0.58	0 to 58.26	46	17.04
2	Medium	0.58 to 0.74	58.27 to 74.49	180	66.67
3	High	above 0.74	above 74.49	44	16.30
	Total/Overall		66.37 (Standard Deviation = 8.11)	270	100.00

The distribution of rice growers were grouped into three categories namely low adopters (17.04%), medium adopters (66.67%) and high adopters (16.30%) as per range of technology adoption index such as below 0.58, 0.58 to 0.74 and above 0.74 respectively. It was revealed from the table that, at the overall level, technology adoption index score in study area was 66.37 percent which indicated large scope to increase the level of adoption. Among the groups as per level of adoption, maximum (66.67 percent) rice growers were in medium adoption group, followed by high adoption group (16.30%) and low adoption (17.04%). Results are in conformity with that of Singh and Yadav (2014), Torane *et al*. (2015), Patil and Nemade (2016), Debberma *et al*. (2018) and Shinde *et al*. (2018) [10].

Extent of adoption of recommended technologies in North Konkan region
The technology adoption of index gives the clear-cut idea about the adoption of a particular technology component whereas the magnitude of composite index gives the aggregate percentage of adoption of all components of technology [Hile *et al*. (2015)]. Dr. Balasaheb Sawant

Konkan Krishi Vidyapeeth, Dapoli has released ten production technologies of rice. The technology wise level of adoption by sample rice growers is given in Table 3.
Table 3 revealed that level of adoption in case of tillage operation, seed technology, fertilizers-N, P, K, urea briquettes and harvesting adopted by rice growers with an adoption index of 0.99, 0.73, 0.70, 0.34, 0.28, 0.41 and 0.91 respectively. The intercultural operation were adopted by 243 rice growers with adoption index of 0.92, transplanting were adopted by 215 rice growers with adoption index of 0.78, followed by Varieties according to soil type and FYM were adopted by 242 and 221 rice growers with adoption index of 0.90, 0.35, respectively.
The lower of technology adoption index were found in use of FYM/green manuring, Urea briquette, P and K. The studies on extent of adoption conducted by Borah and Misra (1986), Chithra and Shanmugasundaram (2002), Singh and Chahal (2009), Singh *et al*. (2010), Mustapha *et al*. (2012) and Wani *et al*. (2013), Anonymous (2014) [3], Hile *et al*. (2015), Sharma *et al*. (2015), Naik *et al*. (2016), Badhala *et al*. (2017) and Debberma *et al*. (2018).

Table 3: Extent of adoption of recommended technologies (No. of rice growers) (Adoption index)

S. No.	Group of Technology	Non Adopters	Level of adoption			Overall (N= 270)
			Low (N= 46)	Medium (N= 180)	High (N= 44)	
1	Tillage operations	0	0.98 (46)	0.99 (180)	0.99 (44)	0.99 (270)
2	Varieties according to soil type	28	0.67 (31)	0.93 (168)	0.98 (43)	0.90 (242)
3	F.Y.M. / Green Manure	49	0.22 (31)	0.32 (148)	0.61 (42)	0.35 (221)
4	Seed technology	0	0.73 (46)	0.71 (180)	0.80 (44)	0.73 (270)
5	Fertilizers					
i)	N	0	0.78 (46)	0.72 (180)	0.53 (44)	0.70 (270)
ii)	P	33	0.24 (38)	0.33 (156)	0.51 (43)	0.34 (237)
iii)	K	31	0.18 (37)	0.28 (159)	0.4 (43)	0.28 (239)
6	urea briquettes	130	0.23 (13)	0.38 (89)	0.71 (38)	0.41 (140)
7	Plant protection	0	0.43 (46)	0.59 (180)	0.62 (44)	0.65 (270)
8	Transplanting	17	0.49 (42)	0.82 (169)	0.92 (42)	0.78 (253)
9	Intercultural Operation	27	0.80 (42)	0.94 (174)	0.95 (27)	0.92 (243)
10	Harvesting	0	0.80 (46)	0.93 (180)	0.93 (44)	0.91 (270)
	Average adoption index		54.71	66.29	78.86	66.37

(Figures in parentheses indicate the number of rice growers who have adopted the particular technology in respective group)

Yield gap in rice with level of technology adoption
The yield gap for rice was estimated and presented in Table no. 4. It is observed from the table that, at overall level total yield gap was 15.79 q (31.58%). The total yield gap per hectare on sample farms reduced from 20.02 q (40.04%) to 14.02 q (28.04%) with increase in level of technology adoption. The yield gap II reduced from 10.02 q (20.04%) to 4.02 q (8.04%).

Table 4: Yield gap in rice with level of technology adoption (q/ha)

S. No.	Particulars	Level of adoption			Overall (N=270)
		Low (N=46)	Medium (N=180)	High (N=44)	
A	Research station Yield	50			
B	Demonstration Yield	40			
C	Yield on sample farms	29.98 (59.96)	33.96 (67.92)	35.98 (71.96)	34.21 (68.42)
1	Yield gap I (A-B)	10.00 (20.00)	10.00 (20.00)	10.00 (20.00)	10.00 (20.00)
2	Yield gap II (B-C)	10.02 (20.04)	6.04 (12.08)	4.02 (8.04)	5.79 (11.58)
3	Total yield gap (A-C)	20.02 (40.04)	16.04 (32.08)	14.02 (28.04)	15.79 (31.58)

(Figures in parentheses are percentage of yield gap to research station yield)

Profitability at different levels of technology adoptions
Considering the difference in input utilization and cost incurred for cultivation of rice in low adopters, medium adopters, high adopters, overall adopters and different varieties of rice, the yield level and economics (profitability) also different. The profitability of rice cultivation in different adoption category groups of rice growers was worked out and results are presented in table no. 5.

It is observed from the table that per hectare yield was increased 29.98 q in low adopters to 35.98 q in high adopters with an overall average of 34.21 q. Per hectare gross returns, it was highest in high adopter (65080.60) followed by medium adopter (61388.70) and low adopter (53958.10). The rice cultivation is profitable at cost A1, cost B1 and cost B2 level. At cost C1 and cost C2 level it is negative on low, medium and overall adopters, it was found to be non-profitable.

Table 5: Profitability of rice cultivation at different level of technology adoptions

S. No.	Particulars	Level of Adoption			Overall
		Low	Medium	High	
1	Yield q/ha	29.98	33.96	35.98	34.21
2	Value of main product	44070.60	49921.20	52890.60	50288.70
3	Value of by product	9887.50	11467.50	12190.00	11435.00
4	Gross income	53958.10	61388.70	65080.60	61723.70
5	**Cost of cultivation**				
	Cost A1 (₹)	39148.99	39632.52	34207.41	38052.13
	Cost B1 (₹)	39816.51	40322.50	34918.45	38737.52
	Cost B2 (₹)	48809.52	50553.95	45765.22	49024.80
	Cost C1 (₹)	87228.51	83162.50	71617.45	81304.52
	Cost C2 (₹)	96221.52	93393.95	82464.22	91591.80
6	Profit at				
	Cost A1 (₹)	14809.11	21756.18	30873.19	23671.57
	Cost B1 (₹)	14141.59	21066.20	30162.15	22986.18
	Cost B2 (₹)	5148.58	10834.75	19315.38	12698.90
	Cost C1 (₹)	-33270.41	-21773.80	-6536.85	-19580.82
	Cost C2 (₹)	-42263.42	-32005.25	-17383.62	-29868.10
7	**Benefit Cost ratio at**				
	Cost A1 (₹)	1.38	1.55	1.90	1.62
	Cost B1 (₹)	1.36	1.52	1.86	1.59
	Cost B2 (₹)	1.11	1.21	1.42	1.26
	Cost C1 (₹)	0.62	0.74	0.91	0.76
	Cost C2 (₹)	0.56	0.66	0.79	0.67

The benefit cost ratio at cost A1 (1.62), cost B1(1.59) and cost B2 (1.26) was positive at overall level. The benefit cost ratio at cost C1 (0.76) and cost C2 (0.67) was negative at overall level, but it was increased from low to high adopters. This revealed that, rice cultivation technology adoption has positive influence in economics of rice cultivation. Similar observations were made by Husain *et al.* (2001) and Torane *et al.* (2015).

Impact of technology on cost reduction at different levels of technology adoption
The impact of technology on cost reduction was done to know how the increased level of technology adoption index of rice has reduced per quintal cost of rice cultivation. The details of analysis on this aspect on are given in table no. 6. It is seen from table that, technology adoption

Table 6: Impact of technology on cost reduction at different level of technology adoptions

S. No.	Particulars	Level of Adoption			Overall
		Low	Medium	High	
1	Output (q/ha)	29.98	33.96	35.98	34.21
2	Gross Returns (₹)	53958.10	61388.70	65080.60	61723.70
3	Increase in Gross Returns (₹/ha)	0.00	7430.60	11122.50	7765.60
4	Decrease or increase in cost of cultivation				
	Cost A1 (₹/ha)	0.00	483.53	-4941.58	-1096.86
	Cost B1 (₹/ha)	0.00	505.99	-4898.06	-1078.99
	Cost B2 (₹/ha)	0.00	1744.43	-3044.31	215.28
	Cost C1 (₹/ha)	0.00	-4066.01	-15611.06	-5923.99
	Cost C2 (₹/ha)	0.00	-2827.57	-13757.31	-4629.72
5	Unit cost reduction (Per quintal)				
	Cost A1 (₹)	0.00	10.63	27.19	14.82
	Cost B1 (₹)	0.00	10.60	26.93	14.74
	Cost B2 (₹)	0.00	8.56	21.87	11.98
	Cost C1 (₹)	0.00	15.83	31.59	18.32
	Cost C2 (₹)	0.00	14.31	28.59	16.58

has positive influence on cost reduction. The per hectare cost of cultivation decrease in cost A1 (1096.86), cost B1 (1078.99), cost C1 (5923.99) and cost C2 (4629.72) at overall level of adoption but increased in cost B2 (215.28) at overall level of adoption over low level of adoption. Decreased in cost of cultivation was found for all Cost (Cost A1, Cost B1, Cost B2, Cost C1 and Cost C2) in high adoption level of technology than the low and medium level of technology adoption. The per quintal unit cost reduction at cost A1

(14.82), cost B1 (14.74), cost B2 (11.98), cost C1 (18.32) and cost C2 (16.58) at overall level of adoption over low level of adoption. Results are in conformity with that of Torane *et al.* (2015) and Hile *et al.* (2015).

Economic impact of technology
It is seen from the Table 7 that, the increase in gross returns over low level of adoption (7430.60) for medium, (11122.50) for high and (7765.60) for overall level of adoption.

Table 7: Economic impact of technology at different level of technology adoptions

S. No.	Particulars	Level of Adoption			Overall
		Low	Medium	High	
1	Output (q/ha)	29.98	33.96	35.98	34.21
2	Gross Returns (₹/ha)	53958.10	61388.70	65080.60	61723.70
	(A) Increase in Gross Returns over low level of adoption(₹/ha)	0.00	7430.60	11122.50	7765.60
	(B) Percent change over low level of adoption	0.00	13.77	20.61	14.39
3	Cost (C2) of cultivation (₹/ha)	96221.52	93393.95	82464.22	91591.80
	(A) Decrease in cost of cultivation over low level of adoption (₹/ha.)	0.00	2827.57	13757.31	4629.72
	(B) Percent change over low level of adoption	0.00	2.94	14.30	4.81
4	Net Incremental benefits (₹/ha) (increase in returns+ decrease in cost)	0.00	10258.17	24879.81	12395.32
	Net Incremental benefits per quintal (4/1)	0.00	302.07	691.49	362.33

Percent change in gross returns over low level of adoption was found maximum (20.61%) in high adoption level group than medium group. At overall level was 14.39 percent change in gross returns over low level of adoption. Percent change in cost of cultivation over low level of adoption was found maximum (14.30%) in high adoption level group than medium group. At overall level was 4.81 percent change in cost of cultivation over low level of adoption. Net incremental benefits was found for medium group (10258.17), high level of adoption group (24879.81) and (12395.32) at overall level of adoption. Per quintal net incremental benefit was found maximum in high adoption level (691.49) followed by medium (302.07) and overall level (362.33). Similar results were observed by Wani *et al*. (2013).

Conclusion

On the basis of results obtained from study following conclusions are drawn. The overall technology adoption index score in study area was 66.37 percent which indicated large scope to increase the level of adoption. There was huge potential to increase the yield through technology adoption. The rice growers need to be motivated to use modern rice production technologies which would add to their farm income. The total yield gap per hectare on sample farms reduced from 20.02 q (40.04%) to 14.02 q (28.04%) with increase in level of technology adoption. The gross value ₹ 65080.60, which was less compared to the total cost. As a result, the benefit cost ratio was 0.79 which indicate that rice was profitable in high level of adoption category as compared to low and medium category of cultivation. It was concluded that, as the technology adoption is improved the benefit cost ratio also found to be increased. Technology adoption has positive influence in economics of rice cultivation. Thus, the economics analysis of rice production in study area indicated that cultivation of rice by using adoption of recommended technology was profitable. Percent change in gross returns over low level of adoption was found maximum (20.61%) in high adoption level group than medium group.

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