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Economic analysis of adoption of recommended technologies for mrig bahar orange production in Nagpur district

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Abstract
The present study entitled "Economic analysis of adoption of recommended technologies for mrig bahar orange production in Nagpur district" was conducted in twelve randomly selected villages from three major tehsils, namely Katol, Kalmeshwar and Saoner of Nagpur district. A total of 120 orange farmers were selected for the study. The extent of adoption was measured using the Total Adoption Index (TAI), based on mean, standard deviation and adoption range. The farmers were categorized into low (19), medium (73) and high (28) adopters. The total cost of cultivation at Cost C_3 increased from Rs. 1,70,490.36/ha for low adopters to Rs. 2,26,609.54/ha for high adopters, with an overall cost of Rs. 1,96,238.53/ha. The average yield increased from 80.30 qtl./ha for low adopters to 130.18 qtl./ha for high adopters, while gross returns increased from Rs. 2,45,971.74 to Rs. 4,02,464.48/ha. Net returns at Cost C_3 were Rs. 75,481.38, Rs. 1,23,491.58 and Rs. 1,75,854.94/ha for low, medium and high adopters, respectively. The benefit-cost ratio at Cost C_3 was 1.44, 1.63 and 1.78 for low, medium and high adopters, respectively, with an overall ratio of 1.60. Thus, higher adoption of recommended technologies was associated with increased productivity, gross returns, net returns and profitability of orange cultivation.

Keywords: Adoption of technology, recommended technology

Introduction
Oranges (*Citrus reticulata*) are grown extensively in regions like Maharashtra, Madhya Pradesh, Rajasthan, and Assam, making India one of the world's top producers of the fruit. Almost two-thirds of the world's citrus fruits are orange, making it the most prevalent. Orange is produced in two significant bahars. Bahar treatment is the process of giving orange gardens water stress so they can produce fruits. Mrig bahar, thus, refers to the application of water to the garden throughout the months of April and May, with blossoming taking place during the months of June and July. Fruits can be harvested between February and March. Ambe bahar, which translates to "water stretch treatment," is applied to the garden between November and December. Because of its ideal climate, the Nagpur area of Maharashtra is well renowned for producing oranges. Understanding the crops profitability is essential. The current investigation has been conducted with the aforementioned factor in mind.
In the year 2024-25 area under orange cultivation in Maharashtra state is 145.85 thousand hectares with annual production 1396.62 thousand metric tonnes and productivity accounting to 9.58 metric tonnes per hectare. (Department of Agriculture and Farmers Welfare, 2024-25)
The study was undertaken with the following objectives:
1. To examine the extent of adoption of production technologies in orange for mrig bahar production
2. To estimate cost and returns at the level of adoption of technologies in orange for mrig bahar production

Methodology
The study was conducted in the Nagpur district, primary data was gathered from three tehsils (Katol, Kalmeshwar, and Saoner). From each tehsil, four villages were selected randomly, and from each village, ten orange farmers were selected randomly. Hence a total, 120 orange

farmers were selected for the study. To accomplish the objectives, primary data was obtained from the farmers of mrig bahar orange during the season by preparing specially designed schedule. The data pertained to mrig bahar orange for the year 2025-26.

Analytical Methods

Extent of adoption of recommended production technologies

It was performed by Total adoption Index.

Actual level of adoption by farmers were identified with the help of recommended technologies developed by Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Following formula was used to calculate Total Adoption Index

$$TAI = \frac{1}{K}\left[\frac{AX1}{RX1} + \frac{AX2}{RX2} + \text{----------} + \frac{AXk}{RXk}\right] \times 100$$

TAI = Total adoption index

K = Number of technologies

AXi = Actual use of selected technology

RXi = Recommended use of selected technology

The components of technology recommended by the university for orange crop expressed in terms of adoption score (X_1, X_2,----------X_n) were utilized for developing total technological adoption index of technology adopted

Total technological adoption index is a single numerical value representing the net adoption of all components of technologies whose values lies between 0 to 1.

The net adoption of recommended technologies expressed in terms of technological adoption index of the 120 farmers are classified as below.

Low adopter = Mean- S.D.

Medium adopter = Mean- S.D. to Mean + S.D.

Higher adopter = Mean + S.D

Table 1: Recommended technologies developed by Dr. PDKV Akola for orange crop (Dr. PDKV Krishi Sanvadini, 2025.)

Sr.no.	Technology name	Recommendations
1	Mrig bahar treatment	i. To induce the regular flowering in mrig bahar
		ii. 25 April to 15 June, 50 days stress should be given
2	Nutrient management	iii. Cow dung - 50 kg per plant
		iv. Nitrogen - 900 gram per plant
		v. Phosphorus - 300 gram per plant
		vi. Potassium - 300 gram per plant
		vii. VAM - 500 gram per plant
		viii. Phosphorus soluble bacteria - 100 gram per plant
		ix. Azospirillium - 100 gram per plant
		x. Trichoderma - 100 gram per plant
		xi. While giving fertilizers, cow dung + half of amount of nitrogen +full amount of phosphorus and potassium as well as bacterial fertilizers and nutrients (mix with cow dung) should be given during the mrig bahar when the water stress is received. The remaining half of amount of nitrogen should be given when fruits are size of peas
3	Fruit development and fruit drop	xii. Water drainage - avoid water logged condition
		xiii. Spray 15 ppm GA-3 with 15 ppm CPPU (forchlorfenuron) or Brassinalide 2 ppm at the first time of flowering and the second spray when fruits are pea-sized
		xiv. Spray zinc sulphate 0.5% + iron sulphate 0.5% + boron 0.1% in Oct- Nov for mrig fruits
4	Disease management	xv. Application of Bordeaux paste At end of May month before the starting of rainy season and in month of October for avoiding gummosis disease and other soil borne diseases
5	Fruit keeping quality	xvi. Spraying of carbendazim 0.1% (10 gram + 10 litre of water) 2 times at interval of 15 days prior to harvesting of fruits

Cost and returns at the level of adoption of technologies

For working out the cost and returns of orange, the cost of cultivation were worked out by using standard cost concepts i.e. Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1, Cost C_2 and Cost C_3.

Cost A1: It includes all actual expenses in cash and kind incurred in production by the farmer. It includes - Value of hired human labour, Value of machinery power, Value of bullock labour, Value of graft, Value of manure, Value of micronutrients, Value of fertilizers, Land revenue, cesses and other taxes, Interest on working capital and Depreciation on implements and farm buildings

Cost A2: It includes;

Cost A_1 + rent paid for leased- in land

Cost B1: It includes;

Cost A_2 + 10 per cent interest on fixed capital

Cost B2: It includes;

Cost B_1 + rental value of owned land

Cost C1: It includes;

Cost B_1 + imputed value of family labour

Cost C2: It includes;

Cost B_2 + imputed value of family labour

Cost C3: It includes:

Cost C_2 + 10 per cent of cost C_2 as management cost

Results and Discussion

Extent of adoption of production technologies in orange for mrig bahar production

Table 2: Adoption range of different adopter group

	Adoption range of different adopter group			
Sr. No.	**Particular**	**Low adopter (Mean-SD)**	**Medium adopter (Mean-SD to Mean+SD)**	**High adopter (Mean+SD)**
1	Adoption Range (per cent)	Below 51.56	51.57 to 81.52	Above 81.52
2	No. of farmers	19	73	28
3	Percentage to number of farmers	15.83	60.83	23.34

(Mean=66.54 and SD=14.98)

Table 2 revealed that sample farmers were categorized as low adopters (less than 51.56 per cent), medium adopters (between 51.57 to 81.52 per cent), and high adopters (above 81.52 per cent), The majority of the farmers were classified as medium adopters (73) between 51.57 to 81.52 per cent, followed by high adopters (28) above 23.88 per cent, and lastly, low adopters (19) to the extent of below 51.56 per cent.

Table 3: Extent of adoption of recommended technologies

Sr.no.	**Technology Name**	**Extent of adoption**		
		Low adopter (N=19)	**Medium Adopter (N=73)**	**High Adopter (N=28)**
1	**Mrig bahar treatment**			
i.	To induce the regular flowering in mrig bahar	100.00	100.00	100.00
ii.	25 April to 15 June, 50 days stress should be given	100.00	100.00	100.00
2	**Nutrient management**			
iii.	Cow dung - 50 kg per plant	56.31	62.46	97.14
iv.	Nitrogen - 900 gram per plant	42.69	64.68	92.85
v.	Phosphorus - 300 gram per plant	50.00	73.28	96.42
vi.	Potassium - 300 gram per plant	47.36	56.16	91.07
vii.	VAM - 500 gram per plant	44.73	71.78	91.78
viii.	Phosphorus soluble bacteria - 100 gram per plant	42.63	64.72	93.75
ix.	Azospirillium - 100 gram per plant	42.10	69.52	95.53
x.	Trichoderma - 100 gram per plant	43.42	68.15	98.21
xi.	While giving fertilizers, cow dung + half of amount of nitrogen +full amount of phosphorus and potassium as well as bacterial fertilizers and nutrients (mix with cow dung) should be given during the mrig bahar when the water stress is received. The remaining half of amount of nitrogen should be given when fruits are size of peas	47.36	53.42	78.57
3	**Fruit development and fruit drop**			
xii.	Water drainage - avoid water logged condition	100.00	100.00	100.00
xiii.	Spray 15 ppm GA-3 with 15 ppm CPPU (forchlorfenuron) or Brassinalide 2 ppm at the first time of flowering and the second spray when fruits are pea-sized	50.87	63.47	96.42
xiv.	Spray zinc sulphate 0.5% + iron sulphate 0.5% + boron 0.1% in Oct-Nov for mrig fruits	36.84	61.64	82.14
4	**Disease management**			
xv.	Application of Bordeaux paste At end of May month before the starting of rainy season and in month of October for avoiding gummosis disease and other soil borne diseases	42.10	58.35	90.71
5	**Fruit keeping quality**			
xvi.	Spraying of carbendazim 0.1% (10 gram + 10 litre of water) 2 times at interval of 15 days prior to harvesting of fruits	36.84	69.17	82.85

Table 3 revealed adoption of mrig bahar treatment and drainage management was highest, with 100.00 per cent adoption among low, medium and high adopters. Nutrient management showed a clear increasing trend with adoption level. Adoption of FYM (50 kg/plant) was 56.31 per cent, 62.46 per cent and 97.14 per cent, while recommended nitrogen application was 42.69 per cent, 64.68 per cent and 92.85 per cent among low, medium and high adopters, respectively. Similarly, phosphorus and potassium adoption ranged from 50.00-96.42 per cent and 47.36-91.07 per cent, respectively. Among biofertilizers, adoption increased from low to high adopters, ranging from 42.10-98.21 per cent. Fruit development practices also showed higher adoption among high adopters; growth regulator application increased from 50.87 per cent to 96.42 per cent, while micronutrient application increased from 36.84 per cent to 82.14 per cent. Disease management through Bordeaux paste recorded 42.10 per cent, 58.35 per cent and 90.71 per cent adoption among low, medium and high adopters, respectively. Similarly, carbendazim application for fruit keeping quality was adopted by 36.84 per cent, 69.17 per cent and 82.85 per cent, respectively.

Table 4: Per hectare input utilization of orange farmers at the different level of adoption

Sr. No.	Particulars	Unit		Inputs/ha			
				Low Adopters (N=19)	Medium Adopters (N=73)	High Adopters (N=28)	Overall Adopters (N=120)
1	Hired human labours	Days	a) Male	22.36	26.18	28.20	25.58
			b) Female	12.50	15.00	17.15	14.88
			Sub-total	34.86	41.18	45.35	40.46
2	Bullock labour	Pairs day	Hired	4.15	5.25	6.42	5.27
3	Machine labour	Hours	Hired	20.80	24.74	28.30	24.61
4	Manures	Qtl.		77.00	80.06	82.21	79.75
5	Fertilizers	Kg	N	130.42	140.50	148.12	139.68
		Kg	P	98.38	102.60	110.20	103.72
		Kg	K	52.16	54.56	58.18	54.96
6	Micronutrient	Rs.		590.80	850.00	960.80	845.00
7	Family labour	Days	a) Male	13.40	15.36	17.20	15.15
			b) Female	9.60	10.20	12.10	10.18
			Sub-total	23.00	25.56	29.30	25.33

Table 4, provided the per-hectare input utilization of orange farmers at the different level of adoption. The overall per-hectare utilization of key inputs such farmyard manure (FYM), and fertilizers N, P, K were noted at 79.75 quintals, 139.68 kg, 103.72 kg, and 54.96 kg, respectively. In terms of hired labour, the per-hectare utilization for orange production varied among the low, medium, and high adopter groups, with figures of 34.86 human days, 41.18 human days, and 45.35 human days, respectively. Additionally, the total machine hours utilized were 20.80 hrs, 24.74 hrs, and 28.30 hrs. for low, medium, and high adopters, respectively. Micronutrients also varied among the low, medium and high adopter groups with overall at Rs. 845. In terms of family labour, per-hectare utilization for orange production varied among the low, medium, and high adopter groups, with figures of 23.00 human days, 25.56 human days, and 29.30 human days, respectively.

Table 5: Cost of cultivation of orange of different adopter groups (Figures in Rs.)

Sr. No	Item	Group			
		Low (N=19)	Medium (N=73)	High (N=28)	Overall (N=120)
1	**Hired Human labour (Days)**				
	i) Male	9036.12 (5.30)	10527.76 (5.43)	11296.92 (4.98)	10267.81 (5.23)
	ii) Female	3189.62 (1.87)	3801.30 (1.96)	4359.35 (1.92)	3769.99 (1.92)
2	Bullock labour (Days)	3112.99 (1.82)	3938.13 (2.03)	4815.77 (2.12)	3953.13 (2.01)
3	Machine charges (hrs)	19562.40 (11.47)	23267.97 (12.01)	26616.15 (11.74)	23145.70 (11.79)
5	Manures	26957.70 (15.81)	28029.00 (14.46)	28781.72 (12.70)	27920.47 (14.22)
6	**Fertilizers (in terms of nutrients) (kg)**				
	1) N	1995.42 (1.17)	2188.99 (1.13)	2347.70 (1.03)	2123.13 (1.08)
	2) P	3852.56 (2.25)	4062.96 (2.09)	4215.15 (1.86)	4046.11 (2.06)
	3) K	1051.02 (0.61)	1129.39 (0.58)	1242.14 (0.54)	1104.69 (0.56)
7	Micronutrients (Rs)	590.80 (0.34)	850.00 (0.43)	960.80 (0.42)	845.00 (0.43)
8	Plant protection	1520.18 (0.89)	1672.00 (0.86)	1820.40 (0.80)	1670.10 (0.85)
9	Weedicide	520.40 (0.30)	575.00 (0.29)	610.45 (0.26)	570.60 (0.29)
10	Incidental charges	620.72 (0.36)	763.52 (0.39)	805.10 (0.35)	760.42 (0.38)
11	Repairing charges	1118.20 (0.65)	1295.00 (0.66)	1410.20 (0.62)	1290.00 (0.65)
12	Working capital (1 to11)	76108.13 (44.64)	82156.18 (42.41)	92297.45 (40.72)	84487.15 (43.05)
13	Interest on working capital @6%	4566.48 (2.67)	4929.37 (2.54)	5537.84 (2.44)	5069.22 (2.58)
14	Depreciation	1980.00 (1.16)	2023.50 (1.04)	2110.12 (0.93)	2050.18 (1.04)
15	Land revenue	102.15 (0.05)	101.50 (0.05)	102.30 (0.04)	101.67 (0.05)
16	Cost A1 (12 to 15)	82756.76 (48.54)	89210.55 (46.05)	100047.71 (44.14)	91708.22 (46.73)
17	Annual-establishment cost	14556.31 (8.53)	15840.99 (8.17)	18894.13 (8.33)	15866.87 (8.08)
18	Interest on fixed capital	8920.20 (5.23)	9525.00 (4.91)	10125.72 (4.46)	9860.54 (5.02)
19	Cost B1(16+17+18)	106233.27 (62.31)	114576.54 (59.14)	129067.56 (56.95)	117435.63 (59.84)
20	Rental value of own land	40893.14 (23.98)	52766.22 (27.23)	66975.11 (29.55)	52302.63 (26.65)
21	Cost B2 (19+20)	147126.41 (86.29)	167342.76 (86.38)	196042.67 (86.51)	169738.26 (86.49)
22	**Family labour (Days)**				
	Male	5415.20 (3.17)	6176.71 (3.18)	6890.32 (3.04)	6081.21 (3.09)
	Female	2449.63 (1.43)	2584.88 (1.33)	3075.69 (1.35)	2579.20 (1.31)
23	Cost C1(19+22)	114098.10 (66.92)	123338.13 (63.66)	139033.57 (61.35)	126096.04 (64.25)
24	Cost C2(21+22))	154991.24 (90.90)	176104.35 (90.90)	206008.68 (90.90)	178398.67 (90.90)
25	Cost C3	170490.36 (100)	193714.78 (100)	226609.54 (100)	196238.53 (100)
26	Yield	245971.74	317206.36	402464.48	314425.81
27	Per quintal cost of production	2123.16	1888.05	1740.74	1928.63

Figures in parentheses indicate percentage to total cost (C3)

Per Hectare Cost of Cultivation: Low Adopters

Table 3 revealed the per-hectare total cost of cultivation (C3) for low adopters, amounting to Rs. 170490.36. This cost was distributed across various components, with Cost-A1 at Rs. 82756.76, Cost-B1 at Rs. 106233.27, and Cost-B2 at Rs. 147126.41. Additional expenses, including micronutrient, manure, and fertilizers N, P, and K, constituted 0.34 per cent, 15.81 per cent, 1.17 per cent, 2.25 per cent, and 0.61 per cent of the total cost, respectively. The annual establishment cost was 8.53 per cent of the total cost. Family labour played a role, contributing 4.60 per cent to the total cost. The gross value of the main produce was Rs. 170490.36 with per quintal cost of production was Rs. 2123.16.

Per Hectare Cost of Cultivation: Medium Adopters

Table 3 revealed the per-hectare total cost of cultivation (C3) for medium adopters as Rs. 193714.78. Components such as Cost-A1, Cost-B1, and Cost-B2 were Rs. 89210.55, Rs. 114576.54, and Rs. 167342.76, respectively. Input percentages for micronutrients, manure, fertilizer components N, P, and K were 0.43 per cent, 14.46 per cent, 1.13 per cent, 2.09 per cent, and 0.58 per cent, respectively. The annual establishment cost was 8.17 per cent of the total cost. Family labor constituted 4.51 per cent of the total cost. The gross value of main produce was Rs. 317206.36 with per quintal cost of production was Rs. 1888.05.

(c) Per Hectare Cost of Cultivation: High Adopters

For high adopters, Table 3 indicated a per-hectare total cost of cultivation (C3) at Rs. 226609.54, with Cost-A1, Cost-B1, and Cost-B2 at Rs. 100047.71, Rs. 129067.56, and Rs. 196042.67, respectively. Input percentages for micronutrients, manure, fertilizer N, P, and K were 0.42 per cent, 12.70 per cent, 1.03 per cent, 1.86 per cent, and 0.54 per cent, respectively. The annual establishment cost was 8.33 per cent of the total cost. Family labor contributed 4.39 per cent to the total cost. The gross value of main produce was Rs. 402464.48 with per quintal cost of production was Rs. 1740.74.

Per Hectare Cost of Cultivation: Overall Adopters

At the overall level, the per-hectare total cost of cultivation (C3) was Rs. 196238.53. Components such as Cost-A1, Cost-B1, and Cost-B2 were Rs. 91708.22, Rs. 117435.63, and Rs. 169738.26, respectively. Input percentages for micronutrients, manure, fertilizer N, P, and K were 0.43 per cent, 14.22 per cent, 1.08 per cent, 2.06 per cent, and 0.56 per cent, respectively. The annual establishment cost was 8.08 per cent of the total cost. Family labour contributed 4.40 per cent to the total cost. The gross value of main produce was Rs. 314425.81 and per quintal cost of production was Rs. 1928.63.

Table 6: Per hectare cost and returns from orange crop (Rs./ha)

Sr. No.	Particulars	Group			
		Low (N=19)	Medium (N=73)	High (N=28)	Overall (N=120)
1	Yield q/ha	80.30	102.60	130.18	101.75
2	Value of main produce	245971.74	317206.36	402464.48	314425.81
3	Gross income	245971.74	317206.36	402464.48	314425.81
4	**Cost of cultivation at**				
	Cost A1 (Rs.)	82756.76	89210.55	100047.71	91708.22
	Cost B1 (Rs.)	106233.27	114576.54	129067.56	117435.63
	Cost B2 (Rs.)	147126.41	167342.76	196042.67	169738.26
	Cost C1 (Rs.)	114098.10	123338.13	139033.57	126096.04
	Cost C2 (`Rs.)	154991.24	176104.35	206008.68	178398.67
	Cost C3 (Rs)	170490.36	193714.78	226609.54	196238.53
5	**Net Returns at**				
	Cost A1 (Rs`)	163214.98	227995.81	302416.77	222717.59
	Cost B1 (`Rs)	139738.47	202629.82	273396.92	196990.18
	Cost B2 (Rs`)	98845.33	149863.60	206421.81	144687.55
	Cost C1 (`Rs)	131873.64	193868.23	263430.91	188329.77
	Cost C2 (`Rs)	90980.50	141102.01	196455.80	136027.14
	Cost C3 (Rs)	75481.38	123491.58	175854.94	118187.28
6	**Output- Input ratio**				
	Cost A1 (`Rs)	2.97	3.55	4.02	3.42
	Cost B1 (`Rs)	2.31	2.76	3.11	2.67
	Cost B2 (Rs`)	1.67	1.89	2.05	1.85
	Cost C1 (`Rs)	2.15	2.57	2.89	2.49
	Cost C2 (Rs`)	1.58	1.80	1.95	1.76
	Cost C3 (Rs)	1.44	1.63	1.78	1.60

Table 6 showed analysis of per hectare cost and returns from orange crop across different adoption categories low adopters, medium adopters, and high adopters revealed notable variations in yield levels and profitability for orange cultivation. The findings, presented in Table 4.4, illustrate that per-hectare yields increased from 80.30 quintals in low adopters to 130.18 quintals in high adopters, with an overall yield of 101.75 quintals. Gross returns per hectare were highest for high adopters at Rs. 402464.48, followed by medium adopters at Rs. 317206.36 and low adopters at Rs. 245971.74. Profitability was evident at the Cost A1, Cost B1, and Cost B2 levels, with output-input ratios of 1:3.42, 1:2.67, and 1:1.85, respectively, at the overall level. However, the output-input ratio was at the C3 cost level for all adoption categories, resulting in an overall ratio of 1:1.60. This indicates that cost and returns are varies as per the different level of adoption.

Conclusion

The investigation concluded that the application of recommended technologies in orange cultivation yielded favorable returns for the sampled farmers. Consequently, the output-input ratios at Cost-C1, C2, and C3 levels at the overall level were determined to be 1:2.49, 1:1.76, and 1:1.60, respectively, indicating that orange cultivation was more profitable in the high level of adoption category compared to the low and medium categories. However orange crop was profitable at cost A1 with output-input ratio 1:3.42. Similarly output-input ratio at cost B1 and B2 at overall level were 2.67 and 1.85 respectively indicating its profitability when family labour was not considered. The study concluded that as technology adoption increased, the output-input ratio also showed an upward trend. The economic analysis of orange production in the study area strongly suggested that cultivating orange through the adoption of recommended technologies was a financially viable and profitable endeavor.

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