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Effect of crop management practices on yields and economics of rice (*Oryza sativa* L.) cultivars

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Abstract
The present investigation, entitled "Effect of crop management practices on yield and economics of rice (*Oryza sativa* L.) cultivars " was carried out at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalay, Raipur (C.G.) during Kharif 2018. The field experiment was laid out in split plot design with three replications and five main plot treatments consist of quality rice cultivars *víz* VI: Trombay CG Dubraj Mutant-1,V2: Tarunbhog Mutant-1, V3: Safri 17-48-2, V4: Trombay Raipur Rice-106, V5: Zinco Rice and five sub plot treatments of crop management practices (Spacing+ nutrient management) *viz* P1: 20x10 cm spacing + 100% RDF through inorganic (Standard check), P2: 20x10 cm spacing + 100% RDF through inorganic and organic, P3: 20x10 cm spacing + 150% RDF through inorganic and organic, P4: 15x10 cm spacing + 150% RDF through inorganic and organic, P5: 20x10 cm spacing + 150% RDF inorganic. In case of P2, P3 and P4 top dressing of vermicompost @ 2 q ha + DAP @ 25 kg hat was done at 25-30 DAT and remaining N:P2O5:K2O was applied through inorganic sources. Crop planted at 15x10 cm spacing + 150% RDF through inorganic and organic observed highest grain yield. Lowest grain yield was recorded in 20x10 cm spacing +100% RDF through inorganic (Standard check). Gross return, net return and B:C. ratio was also obtained higher in cultivar Trombay Raipur Rice-106 followed by Trombay CG Dubraj mutant-1 In the same way among the crop management practices, higher gross and net return was achieved under 15x10 cm spacing + 150% RDF through inorganic and organic sources, whereas, the B:C ratio was higher in 20x10 cm spacing+ 100% RDF through inorganic followed by 15x10 cm spacing + 150% RDF through inorganic and organic sources.

Keywords: Crop management practices, rice cultivars, grain yield, economic return, spacing and fertilization

Introduction
Rice (*Oryza sativa* L.) is a major cereal crop which is used as a main source of food for more than 85% population in the world and 90% in Asia but, lacking imbalanced, inappropriate or excessive use of nutrients in agricultural systems is a major cause for low crop yields in parts of developing countries. During 2017-18 rice was cultivated in an area of 431.94 lakh hectare with a production of 110.41 million tonnes and productivity of 2550 kg ha^{-1} (Annual report, 2017-18) However, considering the present growth rate of population as well as per capita income, the demand for rice has been projected as 156 million tonnes by 2030. Chhattisgarh state is popularly known as "Rice bowl of India" is completely dependent on monsoon with an annual rainfall 1200-1600 mm. It has geographical area of 13.51 mha of which 5.9 m ha area is under cultivation. Rice occupies an area of 3.68 m ha with productivity of 20.20 q ha^{-1}. In Chhattisgarh, rice is mainly grown under rainfed ecosystem, which covers about 74,97 and 95% cropped area of Chhattisgarh plain, Bastar plateau and Northern hill zones respectively. (Krishi Darshika IGKV, Raipur 2017-18). Scented rice occupies an important status in domestic as well as in International market due to its certain outstanding qualities and therefore earns premium prices. The yield of scented rice varieties is comparatively less than high yielding non scented varieties. The farmers prefer high yielding coarse rice because of higher yield and income. It is therefore important to achieve high yield from scented and quality rice varieties, while, maintaining its quality too. Mutation breeding also knows as "Variation breeding" is the process

of exposing seeds to chemicals or radiation in order to generate mutants with desirable traits to be bred with other cultivars. Using this tool the development of cultivars with desired quality traits and change in undesirable traits entirely change the behaviour of the cultivar. This objective cannot be achieved by chemical or organic nutrients source alone. Chemical fertilizers are well known for their effects on the yield enhancement whereas, the aroma is improve by the use of organic nutrients. An appropriate combination of inorganic and organic nutrient can help in achieving high yield of quality rice cultivars. Under such circumstances, the combined use of vermicompost and fertilizers in proper proportions may be another option which may be cheap, socially acceptable and environmentally sound nutrient management for enhancing the productivity of crops in a sustainable manner Therefore, it is essential to assess the ability of vermicompost to replace certain proportions of fertilizers to be applied in scented rice without declining the yields.

The role of plant nutrient would be extremely important from sustainability point of view. With the increasing trend in price of fertilizers and the reduction in the use of chemical fertilizers it has become necessary to judiciously manage the inflow of organic sources of nutrients and their integration with fertilizers. Therefore, information needs to be generated with respect to proper dose of organic manures along with inorganic fertilizers for scented and quality rice varieties.

Rice quality is considered from the viewpoint of milling quality, grain size, shape, appearance and cooking characteristics. Consumers judge the quality of rice mostly on its appearance, particularly the colour, size, shape, and aroma on its elongation during cooking. On the other hand, millers and traders prefer a variety capable of giving high head rice recovery (Sharma, 2002) [44]. Besides, other aspects of quality like amylase content and gelatinization temperature are also significant (Bhattacharya, 1989 and Jennings *et al*., 1979) [45, 46]. Rice with soft gel consistency cook tender and remain soft to medium gel consistency, is preferred by most of the rice consumers (Sarkar *et al*., 1994) [47].

Materials and methods

Table 1: Treatment details

Treatment	Notations used
Main plot: Quality rice varieties (5)	
Trombay CG Dubraj Mutant-1	V1
Tarunbhog Mutant-1	V2
Safri 17-48-2	V3
Trombay Ripur Rice – 106	V4
Zinco Rice	V5
Sub plot: Crop management practices (5)	
20x10 cm spacing + 100% RDF through inorganic (Standard check)	P1
20x10 cm spacing + 100% RDF through inorganic and organic	P2
20x10 cm spacing + 150% RDF through inorganic and organic	P3
15x10 cm spacing + 150% RDF through inorganic and organic	P4
20x10 cm spacing + 150% RDF inorganic	P5

* P2, P3, and P4 Topdressing of vermicompost @ 2 q ha^{-1} + DAP @ 25 kg ha^{-1} at 25-30 DAT and remaining N: P_2O5:K_2O through inorganic.

Test crop – Quality rice cultivars Special features of quality rice varieties

V1: Trombay Chhattisgarh Dubraj Mutant-1 (TCDM-1) (IET 26249)

- **Released by SVRC on dated:** 09/04/2018.
- **Parentage:** Mai Dubraj.
- **Breeding method:** Mutation breeding (Gamma ray based induced mutagenesis).
- **Plant height:** Dwarf stature (90-95 cm).
- **Maturity:** Mid-early maturity (125-130 days).
- **Average grain yield:** 4-4.8 t ha^{-1}.
- **Special features:** Aromatic medium slender fine grain with good grain quality, fertilizer responsive.
- **Distinguishing morphological characters:** Dwarf, dark erect green leaves with good stem strength having fine slender grain with yellowish white colour long awns.
- **Recommendations:** Recommended for Chhattisgarh under irrigated ecology.

V2: Tarunbhog Mutant-1

- Under releasing process.
- Parentage: Tarunbhog land races of chhattishgarh.
- Breeding method: mutation breeding.
- Plant height: 130 cm
- Maturity: Mid early maturity (130-135 Days)
- Average grain yield: 3.5-4.0 t ha^{1}
- Special features: aromatic fine grain, semi dwarf, mid, good grain quality.

V3: Safri 17 48-2

- Under releasing process.
- Parentage: Safri 17.
- Breeding method: mutation breeding.
- Plant height: 110 cm.
- Maturity: 110 Days
- Average grain yield: 4 - 4.5 t ha^{-1}
- Special features: dwarf, early, medium slender grain, good grain quality.

V4: Trombay Raipur Rice -106

- Under releasing process.
- Parentage: Mai Dubraj
- Breeding Method: mutation breeding.
- Plant height: 110 cm
- Maturity: 130 Days
- Average grain yield: 4.5-4.8 t ha^{-1}
- Special features: Aromatic medium slender, fine grain, good grain quality, dwarf plant, dark green leaves.

V5: Zinco Rice

- Released and Notified by CSSC, GOI in February 2019.
- Parentage: Lalmati x IR68144B-18-2-1-1.
- Breeding method: Pedigree method.
- Zinc content: > 24.73 ppm.
- Plant height: 96.33 cm.
- Days to 50% flowering: 100 days.
- Average grain yield: 4254 kg/ha.
- Special features: Medium slender translucent grain with intermediate gelatinization temperature and amylase content.
- Distinguishing morphological characters: Green plant with basal leaf sheath green, strong culm, colourless auricle & green collar leaf pubescence present and medium slender seed with dark red husk.
- Recommendations: Recommended for Chhattisgarh, West Bengal and Odisha.

Economics

1. Cost of cultivation (Rs ha^{-1})

While computing the economics, different variable costs of items were considered. The cost includes expenditure on seeds, manures, fertilizers and labour charges and were considered at the prevailing market price and presented in Rs ha^{-1}.

2. Gross returns (Rs ha^{-1})

Gross returns were calculated by multiplying the grain and straw yield with their respective prevailing market prices. Gross returns are presented as Rs h^{-1}.

3. Net returns (Rs ha^{-1})

The net returns hectare^{-1} was calculated by subtracting the cost of cultivation from the gross returns and presented in Rs ha^{-1}.

4. Benefit: Cost ratio

The Benefit cost ratio (BCR) was worked out by using the following formula:

$$\text{B:C ratio} = \frac{\text{Gross returns (Rs ha}^{-1})}{\text{Cost of cultivation (Rs ha}^{-1})}$$

Results and Discussion

Grain yield

Quality rice cultivars and crop management practices significantly affected the grain and straw yields of rice. The grain yield of Trombay Raipur Rice-106 was significantly higher than other cultivars but, it was at par with Trombay CG Dubraj Mutant-1. Grain yield was lowest under Tarunbhog Mutant -1. On the contrary the rice straw yield was significantly higher under Tarunbhog Mutant -1 while lowest straw yield was obtained under Safri 17-48-2. Trombay Raipur, Rice-106 recorded higher harvest index and it was statistically similar to Safri 17-48-2.

Among the crop management practices the rice grain yield was significantly higher under 15x10 cm spacing + 150% RDF through inorganic and organic. Over other crop management practices the straw yield was higher in 20x10 cm spacing +150% RDF through inorganic and organic but, it was comparable with 15x10 cm spacing +150% RDF through inorganic and organic. No significant difference in harvest index was reported due to crop management practices, but numerically higher harvest index was obtained in 20x10 cm spacing +100% RDF through inorganic sources.

No significant interaction effect of quality rice cultivars and crop management was recorded for yields and harvest index. The higher grain yield (kg ha^{-1}) in closer spacing of 15 x 10 cm spacing + 150% RDF through inorganic and organic sources might be due to fact that all the growth characters and yield attributes like number of effective tillers, panicle length, number of filled grain penicle^{-1}, were higher in this treatment due to higher plant density per unit area and better source to sink relationship Similarly results ware reported by Paraye *et al.* (1996) [48], Mrityunjay *et al* (1996), Yadav *et. al*. (2010) [41], Siddiqui (1999) [49], Obulamma and Reddeppa (2002) [22].

Table 2: Grain yield, straw yield, and harvest index of rice as influenced by quality rice cultivars and crop management practices

Treatment		Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Harvest index (%)
A. Quality rice cultivars				
V1	Trombay CG Dubraj Mutant-1	4460.5	5532.1	44.5
V2	Tarunbhog Mutant -1	3654.4	6032.5	37.7
V3	Safri 17-48-2	4382.7	4873.2	47.6
V4	Trombay Raipur Rice-106	4650.4	5059.2	48.0
V5	Zinco Rice	4278.4	5065.9	45.8
SEm±		68.3	85.0	0.6
CD (P=0.05)		222.8	277.5	2.0
B. Crop management practices				
P1	20x10 cm spacing +100%RDF through inorganic (standard check)	4140.6	4926.9	45.6
P2	20x10 cm spacing +100%RDF through inorganic and organic	4172.7	5130.4	44.9
P3	20x10 cm spacing +150%RDF through inorganic and organic	4311.2	5738.7	42.9
P4	15x10 cm spacing +150% RDF through inorganic and organic	4509.9	5470.6	45.2
P5	20x10 cm spacing + 150%RDF inorganic	4292.1	5296.3	44.9
SEm±		61.9	107.2	0.6
CD (P=0.05)		176.9	306.5	NS
VXP				
SEm±		138.4	239.5	1.4
CD (P=0.05)		NS	NS	NS

* P2, P3, and P4 Top dressing of vermicompost @ 2 q ha^{-1} + DAP @ 25 kg ha^{-1} at 25-30 DAT and remaining N: P_2O5:K_2O through inorganic

Economics

The data with respect to cost of cultivation, gross return, net return and benefit cost ratio of rice. The detail about cost of cultivation of quality rice cultivars and crop management practices are presented in Appendix D, E. The data on economics of quality rice cultivars and crop management

practices of rice revealed that the total cost of cultivation Rs. 39618 was observed in all the quality rice cultivars. Among the crop management practices cost of cultivation was higher in 15x10 cm spacing +150% RDF through inorganic and organic (Rs. 41222). However, minimum cost of cultivation was recorded in 20x10 cm spacing +100%RDF through inorganic (standard check).

Data on gross return emphasized that among quality rice cultivars the higher gross return was recorded under Trombay Raipur Rice -106 (Rs. 102720) followed by Trombay CG Dubraj Mutant -1. In case of crop management practices the higher gross return was recorded under 15x10 cm spacing +150% RDF through inorganic and organic followed by 20x10 cm spacing +150% RDF through inorganic and organic. However minimum gross return was recorded under 20x10 cm spacing +100% RDF through inorganic (standard check) due to lower grain yield. Interaction of different quality rice cultivars and crop management practices was non-significant in respect to gross return.

Net return of quality rice cultivars was significantly higher under Trombay Raipur Rice -106 (Rs. 63102) followed by Trombay CG Dubraj mutant -1. whereas, in of crop management practices the higher net return was recorded in 15x10 cm spacing +150% RDF through inorganic and organic **(**Rs. 58958) and minimum net return was recorded recorded in 20x10 cm spacing +100% RDF through inorganic (Rs. 54627). Interaction of different quality rice cultivars and crop management practices was non-significant in respect to net return.

The data on B: C ratio revealed that in quality rice cultivars significantly higher B: C ratio was obtained in Trombay Raipur Rice-106 (2.60) followed by Trombay CG Dubraj Mutant -1 (2.51).While under crop management practices it was higher in 20x10 cm spacing +100% RDF through inorganic (2.47) and the lowest B: C ratio was found in 20x10 cm spacing +100%RDF through inorganic and organic (2.35). Interaction of different quality rice cultivars and crop management practices was non-significant in respect to B: C ratio.

Table 3: Cost of cultivation, gross return, net return, B: C of rice as influenced by quality rice cultivars and crop management practices

Treatments		Cost of Cultivation Rs ha^{-1}	Gross Return Rs ha^{-1}	Net return Rs ha^{-1}	B:C ratio Rs ha^{-1}
A. Quality rice cultivars					
V1	Trombay CG Dubraj Mutant-1	39618	99203	59586	2.51
V2	Trunbhog Mutant -1	39618	82777	43159	2.09
V3	Safri 17-48-2	39618	96911	57293	2.45
V4	Trombay Raipur Rice-106	39618	102720	63102	2.60
V5	Zinco Rice	39618	94914	55297	2.39
SEm±		-	1436	1436	0.04
CD (P=0.05)		-	4682	4682	0.12
B. Crop management practices					
P1	20x10 cm spacing +100%RDF through inorganic (standard check)	37253	91879	54627	2.47
P2	20x10 cm spacing +100%RDF through inorganic and organic	39237	92758	53521	2.36
P3	20x10 cm spacing +150%RDF through inorganic and organic	40982	96274	55292	2.35
P4	15x10 cm spacing +150% RDF through inorganic and organic	41222	100181	58958	2.43
P5	20x10 cm spacing + 150%RDF inorganic	39394	95432	56038	2.42
SEm±		-	1302	1302	0.03
CD (P=0.05)		-	3723	NS	NS
VXP					
SEm±		-	2912	2912	0.07
CD (P=0.05)		-	NS	NS	NS

* P2, P3, and P4 Top dressing of vermicompost @ 2q ha^{-1} + DAP @ 25 kg ha^{-1} at 25-30 DAT and remaining N: P_2O5:K_2O through inorganic

Discussion on Economics

Cost of cultivation Rs. 39618 was recorded in all quality rice cultivars. Among the crop management practices cost of cultivation was higher in 15x10 cm spacing +150% RDF through inorganic and organic Rs. 41222 due to extra seed rate in this treatment compare than other treatment.

Higher gross return was recorded under Trombay Raipur Rice -106 (Rs. 102720) followed by Trombay CG Dubraj mutant -1. In case of crop management practices the higher gross return was recorded under 15x10 cm spacing +150% RDF through inorganic and organic followed by 20x10 cm spacing +150%RDF through inorganic and organic due to higher grain yield.

Net return of quality rice cultivars was significantly higher under Trombay Raipur Rice -106 (Rs. 63102) followed by Trombay CG Dubraj mutant -1 whereas, in crop management practices the higher net return was recorded in 15x10 cm spacing +150% RDF through inorganic and organic **(**Rs. 58958). B: C ratio revealed that in quality rice cultivars, significantly higher B: C ratio was obtained in Trombay Raipur Rice-106 followed by Trombay CG Dubraj mutant -1. While under crop management practices it was higher in 20x10 cm spacing +100% RDF through inorganic this might be due to lower cost of cultivation and higher return over per rupee invested. Similarly result was found by Kewat *et al.* (1999) [14], Power and Deshpande (2001), Singh *et al*. (2015) [38].

Conclusion

The grain yield of Trombay Raipur Rice-106 was significantly higher than other cultivars. Except Trombay CG Dubraj Mutant-1 both these cultivars were comparable to each other in respect of grain yield. Grain yield was the lowest under Tarunbhog Mutant -1 while straw yield was significantly higher under Tarunbhog Mutant -1, whereas lowest straw yield was observed in Safri 17-48-2. Among the crop management practices the rice grain yield was significantly higher under 15x10 cm spacing + 150% RDF through inorganic and organic, but it was at par with 20x10 cm spacing +150% RDF through inorganic and organic source. Similarly the straw yield was also higher in 15X10 cm spacing + 150% RDF through inorganic and organic which was comparable with 20X10 cm spacing+ 150% RDF through inorganic and organic.

Gross return, net return and B: C. ratio was higher in cultivar Trombay Raipur Rice-106 followed by Trombay CG Dubraj mutant-1. In case of crop management practices higher gross and net return was achieved under 15x10 cm spacing + 150% RDF through inorganic and organic sources, followed by 20x10 cm spacing + 150% RDF through inorganic and organic. However, the B: C ratio was higher in 20x10 cm spacing+100% RDF through inorganic followed by 15x10 cm spacing + 150% RDF through inorganic and organic sources.

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