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Improved Agronomic Practices to Enhance the Productivity of Traditional Finger Millet Varieties (Eleusine Coracana L. Gaertn): Experiences from Eastern Ghats of Koraput District, Odisha

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Abstract

Low productivity and poor market realization are the major constraints faced by millet farmers across India. This necessitates identification of best practices to raise productivity and income from millets. This article illustrates the improved farming methods adopted in finger millet cultivation for enhancing productivity of three finger millet landraces. The demonstrations were carried out during Kharif seasons in three villages namely Machhara, Podheiguda and Chapper, in Koraput district, Odisha, India during 2018-19. Demonstrations on traditional finger millet verities were carried out by the millet farmers with the objective to enhance the productivity through improved farming practices. The improved method applied in transplanting of seedlings with right spacing and proper weed management. Demonstrations were recorded biometric parameters, organized farmers' exposure visit, yield and expenditure analysis in comparison with farmers' practices. It is observed from the biometric data that the improved method resulted in higher yield in case of Bada mandia (1640kg/ha), Bati mandia (1470kg/ha) and Kurma bati (560kg/ha) compared to the yield of these varieties under farmers' practices i.e. Bada mandia (880kg/ha), Bati mandia (910kg/ha) and Kurma bati (910kg/ha). The improved practices provided higher gross return and net return with a higher benefit-cost ratio against farmers' practices.

Keywords: Finger millet (*Eleusine coracana* l. Gaertn**)**, Crop cutting, Demonstrations, Biometric and conservation

Introduction:

Millets are the staple food of resource-poor farmers in hot and drier regions of Africa and Asia (McDonough, 2000). Globally, India is the largest grower of millets with 26.6% of the world and 83% of Asia's millet cropping area (APEDA). In India, millets have been an integral part

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of tribal food in the states of Odisha, Madhya Pradesh, Jharkhand, Rajasthan, Karnataka, and Uttarakhand (Sood et al. 2019; Hrideek and Nampoothiri, 2017). Millets have numerous health benefits. They provide more essential amino acids than most other cereals. They are rich in phosphorous, magnesium and calcium. They help to reduce blood sugar and cholesterol levels. Millets have high content of proteins and minerals such as calcium, iron, etc. that can help in avoiding diseases such as diabetes, obesity and cardiovascular problems. Millet has more protein than rice and is rich in vitamins A and B, iron, phosphorus, magnesium and manganese (Mishra et al 2022; Choudhary et al 2022).

Millets are climate-resilient crops and they can be grown in semi-arid and arid areas because of their resilience to biotic and abiotic stresses and their high yield on low-quality soils with little additional input [Prasad and Staggenborg, 2009). Millets have agricultural superiority over other crops attributed to their ability to adapt under marginal and less input-demanding cultivation. The C4 photosynthetic pathway and ability to withstand environmental stress make them a suitable choice for future agricultural systems. The wheat and rice have higher global warming potential and have higher carbon emission rate, while the millets have lower carbon footprint. Despite their immense agricultural value, global area under millet cultivation and production in the last five decades have declined or remained stagnated compared to major cereals.

The global millet cultivation has declined at the rate of 22.5 lakh ha area per decade. Worldwide the area has come down by 25% in 2016–2018 compared to 1961–1963 levels. In Asia, around 148% reduction in millet cropping area were reported from 1961–1963 to 2016–2018 (FAOSTAT 2018). India is the largest producer of millets with 37.5% of the total global output followed by Sudan and Nigeria. The millet production in India was at peak during the 1980s, thereafter decreased gradually due to sharp reduction under cultivated area. This decline may be attributed to lack of concentrated crop improvement efforts, shift towards high-value cash crops, lack of government policies, and low productivity of millets.

Finger millet is cultivated in Asia (Middle East and Remote East) and Africa (East and South) essentially for grain (Niti Ayog and WFP India, 2023). Finger millet can perform better under unpleasant soil and weather conditions match up to other crops (Gupta et al 2017). The crop has a wide range of seasonal adaptation and can be grown from coastal ecosystem to hilly regions over 2400 m above mean sea level. The finger millet has been cultivated under rain fed conditions as direct sowing because of lack of improved cultivation practices like transplanting, quality Input, proper weeding etc., leading to gradual displacement of this climate smart crop from farmlands. . Finger millet is a dwarf, highly tillering plant with characteristic finger like terminal inflorescences. The height of a mature plant ranges from 30-150 cm and the seeds are very small like mustard and are light brown, or dark brown or white in colour. The crop duration was 90 to 120 days depends on the variety and climate situation. The crop is adapted to fairly reliable rainfall conditions and has an extensive but shallow root system. The grain is very nutritious, and has excellent malt properties. Finger millet is comparatively resistant to storage insect pests which make the crop an important source of food during famine as the grains can be stored as long as 50 years without much loss due to deterioration (Sruti et al 2021; IIMR; Mgoja et al 2007). Finger millet is considered one of the most nutritious cereals. Finger millet has the highest amount of calcium (344 mg%) and potassium (408mg%). Finger millet contains about 5–8% protein, 65–75% carbohydrates, 15–20% nutritional fibre and 2.5 -3.5% minerals. finger millet has low fat content (1.3%) and contains mainly unsaturated fat. 100 grams of Finger millet has approximately 336 KCal of energy in them (Vinita Thapliyal and Karuna Singh 2015; Gupta et al 2017)

Materials and method:

Field demonstrations were carried out under rain-fed conditions during the year 2018 Kharif on farmers' fields in the villages namely Machhara, Podheiguda and Chapper, Koraput block, Odisha state. The soil type is red loamy. Sixteen farmers were selected for demonstration following improved agronomic practices based on their interest and willingness to adopt technology. Where farmers in these villages practice direct sowing of finger millets, the demonstrations consisted of three finger millet varieties cultivated by following the technology of line transplanting (LT) as sole crop. A total of 15.50 acres of land were covered in improved agronomy practices along with farmers' methods. Farmers were trained to prepare raised bed nurseries for seedlings. Between 20-28 days' of nursery finger millet seedlings were transplanted in the field with a space of 25 X 15 cm between row to row and plant to plant respectively. In addition, observations were taken from sixteen farmers who practiced broadcasting method for cultivating three landraces for comparison.

Demonstrations design (Single plot):

Traditional varieties of finger millet namely Bada mandia, Bati mandia, Kurma bati were demonstrated and evaluated against local practices. The demonstration plots were established in 1 acre, 0.75 and 0.50 cents land respectively and 100 kg of compost farm yard manure was applied at the time of nursery preparation. a standard seed rate recommended by Odisha University for Agriculture & Technology (OUAT), Bhubaneswar followed for demonstration

Prepared the nursery bed with a size of 150 square feet plot for one acre. Five beds can be raised each measuring 30 square feet per 1 kg seed. A bed consisted of 3 feet width and 10 feet length respectively. Row sowing methods were applied with 8 cm between the rows. A total of three ploughing has been done for land preparation in an interval of two to three days, depends on moisture availability. 1200 Kg of compost/ farmyard manure were applied after second plough. The third and final plough helped to spread the manure evenly across the field.

The spacing between plants was 15 cm and between rows it was 25cm. Weeding was done two times by using cycle weeder between 25-30 and 50-55 days after transplantation. Cycle weeder was proposed for weeding because it was more efficient and cost effective compared to conventional manual weeding. The cycle weeder doesn't require any fuel or power to operate and the maintenance cost is also negligible.

Biometric and Harvesting data collection:

Qualitative data were collected through field observation and Crop Cutting Experiment was conducted in two places by marking 25 sq. meters and grain were collected and processed. Five plants each from all fields were collected to determine the plant growth characteristics (sixteen demonstration with improved agronomic practice and sixteen for traditional practice). A total of 160 samples and 10 parameters were documented. The research team organized a farm day and gathered farmers' impression and learning from both practices. They were also asked to compare the number of tillers, number of panicles, size and number of fingers from improved farming practice and farmers' practice.

Table 1 Details of Demonstration plots and farmers' plots

variety	Types practice	No of Demonstration	Area covered
Bada mandia	Line transplanting	6	4.25
Bati mandia		6	8.75
kurma Bati mandia		2	2.50
Bada mandia	Conventional method	6	6
Bati mandia		6	6
kurma Bati mandia		2	2
Total		28	29.5

Both improved agronomic and conventional practices were demonstrated in farmers' field. Both demonstration plots and farmers' plots were located close to each other for facilitating farmers to observe and compare changes in agronomic practices and yield performances. Data from 28 plots (including improved and conventional) plots were gathered. Total area for demonstration and observation spread across 29.5 acres.

Table 2. Changes in farming practices in improved and conventional fields

Activities	Farmers method/acre	Improved method/acre
Seed rate	5 kg	1kg
Nursery seedbed	Not done	150 square feet plot - Raised bed
Fertilizer basal application	1200 kg	1200kg
Planting method	Broadcasting	Transplanting 20-28 days from nursery
Plant spacing	Irregular	15" x 25" pattern
Weeding	Hand weeding (Number of times/labour per acre)	At 25-30 and 50-55 days (by cycle weeder)- labour per acre
Branches per plant	1	1.5 to 2
Fingers per tiller	3.6	4.5

Stems	Thin	Thick
Yield per acre	360 Kg	630 kg

Both conventional and scientific plots are located adjacent to each other for facilitating farmers to observe key growth characters and compare the differences between conventional practices and improved practices. Each stage, the scientists interact with farmers in the village and explain the improved practices. This process is helpful to make farmers learn about improve practices and follow it in the next season. In conventional practice, farmers go for direct sowing, while improved practices suggest line transplantation. While, farmers' practice helps them avoid labour for bursary raising and transplantation, improved practices demand more labour for nursery preparation and transplantation. Transplantation and weeding help farmers to realise higher yield under improved farming practice. Improved farming practices resulted in increase the branches per plant and fingers per tiller. There is a significant increase in yield in finger millets under improved practice, as the yield in farmers' practice was just 360 Kg/acre, which increased to 630 Kg/acre under improved practice, indicating over 75% increase in yield over conventional practices.

Results and discussions:

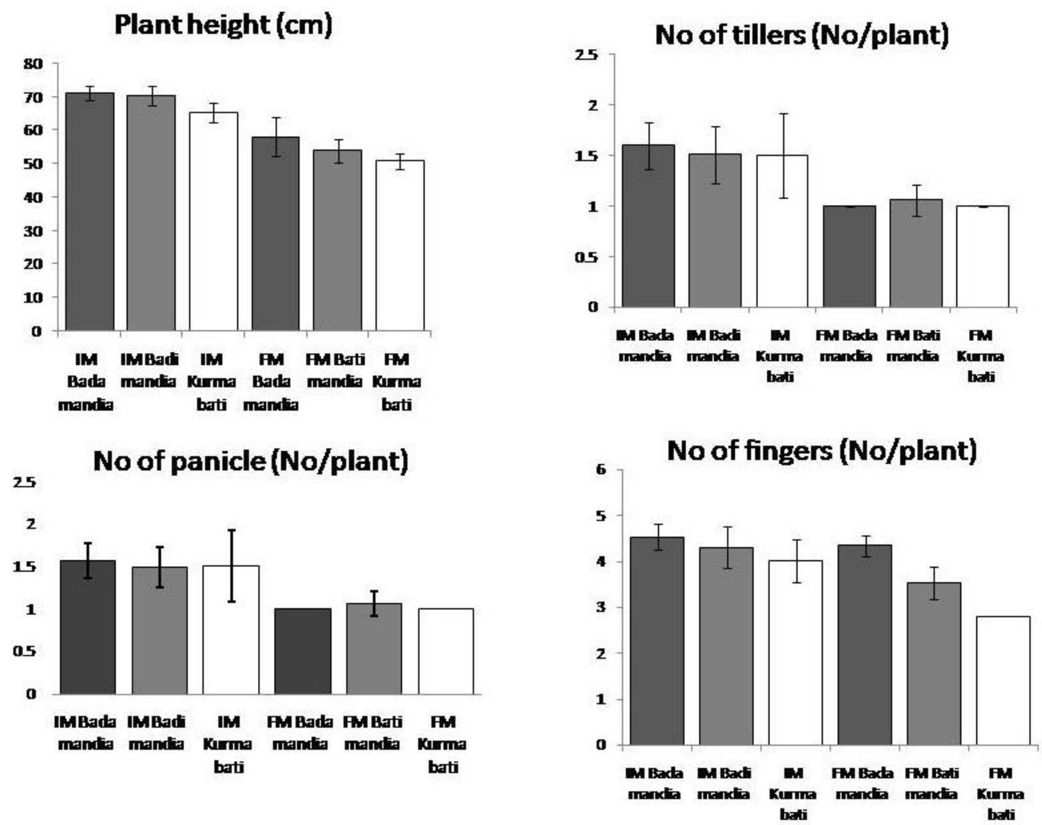
Biometric data analysis:

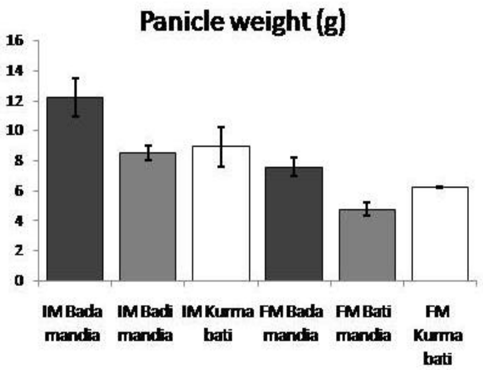
Biometric data of three varieties of finger millets cultivated under conventional and scientific practices analysed using mean value. It is found that scientific practices outperform conventional practices and resulted in significant increase in (1) number of tillers per plant, (2) number of productive tillers per plant, (3) number of panicles per plant, (4) number of fingers per plant, (5) panicle weight, (6) grain weight, (7) straw weight and (8) yield. Bada mandia perform better compared to other varieties under improved practice. The biometric data indicate that if farmers follow improved practices, they can realise higher yield and good return over investment. Better market opportunities and fair price for organically produced finger millets can also fetch higher price from market. Collective effort of farmers in this direction is vital for making finger millet an attractive crop, as they address climate change and malnutrition related disorders in remote tribal villages.

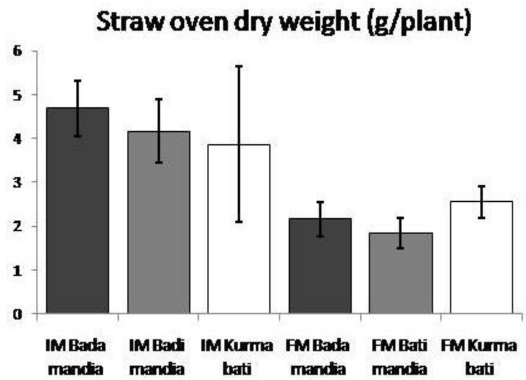
Table 3. Mean biometric values of finger millet varieties under improved and conventional farming practices

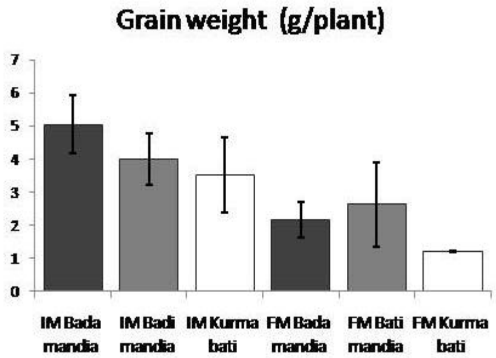
Variety Name	Plant height (cm)	No of tillers (No/plant)	No of Productive tillers (No/plant)	No of panicle (No/plant)	No of fingers (No/plant)	Panicle weight (g)	Grain weight (g/plant)	Straw sundry weight (g/plant)	Straw oven dry weight (g/plant)	Yield (ton/h)
IM Bada	71.37	1.6	1.6	1.57	4.53	12.21	5.04	11.29	4.69	1.64

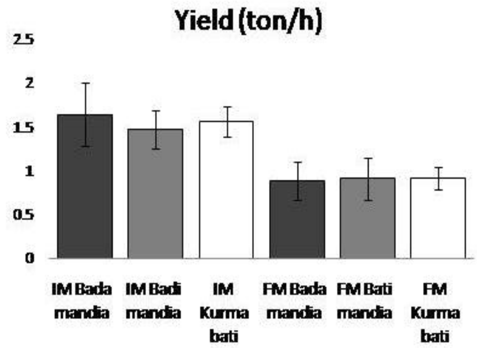
mandi a										
IM Badi mandi a	70.31	1.51	1.49	1.49	4.3	8.47	4.01	8.23	4.17	1.47
IM Kurm a bati	65.3	1.5	1.5	1.5	4	8.9	3.51	9.41	3.87	1.56
FM Bada mandi a	58.09	1	1	1	4.34	7.55	2.17	6.99	2.16	0.88
FM Bati mandi a	53.86	1.06	1.06	1.06	3.52	4.74	2.64	4.6	1.84	0.91
FM Kurm a bati	50.9	1	1	1	2.8	6.22	1.21	6.05	2.56	0.91











Benefit-Cost comparison in Demonstration plots and farmers' plots:

Cost of cultivation under conventional and improved farming practices:

The cost-benefit analysis shows that improved farming practice incur more cost due to nursery raising, transplantation and weeding. At the same time seed rate for improved farming practice is low. All other costs remain more or less same under both practices. For Bada mandia, the cost of cultivation under conventional practice per hectare is Rs. 20439, which go up to Rs. 29935/ha, showing an increase of Rs. 9496/ha compared to conventional practice. This indicates that the cost of cultivation is 46.4% higher in improved farming practices compared to conventional practices. For Bati mandia, the cost of conventional farming is Rs. 20721/ha and Rs. 26066/ha under improved practice, showing a difference of Rs. 5345/ha, an increase of 25.7% over the conventional practice. Similarly, the cost of cultivation of Kurma bati is Rs. 20756/ha under conventional practice and Rs. 26929/ha under improved farming practice with a net difference of Rs. 6173/ha (29.7% higher in improved farming practice). The increase in the cost of cultivation under improved practice is attributed to higher labour cost for preparing nursery, transplanting and weeding.

Table 4. Cost and revenue from conventional and improved farming practices

Variety	Cost of cultivation Rs./Hectare		Gross Income Rs./Hectare		Net Income Rs./Hectare		B:C Ratio		BC Ratio variation
	Farmers	Improved	Farmers	Improved	Farmers	Improved	Farmers	Improved	

	practices	practices	practices	practices	practices	practices	practices	practices	
Bada mandia	20439	29935	25494	47511	5055	17576	1.25	1.59	0.34
Bati mandia	20721	26066	26363	42586	5641	16520	1.27	1.63	0.36
Kurmabati	20756	26929	26363	45193	5606	18263	1.27	1.68	0.41

Gross income from conventional and improved farming practice

Gross income consists of income from grain. The straw from finger millet is hardy, and not used as a fodder. There is a significant difference in gross income from conventional and improved practices. For Badi mandia, the income from conventional practice is Rs. 25494/ha. The improved practice provides higher yield, and hence higher gross income from Badi mandia cultivation. The gross income from Badi mandia under improved practice is Rs. 47511/ha., which is higher than Rs. 22,017/ha from conventional practice, indicating over 86.3% increase in gross income compared to conventional practice.

For Bati mandia, the gross income from conventional practice is Rs. 26363/ha while it is Rs. 42,586/ha from improved farming practice. This shows that improved farming practices provides higher gross income of over 61.5% compared to conventional farming. Similarly, for Kurma bati, the gross income from conventional practice is Rs. 26363/ha and from improved farming practice it is Rs. 45,193/ha, making a difference of Rs. 18,830/ha. The gross income from improved cultivation of Kurma bati is 71.4% higher than the conventional farming practice.

The table shows that improved farming practices help farmers earn gross income over 86.3% for Badi mandia, 61.5% over Bati mandia and 71.4% over Kurma bati. Improved farming practices thus ensure higher yield and return from the cultivation of finger millets.

Net income from conventional and improved farming practices

Net income has been calculated after deducting total cost of cultivation from gross revenue. It is found that the net income from the conventional practice of Badi mandia is Rs. 5055/ha while it is Rs. 17576/ha. The table shows that improved farming practice ensures higher net income from Badi mandia, worth of Rs. 12521/ha, indicating around 2.5 fold increase in net return compared to conventional practice. Similarly, for Bati mandia, the net income from conventional practice is Rs. 5641/ha and from improved practice it is Rs. 16520/ha. The difference in net return from conventional and improved practice is Rs. 10,879/ha, showing 192.8% higher return from improved practice over conventional practice. For Kurma bat, the differences are Rs. 5606/ha and Rs. 18263/ha. The difference in net return over conventional practice is Rs. 12657/ha., which 2.3 times higher net return compared to conventional practice.

The benefit cost ratio also prove that adoption of improved farming practices in finger millets can increase its profitability compared to conventional method. The benefit-cost ratio is above 1.5 for all varieties cultivated under improved farming practices. The demonstration plots with improved agronomic practices hence offer technology and practices for enhancing productivity and profitability of landraces of millets.

Demonstration plots in farmers' field as an effective extension strategy

Demonstration plots with improved agronomic practices have been established for educating farmers and transfer of technologies/ improved agronomic practices. Farm Days were organized for explaining about improved agronomic practices and ensuring the participation of farmers in the village in establishing demonstration plots, observing key growth parameters in comparison with farmers' practices. Such a method was helpful for farmers to learn from the practices demonstrated. Demonstration plots helped farmers to learn about improved farming practices. They found time to interact with researchers and share their experiences and learning.

Farmers in the villages and surroundings were also asked to evaluate the process and results of improved farming practices in comparison with their conventional practices. A total of 41 farmers who participated in the evaluation process are convinced about the effectiveness of improved agronomic practices in terms of number of tillers per plant, more number of panicles per plant, number of fingers per plant and crop yield. The farmers in the participating villages also opined that they learned the process of improved farming practices and can teach others how to follow such practices for increasing crop yield.

Conclusion

Millet play a critical role in the household food security of tribal and rural villages in drier regions of India. Increasing the yield/ profitability of millet cultivation has been treated as an important strategy for promoting climate smart, nutri-dense millets. Traditional varieties of millets in the custody of tribal farmers possess more adaptive traits to harsh environment. Conservation of these landraces is also vital for sustainable agriculture. One of the inherent weakness of these landraces is low productivity. By exposing tribal farmers on improved farming practices, finger millet demonstration proved that landraces can perform better in terms of yield.

Adoption of technology among tribes requires regular handholding and demonstration of practices closer to them. MSSRF adopted a participatory strategy where these farmers join hand with researchers for undertaking research. Improved agronomic practices followed in finger millet cultivation incur additional cost for nursery preparation, transplanting, weeding etc. In order to promote such practices across tribal areas, it is necessary to increase their access to credit at lower cost. Ensuring fair price and market are other requirement for encouraging tribal farmers to follow improved farming practices. Increase in income from finger millets will help tribal and rural farmers in drier regions to improve their living standard. Increase in the yield of finger millets will also lead to increased consumption of millet and thereby ensure nutrition security of economically weaker sections.

Promotion of technologies and linking technology with tribal farmers and their genetic resources are vital for the conservation of valuable genetic resources, dietary diversity among smallholder farmers and adaptation to changing climate for the sustainability of farming.

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