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Effect of integrated crop management practices on yield parameter, yield and economics of Kodo Millet (*Paspalum scrobiculatum* L.) variety JK 13 through OFTs and FLDs in Sidhi district of Madhya Pradesh

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Abstract
Kodo millet provides staple food with cheap protein, minerals and vitamins to poor, marginal, tribal and backward people of Madhya Pradesh. This crop is responsive to the adverse climatic and poor soil conditions. The present investigation was carried out to improve Kodo millet yield through different inputs and their integration to reduce the input cost. The development of the Agriculture is primarily depending on the application of scientific technologies by making the best use of available resources. To increase the production, productivity, profitability and quality of agricultural produce, On Farm Testing and Front Line Demonstrations were implemented at various farmers' fields during kharif seasons of selected farmers of Sidhi district of Madhya Pradesh. Krishi Vigyan Kendra, Sidhi conducted 40 on farm testing and frontline demonstrations on Kodo Millet during four consecutive years from 2013-14 to 2016-17. The critical inputs were identified in existing production technology through meetings and discussions with farmers. Prevailing farmer's practices were treated as a control for comparison with recommended practices. The average yield of recommended practices registered 28.25 percent higher than the farmer's practice. The average technology gap, extension gap and technology index were observed 14.43 q/ha, 2.04 q/ha and 65.58 percent respectively. The highest grain yield (8.20 q/ha) was recorded in the year 2015-16, it was 29.30 percent more than the farmer's practice (5.80 q/ha). Average net profitability of worth Rs. 5862 /ha as compared with farmers practices (Rs. 3852/ha) were obtained an average benefit-cost ratio i.e. 2.96 and 2.46 were recorded in demonstrated plot and farmers practice respectively. The higher additional returns (Rs. 2504/ha) and effective gain (Rs. 2214/ha) obtained under demonstrations could be due to improved technology, timely of crop cultivation operations and scientific monitoring.

Keywords: OFT, FLD, Kodo, JK 13, yield, technology gap, technology index, net returns, effective gain and BC ratio

Introduction

Kodo millet (*Paspalum scrobiculatum* L.) is a small grain crop in India, called by different names (Hindi: Kodra, Tamil: Varagu, Telugu: Arikelu, Karrda: Harka). Kodo millet (*Paspalum scrobiculatum* L.), is a tropical small millet indigenous to India (De Wet *et al*., 1983) [7] and grown for its grain and fodder. The crop is hardy and drought-resistant, and is capable of growing in marginal soils. The grain is enclosed in a hard, corneous husk, which makes debranning difficult. The grain is said to be poisonous after rain; this may be due to a fungal infection. Winnowed, clean, healthy grain seems to pose no health problem. Kodo millet is primarily cooked as rice. It is a traditional, long duration, hardy and drought resistant crop cultivated (Bondale, 1994) [3]. Today millet ranks as the sixth most important grain in the world, sustains one third of the world's population and is a significant part of diet in Africa, India, Northern Chaina, Japan, Manchuria and various area of the former Soviet Union and Egypt (Sahu, 2010) [12]. The area under kodo millet cultivation is witnessing a declining trend in the post-green revolution period due to predominance of the major cereals such as rice and wheat. However, an intensified drive to increase the acreage of small millets is important because millets still contribute to the regional food security of the dry and marginal lands, where major cereal crops fail to yield. Nowadays, thrust to grow millets is given due to their nutritional superiority as compared to the major cereals. Kodo millet has been reported to have higher free radical quenching potential when compared to other millets (Hegde and Chandra,

2005) [8]. Besides, it provides low priced protein, minerals and vitamins in form of sustainable food (Yadava and Jain, 2006) [20]. Growing health consciousness among the consumers also creates demand for this type of nutri-cereals which are anti-diabetic and anti-oxidant in nature (Chandrasekara and Shahidi, 2011) [5]. Grain has 98.3 percent protein, 1.4 percent fat, 65.6 percent carbohydrate and 2% ash. Fiber The overall fiber level of the grain is fairly high throughout. Kodo millet has a lower Phosphorus (P) concentration than other millets, and it has a significantly higher antioxidant capacity than virtually other millets and common cereals (Ratnavathi 2017) [11]. The grain is recommended as a rice supplement for those with diabetes (Bhat 2018) [2]. India's Uttar Pradesh, Rajasthan, Bengal West, Tamil Nadu, Andhra Pradesh and Madhya Pradesh grow this crop (Bhat, 2018 and Baghele *et al*. 2021) [2, 1].

In Madhya Pradesh, India's tribal area, Kodo is a staple meal (Sharma and Mandhyan 1992). The bran layer on the surface of the Kodo kernel makes it tough to digest. The final product is more pleasant and digestible if Kodo is dehusked and then polished to remove the bran layer. Millets are also acceptable for diabetic diets, although their distinctive flavor and difficulties in the processing are limits to their use in diets (Baghele *et al*. 2021) [1].

The millet cultivation was gradually decreased due to green revolution; lower the productivity and less preference among the farming community. The consumption pattern of food is continuously changing due to the high cultivation and production of cereals and pulses over the millets. In recent days, the consumer preference is changing towards the millets because of diabetic prevalence in world. The continuous intake of kodo millet prevents from cardiovascular diseases and reducing the blood pressure and high cholesterol (Bunkar *et al*., 2021) [4]. The productivity of millets was very low due to improper nutrient management, cultivation under dry land conditions and less number of improved varieties. Hence, these crops need attention of scientists, developmental agencies, processors, nutritionists and policy makers in order to not only sustain the production but also to enhance demand so that millet farmers can be benefited. Keeping in view the above facts, the present study was undertaken.

Materials and Methods

The present study was carried out in the Sidhi district of Madhya Pradesh, which is located in the North-East part of Madhya Pradesh state and lies at 24.395603 latitude and 81.882530 longitudes with an altitude of 272 m above the mean sea level. On farm testing and frontline demonstrations were conducted during 2013-14 to 2016-17 with evaluating the performance of the JK 13 variety of Kodo on farmer's field of the district. In this study, 40 farmers were selected during the study period. Total 40 on farm testing and front line demonstrations under real farming situations were conducted during *kharif* seasons of 2013-14 to 2016-17 on farmer's field under Krishi Vigyan Kendra operational area.

The area under each demonstration was 0.4 ha. The soil was sandy clay-loam in texture with moderate water holding capacity, low to medium in organic carbon (0.034-0.055%), low in available nitrogen (116-211 kg/ha), medium in available phosphorus (10-14 kg/ha), low to medium in available potassium (206-303 kg/ha) and soil pH was slightly acidic to neutral in reaction (6.5-7.1). The treatment comprised of recommended practice (Improved variety JK-13, integrated nutrient management-@ 40:20:20 kg NPK/ha + *Azospirullum brasilense* (nitrogen fixing bacterium) and *Aspergillus awamouri* (phosphate solubalizing fungus) @ 25 g kg^{-1} etc. v/s farmer's practice.

The crop was sown in the month of July-August with a spacing of 20 cm x10 cm and the seed rate was 10-15 kg/ha. An entire dose of P through Diammonium Phosphate (DAP), K through Muriate of Potash was applied as basal during sowing. The seeds were treated with carbendazim @ 2.5 g/kg seeds then seeds were inoculated by *Azospirullum brasilense* (nitrogen fixing bacterium) and *Aspergillus awamouri* (phosphate solubalizing fungus) @ 25 g kg^{-1}.

Farmer's practice constituted local variety with degenerated seed was used, the crop was sown July-August, broadcasting method of sowing, higher seed rate (25-30 kg/ha), imbalance dose of fertilizers applied (10 kg DAP/ha), no seed treatment, no biofertilizers, no hand weeding, no irrigation and no plant protection measures were adopted. The crop was harvested at the same time as harvesting of front line demonstration plots. Harvesting and threshing operations were done manually; 5m x 3m plot harvested in 3 locations in each demonstrations and average grain weight taken at 12% moisture level. A similar procedure was adopted on the Farmers Practices plot under each demonstration then grain weight converted into quintal per hectare (q/ha).

Before conducting the demonstrations trainings to farmers of respective villages were conducted concerning technological interventions. All other steps like site selection, farmers selection, the layout of demonstration, farmers participation etc. were followed as suggested by Choudhary, 1999 [6]. Visits of farmers and extension functionaries were organized at demonstration plots to disseminate the technology at a large scale. The data output was collected from both OFT & FLD plots as well as farmer's practices plot and finally the extension gap, technology gap, technology index along with the benefit-cost ratio were worked out (Samui *et al*., 2000) [13] as given below:

Harvest index (%) = (Grain yield/Biological yield) × 100

% increase in yield = [{Demo yield-Farmers practices}/farmers practices} x 100

Technology gap = Potential yield-Demonstration yield.

Extension gap = Demonstration yield-Farmers yield.

Technology index = [(Potential yield-Demonstration yield)/Potential yield] x 100

Additional cost in improved technology (Rs./ha) = Cost of improved technology (Rs/ha)-Cost of farmers practice (Rs./ha).

Additional returns (Rs/ha) = Net returns of improved technology (Rs./ha)-Net returns of farmers practice (Rs./ha)

Effective gain (Rs./ha) = Additional returns-Additional cost of improved technology

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross returns (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}$$

The techniques which were part of the package of practices were emphasized. However, it was left to the farmers to adopt and practice them depending on the individual farmer's resource availability and preference as to inputs (fertilizers and pesticides). Table 1 gives a comparison between the existing practice and those that were recommended.

Results and Discussion

Gap analysis of Recommended and Existing practices

The gap among the existing and recommended technologies of Kodo crop in district Sidhi has been depicted in table-1. The full gap was observed in the case of use of HYVs, seed treatment, seed inoculation, sowing method, spacing, fertilizer management, weed management, and plant protection, while a partial gap was observed in seed rate, irrigation and field preparation, which definitely may be the reason of not achieving potential yield and demonstrated yield by farmer's practices. Farmers were not aware of recommended technologies. Farmers, in general, used degenerated seeds of local or old-age varieties instead of the recommended high yielding varieties. Unavailability of seed in time & at the local level and lack of awareness were the main reasons for this gap in farmer's practices. Farmers applied higher a seed rate than the recommended and they were not using seed treatment techniques for the management of seed born diseases and also not aware of the application of fertilizers for enhancement of yield and quality of Kodo because of lack of knowledge and interest. Sharma *et al*., 2011 [14] and Singh *et al*., 2022 [17] also reported that there is a technological gap between improved practices and existing practices.

Table 1: Comparison between technological interventions and existing farmers practice of Kodo cultivation under front line demonstration programme

S. No.	Component	Technological intervention	Farmers practice	Gap (%)
1.	Land preparation	Three ploughing	Three ploughing	No gap
2.	Variety	JK 13	Kodai	Full gap
3.	Seed rate	10-15 kg/ha	25-30 kg/ha	Partial gap
4.	Seed treatment	Seed treatment was done with 2.5 gm of Carbendazim.	No seed treatment	Full gap
5.	Seed inoculation	*Azospirullum brasilense* (nitrogen fixing bacterium) and *Aspergillus awamouri* (phosphate solubalizing fungus) @ 25 g kg^{-1}	No seed inoculation	Full gap
6.	Sowing method	Line sowing	Broadcasting	Full gap
7.	Spacing	Row to row 20 cm and plant to plant 10 cm	Not maintained	Full gap
8.	Fertilizer dose	40:20:20 (NPK kg ha^{-1})	10 kg DAP/ha	Full gap
9.	Weed management	Application of Pendimethalin 30 EC @ 0.5 kg a.i./ha as pre-emergence	No weed management	Full gap
10.	Irrigation	No need of irrigation	No need of irrigation	No gap
11.	Plant protection	As per need	No plant protection measures	Full gap

Yield attributes

The yields attributing parameters like the number of tillers per meter row length and harvest index (%) of Kodo obtained over the years under recommended practice as well as farmers practice are depicted in Table 2. The Number of tillers per meter row length of Kodo ranged from 10.40 to 12.20 with a mean of 11.35 under recommended practice on farmer's fields as compared to range from 7.60 to 8.16 with a mean of 7.80 recorded under farmers practice. The higher values of the number of tillers per meter row length in recommended practice as compared to farmers practice was may be due to the use of high yielding varieties, weed management, nutrient management-integrated pest management etc. (Singh *et al*., 2021) [16].

Table 2: Yield parameters, Yield, Technology gap, Extension gap and Technology index of Kodo as affected by recommended practices as well as farmer's practices

Year	Area (ha)	No. of farmers	No of tillers/m row length		Grain yield (q/ha)			% increase over FP	Straw yield (q/ha)		Harvest index (%)		Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
			RP	FP	Pot.	RP	FP		RP	FP	RP	FP			
2013-14	4.0	10	11.24	7.64	22	7.86	5.32	32.30	11.16	7.53	41.32	41.40	14.14	2.54	64.27
2014-15	4.0	10	11.56	8.16	22	7.93	6.12	22.80	11.28	8.67	41.28	41.38	14.07	1.81	63.95
2015-16	4.0	10	10.40	7.60	22	8.20	5.80	29.30	11.66	8.25	41.29	41.28	13.80	2.40	62.73
2016-17	4.0	10	12.20	7.80	22	6.30	4.90	28.58	8.97	6.97	41.26	41.28	15.70	1.40	71.36
Total/Average	16.0	40	11.35	7.80	22	7.57	5.54	28.25	10.77	7.86	41.29	41.34	14.43	2.04	65.58

Seed yield

The yield performance of recommended practices and farmers practices are depicted in Table 2. The data revealed that under the demonstration plot, the performance of Kodo yield was found higher than that under farmers practice during consecutive years of demonstrations (2013-14 and 2016-17). The average yield of Kodo under demonstration was recorded 7.57 and highest yield was observed 8.20 q/ha during 2015-16 over farmers practice 5.54 and 6.12 q/ha during the year 2014-15. The highest yield enhancement due to technological intervention was observed 32.3% over farmer's practice. The cumulative effect of the technological intervention of the four years, -revealed an average yield of 7.57 q/ha, 28.25% higher than farmers practice (5.54 q/ha). The year- to-year variations in yield can be explained based on variations in prevailing social, economic and climatic condition of the particular villages (Singh *et al*., 2021 and Singh *et al*., 2016) [16, 15].

Economic Parameter

Economic performances of Kodo under on farm testing and front line demonstrations were depicted in table 3. The inputs and outputs prices of commodities prevailed during the years of demonstrations were taken for calculating cost of cultivation, net returns and benefit-cost ratio. The investment in production by adopting recommended practices ranged from Rs.2710/ha to Rs. 3640/ha with a mean value of

Rs.3029/ha over the farmers practice Rs. 2420/ha to Rs. 3120/ha and average of Rs.2658/ha during the demonstrations period. Cultivation of Kodo under recommended practices gave a higher net return ranges from Rs.4610/ha-Rs. 6701/ha compared to Rs.3300/ha-Rs. 4834/ha under farmers practice during 2013-14 to 2016-17. The average benefit-cost ratio of recommended practices was 2.96, varying from 2.56 to 3.38 during the study period and in farmers practice was 2.46, varying from 2.23 & 2.92. This may be due to higher yields obtained under recommended practices compared to farmer's practices. Similar results have been reported earlier by Tomar, 2010, Patel *et al*., 2014 and Singh *et al*., 2022 [19, 10, 17].

Table 3: Effect of recommended practices as well as farmer's practices on economic parameters of Kodo cultivation

Year	Gross expenditure (Rs./ha)		Additional cost (Rs./ha)	Gross return (Rs./ha)		Net return (Rs./ha)		Additional returns (Rs./ha)	Effective gain (Rs./ha)	B:C Ratio	
	RP	FP		RP	FP	RP	FP			RP	FP
2013-14	2710	2420	290	8646	5852	5936	3432	2504	2214	3.19	2.42
2014-15	2815	2510	305	9516	7344	6701	4834	1867	1562	3.38	2.92
2015-16	3640	3120	520	9840	6960	6200	3840	2360	1840	2.70	2.23
2016-17	2950	2580	370	7560	5880	4610	3300	1310	940	2.56	2.27
Average	3029	2658	371	8891	6509	5862	3852	2010	1639	2.96	2.46

Technology gap, Extension gap and Technology Index

Technology Gap

The technology gap shows the gap in the demonstration yield over potential yield and the average technology gap was 14.34 qt/ha during the study period (Table 2). The trend of technology gap ranging between 13.80 and 15.70 qt/ha in 2013-2014 to 2016-2017, respectively and it reflects the farmers' cooperation in carrying out such demonstrations with encouraging results in subsequent years. The frontline demonstrations were laid down under the supervision of KVK Scientists at the farmer's field. The technology gap observed might be attributed to the dissimilarity in soil fertility status, local climatic situations, varietal suitability and adoption of technological practices. The technology gap implies researchable issues for the realization of potential yield, while the extension gap implies what can be achieved by the transfer of existing technologies. Mukharjee (2003) [9] have also opined that depending on identification and use of the farming situation, specific interventions may have greater implications in enhancing system productivity. Similar findings were also recorded by Singh *et al*., 2022 [17].

Extension Gap

The extension gap is a parameter to know the yield differences between the demonstrated technology and farmer's practice and observed data was depicted in table 2. The extension gap range between 1.40 to 2.54 q/ha during the study period with an average of 2.04 q/ha which emphasized the need to educate the farmers through various means for the adoption of improved high yielding variety and improved agro technologies to reverse this trend of wide extension gap. More and more use of new HYV's and crop management practices by the farmers will subsequently change this alarming trend of developing extension gap. The new technologies will eventually lead the farmers to disenchantment discontinuance of old varieties with the new technology. The results are in agreement with research worker Patel *et al*., (2014) [10], who stated that, location-based problem identification and thereby specific interventions may have great implications in the enhancement of crop productivity.

Technology index

The technology index showed the feasibility of the evolved technology at the farmer's fields. The higher technology index reflected the insufficient extension services for the transfer of technology. The lower value of the technology index shows the efficacy of the good performance of technological interventions. The average technology index was observed 65.58 percent under front line demonstration (Table 2). The range of technology index was observed 62.73 to 71.36 percent during the study period 2013-2014 to 2016-2017. The decreasing trend in the technology index shows that the farmer's interest in adopting technology is increasing. This variation indicates that results differ according to soil fertility status, weather condition, non-availability of irrigation water and insect-pests attack in the crop. The results present study results agree with the findings of (Patel *et al*. 2014, Singh *et al*. 2021 & Singh *et al*. 2022) [10, 16, 17].

Conclusion

It is concluded from the study that through OFTs and FLDs of recommended technologies, yield of Kodo can be increased to its potential yield in Sidhi district. This will substantially increase the income as well as livelihood of the farming communities. Major attention is to be made on development of area specific technology module for enhancing the productivity of minor millets in various agro ecosystem of Madhya Pradesh.

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