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Cite This:J. of Adv. Agri. & Horti. Res. 2022, 1, 1-7

Sciforce

Journal of Advanced Agriculture & Horticulture Research

Journal homepage: www.sciforce.org

A comparative study on yield performance of finger millet varieties under rainfed conditions in south eastern Ghat zone of Odisha

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ARTICLE INFO

Article history:
Received: 20210628
Received in revised form: 20210729
Accepted: 20210729
Available online: 20210729

Keywords:
Finger millet;
Yield gap;
Extension gap;
Technology index

ABSTRACT

Finger millet (*Eleusine coracana* (L) commonly known as ragi is an important crop used for food, forage and industrial products. Finger millet has a wide ecological and geographical adaptability and resilience to various agro-climatic adversities hence; it is highly suited to drought condition and marginal land and requires low external input in cultivation. Farmers participatory field demonstrations of ragi variety Arjun and Bhairabi were conducted at two villages i.e. Pedawada of Malkangiri block and MPV -1 of Kalimela block of Malkangiri district, comprising 40 farmers in cluster approach in Kharif 2018 and 2019, by Krishi Vigyan Kendra, Malkangiri, in South Eastern Ghat Zone of Odisha. Conducting front line demonstrations on farmer's field help to identify the constraints and potential of the finger millet in the specific area as well as it helps in improving the economic and social status of the farmers. Observation on growth and yield parameters were taken and economic analysis was done. The final seed yield was recorded at the time of harvest and the gross return in (Rs ha $^{-1}$) was calculated based on prevailing market prices. The results from the demonstration conclusively proved that finger millet variety Arjun (OEB-526) recorded the higher yield (18.8 q ha$^{-1)}$, followed by Bhairabi (15.3 q ha$^{-1)}$ and farmer's traditional variety Nali Mandia (Dasaraberi) recorded an average yield of (8.6 q ha^{-1}). HYV Finger millet variety Arjun with proper nutrient management and plant protection measures gave 118 % higher over farmer's practices. The technological and extension gap was 1.9 q ha-1 and 12.07qha-1 respectively. Similarly, technological index was 8.2 percent. The benefit cost ratio was 2.4 and 1.9 in case of Arjun and Bhairabi respectively and in case of farmer's variety Nali Mandia it was 1.4. Hence the existing local finger millet variety can be replaced by HYV Arjun ans Bhairabi, since it fits well to the existing rainfed farming situation for higher productivity. By conducting front line demonstrations on millet on large scale in farmer's field, yield potential of finger millet can be enhanced largely which will increase in the income level of farmers and improve the livelihood condition of the farming community.

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Introduction

Among small millets, finger millet (*Elusine coracana* L,) locally known as Ragi/Mandia is the most important crop grown in tribal districts of Odisha and it is the staple food of the tribals. It was originated about 5000 years ago in east Africa (possibly Ethiopia) and was introduced into India, 3000 years ago

(Upadhyaya *et al*., 2006) and it is highly suited to drought condition and marginal land and requires low external input in cultivation. Millet is a collective term referring to a number of small seeded annual grasses that are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical and tropical regions *(Baker, 1996).* Nutritionally finger millet is superior to major cereal crops and rich source of micronutrients such as calcium, phosphorous, magnesium and iron. And it has several health benefits. Finger millet grains contain higher amount of proteins, oils and minerals than the grains of rice, maize or sorghum *(Reed et al., 1976). Vadivoo and Joseph (1998)* mentioned finger millet grains contain 13.24% moisture, 7.6% protein, 74.36% carbohydrate, 74.36% carbon, 1.52% dietary fiber, 2.35% minerals, 1.35% fat and energy 341.6 cal/100g. (*Joshi and Katoch, 1990; Ravindran, 1991*). It is a rich source of micronutrients such as calcium, phosphorus, magnesium and iron. Cysteine, tyrosine, tryptophan and methionine are the right spectrum of amino acids found in finger millet protein *(Rachie, 1975).* The increase in global temperature leads to climate changes that directly affect crop production and increase people's hunger and malnutrition around the world. With regard to protein (6-8%) and fat (1-2%) it is comparable to rice and with respect to mineral and micronutrient contents it is superior to rice and wheat *(Babu et al., 1987*). It is also known for several health benefits such as anti-diabetic, anti-tumerogenic, atherosclerogenic effects, antioxidant, which are mainly attributed due to its polyphenol and dietary fiber contents. Being indigenous minor millet it is used in the preparation of various foods both in natural and malted forms. Grains of this millet are converted into flours for preparation of products like porridge, puddings, pancakes, biscuits, roti, bread, noodles, and other snacks. Besides this, it is also used as a nourishing food for infants when malted and is regarded as wholesome food for diabetic's patients. Diversification of food production must be encouraged both at national and household level in tandem with increasing yields. Growing of traditional food crops suitable for the area is one of the possible potential successful approaches for improving household food security. Malkangiri is one of the seven districts where a flagship programme called "Special Programme for Promotion of Millets in Tribal Areas of Odisha (hereafter, Odisha Millets Mission, (OMM)" has been launched by Department of Agriculture and Farmers Empowerment, Odisha in order to revive millets in rainfed farming systems and household consumption. It was started in kharif 2017 in four blocks of the district, namely Chitrakonda, Korkunda, Mathili and Khairiput. The Government of Odisha launched Odisha Millets Mission (OMM) also known as the Special Programme for Promotion of Millets in Tribal Areas of Odisha in 2017 to revive millets in farms and on plates. The aim was to tackle malnutrition by introducing millets in the public distribution system (PDS) and other state nutrition schemes. The focus is on reviving millets in farms and putting it on plates."

Millet, a nutritious and climate-resilient crop, has traditionally been cultivated and consumed by tribal communities in the rainfed regions of southern Odisha. Technology gap, i.e. poor knowledge about newly released crop production and protection technologies and their management practices in the farmers' fields is a major constraint in Ragi production. So far, no systematic approach was implemented to study the technological gap existing in various components

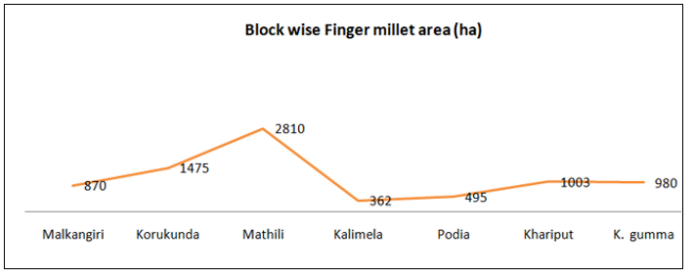

Figure I: Block wise finger millet area in Malkangiri district

of Ragi cultivation. Awareness of scientific production technology like HYV of ragi, seed treatment with fungicide, use of insecticide and bio-fertilizers, is lacking in Malkangiri district which were a key reason for low productivity. The production potential could be increased by adopting recommended scientific and sustainable management production practices with improved high yielding varieties and timely use of other critical inputs.

Objective

The field experiment was undertaken to study the performance of three finger millet varieties Local Mandia (Nali Mandia), Bhairabi and Arjun in rainfed upland situation in kharif season. The present investigation was undertaken to evaluate the field performance of newly released finger millet varieties Arjun and Bhairabi under rainfed condition. The demonstrations were carried out in Malkangiri district covering two villages like Pedawada and MPV-6 to find out the existing technological and extension gap along with technology index with an objective to popularize the ragi varieties having higher yield potential**.**

Material and methods

The study was carried out in operational area of Krishi Vigyan Kendra (KVK), Malkangiri during Kharif season in the year 2018 and 2019. The study was under taken in Malkangiri and Kalimela blocks of Malkangiri district of Odisha and the blocks were selected purposefully as Finger millet is the major cereals crop grown in large area in Kharif season. The demonstrations were conducted in two different adopted villages Pedawada and MPV-6 in cluster approach. The Front Line Demonstration (FLD) is an applied approach to accelerate the dissemination of proven technologies at farmer's fields in a participatory mode with an objective to explore the maximum available resources of crop production and also to bridge the productivity gaps by enhancing the production in national basket.The necessary steps for selection of site and farmers and layout of demonstrations etc were followed as suggested by *Choudhary (1999).* Forty numbers front line demonstrations on HYV Ragi were conducted in two clusters comprising 40 numbers of farmers. All the participating farmers were trained on various aspects of Ragi production technologies and recommended agronomic practices and certified seeds of Raga variety Arjun and Bhairabi were used for demonstration. The soil of demonstration site was slightly

acidic in reaction (pH-5.0 to 5.25) with sandy loam in texture and EC was 0.134 (dS m −1). The available nitrogen, phosphorus and potassium was between 214 .00, 22 .00, 142 .00 (Kg ha−1) respectively with 0.48 (%) Organic Carbon. The crop was sown in under rainfed condition in the first to second week of July. The crop was raised with recommended agronomic practices and harvested within 4th week of November up to 2nd week of December.

Krishi Vigyan Kendra (KVK), Malkangiri conducted front line demonstration with HYV varieties like Bhiarabi and Arjun and farmer' local var Dasaraberi as check Finger millet Variety Arjun (OEB-526) is having Maturity duration 110 days and average yield 20.7q/ha with moderate resistance to leaf, neck and finger blast and brown seed and Bharani is a HYV of Ragi with Maturity duration 110 days and average yield 17.6 q/ha. Moderate resistance to leaf, neck blast and brown seeded and protein content 81%. Local variety Dsaraberi or Nali Mandia is having 105 days duration and drought tolerant variety used as farmers variety as local check.

The technologies demonstrated were as follows: Popularization of high yielding Ragi variety, Seed treatment with *Trichoderma viride* @ 4g kg^{-1} seed , Line sowing with, soil test based fertilizer application along with need based plant protection measures. The field was ploughed two times and planking was done after each plugging, Need based plant protection measures were taken; along with soil test based fertilizer application was done with fertilizer dose 40:30:60 kg. N: P_2O_5: K_2O kg ha^{-1}. In case of local checks existing practices being used by farmers were followed. The observations were recorded for various parameters of the crop. The farmers' practices were maintained in case of local checks. The field observations were taken from demonstration plot and farmer's plot as well. Parameters like Plant height, number of fingers per plant, length of finger , no of fingers per year, 1000 seed weight and seed yield were recorded at maturity stage and the gross returns (Rs ha -1) were calculated on the basis of prevailing market price of the produce. The extension gap, technology gap, technology index along with B: C ratio was calculated and the data were statistically analyzed applying the statistical techniques. Statistical tools such as percentage, mean score, Standard deviation, co-efficient of variation, Fisher's "F" test, were employed for analysis of data. The farmer's practices (FP) plots were maintained as local check for comparison study. The data obtained from intervention practices (IP) and famers practices (FP) were analyzed for extension gap, technological gap, technological index and benefit cost ratio study as per (*Samui et al., 2000*) as given below.

Technology gap = Pi (Potential yield) - Di (Demonstration yield)

Extension gap = Di (Demonstration Yield) - Fi (Farmers yield)

$$\text{Technology index} = \frac{\text{Technology gap}}{\text{Potential Yield}} \quad X \quad 100$$

Result and Discussion

The results obtained from the present investigation are summarized below. The Table 1 depicts the major differences observed between demonstration package and farmer's practices in ragi production in the study area**.** The major differences were observed between demonstration package and farmer's practices were regarding recommended varieties, seed treatment, soil test based fertilizer application, keeping optimum plant population by thinning, weed management and plant protection measures.

The data of Table 1 shows that under the demonstrated plot only recommended high yielding variety, proper weeding and optimum plant population maintaining by thinning and the farmers used herbicides and the farmers timely performed all the other package and practices. It was also observed that farmers were unaware about balanced fertilizer application, seed treatment, and use of fertilizers application and maintenance of plant population for enhancing the yield. Majority of the farmers in the study area were unaware about use of weed management practices. The findings are in corroborated with the findings of (*Katar et al., 2011*)

From the Table 2 it was revealed that in the district Malkangiri the productivity of finger millet was 6.38 (q $ha^{-1)}$ as compare to state average productivity 8.67 (q ha^{-1}), but there exists a gap between potential yield and farmers yield, which can be minimized by adoption High yielding varieties with improved management practices. The productivity of finger millet was very low in the district as the crop is mostly grown along the hillsides on sloppy land on light textured soil. It was also coupled with negligence in adoption of improved varieties no input like fertilizers use and no plant protection measures and improper method and time of sowing. However, there is a wide gap between the Potential and the actual production realized by the farmers due to partial adoption of recommended package of practices by the growers. Several constraints contributed to yield fluctuation on Ragi production, including: unreliable rainfall; lack of high yielding variety ,disease tolerant varieties; pests and diseases incidence; low producer prices; poor agronomic practices; and lack of institutional support (*Bucheyeki et al., 2008; Okoko et al., 1998*). One of the central problems of ragi production and processing in this district is due to an uncertain production environment owing to rain fed cultivation, the low resource base of smallholder farmers and processors, and no scope for post-harvest management and value addition facilities and poor marketing facility.

The results clearly indicated from the Table 3 that the positive effects of FLDs over the existing practices. HYV Ragi Arjun recorded higher yield 18.8(q ha^{-1}) followed by Bhairabi 15.53 (q ha^{-1}) which was 21 % more and the yield performance of these two HYV varieties was higher than the farmer's variety. This is due to higher of panicle length, more number of tillers and more number of fingers per panicle in HYV of ragi as compared to local variety. The results are in conformity with the findings of (*Tomar et al*., 2003). The results clearly indicated the positive effects of FLDs over the existing practices towards enhancing the productivity.

It is revealed form table 4 that, as the calculated 'F' value at α=0.05 level was found to be larger than table value, indicating significant difference in yield between farmer's variety and recommended varieties. There was significant difference between

average yield of ragi under Farmers practice (FP) and Recommended practice (RP) in variety Arjun under this demonstration. It was concluded that the yield of these HYV ragi varieties was significantly higher as compared to farmer's variety.

The economics and B:C ratio of farmers practice and Demonstration practice has been presented in Table 6. From the table it was revealed that Benefit: Cost ratio (B:C) was recorded to be higher under demonstrations against control treatments during all the years of experimentation. The cost of cultivation in HYV variety was higher due to more labor cost involved in transplanting and also it included cost of fertilizers and plant protection chemicals and also net returns was higher as compared to farmer's practice. The B: C ratio was found to be 2.4 in case of variety Arjun as compared to 1.9 in case of variety Bhairabi.

Table 1: Comparison between farmer's practices and Technology demonstrated

Sl no	Particulars	Farmer's practice	Demonstrated Technology
1	Variety	Dsaraberi / Nali madia	Arjun and Bhairabi
2	Seed rate	15kg ha -1	10 kg ha -1
3	Seed treatment	No seed treatment	*Azospirillium* @ 25g/kg seed
4	Method of sowing	Broadcasting	Line sowing with spacing 20 x 10 cm
5	Fertilizer application	No use of nitrogenous fertilizer ,	Fertilizer dose NPK - 50:40:25 N: P2O5: K2O Kg. ha -1. (three equal split of N, ie 25% as basal, 50% at 20 days after sowing and 25% at 35-40 DAS
6	Plant population	No thinning , more plant population	Thinning is done within 2-3 weeks after transplanting for optimum plant population
7	Weed management	Late weeding after 40-50 DAS and Manual weeding	Manual weeding at 25-30 DAS with post emergence spray of @ Bispyrabac sodium 10% SC @ 25 g/ha

Table 2: Area, production and productivity of finger millet in Malkangiri district in comparison with state Odisha

Crop	**Odisha**			**Malkangiri**		
	Area ('000 ha)	Production ('000MTs)	Productivity (q ha^{-1})	Area (000'ha)	Production ('000MTs)	Productivity (q ha^{-1})
Finger millet	143.74	143.74	8.67	7.65	4.88	6.38

(Odisha Agriculture Statistics, (2013-14), Govt. of Odisha)

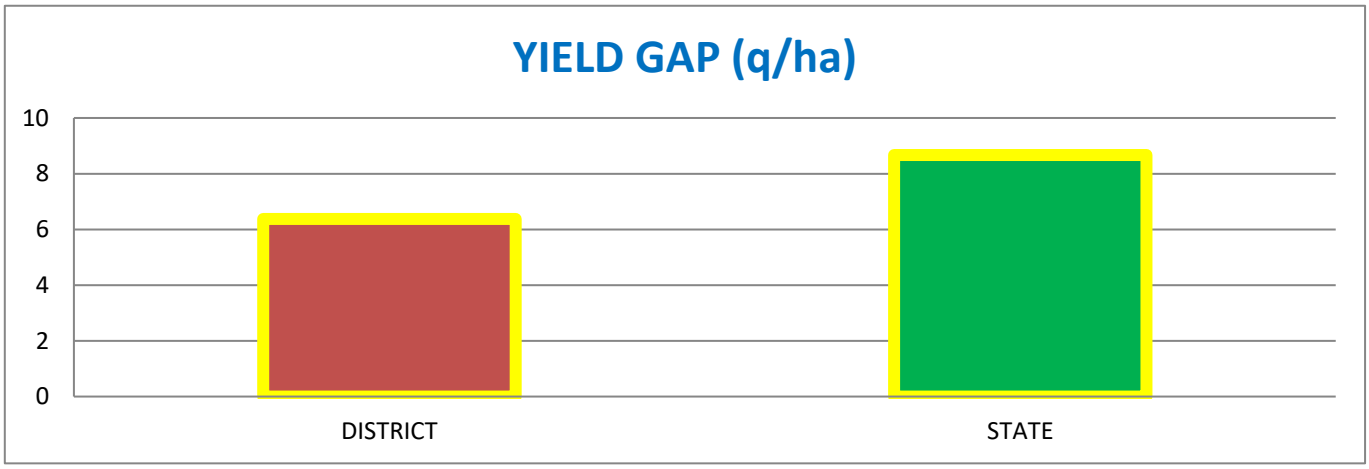

Figure II: Comparison of finger millet productivity between district and state

Table 3: Mean growth and yield attributes of finger millet varieties under rainfed condition

Variety	Yield component					
	Plant height (cm)	No. of effective tillers/hill (no)	Finger length (cm)	Nos of fingers /Ear	1000 grain wt (g)	Grain Yield (q ha^{-1})
Nali mandia (Farmer's variety/ Check)	82.9	1.4	5.88	5.0	2.945	8.62
Bhairabi	84.7	2.0	7.24	6.0	3.02	15.33
Arjun	85.8	2.4	8.08	10.8	3.192	18.80
Standard Error *(SE±)*	0.845	0.290	0.64	1.790	0.073	2.987
Standard Deviation (SD)	1.464	0.503	1.11	3.10	0.126	0.694

Table 4: Comparison of Yield performance of ragi varieties under farmers practice and demonstration

Variety	**Mean Yield (q ha-1)**	**Standard Deviation**	**Standard Error**	***Variance***	**"F" Value**	***F crit***	**"P" value**
Local / Check	8.62	0.694	0.262	0.482	83.666	3.554	0.000000000769
Bharabi	15.33		0.897	0.896			
Arjun	18.80		5.233	5.233			

Table 5: Technology gap, extension gap and technology index of finger millet var. Arjun under frontline demonstration

Treatment	**Average yield (q ha^{-1})**	**Technology gap (q ha^{-1})**	**Extension gap (q ha^{-1})**	**Technology Index (%)**
Farmer's practice (FP)	8.62	1.99	10.18	9.6
Recommended practice (RP)-Arjun	18.8			

The technological and extension gap was 1.99 (q ha^{-1}) and 10.18 (q ha^{-1}) respectively. Similarly, technological index was 9.6 percent. By conducting front line demonstration of intervention practices of proven technologies in farmer's field, yield potential of finger millet enhanced largely. The technology index showed the feasibility of the improved technology at the farmer's field. The lower value of the technology index, the more is the feasibility of the technology; Such fluctuation in technology index during the study period may be attributed to low yield potential of by the farmers' local variety use, dissimilarity in soil fertility status, weather condition, non-availability of irrigation water at critical stages and insect-pest attack, The technology gap observed may be attributing to the dissimilarity in soil fertility status and weather conditions. Similar finding were recorded by *Mitra and Samajdar (*2010).

Table 6: Economics and benefit cost ratio comparison between Farmers practice and recommended practice

Treatment	**Cost of cultivation (Rs ha^{-1})**	**Gross Return (Rs ha^{-1})**	**Net Return (Rs ha^{-1})**	**B:C ratio**
Farmer's Variety	18200	24926	6926	1.4
Var – Bhairabi	23400	44289	21289	1.9
Var- Arjun	23800	54332	31332	2.4

(Market price of ragi was Rs 2890/ per q)

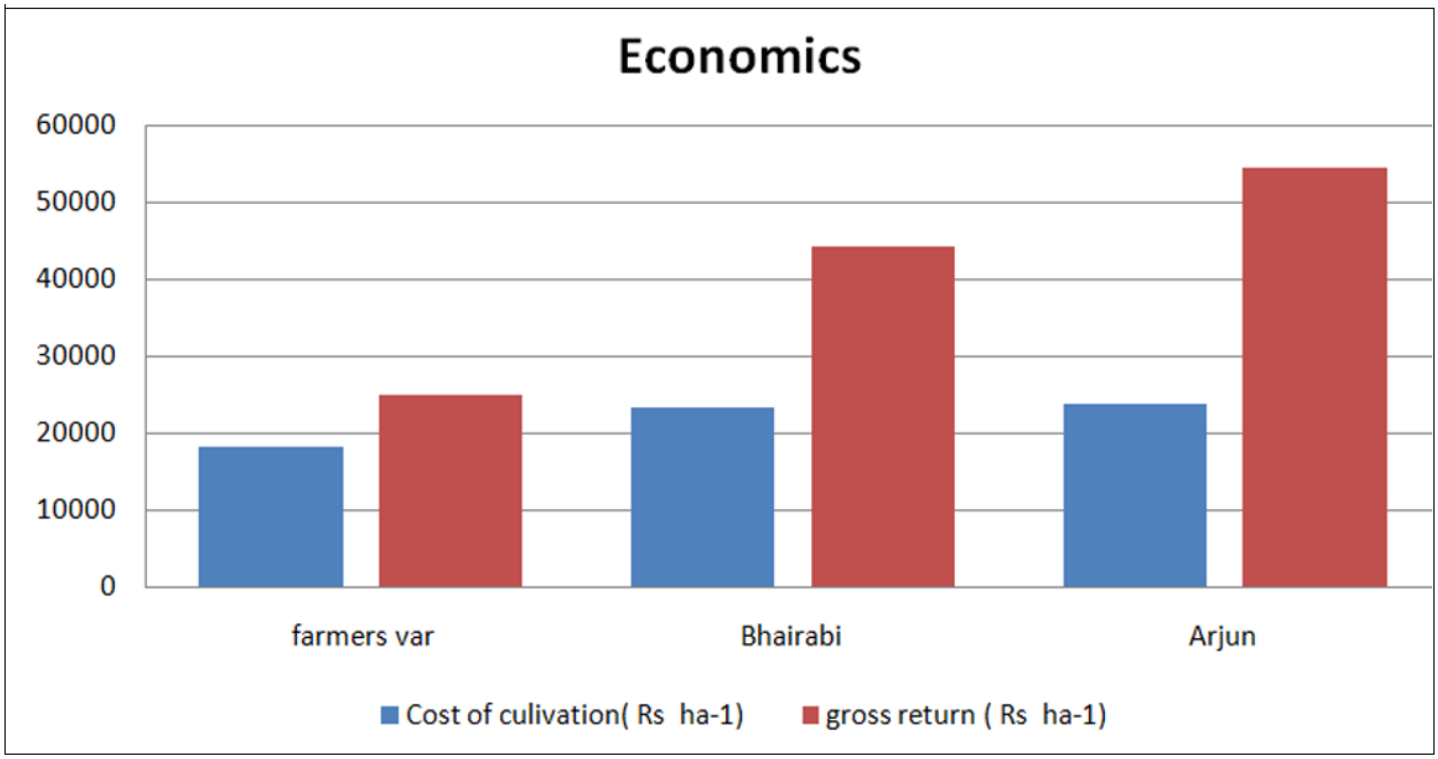

Figure III: Comparison between costs of cultivation with gross return (Rs ha^{-1})

The results on economic analysis indicated that HYV ragi Arjun and Bhairabi performed better than local variety Ragi. The HYV variety Arjun recorded higher gross return upto Rs 54,332 and followed by Bhairabi Rs 44,289 per ha which was significantly higher than farmers practice and it was due to higher productivity of varieties under demonstration.

Conclusion

The results revealed that in Malkangiri district finger millet variety Arjun rerecorded highest yield followed by Variety Bhirabi with proper package and practices under rainfed upland condition. From the above study it was concluded that use of finger millet varieties like Arjun or Bhairabi with scientific methods and technological practices of can reduce the technological gap and enhance the productivity in the district. Yield improvement in Finger Millet in the demonstration was due to use of HYV seed and scientific management practices adopted by the farmers. Yield of Finger Millet can be increased to a great extent by conducting effective front line demonstrations in larger area with proven technologies. Finger millet is one of future smart food crop of India and can be grown in the drought condition. This crop is rich in nutrient for food insecurity and within few years because of increase in population of world and depletion of area of production.. The principal reasons of lower productivity of finger millet in the district Malkangiri were lack of knowledge among the farmers about cultivation of HYV finger millet varieties and improper fertilization, late season sowing and severe weed infestation in crop at critical stages. From the above findings, it can be concluded that use of scientific methods of Finger millet cultivation can reduce the technology gap to a considerable extent thus leading to increased productivity of millets in the district. Moreover, extension agencies in the district need to provide proper technical support to the farmers through different educational and extension methods to reduce the extension gap for better production.

Acknowledgments

The OUAT Bhubaneswar and ICAR-ATRI Kolkata, is acknowledged for financial support to the research program.

Conflicts of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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