Economic and Yield gap analysis of high-yielding Ragi varieties under rainfed situations of Tiruvallur district of Tamil Nadu

Comment [MOU1]: The title is good (18 words)

ABSTRACT

Ragi is an important millet crop cultivated in about 82919 ha in Tamil Nadu, accounting for 77% of the total millet cultivated area. It is rich in protein, dietary fiber, minerals like calcium and iron and has been recommended for diabetes and heart diseases. Ragi is being cultivated in an area of 350ha in the Tiruvallur district of Tamil Nadu and has the potential to be expanded in terms of cultivable area under this central rice-growing district owing to the changing climatic situations. Farmers of the district could realize only low yields and gross returns due to the cultivation of local varieties and non-adoption of improved packages of practices. Hence, the present study was undertaken by Krishi Vigyan Kendra, Tiruvallur, situated in Tirur village, to assess the performance of high-yielding ragi varieties to perform the yield gap and economic Analysis under improved management practices and to motivate the farmers in cultivating high-yielding ragi varieties. The improved varieties ML 365 and C.O. (Ra) 15 performed better than the local cultivar Balamani and gave higher yields, net returns, and B.C. ratio. However, the technology gap noticed during the demonstration could be abridged by improving the soil nutrient status and following an improved package of practices. ML 365 recorded higher Yields and returns and has a high effective gain in comparison to C.O. (Ra) 15 and hence could be recommended for cultivation in the Tiruvallur district.

Comment [MOU2]: Abstract is good (233 words)

Keywords: Economic Analysis, Yield gap, Net returns, Technology index, Effective gain, Ragi.

Comment [MOU3]: Keywords are good (6 words)

INTRODUCTION

Ragi is an important millet crop cultivated in around 82919 ha in Tamil Nadu, with an annual production of 2,88,627 tonnes. It ranks second in India in production after Karnataka (Ministry of Consumer Affairs, Food & Public Distribution, 2023). Globally, 12% of the total millet area is under finger millet cultivation, covering more than 25 African and Asian countries. Finger millet (*Eluesine coracana* L.) is a minor millet crop belonging to the family Gramineae. It is native to Ethiopia and widely cultivated in tropical and subtropical regions of Africa and Asia. Ragi would have probably been first brought to India's south or southwest coasts, which became a secondary center of diversity and distribution (Hilu*et al.*1979). Ragi adapts to a broader range of environments like tropical, semi-arid, and sub-tropical regions and withstands substantial salinity, drought, and water-logged conditions. It can grow under edaphic conditions ranging from rich loamy soil to poor upland shallow soils, topography of sea level to 2300 m, and can tolerate salinity levels of 11-12 ds/m with a rainfall requirement of 50-60cm (Kumar *et al.*, 2018; Satish *et al.*, 2016). It is also a cropthat is easy to manage under irrigated and rain-fed conditions,is pest- and disease-tolerant and gives comparatively higher grain and straw Yield than other minor millet crops. The post-harvest management of Ragi is also simple and easy compared to other minor millets.

Ragi is a rich source of Calcium, Iron, fiber, proteins, and amino acids. Ragi contains 5-8% protein, 15-20% dietary fibers, 2.5-3.5% minerals, 0.38% calcium (344mg/g), 65-75% carbohydrates, 0.48% phytates, 0.61 % tannins, 0.3-3% phenolic compounds and trypsin inhibitors (Sripriya*et al.*1996; Chettan and Malleshi, 2007; Shobana*et al.* 2013) and hence it is considered as antidiabetic, anti-inflammatory, anti-diarrheal, antioxidants and anti-tumorigenic (Chandra *et al.* 2016). Fingermilletisalsovaluable forthe managementofvariousphysiologicaldisorderssuchasdiabetesmellitus,hypertension,vascular fragility,hypercholesterolemia,preventionofoxidationoflow-densitylipoproteins(LDLs),andalsoimprovesgastrointestinal health (Scalbert*et al.* 2005). Moreover, it is also arich sourceof thiamine, riboflavin,iron, methionine, isoleucine, leucine,phenylalanine,and other essential amino acids (Chandra *et al.,* 2016; Kumar *et al.*, 2016).

Ragi can be included in the dietary pattern as other major cereals since more value-added products, such as flour, semolina, noodles, health mix, puttu mix, dosa, and adai mixes, are available. Moreover, extruded products, sweets, and savories go well with Ragi flour and are comparable to rice flour. Owing to the health, nutritional, and therapeutic benefits of more comprehensive adaptation to different edaphic and climatic conditions, Ragi is being promoted as a supplementary crop to Rice in areas of water shortages as well as an alternate crop in crop rotation in Tamil Nadu and Karnataka. Karnataka ranks first in area and production among the states of India, stands well ahead of Tamil Nadu and other Ragi-producing states, and contributes to 63.23 % of India's total annual Ragi production (Sankaran, 2017).

Ragi's low production and productivity in Tamil Nadu could be attributed to local varieties with low yield potential, pest and disease resistance, grain quality, and non-adoption of improved management practices. Tamil Nadu Agricultural University has used research activities to develop high-yielding varieties in Ragi. It has developedsuitable varieties *viz.*, C.O. (Ra) 14, C.O. (Ra) 15, and ATL 1 with high yield potential. In Tiruvallur District, though ragi is cultivated in an area of 350 ha, it can be promoted on a larger scale as an alternative to Paddy during the Sornavari season (April- May) in blocks of Kadambattur, Poondi, Ellapuram, Tiruttani, R.K.Pet and Tiruvalangadu. Hence, to improve the yield potential of Ragi and boost the Ragi production and area, the present study was undertaken in Tiruvallur District of Tamil Nadu to assess the performance ofhigh-yielding ragi varieties.

Comment [MOU4]: Introduction is good

MATERIALS AND METHODS

The study consisted of two improved high-yielding varieties, C.O. (Ra) 15 and ML 365, compared with the local cultivarBalamani of Tiruvallur district. The characteristics of the varieties are given in Table 1. The three varieties were tested in 10 farmers' fields in 2020 and 2021 to assess yield potential, disease tolerance, and economic benefits. The varieties were raised during the Sornavari (April-May) season of the Tiruvallur district under rainfed situations in Kadambattur, Ellapuram, Tiruttani, Tiruvalangadu, and R.K. Pet Blocks in an area of one acre each. As the Tamil Nadu Agricultural University recommended, the improved package of practices was provided to the farmers as pamphlets and given on- and off-campus training to imbibe the knowledge and skill of improved practices. The yield attributes *viz.*, days to maturity, plant height, no. of productive tillers/plant, no. of fingers/gearhead, gearhead length, grain yield/ ha were recorded, and the Net returns and benefit-cost ratio were worked out based on the Cost of cultivation and gross returns. A yield gap analysis was conducted based on the Yield under the demonstration, farmers' practice, and potential Yield, and the technology gap, extension gap, and technology index were calculated. Economic Analysis was conducted based on theCost of cultivation net returns and arrived at the benefit-cost ratio, cost saving, and effective gain.

Comment [MOU5]: Material and methods are good, but it is recommended to add 1-2 references

Yield Gap analysis

Extension Gap = Demonstration Yield- Yield in Farmer's practice
Technology Gap = Potential Yield – Demonstration Yield
Technology Index = {(Potential Yield-Demonstration Yield)/ Potential Yield} x 100

Economic Analysis

Net Returns = Gross Income – Gross cost
Benefit-cost ratio = Gross Income / Gross cost
Cost saving = Cost of cultivation in Farmer's practice – Cost of cultivation in demonstration
Effective gain = Additional Net Income + Saving in Cost

RESULTS AND DISCUSSION

The Analysis of variance for the genotypes and the traits under study are presented in Table 2 and showed significant differences among the genotypes for all the characters.

The mean performance of genotypes for the yield parameters is given in Table 3. Among the Ragi varieties, C.O. (Ra) 15 was medium in duration with an average days to maturity of 124.6 compared to ML 365 with a maturity duration of 109.9 days and the local cultivar Balamani with 104.7 days. The local cultivar

Balamani was taller (124.9 cm) than the other two high-yielding varieties, *viz.*, ML 365 (94.25cm) and C.O.(Ra) 14 (106.7 cm). No. Of productive tillers /plant was highest in ML 365 (8.9) followed by C.O. (Ra) 15 (6.7) among the three varieties,while Earhead length and No. Of fingers/ear head were higher in C.O. (Ra) 15 (9.0 cm and 8.5 no. respectively) compared to ML 365 (6.6cm and 6.5 no. respectively) and Balamani (5.2 cm and 5.5 no. respectively). Percent Blast incidence was lowest in C.O. (Ra) 15 (3.4%) and highest in Balamani (12.1%). ML 365 recorded the maximum grain yield of 4610 kg/ha, followed by C.O. (Ra) 15 with 4250 kg/ha and Balamani with 3335 kg/ha. The higher grain yield in ML 365 may be attributed to its higher no. of productive tillers/plants.Khatiyar e*t al*. 2017 also reported improved productivity of demonstrated bottle gourd, cauliflower, and chili varieties over the local check varieties under advanced technologies.

The Net returns and Benefit-cost ratio obtained by cultivating ML 365 was the maximum with Rs.46500 and 2.02, respectively, followed by C.O. (Ra) 15 (Rs. 39250 and 1.86). The Cost of cultivation was the highest for the local cultivar Balamani compared to C.O. (Ra) 15 and ML 365 (Table 4). The yield advantage of 38.2 percent was obtained for ML 365 and 27.4 per for C.O. (Ra) 15 over the farmers' local cultivar Balamani. The Yield obtained in the on-farm testing was compared with the potential Yield and Farmer's practice to perform the yield gap analysis. ML 365 recorded a technology gap of 390 kg/ha.

In comparison, C.O. (Ra) 15 had a technology gap of 750 kg/ha, which shows a potential to increase the Yield of these varieties by following the recommended package of practices. Dhandhalya*et al*., 2009 opined that several attributing soil and weather conditions, *viz*., dissimilarity in soil fertility status, rainfall, and temperature, have an impact on the performance of varieties, which is reflected in the gap in technology and enriching soil nutrients, especially with organic manure may have a positive effect in the performance of varieties under varied weather conditions. Depending on the identification and use of the farming situation, specific interventions may have more significant implications in enhancing system productivity (Mukherjee, 2003). The extension gap depicts the difference between the Yield of varieties under demonstration compared with the farmers' variety by adopting the same package of practices and hence shows the yield improvement obtained by the farmers by adopting the high-yielding varieties through extension activities. ML 365 registered an Extension gap of 1275 kg/ha compared to C.O. (Ra) 15 (750 kg/ha). Hiremath and Nagaraju, 2009 performed a yield gap analysis in onions and indicated a higher extension gap of onion varieties under demonstration over the local check variety.

The technology index depicts the difference between the potential and the actual Yield obtained by the varieties under demonstration on a percent scale. ML 365 showed a lesser value of 7.8% compared to C.O. (Ra) 15 (15%). Pawar*et al*., 2018 opined that the lower the technology index, the more the feasibility of the technology. The effective gain obtained by cultivating ML 365 is Rs. 27100 /ha, and C.O. (Ra) 15 is Rs. 19750/ha. Hence, ML 365 is more remunerative to the farmers when compared to C.O. (Ra) 15 and the farmers' practice (Table 5).The results conform to the findings of Saravanakumar, 2018.

Comment [MOU6]: The results are good, but for discussion it is recommended to add 1-2 references from the last 10 years

CONCLUSION

Among the two high-yielding varieties of Ragi assessed under farm trial in farmers' fields of Tiruvallur District under rainfed situations, the variety ML 365 gave higher grain yield and Net returns compared to C.O. (Ra) 15 and was found to be more remunerative. The saving in Cost and effective gain was also higher in ML 365 than in C.O. (Ra) 15. The Technology Gap and Technology index were lesser in ML 365, showing its potentiality in expression under Farmer's fields. The higher Yield in ML 365 may be attributed to its higher no. of productive tillers /plants. Given suitable management practices by giving additional manures and better weed control, C.O. (Ra) 15 could also produce better yields in Farmer's fields. This could be noticed from its higher Technology gap and technology index than ML 365.Hence, ML 365 could be recommended for cultivation in the Tiruvallur district owing to its higher yield potential, Benefit-Cost ratio, and Effective gain over the Farmer's practice and the other variety C.O. (Ra) 15.

Comment [MOU7]: Conclusion is good

Reference

Comment [MOU8]: References are good, it is recommended to use APA or IEEE Mendeley applications

1. Chandra, D., Chandra, S., Pallavi and Sharma, A.K. 2016. Review of Finger millet (*Eleusine coracana* (L.) Gaertn): A powerhouse of health benefiting nutrients. *Food Science and Human Wellness*, **5(3)**: 156-162.
2. Chethan, S., &Malleshi, N. G. 2007. Finger millet polyphenols: Characterization and their nutraceutical potential. *American Journal of Food Technology*, **2(7):** 582–592.
3. Dhandhalya, M. G. and Shiyani, R. L. 2009. Production potentials, yield gaps, and research prioritization of production constraints in major oilseed crops of Saurashtra region. *Indian Journal of Agricultural Research*, **43 (1)**: 18-25.
4. Hilu, K. W. de Wet, J. M. J. and Harlan, J. R. 1979. Archaeobotanical Studies of *Eleusine coracana ssp. coracana* (Finger Millet). *American Journal of Botany*, **66 (3)**: 330-333.
5. Hiremath, S.M and Nagaraju, M.V. 2009. Evaluation of front-line demonstration trials on onion in Haveri district of Karnataka. *Karnataka Journal of Agricultural Sciences,***22(5)**:1092-1093.
6. Katiyar, H, Verma, S.K, Singh, K, Chandra, N andLodhi, S.K. 2017. Yield gap analysis in vegetable crops through on-farm testing. *Journal of Pharmacognosy and Phytochemistry*, **SP1**: 773-775.
7. Kumar, A., Metwal, M., Kaur, S., Gupta, A.K., Puranik, S., Singh, S., Singh, M., Gupta, S., Babu, B.K., Sood, S. and Yadav, R. 2016. Nutraceutical Value of Finger Millet [*Eleusine coracana* (L.) Gaertn.], and Their Improvement Using Omics Approaches. *Frontiers in Plant Science*, **7**: 934. **doi: 10.3389/fpls.2016.00934**
8. Kumar, A., Tomar, V., Amarjeet Kaur, Kumar, V. and Gupta, K. 2018. Millets: a solution to agrarian and nutritional challenges. *Agriculture& Food Security*. **7**:31(1-25). **https://doi.org/10.1186/s40066-018-0183-3.**
9. Ministry of Consumer Affairs, Food & Public Distribution, 2023. Area under cultivation of millets in 2021-22 is 15.48 million hectares. In 2013-14, it was 12.29 million hectares. https://pib.gov.in/PressReleasePage.aspx?PRID=1907194.
10. Mukharjee N. 2003. Participatory learning and action. Concept publishing company, New Delhi, India., 63-65.
11. Pawar, Y.D., Sachin H. M, Chaudhary, F.K. Umesh Dobariya and Pate, G. J. Yield gap analysis of groundnut through cluster front line demonstration under north Gujarat condition. *Multilogic in Science*, **7(25)**: 176-179.
12. Sankaran, 2017. Status of ragi crop: changing trends and growth of its area, production, and productivity in India. *EPRA International Journal of Economic and Business Review*, **5 (7)**: 156-164.
13. Saravanakumar, S. 2018. Evaluation of High Yielding Ragi Varieties for Western Zone of Tamil Nadu. *Indian Journal of Hill Farming*, 31 (2): 271-273.
14. Satish, L, Rathinapriya, P, Rency, S.A, Ceasar, S.A., Prathibha, M., Pandian S, Kumar R, Ramesh M. 2016. Effect of salinity stress on finger millet (*Eleusine coracana* (L.) Gaertn): histochemical and morphological Analysis of coleoptile and coleorhizae. *Flora*. **222**:111–20.
15. Scalbert, A., Manach, C., Morand, C., Remesy, C., & Jimenez, L. 2005. Dietary polyphenols and the prevention of diseases. *Critical Reviews in Food Science and Nutrition*, **45**: 287–306
16. Shobana, S. Krishnaswamy, K., Sudha, V. Malleshi, N.G. Anjana R.M., Palaniappan, L. and Mohan, V. Finger Millet (Ragi, *Eleusine coracana* L.). 2013. A Review of Its Nutritional Properties, Processing, and Plausible Health Benefits. *Advances in Food and Nutrition Research*, **69**: 1-39. **doi.org/10.1016/B978-0-12-410540-9.00001-6**.
17. Sripriya, G., Chandrasekharan, K., Murthy, V. S., & Chandra, T. S. 1996. ESR spectroscopic studies on free radical quenching action of finger millet (*Eleusine coracana*). *Food Chemistry*, **57(4)**: 537–540

Table 1. Characteristics of Ragi varieties used in the study

Varieties	Duration	Special features
C.O. (Ra) 15	120-125 days	• Long duration, bold grain, non-shattering, non-lodging, blast resistant with preferable grain quality with nutritious fodder characteristics • Grain yield of 2950 kg/ha under rainfed condition • Released by Tamil Nadu Agricultural University in 2013
ML 365	110-115 days	• Medium height, semi-compact ears with tip incurved fingers, Resistant to neck blast and tolerant to drought • Profuse tillering, high yielding, Average grain yield: 50 – 55 q/ha • Developed and released by the University of Agricultural Sciences, Bangalore, in 2008
Local cultivar (Balamani)	110-115 days	• Short duration, top incurved, medium compact panicle, tolerant to drought • Yield 2200 kg/ha

Table 2. Analysis of variance for Ragi varieties

Particulars	df	Mean Sum of Squares						
		DM	PH	PTP	EL	NFE	PBI	GY
Genotypes	2	1065.2*	2385.9*	43.72*	37.63*	23.33*	195.3*	4.31*
Replications	9	13.17	36.39	0.89	0.33	0.31	2.98	0.16
Error	18	10.16	50.6	0.61	0.43	0.37	1.86	0.13

Where D.M.- Days to maturity, PH-Plant height, PTP-Productive tillers/plant, EL-Earhead length, NFP-No. of fingers/Earhead, PBI- percent Blast Incidence, G.Y.- Grain yield

Table 3. Mean performance of genotypes for different yield parameters

Genotypes	Characters						
	D.M. (days)	P.H. (cm)	PTP (no.)	E.L. (cm)	NFE (no.)	PBI (%)	GY (t/ha)
CO (Ra) 15	124.600	106.700	6.720	9.030	8.500	3.400	4.250
ML 365	109.900	94.250	8.930	6.580	6.500	9.100	4.610
Local cultivar (Balamani)	104.700	124.960	4.750	5.200	5.500	12.100	3.335
SEd	1.43	3.18	0.35	0.29	0.27	0.61	0.16
CD	3.02	6.74	0.74	0.62	0.58	1.29	0.34
CV (0.05%)	2.82	6.55	11.52	9.41	8.91	16.61	8.88

Where D.M.- Days to maturity, PH-Plant height, PTP-Productive tillers/plant, EL-Earhead length, NFP-No. of fingers/Earhead, PBI- percent Blast Incidence, G.Y.- Grain yield

Table 4. Economic parameters of Ragi varieties

Genotypes	Cost of Cultivation (Rs.)	Gross Returns (Rs.)	Net Returns (Rs.)	Benefit-cost ratio
CO (Ra) 15	45750	85000	39250	1.86
ML 365	45700	92200	46500	2.02
Local cultivar	46500	66700	20200	1.43

(Balamani)				

Table 5. Economic and Yield Gap analysis for the Ragi varieties

Genotypes	Per cent Yield Increase over check (%)	Extension Gap (kg)	Technology Gap (kg)	Technology index (%)	Cost saving (Rs.)	Effective gain (Rs.)
C.O. (Ra) 15	27.4	915	750	15	750	19750
ML 365	38.2	1275	390	7.8	800	27100