



Assessment of Finger Millet Genotypes for Yield and Productivity under Rainfed Conditions in South Eastern Ghat Zone of Odisha

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Abstract

Finger millet (*Eleusine coracana* L.) commonly known as ragi is an important nutrient rich and climate resilient 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. A field experiment was conducted in kharif 2021 at Chitrakonda block of Malkangiri district which comes under South Eastern Ghat Zone of Odisha Odisha. A field experiment was done by Odisha Millet Mission and monitored by KVK, Malkangiri to evaluate the suitable finger millet genotypes for this agro climatic zone region, comprising 20 genotypes of national, state check and traditional varieties. This Multi location trial (MLT) was conducted at Center for Agro ecology of Chitrakonda block, Malkangiri district, Odisha in Govt. Horticulture Farm. The final seed yield was recorded at the time of harvest and the results from the experiment conclusively proved that finger millet genotype "PR-202" (National check) matured just in 119 days and produced the highest grain yield of (11.6 q ha⁻¹) followed by the genotype "Bharati-T" (local) matured just in 128 days produced second highest grain yield (11.2 q ha⁻¹) and "GPU-28" (National check) matured just in 119 days produced third highest grain yield (11.04 q ha⁻¹). Finger millet genotypes PR-202, Bharati-T, GPU-28 with proper nutrient management and plant protection measures gave higher yield over other genotypes. Hence the finger millet genotypes can be recommended as it was best suitable genotypes, since it fits good to the existing rainfed farming situation for higher productivity.

Keywords: Finger millet, Drought tolerance, Abiotic and biotic stress, Multi location trial.

Introduction

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). Among small millets, finger millet (*Eleusine 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, H.D. *et al.*, 2006) and it is highly suited to drought condition and marginal land and requires low external input in cultivation (Arshewar, S.P. *et al.*, 2018). 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. (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. 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) [20]. 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, B.V. *et al.*, 1987). Millets with their highly adaptive traits are a treasure trough of important genes and regulatory proteins that can be exploited to develop stress resistant crops. Amongst the small millets, finger millet is the most climate resilient crop, which can be grown under a wide spectrum of extreme climatic conditions. Thus, they can be termed as "farmer friendly" crops providing them better returns in comparison to other crops, which are subjected to changing climatic conditions. Moreover, from a breeder's point of view, these are the source of traits which can improve hardiness of other widely grown cereals. From biotechnological point of view its "hardy" nature is of great interest to the researchers worldwide, exploring it and exploiting it for developing resilience in other economically important crops (Kumar, A. *et al.*, 2015 b). Finger millet is no more called a coarse cereal rather referred as a nutri-cereal or as a nutraceutical crop and is seen as a potential solution for malnutrition and hidden hunger worldwide particularly in tribal area like Malkangiri. Apart from its excellent nutritional value, its ability to tolerate various abiotic stresses and resist pathogens make it an excellent crop for rainfed area and model for exploring vast genetic and genomic potential of this otherwise important crop and related cereal grasses (Gupta, S.M. *et al.*, 2017). Even in temperate regions, several strategies need to be devised for the adaptation of agricultural crops against erratic climate conditions such as changing temperature, erratic rainfall, and onset of severe floods and droughts (Meehl, G.A. *et al.*, 2007). It has been anticipated that climate change may severely

impact food production and food security in several drought-prone regions across the globe (FAO, 2005). It is also enriched with manganese, phosphorus and iron as well as useful amounts of copper and comparatively higher chromium, magnesium, molybdenum, zinc and selenium (Shashi. *et al.*, 2007) and (Tripathi and Platel, 2010). Calcium content of 36 genotypes of finger millet ranged from 162 to 487 mg %. (Singh and Srivastava, 2006) reported the iron content of 16 finger millet varieties ranged from 3.61 mg/100g to 5.42 mg%. Finger millet is the richest source of calcium and iron. Calcium deficiency leading to bone and teeth disorder, iron deficiency leading to anemia can be overcome by introducing finger millet in our daily diet. Also, finger millet straw is excellent as animal fodder with up to a total of 60% digestible nutrients (Singh and Raghuvanshi, 2012).

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.. Malkangiri is one of the seven districts where a flagship programme called "Special Programme for Promotion of Millets in Tribal Areas of Odisha (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 Chittrakonda, 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 (NCDS, 2019). 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.”

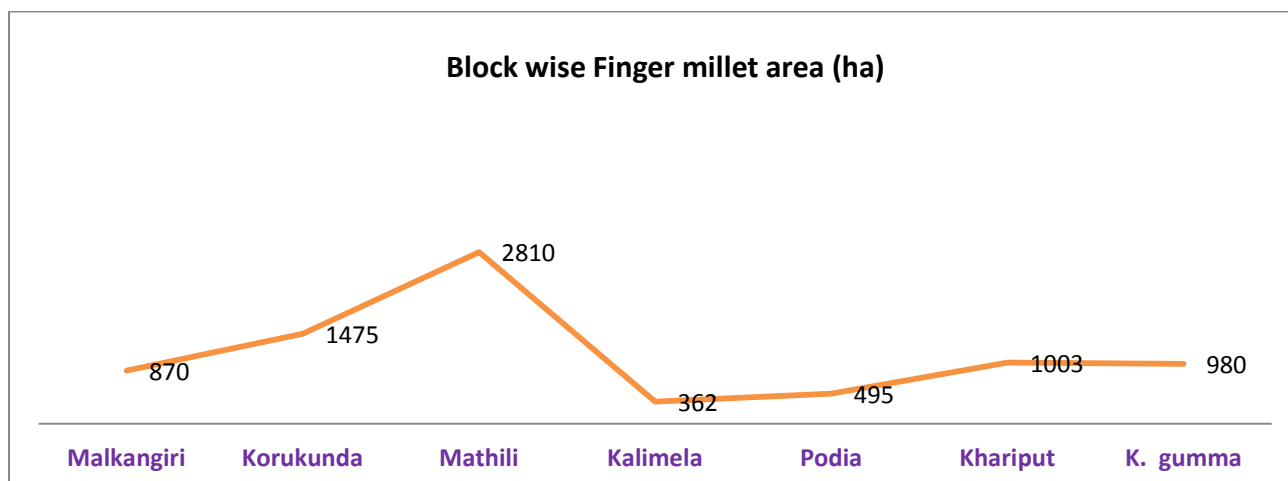


Fig I: Block wise finger millet area in Malkangiri district (Dist. Agriculture Strategy report, 2020, Govt of Odisha)

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 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. Finger millet will be an ideal crop for climate resilient agriculture due to its adaptation in semi-arid tropics which are characterized by unpredicted weather and erratic rainfall. Finger millet will be a good cereal for harsh climate due to global warming. Increasing the finger millet production will make this high nutritional food available for the poor people of developing nations and will help to attain nutritional security (Antony, C. et al., 2018).

Although it is difficult to find a single staple food crop that fulfills all the major criterions, the wide variety and diversity of local food crops provide us a choice of such climate resilient crops (Shukla. et al., 2015).

Abiotic Stress Tolerance in Finger Millet

Abiotic stresses are grave threats to the global food security as crop productivity and geographical distribution of the crops for agriculture are adversely affected causing significant economic losses. The degree of susceptibility to abiotic stresses varies from species to species (Dida and Devos, 2006). Adaptability to stress is a complex phenomenon that is regulated at several levels including physiological, cellular and molecular. Delineating the mechanisms of plant stress tolerance and adaptation has long been the area of interest to agricultural scientists. Finger millet is one of the highly valued crops for its ability to grow under limited resources and also for its high nutrient contents (Gull. et al., 2014). Despite these unique characteristics, it has been neglected for many years. Fortunately, this species has preserved its biodiversity. Global concerns over malnutrition, food insecurity and loss in agricultural productivity due to uncertain climatic changes have resulted in an increased demand for climate resilient crops. According to the World Summit on Food Security at least 70% more food production is required by 2050

to feed the ever increasing population. It would require annual increases of approximately 44 million tons, which is 38% above current annual increases in food production by (Tester and Langridge, 2010). Under this scenario, finger millet has gained focus of scientific research for their extraordinary potential to grow under high temperature, low moisture and poor soils. Though finger millet is considered to be generally abiotic stress tolerant, even then there is a need to identify newer sources of stress tolerance in this crop that can be used for crop improvement programs.

Objective

The research objective of the study was to identify high yielding genotypes of finger millet in this particular agro-ecosystem. Evaluated genotypes were compared with locally popular finger millet varieties to analysis the different trait specific characters as result to the experiment. Thus development of varieties with enhanced nutraceutical value and improved stress tolerance has been one of the priority areas of research these days. Modern crop improvement techniques such as genomics-assisted breeding and genetic engineering play important role in understanding the complexities of stress response and tolerance as well as in providing measures for enhanced crop productivity. However, one of the possible solutions to counter these tribulations can be identifying and improving native crops that are highly adaptive to local climate, have high nutritive value and can efficiently withstand biotic and/or abiotic stresses.

Materials and Methods

The field experiment was conducted at Chitrakonda block of Malkangiri district, Odisha during kharif- 2021 (1st.June - 15th December). The Precise location of the

experiment site was 18.077153'N latitude, 82.08416' E longitude & an altitude of 434.7 m above mean sea level. The block Chitrakonda were selected purposefully as Finger millet is the major cereals crop grown in large area in Kharif season. The soil of the experimental plot 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, 22.0, 142.00 (Kg ha⁻¹) respectively with 0.48 (%) Organic Carbon. The trial field was medium upland where the water was drained easily during rainfall because the finger millet needs the dry condition but slight moisture condition in soil. The Experiment was conducted in rainfed condition at normal nursery sowing to transplanting time adopted by farmer. The date of nursery sowing was second week July & transplanting date was first wk of August. Randomized Block Design (RBD), twenty Treatments with three replication (R1, R2, R3), spacing 10 x 22.5cm (P X R), single seedling/hill, with forming sub plot area (5 x 2.25) sq.m, in row length 5m/each sub plot, replication gap of 1m, varietal gap of 0.6m. The total twenty numbers genotypes used as mentioned below.

- Local Purified - 6no (Bati -P, Mami -P, Kalia -P, Bharati -P, Janha, Dasarakhae)
- Traditionally grown - 7no (Bati -T, Mami -T, Kalia -T, Bharati -T, Panakakahae, Kantameara, Kalakearenga)
- State check - 2 no (Arjuna, Kalua)
- National check - 5 no (GPU -28, GPU -67, MR-06, PR -202, VL -376)

The experiment was laid out in Randomized Randomized Block Design (RBD) with twenty treatments and replicated thrice. And different genotypes under treatments are mentioned below.

Table 1: Ragi Genotypes for evaluation under experiment

Treatments	Ragi Genotype	Treatments	Ragi Genotype
T ₁	Bati -P	T ₁₁	Panakahae
T ₂	Bati -T	T ₁₂	Klakearenga
T ₃	Mami -P	T ₁₃	Kantameara
T ₄	Mami -T	T ₁₄	Arjun
T ₅	Kalia -P	T ₁₅	Kalua
T ₆	kalia -T	T ₁₆	GPU -28
T ₇	Bharati -P	T ₁₇	GPU-67
T ₈	Bharati -T	T ₁₈	MR-06
T ₉	Janha	T ₁₉	PR-202
T ₁₀	Dsarakhae	T ₂₀	VL-376

The seed rate was used @ 200 gm. Per sub plot for to grow in nursery stage with proper care to get healthy seedlings and seedlings of 24 days old was transplanted. Well decomposed FYM 800 kg was applied as basal dose to start transplanting which again followed by "Jeevamurtha" (organic nutrient solution) @ 1:20 ratio soil drenching and foliar spraying in each fifteen days interval period after transplanting .the pest care management was followed by Neem seed extract oil of 1500 PPM @ 5ml/ 1 liter water spraying at minimum incidence stage .Evaluated genotypes were compared with locally popular finger millet varieties to analysis the different trait specific characters and seed yield . The yield attributing characters like Plant height (cm), Tillers hill⁻¹ , EBT hill⁻¹ , Panicle length, Fingers Panicle ⁻¹, Flag leaf length (cm), Finger length, Grain wt Panicle⁻¹ (g), 1000 grain wt.(gm), Dry grain wt. (kg), Dry Straw weight (kg), Seed Yield (q ha⁻¹) at harvest of the crop were studied. .Data on

phonological parameters and crop yield were recorded by per square meter observation method randomly from 3 to 4 places from experimental and check plot. The mean data of these characters were collected and finally the data were tabulated and analyzed to calculate percentage, mean, SD, CV (%) to draw the inferences. Pearson's product-moment correlation, Regression analysis were employed for analysis of data (Cochran, W.G. et al., 1977) by using SPSS .

Results and Discussions

The results obtained from the present investigation are summarized below. From the Table 1 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 (HYV) with improved management practices.

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

Crop	Odisha		Malkangiri	
	Area ('000 ha)	Productivity (q ha ⁻¹)	Area (000'ha)	Productivity (q ha ⁻¹)
Finger millet	143.74	8.67	7.65	6.38

(Odisha Agriculture Statistics (2018), Govt of Odisha)

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. 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. Crop growth and productivity has largely been vulnerable to various abiotic and biotic stresses that are only set to be compounded due to global climate change.

Therefore developing improved varieties and designing newer approaches for crop improvement against stress tolerance have become a priority now-a-days. However, most of the crop improvement strategies are directed toward staple cereals such as rice, wheat, maize etc., whereas attention on minor cereals such as finger millet lags far behind. It is an important staple in several semi-arid and tropical regions of the world with excellent nutraceutical properties as well as ensuring food security in these areas even during harsh environment reported by (Gupta . et al., 2017).

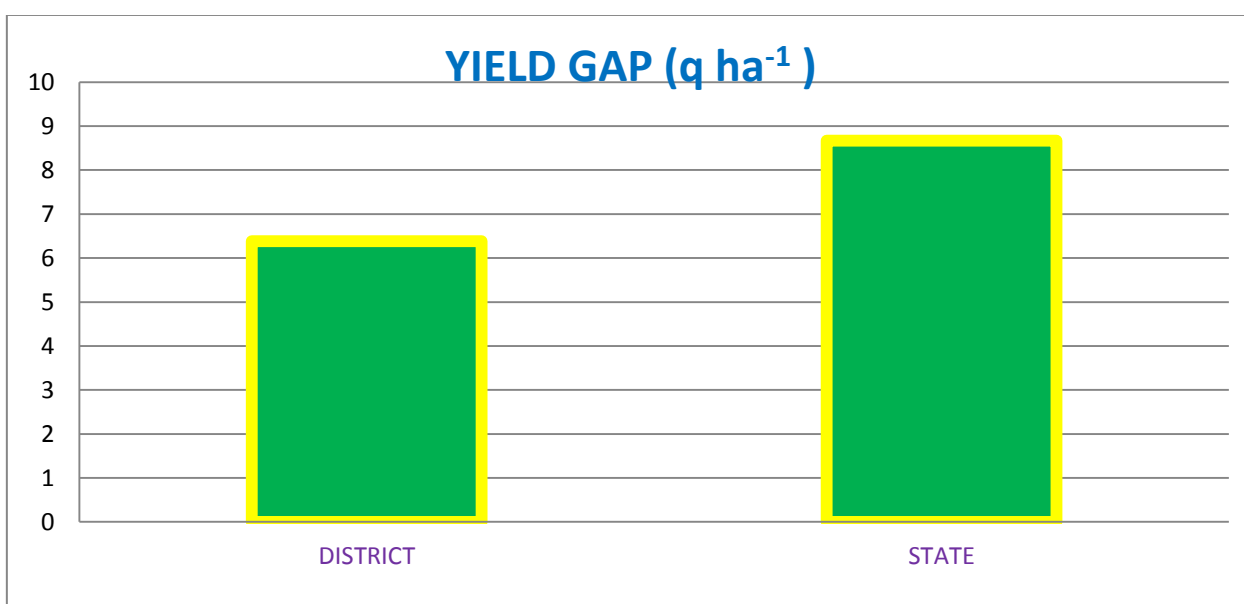


Fig II: Comparison of finger millet productivity between district and state

Several constraints contributed to yield fluctuation on Ragi production, including: climatic factor unreliable rainfall, lack of high yielding variety with disease and pest

tolerance and poor agronomic practices and lack of institutional support as reported by (Buchekeyki. et al., 2008).

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

Treatments	Plant height (cm)	Tilles/hill (no)	EB T/hill (no)	Panicle length (cm)	Finger length (cm)	No. of Fingers Panicle ⁻¹ (no)	Flag leaf length (cm)	Wt of Grains/Mother Panicle (g)	1000 grain wt.(g m)	Dry grain wt. / Sub plot (kg)	Dry Straw weight/ subplot (Kg)	Seed Yield (q ha ⁻¹)	HI (%)

T ₁	98	2	2	6	4	5	28	4.6	2.6	2.4 65	8.223	8.7 6	29. 98
T ₂	108	2	1	6	4	6	26	3.7	2.3	2.8 46	8.383	10. 08	33. 95
T ₃	104	2	1	7	6	5	30	4.2	1.5	2.6 85	6.141	9.5 2	43. 72
T ₄	111	2	1	7	6	5	32	3.6	1.9	2.3 28	5.816	8.2 4	40. 03
T ₅	113	2	1	6	4	5	29	4.6	2.5	2.9 55	8.3	10. 48	35. 60
T ₆	113	2	1	9	4	5	35	3	2.5	2.5 76	7.35	9.1 2	35. 05
T ₇	119	2	1	10	8	6	34	3.2	2	2.6 31	7.316	9.3 2	35. 96
T ₈	125	1	1	8	6	6	31	4.1	2.7	3.1 35	6.766	11. 12	46. 33
T ₉	106	2	2	6	5	6	30	3.2	3	2.8 7	4.98	10. 2	57. 63
T ₁₀	84	2	2	6	4	5	32	2.9	2.9	2.3 11	4.13	8.2	55. 96
T ₁₁	103	2	1	7	5	5	35	3	2.8	2.4 93	5.101	8.8 4	48. 87
T ₁₂	108	2	1	8	7	6	31	5.7	3.5	2.8 91	9.233	10. 24	31. 31
T ₁₃	107	2	1	6	5	5	30	3.4	3.5	1.4 31	5.123	5.0 8	27. 93
T ₁₄	82	2	1	7	5	6	22	3.2	2.8	1.5 88	4.966	5.6 4	31. 98
T ₁₅	107	2	1	7	5	5	35	2.4	3.1	2.2 08	5.43	7.8 4	40. 66
T ₁₆	115	2	1	9	7	6	35	4.1	3	3.1 06	5.873	11. 04	52. 89
T ₁₇	92	2	1	7	5	7	31	4.6	3.5	2.8 03	6.706	9.9 6	41. 80
T ₁₈	122	2	1	9	8	7	31	5.6	3.3	2.8 25	6.731	10. 04	41. 97
T ₁₉	101	2	1	7	5	6	34	3.4	3.3	3.2 73	5.583	11. 6	58. 62
T ₂₀	104	3	1	8	5	7	28	4.2	3	2.8 85	5.6	10. 24	51. 52
Mean	106. 1	2.00	1.1 5	7.30	5.40	5.70	30.9 5	3.84	2.79	2.6 2	6.39	9.2 8	42. 09
SD	11.1 5	0.32	0.3 7	1.22	1.27	0.73	3.36	0.88	0.55	0.4 7	1.38	1.6 8	9.5 9
CV(%)	10.5 1	16.22	31. 86	16.6 9	23.5 8	12.85	10.8 7	22.97	19.85	18. 08	21.68	18. 08	22. 78

The results clearly indicated from the above Table 2 that the positive effects of FLDs over the existing practices. In this experiment ragi

Genotype PR-202 (national check) recorded higher yield (11.6 q ha⁻¹) followed by Bharati - T (local 11.2q ha⁻¹) and (national check) GPU-

28(11.04 q ha⁻¹) and the yield performance of these three genotypes was higher than the other treatments. This is due to higher of panicle length, more number of tillers and more number of fingers per panicle of ragi genotypes in this experiment. The results are

in conformity with the findings of (Tomar, L.S. et al., 2003). The genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice (Dutta, R.K. et al., 2002).

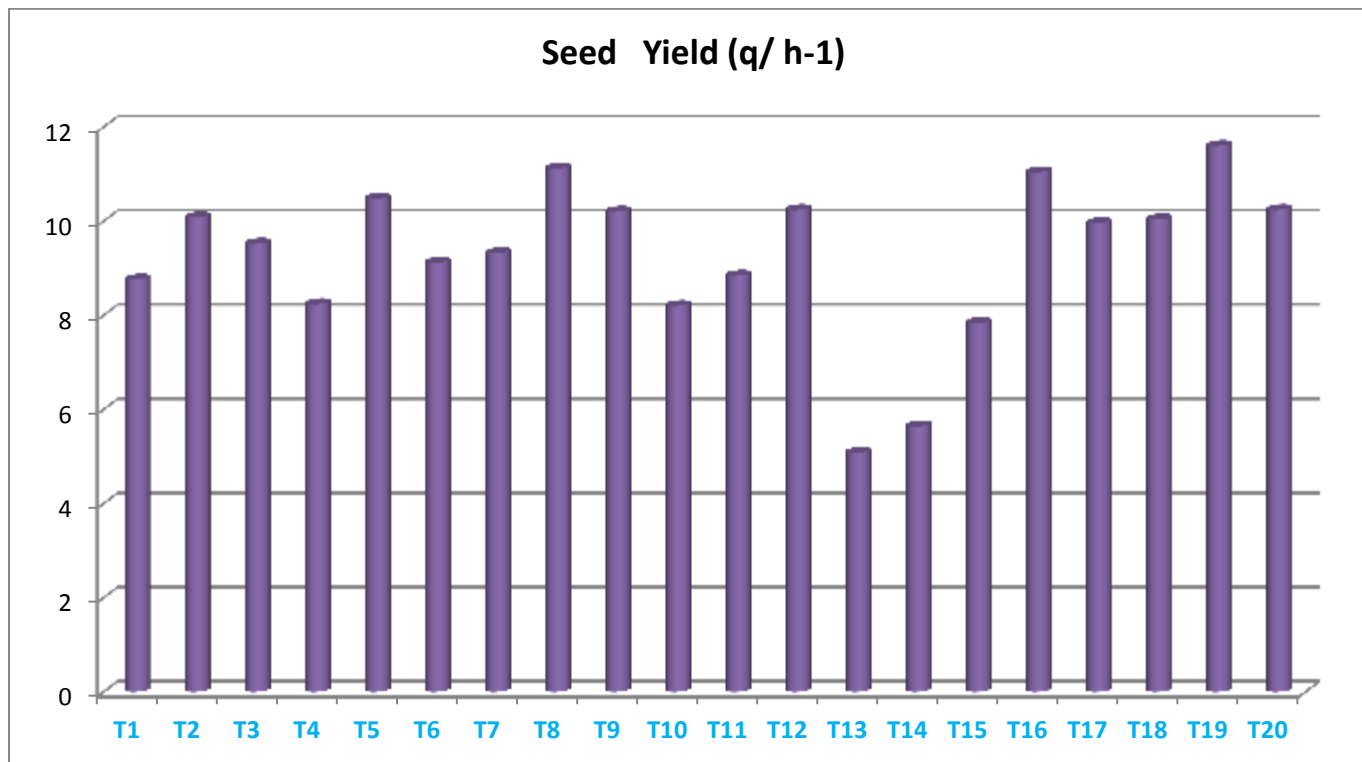


Fig III: Yield performance of different ragi genotypes under the experiment

Table 4: Correlation Matrix of yield attributing parameters in finger millet

Variables	Plant height	Tillers/hill	EBT/hill	Finger length	Fingers / panicle	Flag leaf length	Wt. of grains/mother panicle	1000 grain weight	Yield
Plant height	1.000	0.706*	0.390	0.535*	0.094	0.402	0.265	-0.175	0.441
Tillers/hill		1.000	0.000	-0.127	0.221	-0.145	0.018	0.088	0.085
EBT/hill			1.000	-0.361	0.216	-0.122	-0.131	0.038	0.058
Finger length				1.000	0.417*	0.275	0.395	-0.006	0.213
Fingers/panicle					1.000	-0.220	0.466*	0.417*	0.421
Flag leaf length						1.000	-0.241	0.073	0.298
Wt grains/mother panicle							1.000	0.198	0.420
1000 grain weight								1.000	0.015
Yield									1.000

*Correlation is significant at the 0.05 level (2-tailed)

Pearson's product-moment correlation coefficient was calculated by Using SPSS software to find out the relationship between eight independent variables and dependent variable like grain yield under the experiment. It was revealed from the above table that parameters like tillers hill⁻¹ finger length, No of fingers panicle⁻¹, No. of grains of Panicle⁻¹, 1000 grain wt (Test weight) were significantly correlated with the grain yield. The finding of present investigation corroborates with the findings of

(Prasad. et al., 2014). The most important yield attributing traits were tillers hill⁻¹, Finger length, fingers of panicle⁻¹, weight of grains mother panicle⁻¹ and Test weight which are directly proportional to yield and the findings were in consonance with the findings of (Chavan. et al., 2020), (Anuradha, N. et al., 2013) and (Manoj, K. et al., 2015). This suggests selecting for the characteristics with high positive correlation would improve the grain yield in finger millet.

Table 5: Regression analysis of yield attributing parameters in finger millet

Variables	Coefficients						
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
Plant height	0.027	0.033	0.181	0.831	0.424	-0.045	0.099
Tillers/hill	-0.813	0.855	-0.157	-0.951	0.362	-2.695	1.069
EBT/hill	0.693	0.766	0.151	0.904	0.385	-0.994	2.380
Finger length	-0.812	0.287	-0.617	-2.832	0.016	-1.443	-0.181
Fingers/panicle	1.962	0.509	0.857	3.855	0.003	0.841	3.082
Flag leaf length	0.369	0.104	0.739	3.558	0.004	0.141	0.597
Wt. of grains/mother panicle	0.981	0.370	0.515	2.650	0.023	0.166	1.795
1000 grain weight	-1.494	0.576	-0.492	-2.594	0.025	-2.762	-0.226

R square- 0.758, Adj R square- 0.581, Std. Error- 1.085

Further attempt was made to assess the influence of the parameter variables accelerating the yield of finger millet under experimental plot and the result was depicted in (Table 4.) As observed from the above table, the best fitted regression equation could explain 75.8 % of the total variance in increasing the yield and among the five variables finger length, fingers panicle⁻¹, Flag leaf length and wt. of grains mother panicle⁻¹ exhibited significant influence on enhancing the seed yield. The results of the study are in line with the similar findings reported by (Prasad, S.K. et al., 2014).

Conclusion

Based on the results of this trial, it can be concluded that the genotypes, namely PR-202 from (national check) category gene pool was the superior in grain production as well

as in other phenotypic characters & where as the second highest grain yield was recorded by the genotype Bharati-T (traditional) from traditionally local grown was superior in grain production as well as in other phenotypic characters followed by the genotype namely GPU-28 from (national check) category gene pool was the superior in third highest grain production as well as in other phenotypic characters. Hence, it could be worthwhile to lay more emphasis on these characteristics of these genotypes in selection programme to improve the grain yield in finger millet.

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