

Genetic enhancement of finger millet in Karnataka – An overview

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Abstract

In Karnataka finger millet is grown in an area of 7.50 lakh ha, which is 49% of total National area and also ranks no.1 in production of finger millet, area is largely confined to Zone-4,5,6 and 7. Where, ragi is a major food crop. The crop improvement work on finger millet has been carried out in 5 phases at Zonal Agricultural Research Station, VC Farm, Mandya (UAS, Bangalore). Under phase I (1931-1951), 11 varieties were released which had an yield potential ranging from 285-512 kg/ha, which were mostly developed from indigenous collections. In phase II (1951-1964), Dr. Leslie C. Colman, an eminent Canadian scientist and 1st Director of Agriculture and 1st Associate Director of Research of Zonal Agricultural Research Station, VC Farm, Mandya, made pure line selections which had an yield potential of 900-2700 kg/ha. Phase-III (1964-1986) witnessed a revolution in finger millet varietal development due to the introduction of Indo-African crosses of finger millet by late Dr. C.H. Lakshmanaiah, who has been regarded as ‘Ragi Brahma’, his pioneering work resulted in release of 16 varieties designated as ‘INDAF’ series. The yield levels of these varieties ranged from 3000-4500 kg/ha. During phase-IV (1986-2000) the yield potential has further improved ranging from 4500-5000 kgs/ha which are resistant to Blast disease. During phase -V (2000-2012) upon establishment of AICSMIP, emphasis was laid on developing productive lines with elite background through hybridization to improve high grain and straw yield suitable for Kharif as well as Rabi season. The yield levels shot up, subsequently, ranging from 5000-5500 kgs/ha. Further, the research efforts are underway, to develop medium and short duration varieties with high grain yield, resistant to blast disease and to address the challenges like Drought, saline and alkaline soils, cold season and hilly areas, mechanical harvesting and value addition of finger millet.

Key words: Finger millet, Indigenous varieties, Hybridization, Mutants

Introduction

Finger millet (*Eleusine coracana* L. Gaertn.) is a major food crop of the semiarid tropics of Asia and Africa and has been an indispensable component of dry farming system. It has wide range of seasonal adaptation and is grown in varying soil and temperature condition. It can be grown throughout the year if the moisture is adequate and the temperatures are above 15 degree celcius. It has adapted to conditions prevailing from sea level to an altitude of 3000 m although, finger millet is a warm season crop. Finger millet is commonly known as ‘Ragi’ is one of the important food crops and largely grown in Southern States of India. In Karnataka, finger millet occupy an area of 1.02 million hectare with a production of 1.875 million tonnes, accounting for 53.95 per cent area and 44.94 per cent production and its cultivation is concentrated mostly in the districts of Bangalore, Kolar, Tumkur, Chitradurga, Hassan, Mysore, Mandya and Chamarajanagara. Crop improvement work in ragi was initiated at Zonal Agricultural Research

Station, V.C.Farm, Mandya by Dr.Leslie C. Coleman during 1913. The yield levels were very low due to poor yielding varieties poor soil fertility ,rain fed farming ,lack of improved crop management practices, and lack of inputs .

Phase – I -1913-1951 (38 years)

The varietal improvement work was carried out at different centers in Karnataka viz., Hunusur, Hagari, Hebbal and Mandya. Dr. Leslie C. Coleman made pure line selections from indigenous varieties (Table-1) .The concerted efforts resulted in the development and release of the varieties viz., H-22, K-1, R0870, ES-11, CO-1, ES-13 and H-1. (Table-2.) He also worked on **floral biology, anthesis and pollination** in ragi and found that complete emergence of inflorescence required about 10 days and flowering attains 7-8 days. The flower open between 1 to 5 AM and progress from top to bottom in a finger, however, in a spikelet the order is reversed and proceeds from bottom to top and bigger to smaller flower. The stigma is receptive for a very short period after its emergence from the glumes. The period of anthesis being very short and is conducive for self pollination and rarely cross pollination occurs. Coleman also studied artificial germination on filter paper. He observed that large quantity of pollens are obtained when ragi flowers with several peduncles were immersed in water and kept overnight. Ample pollen was obtained the next-day in the morning between 7 & 9 AM. when the anthers are kept moist but they readily burst when allowed to dry. They found that early mornings with heavy humidity results in more pollen dehiscence in a day.

Table 1 Characteristic features of Indigenous Ragi Varieties

Sl.No	Variety	Description	Grain Yield (kg/ha)	Straw Yield (kg/ha)
1	Hullubele	Green glumes- open spikes	512	646
2	Karegidda	Violet glumes-incurved	398	642
3	Gidda	Violet glumes-incurved	417	661
4	Jasarlambi	Green glumes- open spikes	450	704
5	Madayyanagiri-1	Green glumes- open spikes	432	639
6	Madayyanagiri-2	Green glumes- open spikes	430	642
7	Dodda	Green glumes- open spikes	422	660
8	Goubile	Green glumes- incurved	423	304
9	Majjige	Light green glumes-open spikes	285	550
10	Majjige-ing	Light green glumes-open spikes	285	704
11	Jenumudda	Green glumes- open spikes	467	790
12	Rudrajade	Green glumes- branched spikes	269	480
13	Jadesanga	Violet glumes- branched spikes	490	628

Table 2 The special features of ragi varieties released during phase-I

Sl.No	Varieties	Pedigree	Year of release	Duration (days)	Yield Q/ha	Season	Area of suitability
1	H-22	--	1918	150-155	13-18	Kharif	Monsoon dry land with good rains
2	K-1	Selection from Kolar gidda ragi	1939	120-125	11-13	Early kharif	Suitable for Kar tracts under rainfed condition

3	R-0870	Selection from Ec-47 of Coimbatore	1939	130-135	11-13	Kharif	Kar tracts of mysore
4	ES-11	Selection from Kolar gidda ragi	1939	110-120	9-13 (K) 11-16(S)	Kharif and summer	Suitable for both rainfed and irrigation condition
5	ES-13	Selection from Kolar gidda ragi	1939	115-120	16-17	Kharif	Suitable for kharif tracts
6	H-1	Mutant from Gidda Aryam	1941	120-130	22-24	Kharif and summer	Suitable for Kharif tracts and irrigation
7	CO-1	Mutant from Gidda Aryam	-	120-125	24-27	Kharif	Suitable for both rainfed and irrigation condition

Dr. Coleman also made Classification of plant types in the cultivated species of *Eleusine Coracana* in to three groups.

Group- 1: The glumes tinged with violet, the grain are reddish brown, Spikes incurved or compact and these are referred as type-1. The second type has straight spikes or open and are referred as type- 2 and Spikes branching is type- 3.

Group -2: The glumes are green in color, grains reddish brown, spikes in curved or compact and these are referred as type- 4, Spikes straight or open is referred as type- 5, Spikes are branching is type -6.

Group- 3: Glumes pale green and grains white, Spikes straight or open is type-7, rare type (8) was observed having long spikes or about 50 per cent longer than normal. On the basis of these he conclude that: 1) Color of the glume has no effect on yielding ability 2) Straight spikes tend to yield more than those incurved spikes 3) Pure strains tend to yield substantially more than the normal 4) An inverse correlation exists between weight of ear head and tillering 5) Non-tillering large head types may be more suitable for irrigated situation.

Phase -II -1951-1964 (13 years) Indigenous crosses

Hybridization in ragi had its beginning in 1951 when contact method of crossing in ragi was established. Through this technique potential genetic variability was created and five high yielding varieties were evolved viz., Aruna, Poorna, Udaya, Annapurna and Cauvery (Table- 4) The yield potential was increased by 50 per cent combining different growth duration to cater to the needs of different ragi growing seasons and tracts. These varieties maintained their popularity for a good number of years by replacing the local varieties.

Table 3 Characteristic features of new ragi varieties released during phase – II

Sl.No	Varieties	pedigree	Year of release	Duration	Yield Q/ha	Season	Area of Suitability
1	Aruna	Selection from local Giddaragi	1956	95-100	25-28	Summer	Irrigation
2	Purna	Co-1xAruna	1959	105	40	All season	Irrigation and rainfed

3	Udaya	K-1 x Aruna	1959	90	30	Summer	Irrigated
4	Annapurna	K-1 x Aruna	1962	110	40	Kharif	Heavy rainfall area
5	Cauvery	Hulluble x H22	1962	120	40	Kharif	Estern region of the state

Phase -III -1964-1986 (22 years) INDAF Series

Dr. C.H. Lakshmanaiah started hybridization work to create new variability. He crossed Indian varieties with African ecotypes during 1964. Screening of world germplasm resulted in identification of few African donar parents such as IE- 927, IE-929, IE – 980R, IR-810 and IE – 902 in eight years . These lines were used in crosses with locals such as Hallubele, K1, Annapurna , purna, Cauvery, Shakti, Co-1 and Hamsa. Sixteen Indo-African varieties were evolved and these were designated as “ INDAF” varieties (Table- 5).The breeding work continued further with a view to evolve strains for cultivation throughout the year both for irrigated and rain fed situations.

Table 4 Characteristic features of ragi varieties released during phase-III

Sl. no	Varieties	pedigree	Year of release	Duration	Yield Q/ha	Season	Area of Suitability
1	Shakti	Ro 013 x H 22	1972	120-125	30- 45	Khariff	All over the state
2	5-6	Co-1 x H-22	1974	95-100	30	All season	Irrigation area
3	Indaf-1	Hullubele x IE 929	1976	120-125	36- 38	Khariff	Irrigated/ rainfed
4	Indaf-3	Cauvery x IE 927	1976	130-135	36- 40	Khariff	Irrigated/ rainfed
5	Indaf-5	Cauvery x IE 927	1977	105-110	30 -45	All season except rabi	Irrigated/ rainfed
6	Indaf-7	Annapurna x IE 927	1981	115-125	50- 60	rabi	irrigated
7	Indaf-8	Hullubele x IE 929	1982	120-125	40- 50	All season except rabi	Irrigated/ rainfed
8	Indaf-9	K-1 x IE - 980	1985	95-105	35- 45	All season except rabi	Irrigated/ rainfed
9	Indaf-6	K-1 x IE - 980	-	115-120	35- 40	Khariff	rainfed
10	Indaf-10	Hullubele x IE 929	-	120-125	40- 50	Khariff	Irrigated/ rainfed

He described different panicle size and shape and are broadly classified in to two groups: a) where digitated spikes curve in b) and those in which they open. The curved type are again classified into curved and top incurved. This spikes curve in while in top curved they are longer and only tips are curved. The fingers of the incurved are short and practically close up the central hallow giving the ear head on obovate shape, on drying. There is another type called fistful fingers

or first type were noticed in EC 593. In some ear heads a thums was noticed at the base of the ear head in EC 4713 and this was found to be due to branching of the rachis later came to be known as Cocks combing. He was started crossing cultivated types with wild types of ragi. The cultivated types are

1) *Eleusine coracana*, (African Island type) $2n = 36$, longer lemmas, glumes, and spikelets are non shattering and it has plump grain. The seeds are enclosed inside the glumes (2) *Eleusine coracana* (Afroasiatic) $2n = 36$, it has shorter glumes and lemmas and Spikelets are non shattering and plump seed, and are free from glumes. The wild type are (1) *Eleusine indica*, $2n=18$, it had a smaller plant, narrow rachis, thin stem, relatively short glumes and lemmas, Shattering spikelets, small seeds and are enclosed in glumes and thin racemes.

2) *Eleusine africana*, $2n = 36$. It had a longer plant but generally similar to *Eleusine indica*. It has wider rachis, thicker stem and longer spikelets, glumes and lemmas. The cultivated types are readily recognized by the head shape 1) top curved 2) incurved and 3) open, the incurved have short fingers of 4-7 cm length and curved and close up in central hollow giving the ear head an obvate shape. The top curved ear heads have intermediate finger length (5-10 cm) and tend to curve at the tips. Central hollow the open types have longest finger length (8-15 cm) and typical funnel shape appearance which tend to curve slightly. In all these groups the spikelet density is high towards the tip.

Phase- IV -1986 to 1990 (4 years) MR Series

During this period research was initiated to develop varieties with high grain and straw yield coupled with blast resistance. The newly developed varieties are MR-1, MR-2, Indaf – 15, L-5 and MR-6, Efforts are underway to develop varieties with high yield and high harvest index, higher levels of blast tolerance and varieties for production of value added foods.

SL.No	Variety	Pedigree	Year of release	Duration	Yield (Q/ha)		Season
					IR	RF	
1	MR-1	Hamsa xIE-927	1990	120-125	35-45	25-30	Kharif
2	Indaf-15	IE-67 xIE-927	1991	125-135	30-35	20-25	Kharif/rabi
3	MR-2	Indaf-5 xPR-202	1994	120-125	35-40	25-30	Kharif/late kharif
4	L-5	Malavi xIndaf-9	1999	120-125	45-50	30-35	Kharif/late kharif
5	MR-6	African white xRoH2	2004	120-125	45-50	30-35	Kharif/late kharif
6	KMR-301	MR-1xGE-1409	2009	120-125	50-55	35-40	Kharif/rabi
7	KMR-204	GPU-26 xGE-1409	2012	100-104	40-45	30-35	All seasons

Table 5 Characteristic features of new ragi varieties released during phase-I

Phase V (2000-2012) KMR & GPU Series

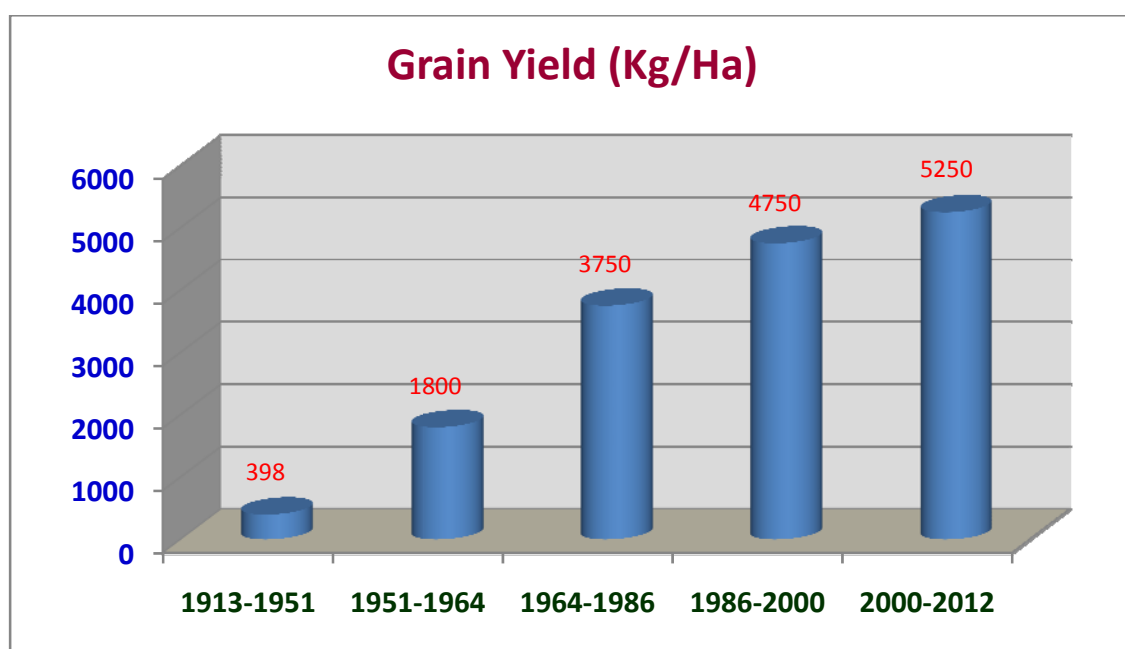
During phase-V, emphasis has been laid on developing varieties involving productive lines with elite background through hybridization. The varieties released during this phase were MR-1, Indaf-15, MR-2, L-5, MR-6, KMR-301 and KMR-204 (Table-6). Most of the varieties are of long duration type except KMR-204 (short duration) with high yield potential and resistant to blast disease (neck and finger blast) suitable for both irrigated as well as rain fed situation.

Way back in 1931, Crop improvement programme on ragi was initiated at, College of Agriculture, Hebbal campus, Bangalore. Two ragi varieties Viz., PR-202 and HR-911 were identified from the initial work. Subsequently upon establishment of AICRP on small millets during 1980s the location was shifted to GKVK campus, Bangalore. The main breeding objective was to develop varieties for high grain yield associated with blast tolerance which are suitable to both rain fed as well as irrigated ecosystem. The pioneering work on small millets resulted in identification of *GPU series* namely., GPU-26, GPU-28, GPU-45, GPU-48, GPU-66 and ML-365. The salient features of the ragi varieties released from PC Unit are given below.

Table 6 Ragi varieties released from, Bangalore centre.

Sl. No	Varieties	Pedigree	Year of Release	Duration	Yield Q/ha	Season	Area of Suitability
1.	PR-202	Selection from Mettachodu (pure line Selection)	1982	118-120	20-30	Late Kharif	Suitable for rainfed & irrigated condition
2.	HR-911	UAS1x1E927	1986	116-120	25-30	Late Kharif	Suitable for rainfed & irrigated condition
3.	GPU-28	Indof5x IE1012	1998	110-115	35-40	Late Kharif Summer	Blast resistant, Suitable for rainfed & irrigated condition
4.	GPU-26	(Ind5 x Ind9) x IE1012	2000	100-105	28-30	Late Kharif Summer	Suitable for rainfed & irrigated condition
5.	GPU-45	GPU26 x L-5	2001	105-110	27-30	Late Kharif Summer	Suitable for rainfed & irrigated condition
6.	GPU-48	GPU26 x L-5	2005	100-105	30-35	Late Kharif	Zone-4,5,6 &7, of rainfed & irrigated

						Summer	condition
7.	ML-365	IE1012 x Indaf-5(Ril)	2008	100-110	40-45	Kharif & Late Kharif	Zone – V, Suitable for rainfed & irrigated condition
8.	GPU-66	PR202xGPU-28	2009	115-120	30-35	Late Kharif	Suitable for Zone-4,5,6 &7, of rainfed & irrigated condition



Future challenges:

- Breeding short duration ragi varieties suitable for **drought** under climate change scenario
- Breeding varieties for **saline and alkaline soils** especially for command areas
- Breeding early and **medium duration** varieties suitable for **cold season** in hilly tracts
- Breeding varieties for **value addition** and medicinal purpose
- Breeding ragi varieties suitable for **machine harvesting and threshing**

