(iii) RAGI (*Eleusine coracana*)

CLIMATE REQUIREMENT

T_Max°C	T_Min°C	Optimum° C	Rainfall mm	Altitude m MSL
40	8 - 10	25 - 35	500 - 1000	up to 2100

Tropical and sub tropical. It is a heat loving plant and requires minimum of 8 - 10°C for germination, 26 - 29°C for the growth. Does not tolerate heavy rainfall and requires a dry spell during grain ripening. Short day plant.

CROP IMPROVEMENT

SEASONS AND VARIETIES

Sl. No.	Agro ecological zones	Districts	Season	Varieties
1	North Eastern Zone	Vellore, Thiruvannamalai, Cuddalore, Villupuram, Thiruvallur and Kancheepuram	Dec-Jan (Marghazipattam) April-May (Chithiraipattam) June-July (Adipattam)	CO (Ra) 14 CO 15
2	North Western Zone	Salem, Namakkal, Dharmapuri and Krishnagiri	Dec-Jan (Marghazipattam) April-May (Chithiraipattam) June-July (Adipattam)	CO (Ra) 14 CO 15 Paiyur 2
3	Western Zone	Coimbatore, Erode, Karur, Tiruppur and Dindigul	Dec-Jan (Marghazipattam) April-May (Chithiraipattam) June-July (Adipattam)	CO (Ra) 14 CO 15
4	Cauvery Delta Zone	Trichy, Thanjavur, Thiruvarur, Nagapattinam, Pudukkottai, Perambalur and Ariyalur	Dec-Jan (Marghazipattam) April-May (Chithiraipattam) June-July (Adipattam)	

5	Southern Zone	Madurai and Theni	Dec-Jan (Marghazipattam) April-May (Chithiraipattam) Sep-Oct (Puratassipattam)	CO (Ra) 14 CO 15
		Sivagangai, Virudhunagar, Ramanathapuram, Tirunelveli and Thoothukudi	Sep-Oct (Puratassipattam)	
6	Hilly and High Altitude Zone	Ooty	Dec-Jan (Marghazipattam) June-July (Adipattam) Sep-Oct (Puratassipattam)	

I. PARTICULARS OF RAGI VARIETIES

PARTICULARS	Paiyur 2	CO (Ra) 14	CO 15
Year of Release	2008	2013	2015
Year of Notification	SO.2187(E)/27.08.2009	SO.1177(E)/25.08.2005	SO.2805(E)/25.08.2017
Parentage	VL 145 x Selection 10	Malawi 1305 x CO 13	CO 11 x PR 202
Duration (days)	115	105-110	120 – 125
Rainfed/ Irrigated	Rainfed	Both	Both
Grain yield (kg/ha)			
Irrigated	--	2892	3461
Rainfed	2527	2794	2950

Straw yield (kg/ha)			
Irrigated	--	8113	6698
Rainfed	4200	8503	5030
Stem	Erect	Erect	Erect
Height (cm)	90	115-120	95-100
Tillers	3-4	8-9	5-7
Days to 50% flowering	81	72	84-88
Ear size and shape	Incurved	Top curved	Large, Compact fingers top curved
Fingers	7-8	9-12	8-11
Ear length (cm)	7.0	10-12	9-12
Grain colour	Brown	Brown	Copper brown
1000 grain wt (g)	2.9	3.1	3.2

CROP MANAGEMENT

I. PREPARATION OF NURSERY (IRRIGATED TRANSPLANTED CROP)

1. PREPARATION OF LAND

i. For raising seedlings to plant one ha of main field, select 12.5 cents (500 m^2) of nursery area near a water source, where water does not stagnate.

ii. Mix 37.5 kg of super phosphate with 500 kg of FYM or compost and spread the mixture evenly on the nursery area.

iii. Plough two or three times with a mould board plough or five times with a country plough.

2. FORMING RAISED BED

i. Mark units of 6 plots each of size 3 m x 1.5 m. Provide 30 cm space between plots for irrigation.

ii. Excavate the soil from the interspace and all around to a depth of 15 cm to form channels and spread the soil removed from the channels on the bed and level.

3. PRE-TREATMENT OF THE SEEDS WITH FUNGICIDES

i. Seed treatment with Azospirillum may be done @ 3 packets/ha (600 g/ha) and 3 packets (600 g/ha) of Phosphobacteria or 6 packets of Azophos (1200 g/ha).

ii. Mix the seeds in a polythene bag to ensure a uniform coating of seeds with Thiram 4 g/ kg or Captan 4 g/kg or Carbendazim 2 g/kg of seeds.

4. SOWING AND COVERING THE SEEDS

i. Make shallow rills not deeper than one cm on the beds by passing the fingers vertically over them.

ii. Broadcast 5 kg of treated hand seeds evenly on the beds.

iii. Cover the seeds by the hand lightly over the soil.

iv. Sprinkle 500 kg of powdered FYM over the beds evenly to cover the seeds which are exposed and compact the surface lightly.

NOTE: Do not sow the seeds deep as germination will be adversely affected.

5. WATER MANAGEMENT

i. Provide one inlet to each nursery unit.

ii. Allow water to enter so as to cover all the channels around the bed. Allow the water in the channel to raise till the raised beds are fully wet and then cut off water.

iii. Adjust the frequency of irrigation according to the soil type.

No. of irrigations	RED SOILS	HEAVY SOILS
1st	Immediately after sowing	Immediately after sowing
2nd	3rd day after sowing	4th day after sowing
3rd	7th day after sowing	9th day after sowing
4th	12th day after sowing	16th day after sowing
5th	17th day after sowing	

NOTE:

1. One irrigation is given on the 3rd day in the case of red soil to soften the hard crust formed on the soil surface and also to facilitate seedlings to emerge out.
2. Do not allow cracks to develop in the nursery bed by properly adjusting the quantity of irrigation water.

6. PULLING OUT THE SEEDLINGS FOR PLANTING

Pull out seedlings on the 17th to 20th day of sowing for planting.

II. PREPARATION OF MAIN FIELD

1. PLOUGHING THE FIELD

Plough twice with mould board plough or thrice with wooden plough till a good tilth is obtained.

2. APPLICATION OF FYM OR COMPOST

Spread 12.5 t/ha of FYM or compost or composted coir pith evenly on the unploughed field and then plough and incorporate in the soil. NOTE: Do not spread and leave the manure uncovered in the field as nutrients will be lost.

3. APPLICATION OF FERTILIZERS

In soils having high intensive cropping system viz., Ragi-Maize-Cowpea, having high soil available K (310 kg/ha) potassium need not be applied.

- If soil test recommendation is not available, adopt a blanket recommendation of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O per ha.
- Apply half the dose of N and full dose of P_2O_5 basally before sowing and the remaining 50% in two equal splits at 25-30 and 40-45 days after sowing is recommended.
- Broadcast the fertilizer mixture over the field before the last ploughing and incorporate into the soil by working a country plough.

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished)

Ragi (1)

Soil : Mixed black calcareous (Perianaickenpalayam series)

Target : 3.5 - 4.0 t ha^{-1}

FN = 4.35T-0.37 SN-0.98 ON

FP_2O_5 = 1.18T-1.03 SP-0.80 OP

FK_2O = 2.68T-0.14SK-0.40 OK

Initial soil test values (kg ha^{-1})			Yield target – 3.5 t ha^{-1}			Yield target – 4.0t ha^{-1}		
			NPK (kg ha^{-1}) + FYM @ 12.5 t ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}			NPK (kg ha^{-1}) + FYM @ 12.5 t ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}		
SN	**SP**	**SK**	**FN**	**FP_2O_5**	**FK_2O**	**FN**	**FP_2O_5**	**FK_2O**
180	12	300	34	15*	15*	55	15*	25
200	14	340	30*	15*	15*	48	15*	20
220	16	380	30*	15*	15*	41	15*	15*
240	18	420	30*	15*	15*	33	15*	15*
260	20	460	30*	15*	15*	30*	15*	15*

* Maintenance dose

Ragi (2)

Soil : Red sandy loam (Somayanur series)

Target : 3.5 – 4.0t ha^{-1}

FN =4.94T-0.55 SN

FP_2O_5=1.36T-0.96 SP

FK_2O=4.20T-0.46 SK

Initial soil test value (kg ha^{-1})			Yield target – 3.5 t ha^{-1}			Yield target – 4.0 t ha^{-1}		
			NPK (kg ha^{-1}) + FYM @ 12.5 t ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}			NPK (kg ha^{-1}) + FYM @ 12.5 t ha^{-1} + *Azospirillum* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}		
SN	**SP**	**SK**	**FN**	**FP_2O_5**	**FK_2O**	**FN**	**FP_2O_5**	**FK_2O**
160	12	160	33	15*	33	58	15*	54
180	14	180	30*	15*	24	47	15*	45
200	16	200	30*	15*	15*	36	15*	36
220	18	220	30*	15*	15*	30*	15*	27
240	20	240	30*	15*	15*	30*	15*	18

* Maintenance dose

Note: FN, FP_2O_5 and K_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is the yield target in q ha^{-1}; SN, SP and SK respectively are available N,P and K in kg ha^{-1} and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg ha^{-1}.

Apply 10 packets (2000 g/ha) of Azospirillum and 10 packets (2000 g/ha) of Phosphorous solubilizing bacteria or 20 packets of Azophos (4000 g/ha) after mixing with 25 kg of soil and 25 kg FYM before transplanting. Apply TNAU MN mixture @12.5 kg/ha for irrigated and 7.5 kg/ha for rainfed crops as enriched FYM (prepare enriched FYM at 1:10 ratio of MN mixture and FYM at friable moisture and incubate for one month in shade.

4. FORMING BEDS AND CHANNELS

i. Form beds of size 10 m^2 to 20 m^2 according to topography of the field.

ii. Provide suitable irrigation channels.

5. APPLICATION OF MICRONUTRIENTS

Mix 12.5 kg of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu with enough sand to make a total quantity of 50 kg/ha (or) Apply the mixture evenly on the beds. (or) For alleviating Zn deficiency in plants, spray 0.5% $ZnSO_4$ on 30, 40 and 50 days after sowing. For specific micronutrient deficiencies, apply 25 kg $ZnSO_4$, 10 kg $CuSO_4$ and 50 kg $FeSO_4$ + 12.5 t FYM /ha can be followed.

III. MANAGEMENT OF MAIN FIELD

1. TRANSPLANTING THE SEEDLINGS

i. Let water into the bed, level the bed, if it is not levelled.

ii. Plant 2 seedlings per hill.

iii. Plant the seedlings at a depth of 3 cm.

iv. Plant 18 to 20 days old seedlings.

v. Adopt a spacing of 30x10 cm for planting.

vi. Adopt 22.5 x 10 cm spacing for direct sowing.

vii. Root dipping with Azospirillum: Prepare slurry with 5 packets (1000 g/ha) of Azospirillum and 5 packets (1000g/ha) of Phosphobacteria or 10 packets of Azophos (2000 g/ha) in 40 litres of water and dip the root portion of the

seedlings in the solution for 15-30 minutes and transplant.

2. WEED MANAGEMENT

i. Apply PE Oxyfluorfen @ 0.05 kg /ha on 3 DAS using Backpack Knapsack/Rocker sprayer fitted with flat fan type of nozzle with 500 litre of water/ha followed by one hand weeding on 20 DAS.

ii. Apply the herbicides when there is sufficient moisture in the soil or irrigate immediately after application of herbicide.

iii. If pre-emergence herbicide is not applied, hand weed twice on 10^{th} and 20^{th} DAT.

iv. For rainfed direct seeded crop, apply post emergence herbicide; 2,4-DEE or 2,4-D Na salt at 0.5 kg/ha on 10 DAS depending on the moisture availability.

3. HOEING AND HAND WEEDING

i. Hoe and hand weed on the 15^{th} day of planting in light soils and 17^{th} day of planting in heavy soils and subsequently on 30^{th} and 32^{nd} days, respectively.

ii. Allow the weeds to dry for 2 or 3 days after hand weeding before giving irrigation. NOTE: Do not adopt hoeing and hand weeding if herbicide is applied.

IV. WATER MANAGEMENT

Regulate irrigation according to the following growth phases of the crop

Stages/ Phase	No. of irrigations	Crop duration days		
		80	100	120
Vegetative phase (Nursery)	As per soil type	1 to 16	1 to 18	1 to 20
Vegetative phase (main field)		1 to18	1 to 20	1 to 22
Flowering phase		19 to 40	21 to 55	23 to 69
Maturity phase		Beyond 40 days	Beyond 55 days	Beyond 69 days

Heavy soils				
Establishment	1	1st day	1st day	1st day
(1-7 days)	2	5th day	5th day	5th day
Vegetative phase	1	18th day	20th day	20th day
(8-20 days)	2	31st day	33rd day	30th day
Flowering phase	1	41st day	42nd day	37th day
(21-55 days)	2	51st day	52nd day	44th day
	3	--	--	63rd day
Maturity phase	1	61st day	62nd day	78th day
(56-120 days)	2	--	--	93rd day
Stop irrigation thereafter				
Light soils				
Establishment	1	1st day	1st day	1st day
(1 – 7 days)	2	5th day	5th day	5th day
Vegetative phase	1	15th day	16th day	16th day
(8 - 20 days)	2	26th day	28th day	28th day
Flowering phase	1	36th day	36th day	36th day
(21 - 55 days)	2	45th day	45th day	45th day
	3	--	54th day	54th day
Maturity phase	1	58th day	69th day	78th day
(56 - 120 days)	2	70th day	85th day	93rd day

NOTE: The irrigation schedule is given only as a general guideline. Regulate irrigation depending upon the prevailing weather conditions and receipt of rain.

V. HARVESTING

1. DECIDE WHEN TO HARVEST

i. Ragi crop does not mature uniformly and hence the harvest is to be taken up in two stages.

ii. When the ear head on the main shoot and 50% of the ear heads on the crop turn brown, the crop is ready for the first harvest.

2. HARVEST OF THE CROP First harvest

i. Cut all ear heads which have turned brown.

ii. Dry, thresh and clean the grains by winnowing.

Second Harvest

i. Seven days after the first harvest, cut all the ear heads including the green ones.

ii. Cure the grains to obtain maturity by heaping the harvested ear heads in shade for one day without drying, so that the humidity and temperature increase and the grains get cured.

iii. Dry, thresh and clean the grains by winnowing and store the grains in gunnies.

Threshing

Green ear heads if harvested will contaminate the seeds with immature seeds and interfere cleaning, drying and grading. Dry ear heads until seed moisture content reaches 15% and separate manually by threshing with bamboo stick or machine thresher.

Precleaning and drying

Threshed seeds should be precleaned before sundrying, seeds must be dried to 12% moisture content before grading.

Protection from storage pests

1. Grain purpose: Dry the seeds adequately to reduce the moisture level to 10%.
2. Seed purpose: Admix one kg of Activated kaolin or Malathion 5% D for every 100 kg of seed. Pack in gunny or polythene lined gunny bags for storage.

Special problems

i. Root Aphids: Mix Dimethoate 3 ml in one litre of water and drench the rhizosphere of the infested and surrounding plants with the insecticidal solution.

ii. Rainfed ragi: Azospirillum mixed with FYM and applied to field saves the cost of nitrogen by 50% with a comparable yield obtained with 40 kg N/ha.

iii. Management of aged seedlings of ragi under rainfed conditions: When planting ragi seedlings beyond 21 days, increase the number of seedlings to 3/hill and increase N level by 25% to minimise yield loss.

iv. Apply VAM culture (*Glomus fasciculatum*) at 100 g/m^2 in the nursery and also treat with Azospirillum and Phosphobacterium as seed treatment, seedling dip and field application to reduce the reniform nematode population in ragi.

RAGI : RAINFED

Rainfall

Average and well distributed rainfall of 450-500 mm is optimum for rainfed ragi

Season

Finger millet is grown in different seasons in different parts of the country. As a rainfed crop, it is normally sown in June- July in Tamil Nadu. It also grown in winter season (rabi) by planting in September – October in Tamil Nadu and as a summer irrigated crop by planting January – February.

Tillage

Fall ploughing is advantageous for moisture conservation. In the month of April or May, one deep ploughing with mould board plough followed by ploughing with wooden plough twice is necessary. Before sowing secondary tillage with cultivator and multiple tooth hoe to prepare smooth seed bed is necessary.

Seed rate and planting

A plant population of 4 – 5 lakhs per ha is optimum for getting higher yields and higher or lower population than the optimum will reduce the yield. Line sowing is ideal and seed drills giving spacing of 22.5 – 30 cm between rows should be used. Finger millet seeds are very small (400 seeds/g) and the recommended seed rate is 10 kg/ha. Therefore, even when seed drill is used thinning within the row leaving a spacing of 7.5 – 10 cm between plants, must be followed.

Sowing by seed-cum-fertilizer drill is advantageous for line sowing besides efficient utilization of applied nutrients.

Maintenance of optimum plant population is an important prerequisite for getting higher yield under rainfed conditions. Poor germination, often, is the result of inadequate moisture after sowing in low rainfall areas. Under these conditions, the adoption of a simple technique like seed hardening will not only improve germination and subsequent plant stand but also impart early seedling vigour and tolerance to drought.

The procedure of seed hardening technique is as follows.

1. Soak seeds in water for 6 hours. Use one litre water for every kg seed for soaking.

2. Drain the water and keep the seeds in wet cloth bag tightly tied for two days.
3. At this stage, the seeds will show initial signs of germination.
4. Remove seeds from the wet cloth bag and dry them in shade on a dry cloth for 2 days.
5. Use the above hardened seeds for sowing.

Manuring and fertilization

Finger millet responds well to fertilizer application especially to N and P. The recommended doses of fertilizers vary from state to state for rainfed crop. Recommended dose of 40:20:20 kg/ha N:P:K was applied. With judicious application of farmyard manure inorganic fertilizer efficiency is enhanced. Entire P_2O_5 and K_2O are to be applied at sowing, whereas nitrogen is to be applied in two or three split doses depending upon moisture availability. In areas of good rainfall and moisture availability, 50% of recommended nitrogen is to be applied at sowing and the remaining 50% in two equal splits at 25-30 and 40-45 days after sowing. In areas of uncertain rainfall, 50% at sowing and the remaining 50% around 35 days after sowing is recommended.

Bio-fertilizers

Treating seeds with *Azospirillum brasilense* (N fixing bacterium) and *Aspergillus awamori* (P solubilizing fungs) @ 25 g/kg seed is beneficial. In case seeds are to be treated with seed dressing chemicals, treat the seeds first with seed dressing chemicals and then with bio-fertilizers at the time of sowing.

Procedures for inoculating seeds with biofertilizers

1. Bio-fertilizer culture specific to the crop is to be used @ 25 g per kg of seed.
2. Sticker solution is necessary for effective seed inoculation. This can be prepared by dissolving 25 g jaggery or sugar in 250 ml water and boiling for 5 minutes. The solution thus prepared is cooled.
3. Smear the seeds well using the required quantity of sticker solution. Then add culture to the seeds and mix thoroughly so as to get a fine coating of culture on the seed.
4. The culture-coated seeds is to be dried well in shade to avoid clumping of seeds.
5. Use the inoculated seeds for sowing.

Weed control

i. In line sown crop 2-3 inter-cultivations are necessary. In assured rainfall and irrigated areas spraying 2,4-D sodium salt @ 0.75 kg.a.i./ha as post-emergent spray on 20-25 days after Sowing effectively controls weeds.

ii. Apply, Isoproturon @ 0.5 a.i/ha as pre-emergence on 3 DAS is also effective in control of weeds. In broadcast crop two effective hand weedings will minimize weeds as inter cultivations is not possible.

iii. For direct sown rainfed ragi post-emergence application of 2, 4 D Na salt (or) EE formulation at 0.5 kg ha^{-1} applied on 10 days after sowing and at 0.75 kg ha^{-1} applied on 15 days after sowing will give effective weed control as well as higher grain yield.

Cropping systems

Crop rotation

Rotation with legumes like Greengram / Blackgram / Field bean / Soybean / Horse gram or Ground nut in southern state will minimize inorganic fertilizer application and also sustain higher yields.

Intercropping

Finger millet based inter cropping system with pigeon pea at 4:1 ratio is recommended for rainfed situation to obtain high grain yield

CROP PROTECTION

A. Pest Management

Aphids *Schizaphis graminum, Rhopalosiphum maidis*	Spray Dimethoate 30EC 20 ml per 5 cent nursery
Stem borer *Sesamia inferens*	Apply Carbofuran 3CG 50 kg/ha in leaf whorls
Root aphid *Tetraneura nigriabdominalis*	Drench Dimethoate 30EC 1:1 (with water) in the rhizosphere of infested and surrounding plants
Ear head bug *Calocoris angustatus*	**Apply any one of the following/ha on 3rd and 18th day after panicle emergence** • Malathion 5D 25 kg • Neem seed kernel extract 5% • Malathion 50EC 500 ml/ha (twice at 10% heading and 9 days after)

B. DISEASE MANAGEMENT

Nursery:

Treat the seeds with Thiram or Captan @ 4 g or Carbendazim @ 2 g/kg or *Pseudomonas*

fluorescens @ 10 g/kg of seed.

Main field:

Name of the Disease	Recommendations
Blast: *Pyricularia grisea*	• Spray Carbendazim @ 500 g or iprobenphos(IBP) @ 500 ml/ha immediately after symptom development and repeat at flowering stage and 15 days later to manage neck and finger blast • Spray Aureofungin sol 100 ppm (100 mg/l) at 50% ear head emergence followed by spray with Mancozeb 1000 g/ha or *Pseudomonas fluorescens* @ 0.2% ten days later • Two sprays of Tricyclazole 75% WP @ 500 g/ha at maximum tillering and heading stages
Virus diseases **Mosaic and Mottle streak**	• Rogue out the virus infected plants • Spray Methyl demeton 25EC @ 500 ml/ha on noticing symptoms and repeat twice at 20 days interval, if necessary

RAGI (FINGER MILLET) - VARIETAL SEED PRODUCTION

Land Requirement

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

Isolation

- For certified / quality seed production leave a distance of 3 m all around the field from the same and other varieties of the finger millet.

Pre-sowing seed treatment

- Soak the seeds in 0.5 % $CaCl_2$ for 6 h at 1:1 ratio and dry back the seeds to original seed moisture content (8 - 9 %) under shade. This can be adapted both for the garden and dry land ecosystem.
- Treat the graded seed with Carbendazim @ 2 g / kg of seed.

Nursery sowing

- In raised bed, sow the seeds not deeper than 1 cm and sprinkle with 200 kg of powdered FYM. Lightly level and compact the surface of nursery.

Harvesting

- Harvest the crop in 2 harvests.
- First harvest should be taken up when 50 % of seeds in the ear-heads have attained the characteristic brown colour.
- Second harvest should be taken up a week to ten days after first havest, when all the remaining ear heads turned brown (spikelets are non-shattering).

Threshing

- Dry the ear heads until the seed moisture content is reduced to 15 % and seeds are separated manually by threshing with pliable bamboo stick or machine thresher.
- Pre-clean the threshed seeds before sun drying.
- Dry the seeds to 12 % moisture content before grading.

Seed grading

- Grade the seeds either with BSS 10 x 10 or BSS 12 x 12 depending upon the variety.

Pre-storage seed treatment

- Treat the seeds with Carbendazim @ 2 g / kg of seed.

Storage

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 10 to 12 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 to 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.