2. MILLETS

(i) SORGHUM (*Sorghum bicolor*)

CLIMATE REQUIREMENT

T_Max°C	T_Min°C	Optimum °C	Rainfall mm	Altitude m MSL
40	7 - 8	27 - 35	400 - 600	up to 2300

Tropical crop. It can tolerate drought conditions as well as water logging condition. Short day plant

CROP IMPROVEMENT

I. SEASON AND VARIETIES

Sl. No.	Agro ecological zones	Districts	Season	Varieties/ Hybrids
1	North Eastern Zone	Vellore, Thiruvannamalai, Cuddalore, Villupuram, Thiruvallur and Kancheepuram	Jan-Feb (Thaipattam) April - May (Chithiraipattam) June-July (Adipattam) Sep-Oct (Puratassipattam)	CO 30
2	North Western Zone	Salem, Namakkal, Dharmapuri and Krishnagiri		
3	Western Zone	Coimbatore, Erode, Karur, Tiruppur, Theni and Dindigul		
4	Cauvery Delta Zone	Trichy, Thanjavur, Thiruvarur, Nagapattinam, Pudukkottai Perambalur and Ariyalur	Jan-Feb (Thaipattam) April - May (Chithiraipattam) June-July (Adipattam)	
5	Southern Zone	Madurai, Sivagangai, Virudhunagar, Ramanathapuram Tirunelveli and Thoothukudi	Jan-Feb (Thaipattam) April - May (Chithiraipattam) Sep-Oct (Puratassipattam)	CO 30 and K 12

II. PARTICULARS OF SORGHUM VARIETIES

PARTICULARS	K 12	CO 30
Year of Release	2015	2010
Year of Notification	SO.1379(E)/ 27.03.2018	SO.1708(E)/26.07.2012
Parentage	Derivative of SPV 772 × S 35-29	Derivative of APK 1 x TNS 291
Duration (Days)	95-100	95-105
Area (Districts)	Southern districts of Tamil Nadu	All districts
Season (Pattam)		
Rainfed	Puratasi	Adi,Puratasi
Irrigated	Chithirai	Thai, Chithirai
Grain yield (kg/ha)		
Rainfed	3123	2400
Irrigated	-	3360
Fodder yield (kg/ha)		
Rainfed	11900	7000
Irrigated	-	9200
Stalk	Juicy	Juicy
Plant height (cm)	225-240	220-240
Sheath Colour	Reddish purple	Tan Green
Midrib	White	Dull white
Ear head shape	Elongated	Cylindrical
Compactness	Semi Compact	Semi Compact
Grain Colour	Creamy white	White
Special features	Tolerant to drought, photo insensitive, moderately resistant to shoot fly and stem borer, resistant to downy mildew. Suitable for rainfed situation	High dry Matter digestibility, tolerance to shoot fly, grain mould and downy mildew

CROP MANAGEMENT

I. SELECTION OF SEEDS

Good quality seeds are to be collected from disease and pest-free fields.

Quantity of seed required

Irrigated Transplanted - 7.5 kg/ha; Direct sown - 10 kg/ha Rainfed Direct sown - 15 kg/ha Sorghum under irrigated condition is raised both as a direct sown and transplanted crop. Transplanted crop has the following advantages:

a. Main field duration is reduced by 10 days.

b. Shoot fly, which attacks direct sown crops during the first 3 weeks and which is difficult to control, can be effectively and economically controlled in the nursery itself.

c. Seedlings which show chlorotic and downy mildew symptoms can be eliminated, thereby incidence of downy mildew in the main field can be minimised.

d. Optimum population can be maintained as only healthy seedlings are used for transplanting.

e. Seed rate can also be reduced by 2.5 kg/ha.

II. NURSERY PRACTICES

1. NURSERY PREPARATION

For raising seedlings to plant one hectare, select 7.5 cents (300 m^2) near a water source where water will not stagnate.

2. APPLICATION OF FYM TO THE NURSERY

i. Apply 750 kg of FYM or compost for 7.5 cents nursery and apply another 500 kg of compost or FYM for covering the seeds after sowing.

ii. Spread the manure evenly on the unploughed soil and incorporate by ploughing or apply just before last ploughing.

3. LAYING THE NURSERY

i. Provide three separate units of size 2 m x 1.5 m with 30 cm space in between the plots and all around the unit for irrigation.

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

4. PRE-TREATMENT OF SEEDS

i. Treat the seeds 24 hours prior to sowing with Carbendazim or Captan or Thiram at 2g/kg of seed.

ii. Carrier based formulation: Treat one hectare of seeds with 1 kg each of biofertilizers *viz., Azsopirillum,* Phosphobacteria (or) Azophos, Silicate solubilizing bacteria (SSB) / Potash bacteria (KRB) and 25 g of powder formulation of AM fungi using binder (polymer), shade dry for 30 minutes before sowing.

iii. Liquid formulation: Treat one hectare of seeds with 125 ml of each biofertilizers *viz., Azsopirillum,* Phosphobacteria (or) Azophos and Silicate solubilizing bacteria (SSB) shade dry for 30 minutes before sowing

5. SOWING AND COVERING THE SEEDS

1. Make shallow rills, not deeper than 1 cm on the bed by passing the fingers vertically over it.
2. Broadcast 7.5 kg of treated seeds evenly on the beds.
3. Cover by levelling the rills by passing the hand lightly over the soil.

6. WATER MANAGEMENT

i. Provide one inlet to each nursery unit.

ii. Allow water to enter through the inlet and cover all the channels till the raised beds are covered with water and then cut off.

iii. Adjust the frequency of irrigation according to the soil types as follows:

Number of irrigations	Red soil	Heavy soil
First irrigation	Immediately after sowing	Immediately after sowing
Second irrigation	3rd day after sowing	4th day after sowing
Third irrigation	7th day after sowing	9th day after sowing
Fourth irrigation	12th day after sowing	16th day after sowing

NOTE: Do not keep the seedlings in the nursery for more than 18 days. If older seedlings are used, establishment and yield are adversely affected. Do not allow cracks to develop in the nursery by properly adjusting the quantity of irrigation water.

MAIN FIELD PREPARATION FOR IRRIGATED CROP

1. PLOUGHING

Plough the field with an iron plough once (or) twice. Sorghum does not require fine tilth since it adversely affects germination and yield in the case of direct sown crop. To overcome the subsoil hard pan in Alfisols (deep red soils) chiselling the field at 0.5 m intervals to a depth of 40 cm on both the directions of the field followed by disc ploughing once and cultivator ploughing twice help to increase the yield of sorghum and the succeeding crops.

Application of FYM and 100% of recommended N can also be followed. In soils with sub-soil hard pan, chiselling should be done every year at the start of the cropping sequence to create a favourable physical environment.

2. APPLICATION OF FYM

Spread 12.5 t/ha FYM or any compost along with 2 kg each *Azospirillum,* Phosphobacteria or 2 kg of Azophos on the unploughed field and incorporate the manure in the soil. Apply well decomposed poultry manure @ 5 t/ha to improve the grain yield as well as physical properties of soils.

3. FORMATION OF RIDGES AND FURROWS

i. Form ridges and furrows of 6 m length and 45 cm apart

ii. Form irrigation channels across the furrows

iii. Alternatively form beds of size 10 m^2 and 20 m^2 depending on the availability of water.

4. APPLICATION OF FERTILIZERS

Transplanted crop

If soil test recommendations are not available, adopt a blanket recommendation of 90 N, 45 P_2O_5 45 K_2O kg/ha. Apply N @ 50:25:25 % at 0, 15 and 30 DAS and full dose of P_2O_5 and K_2O basally before planting. Apply 30 kg S basally for Sulphur deficient soils. 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).

Sorghum - Hybrid (1)

Soil : Red sandy loam (Irugur series)
Target : 4.0 - 5.0 t ha^{-1}

FN = 4.86T - 0.53 SN - 0.98 ON
FP_2O_5 = 1.63T - 0.87 SP - 0.90 OP
FK_2O = 4.56T - 0.59SK - 0.76 OK

Initial soil test values (kg ha^{-1})			Yield target – 4 t ha^{-1}			Yield target – 5 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	58	23	48	106	39	68**
180	14	180	47	23*	36	96	37	68**
200	16	200	36	23*	24	85	36	68**
220	18	220	26	23*	23*	74	34	58
240	20	240	45*	23*	23*	64	32	46

* Maintenance dose; ** Maximum dose

Sorghum -Varieties (2)

Soil : Mixed black calcareous (Perianaickenpalayam series)
Target : 4.0- 5.0 t ha^{-1}

FN = 6.06T-0.81SN-0.53 ON
FP_2O_5 = 2.06T-3.14 SP-0.72 OP
FK_2O = 5.03T-0.47SK-0.66 OK

Initial soil test values (kg ha^{-1})			Yield target – 4 t ha^{-1}			Yield target – 5 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**
180	12	300	45*	23*	23*	105	33	71
200	14	340	45*	23*	23*	89	27	52
220	16	380	45*	23*	23*	73	23*	33
240	18	420	45*	23*	23*	57	23*	23*
260	20	460	45*	23*	23*	45*	23*	23*

* 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 inkg ha^{-1}.

i. In the case of ridge planted crop, open a furrow 5 cm deep on the side of the ridge at two thirds the distance from the top of the ridge and place the fertilizer mixture along the furrow and cover with soil upto 2 cm.

ii. Soil application of Azospirillum at 10 packets (2 kg/ha) and 10 packets (2000 g/ha) of Phosphobacteria or 20 packets of Azophos (4000 g/ha) after mixing with 25 kg of FYM + 25 kg of soil may be carried out before sowing/planting.

Direct sown crop

i. Apply NPK fertilizers as per soil test recommendations as far as possible. If soil test recommendations are not available, adopt a blanket recommendation of 90 N, 45 P_2O_5, 45 K_2O kg/ha.

ii. Apply N @ 50:25:25 % at 0, 15 and 30 DAS and full dose of P_2O_5 and K_2O basally before sowing and if basal application is not possible the same could be top dressed within 24 hours.

iii. In the case of bed planted crop, mark lines to a depth of 5 cm and 45 cm apart. Place the fertilizer mixture at the depth of 5 cm along the lines. Cover the lines upto 2 cm from the top before sowing.

iv. In the case of sorghum raised as a mixed crop with a pulse crop (Blackgram, Greengram or Cowpea) open furrows 30 cm apart to a depth of 5 cm.

v. Apply fertilizer mixture in two lines in which sorghum is to be raised and cover upto 2 cm.

vi. Skip the third row in which the pulse crop is to be raised and place fertilizer mixture in the next two rows and cover upto 2 cm with soil.

vii. Application of bio-fertilizers: When Azospirillum is used apply only 75% of recommended N for irrigated sorghum.

5. APPLICATION OF MICRONUTRIENTS

Transplanted Crop

i. Mix 12.5 kg/ha of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu with enough sand to make a total quantity of 50 kg and apply the mixture over the furrows and on top one third of the ridges (or) TNAU MN mixture @ 12.5 kg ha^{-1} for irrigated; 7.5 kg for rainfed crop as enriched FYM. Prepare enriched FYM @ 1:10 ratio of MN Mixture & FYM at friable moisture and incubate for one month in shade.

ii. If micronutrient mixture is not available, mix 25 kg of Zinc sulphate with sand to make a total quantity of 50 kg and apply on the furrows and on the top one third of the ridges.

Direct Sown Crop

i. 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.

ii. Spread the mixture evenly on the beds.

iii. Basal application of 25 kg $ZnSO_4/ha^{-1}$ (or) 12.5 kg kg Zn SO_4 + 12.5 t/ha FYM for deficient soils.

iv. Basal application of $FeSO_4$ @ 50 kg/ha along with 12.5 t/ha FYM for iron deficient soils.

v. Foliar spraying of 0.5% $ZnSO_4$, 1.0% $FeSO_4$+0.1% citric acid thrice on 30, 40 and 50 DAS if deciciency observed in plants.

III. MANAGEMENT OF MAIN FIELD

Spacing: 45 x 15 cm Population: 15/m^2

1. TRANSPLANTED CROP

i. Pull out the seedlings when they are 15 to 18 days old.

ii. Prepare slurry with 5 packets of Azospirillum (1000 g/ha) and 5 packets (1000 g/ha) of Phosphobacteria or 10 packets of Azophos (2000 g/ha) in 40 lit. of water and dip the root portion of the seedlings in the solution for 15-30 minutes and transplant.

iii. Let in water through the furrows

iv. Plant one seedling per hill

v. Plant the seedlings at a depth of 3 to 5 cm.

vi. Plant the seedlings on the side of the ridge, half the distance from the top of the ridge and the bottom.

2. DIRECT SOWN CROP

i. In the case of pure crop of sorghum, maintain the seed rate at 10kg/ha.

ii. In the case of inter crop of sorghum with pulse crop, maintain the seed rate of sorghum at 10 kg/ha and pulse crop at 10 kg/ha.

iii. In the case of pure crop of sorghum, sow the seeds with a spacing of 15 cm between seeds in the rows which are 45 cm apart.

iv. Maintain one plant per hill.

v. If shoot fly attack is there, remove the side shots and retain one healthy shoot.

vi. Sow the seeds over the lines where fertilizers are placed.

vii. Sow the seeds at a depth of 2 cm and cover with soil.

viii. In the case of sorghum intercropped with pulses sow one paired row of sorghum alternated with a single row of pulses. The spacing between the row of sorghum and pulse crop is 30 cm.

Forage cowpea CO 1 can be intercropped in sorghum at two rows of fodder cowpea in between paired rows of sorghum.

3. WEED MANAGEMENT

i. Apply PE Atrazine @ 0.25 kg/ha on 3-5 DAS followed by 2,4-D @ 1 kg/ha on 20-25 DAS on the soil surface, using Backpack/Knapsack/Rocker sprayer fitted with a flat fan nozzle using 500 litres of water/ha (or) if herbicides are not used, hand weeding twice on 10-15 DAS and 30-35 DAS.

ii. Apply PE Atrazine@0.25 kg/ha on 3-5 DAS followed by one hand weeding on 30-35 DAS.

iii. In line sown crop, apply PE Atrazine @ 0.25 kg/ha on 3-5 DAS followed by Twin Wheel hoe weeder weeding on 30-35 DAS.

iv. In transplanted crop, apply PE Atrazine @ 0.25 kg/ha on 3-5 DAT followed by 2,4-D @ 1 kg/ha on 20-25 DAT.

v. If pulse crop is to be raised as an intercrop in sorghum do not use Atrazine, spray PE Pendimethalin @ 0.75 kg/ha on 3-5 DAS

4. THINNING OF THE SEEDLINGS AND GAP FILLING

Direct sown crop

Thin the seedlings and gap fill with the seedlings thinned out. Maintain a spacing of 15 cm between plants after the first hand weeding. Thin the pulse crop to a spacing of 10 cm between plants for all pulse crop except cowpea, for which spacing is maintained at 20 cm between plants.

5. DEFICIENCY SYMPTOMS

Zinc: Deficiency symptoms first appear in the newly formed leaves at 20 to 30 days age. Older leaves have yellow streaks or chlorotic striping between veins.

Iron: Interveinal chlorosis will be observed. If the deficiency continues the entire leaf including the veins may exhibit chlorotic symptoms. Newly formed leaves exhibit chlorotic symptoms. The entire crop may exhibit bleached appearance, dry and may die.

Direct sown crop

i. Foliar spraying of 1% $FeSO_4$+0.1% citric acid thrice if deficieny symptom appeared.

ii. Recommendation given in transplanted crop may be followed.

NOTE:

a. Spray only if micronutrient mixture is not applied.

b. Apply in case of iron deficiency.

c. If soil is calcareous

IV. WATER MANAGEMENT

Regulate irrigation according to the following growth phase of the crop.

	Transplanted crop	Direct sown crop
Growth phase	1 to 40 days	1 to 33 days
Flowering phase	41 to 70 days	34 to 65 days
Maturity phase	71 to 95 days	66 to 95 days

Stages	No. of Irrigation	Days of Transplanting / Sowing of Crop	
		Transplanted	Direct Sown
Light Soils			
i. Irrigate for germination	1	1st day	1st day
or establishment	2	4th day	4th day
ii. Regulate irrigation during vegetative phase	1	15th day	15th day
	2	28th day	28th day
iii. Flowering phase (copious irrigation)	1	40th day	40th day
	2	52nd day	52nd day
	3	..	64th day
iv. Maturity phase (Control irrigation)	1	65th day	76th day
	2	..	88th day

v. Stop irrigation thereafter	..	..	
Heavy soils			
i. Irrigate for germination	1	1st day	1st day
or establishment	2	4th day	4th day
ii. Regulate irrigation during vegetative phase	1	17th day	17th day
	2	30th day	30th day
iii. Flowering phase (give copious irrigation)	1	40th day	45th day
	2	52nd day	60th day
	3	..	75th day
iv. Maturity phase (Control irrigation)	1	72nd day	90th day

v. Stop irrigation thereafter

NOTE : Adjust irrigation schedule according to the weather conditions and depending upon the receipt of rains. Contingent Plans to be done before 75% of soil moisture is lost from available water. Foliar Spray of 3% Kaolin (30 g in one litre of water) during period of stress will mitigate the ill effects.

v. HARVESTING AND PROCESSING

i. Consider the average duration of the crop and observe the crop. When the crop matures, the leaves turn yellow and present a dried up appearance.

ii. The grains are hard and firm.

iii. At this stage, harvest the crop by cutting the ear heads separately.

iv. Cut the stalk after a week, allow it to dry and then stack.

v. In the case of tall varieties, cut the stem at 10 to 15 cm above ground level and afterwards separate the ear heads and stack the stalk.

vi. Dry the ear heads.

vii. Thresh using a mechanical thresher or by drawing a stone roller over the ear heads or by using cattle and dry the produce and store.

RATOON SORGHUM CROP

1. RATOONING TECHNIQUE

i. Harvest the main crop leaving 15 cm stubbles.

ii. Remove the first formed two sprouts from the main crop and allow only the later formed two sprouts to grow. Allow two tillers per hill.

2. HOEING AND WEEDING

i. Remove the weeds immediately after harvest of the main crop.

ii. Hoe and weed twice on 15^{th} and 30^{th} day after cutting.

3. APPLICATION OF FERTILIZERS

i. Apply 100 kg N/ha in two split doses.

ii. Apply the first dose on 15^{th} day after cutting and the second on 45^{th} day after cutting.

iii. Apply 50 kg $P_2 O_5$ /ha along with the application of N on 45^{th} day.

4. WATER MANAGEMENT

i. Irrigate immediately after cutting the main crop.

ii. Irrigation should not be delayed for more than 24 hours after cutting.

iii. Irrigate on 3^{rd} or 4^{th} day after cutting.

iv. Subsequently irrigate once in 7 - 10 days.

v. Stop irrigation on 70 - 80 days after ratooning.

5. HARVEST

Harvest the crop when the grains turn yellow.

NOTE: The duration of the ratoon crop is about 15 days less than the main crop.

RAINFED SORGHUM

1. RAINFALL

Average and well distributed rainfall of 250-300 mm is optimum for rainfed sorghum.

2. DISTRIBUTION

Madurai, Dindigul, Theni, Ramanathapuram, Tirunelveli, Thoothukudi, Virudhunagar, Sivagangai, Tiruchirapalli, Erode, Salem, Namakkal, Coimbatore and Dharmapuri Districts.

3. SEASON

The crop can be grown in South West and North East monsoon seasons provided the rainfall is evenly distributed.

4. FIELD PREPARATION

i. Field has to be prepared well in advance taking advantage of early showers. FYM application should be done @ 12.5 t / ha and well incorporated at the time of ploughing.

ii. Chiseling for soils with hard pan: Chisel the soils having hard pan formation at shallow depths with chisel plough at 0.5 m interval, first in one direction and then in the direction perpendicular to the previous one once in three years. Apply 12.5 t FYM or composted Coir pith/ha besides chiseling to get an additional yield of about 30% over control.

iii. To conserve the soil moisture sow the seeds in flat beds and form furrows between crop rows during inter cultivation or during third week after sowing.

5. SEED RATE

15 kg/ha

6. SEED TREATMENT

Direct sown crop

Seed hardening ensures high germination. The seeds are pre-soaked in 2% Potassium Dihydrogen Phosphate solution for 6 hours in equal volume and then dried back to its original moisture content in shade and are used for sowing. (or)

i) Harden the seeds with 1% aquous fresh leaf extract of *Prosopis juliflora* and Pungam, (*Pongamia pinnata*) mixed in 1:1 for 16 hrs at 1:0.6 ratio (Seed and

solution) followed by drying and subsequently pelleting the seeds with Pungam leaf powder @300 g/kg with gruel.

ii) Halogenise the seeds containing CaOCl, $CaCO_3$ and *arappu* leaf powder @ 5:4:1 ratio or iodine based (containing 2 mg of Iodine in 3 g of $CaCO_3$) formulation @ 3g/kg packed in polylined cloth bag to maintain seed viability for more than 10 month.

iii) Treat the seeds with three packets of Azospirillum (600 g) and 3 packets of Phosphobacteria or 6 packets of Azophos (1200 g/ha). In the main field, apply 10 packets of Azospirillum 2000g/ha and 10 packets (2000g/ha) of Phosphobacteria or 20 packets of Azophos (4000 g/ha) with Phosphobacteria 2 kg with 25 kg FYM + 25 kg soil.

iv) The seed is pelletised with 15 g of Chloropyriphos in 150 ml of gum and shade dried.

7. SOWING

Sow the seeds well before the onset of monsoon at 5 cm depth (by seed drill or by country plough).

Pre-monsoon sowing

Sow the hardened seeds at 5 cm depth with seed cum fertilizer drill to ensure uniform depth of sowing and fertilizer application before the onset of monsoon as detailed below:

District	Optimum period
1. Coimbatore	37-38th week (II to III week of Sep.)
2. Erode	38 th week (III week of Sep.)
3. Sivaganga	40 th week (I week of Oct.)
4. Ramanathapuram	40 th week (I week of Oct.)
5. Thoothukudi	39-40 th week (Last week of Sep. to I week of Oct)
6. Vellore, Tiruvannamalai	37 th -38 th week (Sep. II week to Sep. III week)

i. Sow the sorghum seeds over the line where the fertilizers are placed.

ii. Sow the seeds at a depth of 5 cm and cover with the soil.

iii. Sow the seeds with the spacings of 15 cm in the paired rows spaced 60 cm apart.

iv. Sow the pulse seeds to fall 10 cm apart in the furrows between the paired rows of sorghum.

8. SPACING

45 x 15 cm or 45 x 10 cm.

9. FERTILIZER

Apply 12.5 t/ha of Composted Coir pith + NPK at 40:20:0; Apply enriched FYM @ 750 kg/ha. The recommended dose of 40 kg N and 20 kg $P_2 O_5$ /ha for rainfed sorghum can be halved if FYM @ 5 t/ha is applied.

10. WEED MANAGEMENT

Keep sorghum field free of weeds from second week after germination till 5^{th} week. If sufficient moisture is available spray Atrazine 0.25 kg/ha as pre-emergence application within 3 days after the receipt of the soaking rainfall for sole sorghum and for sorghum based intercropping system with pulses, use Pendimethalin at 0.75 kg/ha.

Under rainfed sorghum intercropped with cowpea as a pre-plant incorporation of Isoproturan @ 0.5 kg ha^{-1} gave good control of weed with applied after 1^{st} and 2^{nd} spell of rainfall pendimethalin 1.0 kg ha^{-1} will be safer for both the crops.

11. CROPPING SYSTEM

- The most profitable and remunerative sorghum based cropping system adopted is sorghum with cowpea, redgram, lab-lab, blackgram.
- In rainfed Vertisol, adopt paired row planting in sorghum and sow one row of blackgram/ cowpea in between paired rows of sorghum to have 100% population of sorghum plus 33% population of blackgram/cowpea.
- Intercropping of sunflower CO 1, with the main crop of sorghum CO 26 in 4:2 ratio is recommended under rainfed conditions during North-East monsoon for black soils of Coimbatore.
- Intercropping of soybean with sorghum in the ratio 4:2 is recommended for kharif seasons.
- For sorghum - blackgram intercropping system as well as sole cropping, application of 20 kg N and 20 kg $P_2 O_5$ /ha through enriched FYM and treating the seeds with Azospirillum is 25 recommended for Aruppukottai region.
- For sorghum (CO 25) + Fodder cowpea (CO 1) intercropping system, application of 20 kg N and 20 kg $P_2 O_5$ /ha with enriched FYM is recommended for Coimbatore region

- The intercropping system, fodder sorghum (K 7) + Fodder cowpea (CO 5) at 3:2 ratio is found profitable for rainfed Vertisols of Aruppukottai.
- Tamarind and Neem trees upto 3-4 years from date of planting form an ideal tree component for agroforestry in black cotton soils of Kovilpatti. Sorghum and black gram gave higher yield even at 50 per cent of the recommended level of fertilizer application.

CROP PROTECTION

A. Pest management

- Protect nursery by applying any one of the following insecticides (in 6 litres of water) on 7th and 14th day of sowing
  - Methyl demeton 25% 12 ml
  - Dimethoate 30% 12 ml
- Plough soon after harvest, remove and destroy the stubbles.
- Treat seeds with Chlorpyriphos 20% or Phosalone 35 EC (4 ml/kg) or Imidacloprid 48FS or Imidacloprid 70WS or Thiamethoxam 30FS (10 g/kg) before sowing.
- Avoid repeated application of insecticides which may induce resurgence
- The sowing of sorghum should be completed in as short a time as possible to avoid continuous flowering which favours grain midge and ear head bug multiplication in an area.
- Set up light traps till mid night to monitor, attract and kill adults of stem borer, grain midge and ear head caterpillars.

Economic threshold level (ETL) for important pests

Insect pest	**ETL**
Shoot fly	1 egg/plant in 10% of plants in the first two weeks of sowing or 10 % dead hearts
Mite	5 mites/cm^2 of leaf area
Stem borer	10 % damage
Grain midge	5 / ear head
Ear head caterpillar	2 / ear head
Ear head bug	10 / ear head
Shoot fly *Atherigona soccata*	• Take up early sowing of sorghum immediately after the receipt of South West or North East monsoon to minimise shoot fly incidence

	• In case of direct seeding, use increased seed rate up to 12.5 kg/ha and remove shoot fly damaged seedlings at the time of thinning • In case of transplanting, transplant only healthy seedlings • Spray Dimethoate 30EC 12 ml for an area of 120 m^2 nursery • Set up fish meal trap @ 12/ha till the crop is 30 days old • Plough soon after harvest, remove and destroy the stubbles **Apply any one of the following/ha** • Carbofuran 3 CG 33.3 kg (at the time of sowing) • Dimethoate 30% EC 500 ml • Neem seed kernel extract 5% • Quinalphos 25% EC 1500 ml
Mite, *Oligonychus indicus*	Spray Quinalphos 25% EC1500 ml/ha Spray Dimethoate 30% EC 500 ml/ha
Aphids *Rhopalosiphum maidis Melanaphis sacchari*	Spray Dimethoate 30% EC 500 ml/ha
Stem borer, *Chilo partellus, Sesamia inferens*	• Sowing lab-lab / cowpea as an intercrop to minimize stem borer damage (Sorghum: Lab-lab /cowpea 4:1) • Apply Carbofuran 3 CG 17 kg/ha (with sand) to make up a total quantity of 50 kg/ha and apply in leaf whorls
Grain midge, *Contarinia sorgicola*	• **Apply any one of the following/ha on 3rd and 18th day after panicle emergence** • Dimethoate 30% 1650ml • Malathion 50% EC; 1600 ml • Malathion 5% D; 25 kg • Neem seed kernel extract 5% • Phosalone 35% 1150 ml • Phosalone 4% D 25 kg
Ear head bug, *Calocoris angustatus*	**Apply any one of the following/ha on 3rd and 18th day after panicle emergence** • Malathion 50% EC; 1000 ml • Malathion 5% D; 25 kg • Neem seed kernel extract 5%
Ear head caterpillar, *Helicoverpa*	• Set up sex pheromone traps at 12 nos./ha to attract males of *Helicoverpa armigera* from flowering to grain hardening

armigera	• Apply NPV at 1.5 X10^{12} POB along with crude sugar 2.5 kg + cotton seed kernel powder 250 g on the ear heads twice at 10 days interval (preferably during early morning or evening) **Apply any one of the following/ha on 3rd and 18th day after panicle emergence** • Malathion 5% D 25 kg • Phosalone 4% D 25 kg
Rice weevil, *Sitophilus oryzae*	• Treat seeds with Chlorpyriphos 20EC 4 ml/kg

Disease Management

Nursery practices

Seed treatment: Treat the seeds 24 hours prior to sowing with Carbendazim or Captan or Thiram @ 2 g/kg of seeds or Metalaxyl @ 6 g/ kg of seeds.

Name of the Disease	Recommendations
Rust: *Puccinia purpurea*	• Spray Mancozeb @ 1 kg/ha. Repeat fungicidal application after 10 days
Ergot or Sugary disease: *Sphacelia sorghi*	• Adjust the sowing period to prevent flowering during rainy and winter seasons • Spray Mancozeb @ 1000 g/ha or Propiconazole @ 500 ml/ha at 5 - 10% flowering and at 50% flowering stages. Repeat the spray after a week, if necessary
Head Mould: Fungal complex *Fusarium, Curvularia, Alternaria, Aspergillus* and *Phoma*sp.	• Spray Mancozeb or Captan @ 1000 g + Aureofungin sol 100 g/ha in case of intermittent rainfall during ear head emergence and repeat, if necessary a week later
Downy Mildew: *Peronosclerospora sorghi*	• Rogue out infected plants up to 45 days of sowing • Spray Metalaxyl + Mancozeb @ 500 g or Mancozeb @ 1000 g/ha after symptom development

	CIB recommendation • Seed treatment with Metalaxyl -M 31.8% ES @ 2 ml/kg of seed or slurry seed treatment with Metalaxyl 35%WS @ 2 g/ kg seed
Charcoal Rot: *Macrophomina phaseolina*	• Treat the seeds with *Pseudomonas fluorescens* @10 g/kg or *Trichoderma viride* @ 4 g/kg of seed
Grain smut : *Sphacelotheca sorghi*	**CIB recommendation** • Treat the seeds with Sulphur 80% WP @ 3-4 g/kg seed

SORGHUM - 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 100 m all around the field from the same and other varieties of the crop.
- The distance may be extended to 400 m for the presence of Johnson grass.

Season

- June - July and October - November.

Pre-sowing seed treatment

- Soak the seeds in KH_2PO_4 2 % for 16 hr at 1:0.6 ratio and dry back the seeds to original seed moisture content (8 - 9 %) under shade. This can be adopted both for the garden and dry land ecosystem.
- Soak the seed in 4% *Pseudomonas fluorescens* for 12 hr at 1:1 ratio and dry back the seeds to original seed moisture content under shade.

Fertilizer requirement

- As basal application NPK @ 100 : 50 : 50 kg / ha.

Spacing

- 45 x 10 cm.

Pre-harvest sanitation spray

- Spray 2 % Carbendazim at ten days before harvest against black mould.

Harvesting

- Seeds attain physiological maturity 40 - 45 days after 50 % flowering.
- Harvest the ear heads as once over harvest, when the seeds have attained the characteristic yellow colour.

Threshing

- Thresh the ear heads either manually or mechanically at a moisture content of 15 - 18 %.

Seed grading

- Size grade the seeds either with 9 / 64” or depending upon the variety.

Pre-storage seed treatment

- Treat the seeds with Carbendazim @ 2 g / kg.
- Treat the seeds with Halogen mixture @ 3 g / kg ($CaOCl_2$ + $CaCO_3$ + *arappu* (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 as eco-friendly treatment.

Storage

- Store the seeds in gunny or cloth bags for short term storage (8-9 months) with a seed moisture content of 10 - 12 %.
- Store the seeds in poly lined gunny bag for medium term storage (12- 15 months) with a seed moisture content of 8 - 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 %.

SORGHUM - HYBRID SEED PRODUCTION

Land requirement

- Fertile land with good drainage and irrigation facility.
- Field should not have volunteer plants. Hence, the previous crop should not be the same or different variety / hybrid of sorghum.

Isolation

- For certified / quality seed production leave a distance of 200 m all around the field from same and other varieties of sorghum.

Season

- For increased seed set and effective synchronization, sow the crop during October - November.

Planting ratio

- Sow the female and male parents in the ratio of 4:2 for foundation seed production and 5:2 for certified seed production

Border rows

- Sow the male parent in four rows around the field for the availability of adequate pollen.

Fertilizer requirement

- NPK @ 100: 50: 50 kg / ha.
- Apply NPK @ 50:50:50 kg / ha as basal; 25 kg of Nitrogen after first weeding and during boot leaf stage as top dressing.

Foliar Application

- Foliar spray of 0.5% $FeSO_4$ at primordial initiation stage and there after two sprays at ten days interval to enhance the seed set.

Synchronization techniques (Adopt any one of the following)

- Apply 1 % urea at flower initiation to the delayed parent.
- Withhold one irrigation to the advanced parent.
- Staggering the sowing of male and female parents depending upon the hybrid and location.
- Foliar spray of Cycocel (CCC) @ 300 ppm to delay the flower formation
- Foliar spray of growth retardant, MH @ 500 ppm at 45 DAS to the advanced parent.

Harvesting

- Harvest the male parent (R line) first and remove from field.
- Harvest the hybrid crop when 90 % of seeds in the ear head have attained the characteristic yellow colour.

Other management practices

The techniques recommended for varieties can be adapted.