80th SCIENTIFIC WORKERS' CONFERENCE

(AGRICULTURE, HORTICULTURE, AGRL. MARKETING, AGRICULTURAL ENGINEERING, SEED CERTIFICATION, SERICULTURE AND FORESTRY)

29 - 30 May, 2014

NOTES FOR DISCUSSION

Directorate of Research
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C O N T E N T S

RESEARCH HIGHLIGHTS 2014

I. AGRICULTURAL CROPS: VARIETY RELEASE AND BREEDER SEED PRODUCTION

Newly released varieties during 2014

RICE TPS 5

Parentage	ASD 16/ADT 37
Duration	118 days
Season	Kar and late Pishanam
Yield	6301 Kg/ha
Highest yield obtained	11,567 Kg/ha (Mohanoor, Namakkal District)
Area of adoption	Throughout Tamil Nadu during Kar and late Pishanam season except Ramanathapuram, Sivagangai and Nilgris Districts

Special features

- Moderately resistant to stem borer, leaf folder and hoppers
- Intermediate amylose content, gelatinization temperature and soft gel consistency

BLACK GRAM MDU 1

Parentage	ADB 2003 × VBG 66
Duration	70 - 75 days
Season	Exclusively for Rabi season (Purattasi pattam; September-October)
Average yield	790 kg/ ha 14.5 % increased yield over the check Co (Bg) 6 and 12.4 % over the check VBN 6
Area of adoption	All districts of Tamil Nadu except The Nilgiris, Kanyakumari, Tiruvarur & Thanjavur during Rabi season

Special features

- Good battering Quality (Arabinose 7.0 % and Globulin 12.1 %)
- Long pods (5.2 cm) with bold seeds (100 grain weight 5 g)
- Moderately resistant to YMV and pod borer

FODDER SORGHUM CO 31

Parentage	Gamma ray induced mutant of CO (FS) 29
Season	Kar and late Pishanam
Yield	Green fodder yield - 192 t / ha / yr Seed yield - 0.991 t / ha / yr Dry matter yield – 49.73 t / ha / yr
Area of adoption	All districts of Tamil Nadu

Special features

- High tillering with broad leaves
- Enhanced seed yield due to intact seeds
- Low HCN (172 ppm) and crude fibre (19.8 %)
- High dry matter yield (49.73 t/ha/yr)
- Superior ratooning ability rendering 6-7 harvests per year
- Highly palatable, preferred by milch cattle, goat and sheep

LATEST VARIETIES IN AGRICULTURAL CROPS

RICE

1. RICE CO 51

Parentage	ADT 43 / RR 272-1745
Duration	105-110 days
Grain yield	6600 kg / ha Yields 13.4 % higher over ADT 43

Special features

- Medium slender grain with superior cooking quality
- Resistant to blast, moderately resistant to RTD & sheath rot
- Non lodging

2. RICE - CO (R) 50

Parentage	CO 43/ ADT 38
Duration	130-135 days
Season	Late Samba / Thaladi
Grain yield	6338 kg /ha
Highest yield obtained	10,662 kg/ha
Area of adoption	Throughout Tamil Nadu except Virudhunagar, Ramnad, Sivaganga and Nilgiris districts

Special Features

- Moderately resistant to stem borer, leaf folder and gall midge as well as for the diseases blast, sheath blight, brown spot, BLB and RTD.under field condition.
- Medium slender white rice with intermediate amylose, soft gel consistency and moderate gelatinization temperature.
- Good quality cooked rice and also suitable for idly making.

3. TNAU RICE HYBRID CO 4

Parentage	COMS 23 A / CB 174R
Duration	130 – 135 days
Season	Late samba / Thaladi
Yield	7348 kg/ha
Highest yield obtained	11250 kg/ha 17.2% & 13.6% higher yield than CO (R) 49 and 27P11

Special feature

- Resistant to blast

4. ANNA (R) 4

Parentage	Pantdhan 10 × IET 9911
Duration	100-105 days
Yield	3700 kg/ha 14.7% increase over PMK 3

Special features

- Drought tolerant
- Semi-dwarf, erect, non-lodging
- Long slender white rice
- High head rice recovery (62.1%)
- Tolerant to blast and leaf folder

5. RICE – TRY (R) 3

Parentage	ADT 43 / Jeeraga Samba
Duration	135 days
Season	Samba / Late samba / Thaladi
Grain yield	5833 kg /ha
Area of adoption	Throughout Tamil Nadu

Special Features

- Highly suitable for 'Idli' making
- Moderately tolerant to sodicity
- High milling (71.3%) and head rice recovery (66%)
- High out turn of rice flakes (82.2 per cent)
- Resistant to major pests *viz*., leaf folder, stemborer and BPH
- Resistant to major diseases *viz*., blast, brown spot, sheath rot and sheath blight

6. TNAU RICE ADT 50

Parentage	BPT 5204 × CR 1009
Duration	150 days
Average yield	5950 kg / ha
Potential yield	10.49 t / ha

Special features

- Moderately resistant to stem borer, GLH, brown spot, blast and RTD
- Resistant to leaf folder
- Medium slender rice

7. TNAU RICE ADT 49

Parentage	CR 1009 / J.samba
Duration	135 days
Grain yield	6170 kg/ha (10.5% over BPT 5204)
Potential yield	10.25 t/ha

Special features

- Moderately resistant to sheath rot, sheath blight, blast
- Resistant to RTD
- Field tolerance to brown spot and leaf folder
- All purpose rice

II. MILLETS

1. MAIZE HYBRID CO 6

Duration	110 days
Mean yield	8300 kg/ha
Yield increase over	NK 6240 : 10 % 900 M (G): 8 %
Potential Yield	13273 kg/ha

Salient features

- Multiple disease resistance to MLB, TLB, DM, PFSR and BLSB
- High shelling (81%)
- High test weight (390g / 1000 seeds)

2. SORGHUM – CO (S) 30

Parentage	APK 1 x TNS 291
Duration	100 - 105 days
Season	Kharif, Rabi and Summer
Grain yield	Irrigated : 3360 kg /ha; Rainfed : 2800 kg / ha
Straw yield	Irrigated : 9290 kg / ha; Rainfed : 6990 kg / ha
Area of adoption	Throughout Tamil Nadu

Special features

- Dual purpose variety suited for grain and fodder
- Creamy white grains
- High dry matter digestibility
- Moderately resistant to shoot fly and stem borer
- Resistant to downy mildew

3. TNAU SORGHUM HYBRID CO 5

Parentage	ICSA 51 × TNS 30		
Duration	95-100		
Season	June-July, Sep-Oct, Feb- March		
Yield (kg/ha)		Rainfed	Irrigated
	Grain :	2769	4338
	Fodder :	7563	10548

Special features

- Dry fodder with high dry matter digestibility
- Moderately resistant to shoot fly and grain mould
- Semi loose ear heads with white grains

4. TNAU CUMBU HYBRID CO 9

Duration	75-80 days
Grain Yield	Irrigated : 3317 kg/ha Rainfed : 2905 kg/ha
Percent yield increase over	X7 Irrigated : 26.0 Rainfed : 19.0 NH07 Irrigated : 20.0 Rainfed 19.0

Special features

- Resistant to downy mildew
- High Fe content (8mg/100g)
- Acceptable cooking quality

5. RAGI CO 15

Parentage	CO 11 x PR 202 946
Duration	120 days
Grain yield	3.0 t / ha Yields 19.1 % higher over CO (Ra) 14

Special features

- Synchronized maturity and non lodging
- Resistant to neck blast and finger blast

III. PULSES

1. BLACKGRAM VBN 7

Parentage	Vamban 3 × *Vigna mungo var*. *sylvestris*
Duration	65 - 70 days
Yield	Irrigated : 961 kg / ha Rainfed : 882 kg / ha 24 % over National checks LBG 402 & LBG 17

Special features

- Resistant to yellow mosaic virus, leaf curl virus and pod borer

2. BLACKGRAM – CO (Bg) 6

Parentage	DU 2 × VB 20
Duration	60-65 days
Season	Rabi (September – October)
Yield	733 kg/ha
Area of adoption	Irrigated and medium rainfall areas of plains and hills in TN

Special Features

- Determinate plant type and non- shattering of pods
- Bold seed with mean 100 seed weight of 5.5 gram
- Good batter qualities and organoleptic traits
- Moderately resistant to mungbean yellow mosaic virus (MYMV), stem necrosis and root rot
- Field tolerance to sucking pests like aphids, stemfly and spotted pod borer

3. GREEN GRAM - CO 8

Parentage	COGG 923 x VC 6040A
Duration	55-60 days
Grain yield	845 kg/ha 20.2 % yield increase over CO (Gg) 7

Special features

- Synchronized maturity
- Suitable for single / mechanical harvest
- Resistant to mung bean yellow mosaic / stem necrosis
- Field tolerance to aphids, stemfly and spotted pod borer.

IV. OILSEEDS

1. GROUNDNUT CO 7

Parentage	ICGV 87290 × ICGV 87846
Duration	105-110 days
Pod yield	2806 kg/ha (irrigated) 16.5 % increased pod yield over VRI (Gn) 6

Special features

- High yield and high oil content - 51%
- Tolerant to drought
- Moderately tolerant to Late Leaf Spot and Rust

2. GROUNDNUT – CO (Gn) 6

Parentage	Derivative of the cross CS 9 × ICGS 5
Duration	125 -130 days
Season	Kharif rainfed (May – June)
Pod Yield	Rainfed : 1914 kg/ha
Area of adoption	Rainfed tracts of Namakkal district

Special Features

- Tolerant to drought
- Shelling outurn : 73.5 %
- Oil content : 49.5 %
- Acceptable pod traits

3. GROUNDNUT – VRI (Gn) 7

Parentage	Cross derivative of TMV 1 / JL 24
Duration	120-125 days
Season	Rainfed
Yield	1865 kg/ha (19.0% increase over TMV1 & 14.7% increase over TMV10)
Highest yield obtained	2517 kg/ha
Area of adoption	Rainfed tracts of Namakkal, Salem, Erode, Dharmapuri and Perambalur districts

Special features

- Semi spreading type
- Suited for rainfed condition
- Moderately resistant to rust and late leaf spot diseases
- Shelling: 72% and oil content: 48%
- Seed dormancy upto 45 days – non sprouting during harvest

4. GROUNDNUT – VRI (Gn) 6

Parentage	Hybrid derivative of ALR 2 / VG 9513
Duration (days)	100 – 105
Season	Rainfed: June-July Irrigated: December – January
Yield (Kg / ha)	Rainfed Irrigated 1916 2403
% increase over	VRI 2 Rainfed Irrigated 10.5 13.5

Highest yield obtained	5200 kg/ha
Area of adoption	Rainfed and irrigated tracts of Tamil Nadu. Red laterite / sandy soil

Special features

- Basal pod setting
- Tolerant to drought
- High shelling (75%) and hgh oil content (50%)
- Small pods with rose kernels
- Moderately resistant to late leaf spot, rust and peanut bud necrosis diseases

5. TNAU SUNFLOWER HYBRID CO 2

Parentage	COSF 1A × CSFI 99
Duration	85 - 90 days
Season	Kharif and Rabi / Summer
Yield	Kharif : 1950 kg/ha Rabi / Summer : 2230 kg /ha
Area of adoption	Entire Tamil Nadu

Special Features

- High oil content (39.8 %)
- High volume weight (48 g / 100 ml)

V. SUGARCANE

1. TNAU SUGARCANE Si 8

Parentage	CoC 90063 × Co 8213
Duration	300-330 days
Cane yield	146 t/ha in plant crop 14.8% superior than CO 86032

Special features

- Sugar yield :17.98 t / ha
- Moderate resistance to red rot and smut
- Tolerates early drought and late water logging
- Produces straight cane - suitable for mechanized cultivation
- High fibre content (13%) - suitable for co-generation

2. SUGARCANE – CO Si (SC) 7

Parentage	CO 99043 × COG 93076
Duration	300-330 days
Season	Early season
Yield	155 t / ha
Area of adoption	Entire Tamil Nadu

Special Features

- High cane yield, CCS% and sugar yield
- Moderately resistant to red rot and smut
- Tolerant to early drought and late water logging
- Non flowering clone suitable for early season
- Suitable for mechanical harvest

BREEDER SEED PRODUCTION

1. Varieties in seed chain

S. No.	*Crop*	*Varieties*	Total Numbers
1.	**PADDY**	ADT 36, ADT 37, ADT 38, ADT 39, ADT 42, ADT 43, ADT 44, ADT (R) 45, ADT (R) 46, ADT (R) 47, ADT (R) 48, ADT 49, ADT 50, ASD 16, ASD 19, CO 43, CO (R) 48, CO (R) 49, CO (R) 50, CR 1009, IR 36, IR 50, I.W.Ponni, TRY 1, TRY 3, TPS 3, TKM 9, Paiyur 1, PMK (R) 3, Anna (R) 4, CORH 3 Parents, CO 4 Parents	***36***
2.	**MILLETS**		
	Sorghum	APK 1, CO (S) 28, K8, CO (S) 30, Hybrid Co 5 parents	5
	Ragi	CO 13, CO (Ra) 14	2
	Bajra	CO (Cu) 9, ICMV 221, Hybrid Co 9 parents	3
	Maize	CO 1, COH(M) 5, Hybrid CO 6 parents	3
	Samai	CO (Samai) 4	1
	Varagu	CO 3	1
	Tenai	CO 6, CO (Te) 7	2
	Kudiraivali	CO (Kv) 2	1
		Millets Total	***18***
3.	**PULSES**		
	Redgram	VBN 2, VBN 3, APK 1, CO 6, CO(Rg) 7	5
	Blackgram	TMV 1, ADT 3, ADT 5, VBN 3, VBN (Bg) 4, VBN (Bg) 5, VBN 6, VBN 7, CO 6, APK 1	10
	Greengram	KM 2, ADT 3, VBN 2, VBN 3, CO 6, CO(Gg) 912 (CO7), VRM (Gg) 1	7
	Cowpea	VBN 1, VBN 2, CO 6, CO (Cp) 7	4
	Horsegram	Paiyur 2	1
	Bengalgram	CO 4	1
		Pulses Total	***28***
4.	**OILSEEDS**		
	Groundnut	VRI 2, VRI 3, CO (Gn) 4, TMV 7, TMV (Gn) 13, ICGV 00348, Co 6, VRI 6, VRI 7	9
	Sesame	VRI Sv.1, TMV 3, TMV 4, TMV 6, SVPR 1, VRI 2, TMV (Sv) 7	7
	Castor	TMV 5, TMV 6, YRCH 1 parents	3
	Sunflower	Morden, CO 4, Hybrid CO 2 parents	3
		Oilseeds Total	***22***
5.	**COTTON**	MCU 5, MCU 7, MCU 12, SVPR 2, SVPR 3, K11, KC 3, MCU 13, SVPR 4	***8***
6.	**FORAGE**	Fodder Sorghum - CO (FS) 29	***1***
7.	**VEGETABLES**	Bittergourd – CO 1, Ridge gourd – CO 1, CO 2, Tomato – PKM 1, CO 3, Cluster bean – PNB, Snake gourd – CO 2, Pumpkin – CO 1, CO 2	***9***
		Grand Total	**122**

BREEDER SEED DISTRIBUTION FROM TNAU FOR THE YEAR 2014-15

PADDY

(Unit : Kg)

Crop / Variety	Qty. under supply during 2014-15 to the Indenting agency			Total qty. produced in 2013-14 and supply during 2014-15
	State	GOI	Priv.	
I. PADDY				
ADT 36	665	-	4375	5040
ADT 37	500	-	6285	6785
ADT 38	825	-	4830	5655
ADT 39	2050	600	7270	9920
ADT 42	-	-	750	750
ADT 43	1800	800	13105	15705
ADT 44	-	50	-	50
ADT (R) 45	2070	200	11435	13705
ADT (R) 46	1375	-	3345	4720
ADT (R) 47	-	-	200	200
ADT (R) 48	245	100	-	345
ADT (R) 49	380	-	310	690
ASD 16	710	-	6285	6995
ASD 18	195	-	120	315
ASD 19	400	-	1550	1950
CO 43	375	-	2820	3195
CO (R) 48	230	-	30	260
CO (R) 49	250	-	130	380
CO (R) 50	855	-	30	885
CR 1009	2000	-	3640	5640
IR 20	-	-	1285	1285
IR 36	-	-	1000	1000
IR 50	-	650	850	1500
I.W.Ponni	915	-	4335	5250
TRY 1	-	-	1780	1780
TPS 3	50	-	-	50
TKM 9	-	-	1430	1430
Anna (R) 4	30	-	-	30
CORH 3 Parents				
TNAU CMS 2A	120	-	-	120
CB 87 R	40	-	-	40
Total	**16080**	**2400**	**77190**	**95670**

MILLETS

(Unit : Kg)

Crop / Variety	Qty. under supply during 2014-15 to the Indenting agency			Total qty. produced in 2013-14 and supply during 2014-15
	State	GOI	Priv.	
Sorghum				
CO (S) 28	22	-	-	22
APK 1	-	-	-	-
K 8	23	-	-	23
K 11	40	-	-	40
Total	**85**	-	-	**85**
Maize				
CO 1	31	-	-	31
COH (M) 6 Parents				
A line	152	-	-	152
R line	76	-	-	76
Total	**259**	-	-	**259**
Cumbu				
ICMV 221	-	-	10	10
CO (Cu) 9	68	-	-	68
Total	**68**	**-**	**10**	**78**
Ragi				
CO (Ra) 13	15	-	-	15
CO (Ra) 14	29	-	-	29
Paiyur 1	24	-	-	24
Total	**68**	-	-	**68**
Kudiraivali				
CO (Kv) 2	53	-	-	53
Total	**53**	-	-	**53**
Samai				
CO 4	31	-	-	31
Total	**31**	**-**	**-**	**31**
Varagu				
CO 3	13	-	-	13
Total	**13**	-	-	**13**
Tenai				
CO (Te) 7	16	-	-	16
Total	**16**	**-**	**-**	**16**
Millets Total	**593**	**-**	**10**	**603**

PULSES

(Unit : Kg)

Crop / Variety	Qty. under supply during 2014-15 to the Indenting agency			Total qty. produced in 2013-14 and supply during 2014-15
	State	GOI	Priv.	
Redgram				
VBN 2	95	-	-	95
VBN 3	102	-	-	102
APK 1	64	-	-	64
CO 6	60	-	-	60
CO(Rg) 7	300	987	-	1287
Total	**621**	**987**	**-**	**1608**
Blackgram				
CO 6	140	-	-	140
VBN (Bg) 3	790	-	145	935
VBN (Bg) 4	460	500	595	1555
VBN (Bg) 5	100	-	185	285
VBN (Bg) 7	80	-	-	80
TMV 1	540	-	-	540
ADT 3	600	-	40	640
ADT 5	700	-	445	1145
Total	**3410**	**500**	**1410**	**5320**
Greengram				
VBN (Gg) 2	270	185	560	1015
VBN (Gg) 3	190	580	80	850
ADT 3	260	-	30	290
CO 6	424	-	-	424
CO (Gg) 7	400	1140	140	1680
VRM (Gg) 1	180	-	-	180
KM 2	-	-	40	40
Total	**1724**	**1905**	**850**	**4479**
Cowpea				
CO 6	40	-	-	40
CO (CP) 7	450	600	-	1050
VBN 1	50	-	-	50
Total	**540**	**600**	**-**	**1140**
Horsegram				
Paiyur 2	300	-	-	300
Total	**300**	**-**	**-**	**300**
Bengalgram				
CO 4	200	-	-	200
Total	**200**	**-**	**-**	**200**
Pulses Total	**6795**	**3992**	**2260**	**13047**

OILSEEDS

(Unit : Kg)

Crop / Variety	Qty. under supply during 2014-15 to the Indenting agency				Total qty. produced in 2013-14 and supply during 2014-15
	State		GOI	Priv.	
	Kharif	***Rabi****			
Groundnut					
TMV 7	3980	6020	-	-	10000
VRI 2	4800	4800	5000	-	14600
VRI 3	-	-	-	-	-
VRI (Gn) 6	1480	400	-	-	1880
CO (Gn) 4	1300	1900	-	-	3200
CO (Gn) 6	560	440	-	-	1000
TMV (Gn) 13	11690	4640	1500	-	17830
ICGV 00348	-	-	1000	-	1000
Total	**23810**	**18200**	**7500**	**-**	**49510**
Sesame					
VRI Sv. 1	-	10	-	**-**	10
SVPR Sv.1	24	71	-	**-**	95
TMV 3	55	72	-	30	157
TMV 4	109	-	-	60	169
TMV 6	6	218	-	40	264
TMV 7	2	-	-		2
Total	**196**	**371**	**-**	**130**	**697**
Sunflower					
CO 4	50	-	-	-	50
CO (SFV) 5	-	50	1	-	51
Morden	45	5	-	-	50
Total	**95**	**55**	**1**	**-**	**151**
Castor					
TMV 5	-	-	-	-	-
TMV 6	10	-	-	-	10
Total	**10**	**-**	-	-	**10**
Oilseeds total	**24111**	**18626**	**7501**	**130**	**50368**

COTTON & FORAGE CROPS

(Unit : Kg)

Crop / Variety	Qty. under supply during 2014-15 to the Indenting agency			Total qty. produced in 2013-14 and supply during 2014-15
	State	GOI	Priv.	
COTTON				
MCU 5	15	10	-	25
MCU 7	5	20	-	25
MCU 12	-	-	-	0
SVPR 2	20	-	-	20
SVPR 3	10	-	-	10
SVPR 4	5	-	54	59
Total	**55**	**30**	**54**	**139**
FORAGE CROPS				
Sorghum				
CO (FS) 29	-	275	-	275
Total	**-**	**275**	**-**	**275**

VEGETABLE CROPS

(Unit : Kg)

Crop / Variety	Qty. under supply during 2014-15 to the Indenting agency			Total qty. produced in 2013-14 and supply during 2014-15
	State	GOI	Priv.	
1.Tomato				
PKM 1	-	-	3	3
Total	**-**	**-**	**3**	**3**
2. Snake gourd				
CO 2	-	-	3	3
Total	**-**	**-**	**3**	**3**
3. Ash gourd				
CO 2	-	-	2.5	2.5
Total	**-**	**-**	**2.5**	**2.5**
4. Ridge gourd				
PKM 1	-	-	0.5	0.5
Total	**-**	**-**	**0.5**	**0.5**
5. Bittergourd				
CO 1	-	-	1.5	1.5
Total	**-**	**-**	**1.5**	**1.5**
6. Chillies				
K 1	-	-	6	6
K 2	-	-	9.5	9.5
PKM 1	-	-	1	1
Total	**-**	**-**	**16.5**	**16.5**
7. Clusterbean				
PNB	-	-	100	100
Total	**-**	**-**	**100**	**100**
8. Bhendi				
Arka Anamica	-	-	5	5
Total	**-**	**-**	**5**	**5**
Grand Total	**-**	**-**	**132**	**132**

II. IMPROVEMENT AND MANAGEMENT OF HORTICULTURAL CROPS

FRUIT CROPS
CROP MANAGEMENT

1. Grapes

In grape, a new Californian variety 'Red Globe' was introduced at Coimbatore for studying the performance to replace the existing variety Muscat (or) Paneer. Against the conventional practice of allowing fruiting in all the canes of a vine, allowing fruiting in 50% of the canes and vegetative growth in remaining 50% of the canes was found to give the highest cumulative yield of 38.2 kg / vine against 31.5 kg in conventional method.

2. Banana

In banana cv. Rasthali, application of 100% RDF (110 : 35 : 330 g NPK / plant; N & K 3 splits at 3,5,7th month, full dose of P at 3rd month) along with *Arbuscular mycorrhiza* fungi (250 g / plant) + Phosphate Solubulishing Bacteria (PSB) (50 g / plant) + *Azospirillum* (50 g / plant) + *Trichoderma harzianum* (50 g / plant) recorded the highest bunch weight (11.49 kg), with the least *Fusarium* wilt incidence (5.53%) as compared to control which recorded a bunch weight of 8.53 kg and wilt incidence of 13.86%. The cost benefit ratio was 1 : 2.87 in this treatment schedule as against 1 : 2.41 in control.

VEGETABLE CROPS
CROP IMPROVEMENT

1. Bhendi hybrid CBhH 2

CBhH 2 is a high yielding F_1 hybrid. Fruits are slender, dark green with 14.1 cm length. Each plant produces about 27.8 fruits. Yield potential of the hybrid is 24.1 t/ha which is 28.4 % increase over Sakthi. This hybrid is resistant to YVMV disease as well.

2. Bhendi hybrid CBhH 3

The bhendi hybrid CBhH 3 is a F_1 hybrid with the yield potential of 25.6 t/ha which is 32.6 % increase Sakthi. Fruits are slender, dark green with 15.4 cm length. It produces 28.9 fruits per plant. This hybrid is also resistant to YVMV disease.

4. Snake gourd hybrid CSgH 1

CSgH 1 is a high yielding short fruited F_1 hybrid developed by crossing Kethanur Local X CO2. Fruits are fleshy, greenish white with white streaks having 32.7 cm length and 24.1 cm width. Each vine produces on an average of 61 fruits each weighing 360 g. It yields on an average of 57.65 t / ha which is 60 % increased yield over BSS 694.

5. Ridge gourd hybrid CRgH 1

CRgH 1 is a high yielding F_1 hybrid between IC 410147 and IC 373361. The fruits are cylindrical medium size with 30.5 cm length and 15.55 cm girth weighing 200-250 g. Each plant produces on an average 26 fruits. It yields on an average of 27.0 t/ha which is 35.15 % increase yield over Ankur Latha.

CROP MANAGEMENT

1. Grafting in brinjal

Grafted brinjal can be developed by using seedlings of non bitter *Solanum torvum* 09 – 05 as a rootstock with the seedlings of desirable variety or hybrid of brinjal in uniform stem thickness as a scion by wedge grafting. The grafts will be ready for planting in 40-45 days after sowing. Optimum spacing for planting grafted brinjal in the main field is 1.0 x 1.0 m with the population of 10,000 plants / ha. Crop duration is about six months. After that, two ratoons can be possible. The duration of each ratoon crop is four months. Yield potential of main crop when COBH2 used as scion is 90.2 t/ha and 60.0 t/ha in the ratoon crop. Recommended dose of fertilizer is 250:187.5: 125 kg NPK/ ha. The grafted plant is resistant to root knot nematode and dry root rot.

SPICES AND PLANTATION CROPS
CROP IMPROVEMENT

1. TURMERIC: *CO 2*

The high yielding turmeric culture CL 101 is evolved with high rhizome yield potential of 42 tonnes per ha with a curcumin content of 4.20 percent which is 28.25 per cent higher yield over check variety BSR-2. CL 101 is field tolerant to thrips, shoot borer, leaf folder and scale insect and moderately resistant to leaf blotch and leaf spot and also highly resistant to rhizome rot. It is recommended for Coimbatore, Erode and Salem districts of Tamil Nadu.

CROP MANAGEMENT

1. TURMERIC

Rapid multiplication of turmeric using portray (Single bud rhizome)
Constraints in conventional method

- Scarce in quality planting material
- Requirement of planting material (seed rhizome) per ha is high (2.5 t/ha)
- High cost of planting material (Rs. 75,000 to Rs. 1,00,000/ha)
- Crop establishment is 80%
- Rhizome developed five months after planting

Need for Rhizome single bud method

Characters	Direct planting method	Transplanting method
Propagation through	Whole Rhizome	Rhizome single bud
Seed rate	2500 kg/ac	750 kg/ac
Cost of planting material	Rs.12,000 /-	Rs. 3,600 /-
Crop establishment	75 - 80%	95 -100 %
Rhizome development	Starts 5 months after planting	Starts 2 months after planting
Productivity	10 - 12 tons/ac	20 - 22 tons/ac

Rapid multiplication of turmeric using rhizome single bud (Stepwise procedure)

1. Drying of rhizomes (1 – 1½ months)
2. Rhizome treatment (Carbendazin @ 2 g/l + Monocrotophos @ 2 ml/l)
3. Entire buds were covered with cocoapeat
4. Rhizome pieces with single bud were placed in palm mat.

5. Water was sprinkled over the beds and kept for 4 days
6. Rhizomes were cut into small pieces with single bud
7. After bud emergence, the rhizome buds were sown in protray (Cocoapeat (100g) + *Pseudomonas fluorescens* (5g)).
8. Covered the trays with polythene sheets upto 7 days
9. Covers were removed (sprouting was completed).
10. Protrays were kept under shade net and watered regularly
11. After one leaf sprouting, spraying of humic acid (0.5 %).
12. Seedlings ready for transplanting within 25 – 30 days.

2. CASHEW

Effect of pruning and foliar spray in Cashew - Variety - VRI 3

A technology has been standardized on pruning and foliar spray schedule to increase the current season's shoot, flowering and yield in cashew. The technology consisted of pruning tertiary branches every year during June-July to induce more number of current season's shoots followed by a foliar spray schedule. The foliar spray schedule consisted of NPK 19:19:19 @ 1 % at new flush stage (August), Mono-ammonium phosphate @ 1 % + boron 0.1 % at flowering stage (December) followed by third spray of TNAU Panchagavya 3 % at fruit set stage (Jan.-Feb.).

. This technology has resulted in a yield increased by 42 per cent. BCR of 5.3. Partial budgeting analysis has revealed an additional returns of Rs.11,640 per acre over and above the control due to the adoption of this technology. On-farm trials conducted in farmer's field resulted in 36.5 per cent yield increase over the previous years.

Tertiary shoot pruning
+
Foliar application of NPK mixture during June – July
+
Mono ammonium phosphate (MAP)1 % + boron 0.1 % during flower initiation
+
Panchagavya 3 % spray during fruit set

Result

Nut yield – 6.55 kg/tree
Control – 4.00 kg/tree

3. COCONUT

At CRS Veppankulam, among the tall x tall hybrids evaluated, LCOT x CCNT recorded the highest cumulative mean nut yield of 150 nuts for a period of 10 years from the stabilized yielding period and was found to be superior.

FLORICULTURE & LANDSCAPING
CROP MANAGEMENT

1. Export packaging technology for jasmine

An export packaging technology was developed with the objective of minimizing the high post harvest losses (40%) encountered in jasmine flowers during transit. Details of the technology are

- Harvesting Jasmine buds early in the morning before 7.00 a m at fully developed tight bud stage.
- Making them into strings of 30 cm length
- Dipping in 4% boric acid
- Thus treated jasmine strings are surface dried and five pieces of strings are packed in a small aluminium lined cardboard box of dimension 11x13.5 x4 cm

- These boxes are then packed in a larger thermocole box of dimension 60 x 45 x 30 cm lined with aluminium foil in three layers comprising of 24 boxes with 8 boxes per layer
- Ice gel sheets are placed in between each layer
- Finally, the top layer is covered with aluminium foil and the boxes are closed and covered with brown sealing tape and are airlifted to the USA market.
- This technology has been filed for patent (Patent No.1370/CHE/2010 dt. 14.05.2010).

Packaging technology for Export of Jasmine

OTHER TECHNOLOGIES

1. Improved dry flower processing technologies

The following improved processing technologies have been standardized for dry flower making.

i) Delicate flower species suitable for freeze drying

Carnation and jasmine flowers were found suitable for freeze drying. These flowers recorded optimum percentage of moisture loss and scored better for quality parameters (colour and shape retention).

ii) Glycerinisation technique for fragile leaves

Glycol preservation with 30 % Glycerine followed by 30 % Ethylene glycol was found ideal for glycerinization of foliage of My*rtus* sp., *Thuja orientalis, Eucalyptus glaucescens and Asparagus virgatus. This treatment resulted in* ***soft foliage with natural appearance and maximum colour and shape retention.***

iii) Bleaching techniques to achieve varying degree of whiteness

The following bleaching techniques were developed for plant parts of *Acacia auriculiformis, Pongamia glabra, Gossypium hirsutum, Pinus spp. and Sesamum indicum.*

- **For half whiteness:** Single step bleaching with 20% Sodium chlorite + 5 % Hydrochloric acid proved superior with minimum bleaching time of 6 h resulting in the required degree of half whiteness and maximum scores for shape retention with minimum percentage of damage.

- **For super whiteness** Double step bleaching with a first step bleaching with 30% Sodium chlorite + 5% HCl followed by the second step bleaching with 30% of first dip + 40% Hydrogen peroxide proved superior with minimum bleaching time and maximum super whiteness with highest whiteness index and minimum percentage of damage and brittleness.

iv) Dyeing techniques with mordant to improved fastness property

Treatments involving 2g dye with 5% Alum mordant for 3 minutes resulted good colour strength with maximum scores for rubbing, washing and light fastness properties**.**

MEDICINAL & AROMATIC CROPS
CROP IMPROVEMENT

1. COLEUS

Promising culture – *Cf* 36

The promising culture *Cf* 36 is a selection from Theni local and propagated through terminal cuttings. The salient features of the culture are high yield and high alkaloid content .It recorded 1.98 tonnes of dry tuber/ha with 0.54% of forskohlin content and 32.89 % increased yield over the local type. It is tolerant to root rot, wilt diseases and nematode.

III. CROP MANAGEMENT TECHNOLOGIES

Rice cum green manure seeder

Farmer may not come forward to go for separate cultivation of green manure. If green manure cultivation is incidental it can be promoted. On this basis rice – cum – green manure seeder has been developed at TNAU. The advantage is no separate cultivation of green manure and serves as good weed control measure.

Rice cum dhaincha seeder

A manually-drawn seeder developed at TNAU to sow pre-germinated paddy and green manure crop (*Sesbania aculaeta*) in alternate rows on puddle soil. On attaining a height of 40 cm after about one month of sowing, the dhaincha crop was trampled using long handled IRRI design cono-weeder which simultaneously does the weeding operation. The seeder sows four paddy rows and four dhaincha rows in a single pass. Using one (male) operator and two women labourers half of ha can be sown with the seeder in a day of 8 hours. Paddy was sown at 60 kg/ha seed rate and green manure crop at 20 kg/ha seed rate. The distance between the adjacent rows is 12.5 cm. When compared to sole wet seeded rice, weeds are better controlled in the wet seeded rice inter-cropped with green manure. Also intercropping of rice with green manure dhaincha and incorporation at 7.0 t/ha enhanced the growth and yield of rice and beneficial in terms of N addition (40 kg N /ha). There is greater possibility of intercropping green manures during early stage of rice crop with increased grain yield by one tones / ha.

Weed management in rice

Transplanted rice

- Pre-emergence application of butachlor 0.75 kg a.i. ha^{-1} + bensulfuron methyl 50 g ha^{1} on 3 DAT + HW on 45 DAT recorded higher WCE, yield and economic returns in transplanted rice.
- Pre emergence butachlor 1.0 kg a.i. ha^{-1} on 3 DAT + finger type single row or double row rotary weeders weeding on 45 DAT resulted in higher grain yield and net profit. If pre-emergence herbicide is to be avoided then finger type single/ double row rotary weeders weeding 20 and 40 DAT.

Wet seeded rice

- Pre-emergence pretilachlor 0.45 kg ha^{-1} on 3 DAS + two row rotary weeder weeding on 45 DAS in wet seeded rice resulted higher grain yield, net monetary return and B:C ratio.

Drum seeded rice

- Combination of drum seeded rice intercropped with green manure (dhaincha) along with pre-emergence herbicide application of pretilachlor (30.7 EC) @ 0.45 kg ha^{-1} + safener on 5 DAS was the best weed control method on the

basis of better weed control, crop yield and economic indices in drum seeded rice.

Aerobic rice

- Higher crop yield and B:C ratio were obtained with PE pendimethalin 1kg ha^{-1} on 3 DAS + single tyne sweep weeder weeding on 45 DAS.

Drip fertigation technology with WSF for maize- bhendi cropping sequence

- Drip irrigation at 100 per cent PE enhanced the productivity of maize and bhendi besides saving of irrigation water.
- Drip fertigation at 150 per cent RDF with P as WSF (urea phosphate) enhanced the productivity of maize and bhendi. Benefit cost ratio was less at this fertigation level due to high cost of water soluble fertilizer.
- The productivity of maize and bhendi crops under drip fertigation at 75 per cent RDF with P as WSF was comparable with that of 125 per cent RDF with P as soil application. Thus drip fertigation with all the three major nutrients resulted in substantial saving of nutrients.
- To realize higher productivity in maize - Bhendi cropping sequence, drip irrigation at 100 per cent PE with a fertigation schedule of 150 per cent RDF (225:113:113 NPK kg ha^{-1}) with P as WSF is found to be a promising option. Though the productivity of maize and Bhendi is enhanced considerably under drip fertigation, the high cost of water soluble fertilizers is a limiting factor to realize higher net return.

Drip fertigation schedule for Bt cotton

- Drip fertigation with WSF at 125 % RDF was registering higher seed cotton yield of 4118 kg ha^{-1} as compared to 100 and 75 per cent doses as well as drip fertigation with CF at 100 per cent RDF.

Fertigation technology for maximizing cane yield in Sugarcane

- Drip fertigation with WSF at 125% NPK recommended dose increased the cane yield upto 206.45 t ha^{-1} at 125% NPK dose and sugar yield 31.05 t $ha^{-1}$with a Commercial Cane Sugar of 15%

Fertigation technology for maximizing yield in Banana

- Drip irrigation once in 2 days along with fertigation at 75% NPK with WSF has registered a fruit yield of 35.1 t ha^{-1}, which was 37 % increase over control (25.6 t ha^{-1}) with water saving of 47% as compared to conventional irrigation and soil application of normal fertilizer at 100 % dose.

Alternate Wetting and Drying Irrigation(AWDI) – A water saving technology for Rice

- Alternate Wetting and Drying may be a well known terminology with regard to rice irrigation.
- Alternate Wetting and Drying(AWD) technique of irrigation and found out that the safe AWD threshold of 15 cm as the suitable depletion level for sustained productivity.
- The threshold of 15 cm water depth (below the surface) before irrigation is called ‘Safe AWDI”as this will not cause any yield decline.
- A practical way to implement AWDI is to monitor the depth of ponded water on the field using a ‘field water tube’.
- After irrigation, the depth of ponded water will gradually decrease.
- When the ponded water has dropped to 15 cm below the surface of the soil, irrigation should beapplied to re-flood the field with 5 cm of ponded water.

- From one week before to one week after flowering, ponded water should always be kept at 5 cm depth.
- After flowering, during grain filling and ripening, the water level can drop again to 15 cm below the surface before re irrigation. AWD can be started a few days after transplanting.

The field water tube

- A tube can be made of 40-cm long plastic pipe or bamboo,and have a diameter of 15 cm or more so that the water table is easily visible.
- Perforate the tube with holes on all sides. Dig the tube in the soil so that 20 cm protrudes above the soil surface.
- Take care not to penetrate through the bottom of the plow pan. Remove the soil from the inside so that the bottom of the tube is visible.
- Check that the water table inside the tube is the same as outside the tube.
- The tube can be placed in a flat part of the field close to a bund, so it is easy to monitor the ponded water depth. Successful AWD rice needs adapted varieties, robust grass weed control, and careful nitrogen management and soil selection.

Salient features of the Technology

- **Higher paddy productivity:** AWDI reduced water-use by 40-70% without significant loss in yield. The introduction of AWDI not only reduced water-requirements, but also increased paddy yields
- **Improvement in paddy environment:** AWDI practice supplies enough oxygen to the rice-roots and induces an oxidized condition of soil. The oxidation - reduction potential under AWD conditions was always higher after about 30 days of transplanting than those under continuous flooding condition.. AWDI practices lead to a sound ecological environment for rice.
- **Higher Nutrient Use Efficiency:** Nitrogen recovery efficiency of the field with AWDI technique was comparatively higher than that with traditional irrigation-system. Total losses of N from paddy-fields with AWDI were lower than those with continuous flooding. The lower temperature at night in paddy fields under AWDI was favourable for absorption of nutrients of rice-plant.
- **Better Utilization of Rainwater:** The capacity of paddy fields to store rainfall increased greatly with AWD practice. With the heavier rainfall, higher utilization of rainfall was observed. The efficient rainfall-use reduced the use of irrigation-water. Moreover, the drainage-water was reduced.
- **Less Infestation/Population of Insect Pests:**. Higher levels of water in paddy-fields were conducive for proliferation of the brown plant hopper

Redgram Transplanting

Possible areas of adoption in Tamil Nadu and varieties

- In areas receiving both monsoons like Vellore, Thiruvannamalai, Dharmapuri, Krishnagiri, Thiruvallur, Namakkal, Perambalur and Pudukottai districts, this practice may be tried with long duration varieties like Co 6, LRG 41 (180 – 200 days)
- In monomodal rainfall receiving Districts like Erode, , Karur, Trichy Madurai, Theni, Dindigul, Viruthunagar, Thoothukudi, and Villupuram, this practice may be tried with varieties like Co(Rg)7 maturing in 120-135 days

Management techniques

- Select only long duration redgram varieties
- Transplant before August either under rainfed or under irrigated condition
- Select poly bag with a size of 6x4 inches and 200 micron thickness

- Fill the poly bag with native soil: Sand: FYM @1:1:1 and put 3-4 holes in the bottom to avoid water stagnation
- Soak the seeds in 0.2% Calcium chloride for one hour and dry it under shade for 7 hours to harden the seeds
- Treat the hardened seeds with *T. viride* @ 4g/kg and 100 g Rhizobium and 100 g phosphobacterium. Sow the seeds @ 2/poly bag at 1 cm depth
- Sow the seeds in polybags 30-45 days prior to transplanting
- Age of seedlings is 20-25 days for short duration and 30-35 days for long duration redgram varieties.
- In medium to deep soils for raising long duration varieties, dig 15 sqcm pits at 5' X 3' for pure crops and 6' x 3' for intercropping under irrigated condition. In rainfed conditions dig the pits at a spacing of 5'x3'. For short duration varieties dig 15 sq cm pits at 3' x 2' spacing.
- Under water logging condition, form furrows before digging pits
- Apply inorganic fertilizers @ 25:50:25 kg NPK /ha at 20-30 days after planting around the seedlings
- Apply ZnSO4 @ 25 kg/ ha as basal along with FYM or sand
- Nip (removal of top 5 cm) the plants at 20 – 30 days after planting to arrest the terminal growth
- Spray planofix @ 0.5 ml/litre to control flower dropping

Performance of transplanted pigeonpea (Co 6) under drip fertigation

Direct sowing Single row
150 x 60 cm

Transplanted Single row
150 x 60 cm

Inter-cropping of redgarm

- Raising one row of long duration redgram varieties as inter crop for every six rows of groundnut (6:1 for rainfed crops.
- Raising one row of short and medium duration redgram as inter crop for every four rows of groundnut (4:1) for rainfed as well as for irrigated crops.
- Cotton+ Redgram
- Sugarcane+ soybean/greengram/ blackgram
- Urdbean+ Maize (2:2 ratio)
- Urdbean grain equivalent yield: 1152 kg/ha , LER (1.41) and B:C ratio (3.02).
- Blackgram + maize (1:1 ratio)
- Maize grain equivalent yield: 5349 kg/ha, LER:1.46, BC ratio : 2.43
- Redgram + Greengram (1:3 ratio) in sandy clay loam soil under irrigated situation
- Pigeonpea yield : 1630, Greengram yield: 303 kg/ha, PEY: 2059 kg/ha, LER: 1.34, Net income: Rs. 43,915/ ha and B:C ratio: 3.14).

Bund cropping of redgram

Variety	:	BSR 1
Economic uses	:	Tender beans are pinkish green in colour and can be cooked as curry or added to *Kurma* or *Sabji.* When the beans mature they can be used as d*hal*. Recommended for growing in kitchen gardens, backyards, farm road sides, as border crop in sugarcane, banana and betelvine and as a shade crop in turmeric and as a bund crop in paddy double cropped wetlands.
Season	:	June – July
Height of the plant	:	150 - 200 cm
Number of branches	:	7 - 10
Flowering	:	Five months from date of sowing
Pit Size	:	Small pits are dug 90 cm apart and the pits are filled with a mixture of well decomposed manure or compost and soil.
Fertilizer application	:	Urea 15 g and superphosphate 30 g / pit.
Planting methods	:	Two to three seeds are dibbled per pit and watered. When they grow six inches height one plant may be retained in each pit.
Irrigation	:	Need based
Harvesting	:	If harvested when the pods are tender the beans will be fit for making curry. Each plant will yield two to three kg of green pods at an average seed yield of 750 g to one kg per plant. After the first harvest the branches are pruned and allowed to grow further. In another 45 - 60 days the plants produce the second flush. For pure crop, about 3 kg of seeds may be required

Management technologies for normal, deficit and excess rainfall condition

A. Rice

Normal rainfall condition

1. Machine transplanting in rice

- Levelling with laser leveller
- Upgrading of seed quality by removal of ill-filled and immature seeds using specific gravity and pre-sowing seed treatment with 1% KCl for 16 hrs
- Planting 14-16 day old seedlings with machine planting
- Pre emergence application of Pretilachlor at 1.0 Kg a.i. /ha on 3 DAT + one Hand weeding on 45 DAT.
- Alternate wetting and drying method of irrigation. (Irrigation at 5 cm depth when the standing water is 15-20 cm below the surface - using perforated PVC pipes)
- Application of 2 kg of *Azospirillum* and 2 kg of Phosphobacteria (or) 4 kg of Azophos inoculants per hectare with 25 kg FYM and 25 kg of soil in the main field before transplanting
- Application of *Pseudomonas fluorescens* (Pf 1) at 2.5 kg/ha mixed with 50 kg FYM and 25 kg of soil before transplanting.

- Application of inorganic fertilizers as per soil test recommendations. The N and K are to be applied in four equal splits viz., basal, tillering, panicle initiation and heading stages and phosphorus as single dose at basal.

2. Wet seeded rice

- Direct seeding with drum seeder using pre germinated seeds in puddled soil.
- Pre-emergence application of pretilachlor 0.75 kg a.i. /ha on 8 DAS or pretilachlor + safener (Sofit) at 0.45kg a.i. /ha on 3-4 DAS followed by one hand weeding on 40 DAS
- Controlled irrigation (thin film at sowing, 2.5 cm depth upto panicle initiation, 5 cm during flowering stages)
- Application of 2 kg of *Azospirillum* and 2 kg of Phosphobacteria (or) 4 kg of Azophos inoculants per hectare with 25 kg FYM and 25 kg of soil in the main field before transplanting
- Application of *Pseudomonas fluorescens* (Pf 1) at 2.5 kg/ha mixed with 50 kg FYM and 25 kg of soil before transplanting.
- Application of inorganic fertilizers as per soil test recommendations. The N and K are to be applied in four equal splits viz., basal, tillering, panicle initiation and heading stages and phosphorus as single dose at basal.

Deficit rainfall condition

1. Dry Direct Seeding

- Upgrading of seed quality by removal of ill-filled and immature seeds using specific gravity
- Seed hardening with 1% KCl for 16 hrs
- Dry direct sowing with tractor drawn seed cum fertilizer drill
- Land leveling with laser leveler
- Application of pendimethalin 1.0 kg a.i. /ha on 5 days after sowing or Pretilachlor + safener (Sofit) 0.45 kg a.i. / ha on the day of receipt of soaking rain followed by one hand weeding on 30 to 35 days after sowing.
- Foliar spray of KCl 1% during moisture stress periods
- Foliar spray Cycocel 1000 ppm (1 ml of commercial product in one lit. of water) under water deficit situations to mitigate ill-effects.
- Application of Pink Pigmented Facultative Methylotroph (*Methylobacterium* sp.) as seed treatment (@ 200 g / 10 kg seeds), soil application (@ 2 kg / ha) and foliar spray (@ 500 ml / ha) at panicle initiation and flag leaf stages for alleviation of water stress effects.

Excess rainfall condition

- Proper drainage facilities may be created to drain the excess rainwater
- Topdressing of nitrogenous fertilizer after the rainfall event

2. Maize

Normal rainfall condition

- Adopt a spacing of 60 cm between rows and 25 cm between plants in the row.
- Population : 6 -7plants/m^2
- Apply PE Atrazine @ 0.25 kg/ha on 3-5 DAS followed by power weeder weeding on 30-35 DAS
- Application of fertilizer based on STCR recommendation
- Apply 25 %N and full dose of P_2O and K_2O as basal, with Azospirillum (10 packets/ha).
- 50 % of N as top dressing at 25^{th} day and 25% on 45^{th} day.

- Apply TNAU MN mixture @ 7.5 kg /ha as Enriched FYM .
- Foliar spray of Maize maxim @ 7.5 kg/ha at tasselling and grain filling
- Drip irrigation wherever possible

Deficit rainfall conditions

- Summer ploughing
- Sowing in ridges and furrows
- Adopt a spacing of 45 cm between rows and 20 cm between plants in the row.
- Population: 11plants/m^2
- Apply PE Atrazine @ 0.25 kg/ha on 3-5 DAS depending on moisture availability.
- If STCR recommendation is not available, adopt a blanket recommendation of 60 : 30 : 30 NPK kg/ha for Alfisols and 40 :20 : 0 NPK kg/ha for Vertisols.
- Apply half of N and full dose of P_2O and K_2O with enriched FYM as basal along with Azospirillum (10 packets/ha).
- Top dress remaining half of N at tasseling.
- Apply TNAU MN mixture @ 7.5 kg /ha as Enriched FYM .
- Foliar spray of Maize maxim @ 7.5 kg/ha at tasselling and grain filling
- PPFM @ 500 ml/ha as foliar spray during moisture stress

3. Sorghum

Normal rainfall condition

- Adopt a spacing of 45 cm between rows and 15 cm between plants in the row.
- Population : 15 plants/m^2
- Apply PE Atrazine @ 0.25 kg a.i./ha on 3-5 DAS followed by weeding on 30-35 DAS
- If STCR recommendation is not available, adopt a blanket recommendation of 90:45:45 NPK kg/ha.
- Apply 25 %N and full dose of P_2O and K_2O as basal, with Azospirillum (10 packets/ha).
- 50 % of N as top dress at 25^{th} day and 25% on 45^{th} day.
- Apply TNAU MN mixture @ 7.5 kg /ha as Enriched FYM

Deficit rainfall condition

- Summer ploughing
- Premonsoon sowing
- Adopt BBF for vertisols and Compartmental bunding for alfisols
- Presoaking of seeds in 2% potassium dihydrogen phosphate solution (20 g in one litre of water) for 6 hours
- Adopt higher seed rate @15 Kg/ha
- Adopt a spacing of 45 cm between rows and 15 cm between plants in the row.
- Population : 15 plants/m^2
- Mulching with crop residues @ 5t/ha
- Apply PE Atrazine @ 0.25 kg/ha on 3-5 DAS depending on moisture availability followed by weeding on 30-35 DAS
- Adopt a blanket recommendation of 40 : 20 : 0 NPK kg/ha
- Apply as half N as enriched FYM as basal along with Azospirillum (10 packets/ha).
- Apply TNAU MN mixture @ 7.5 kg /ha as Enriched FYM .
- Foliar spray of 1% KCl during moisture stress

4. Pearl millet

Normal rainfall condition

- Summer ploughing
- Seed treatment with 2% KCl or 3% NaCl for 16 hours followed by 5 hours shade drying
- Adopt a spacing of 45 cm between rows and 15 cm between plants in the row.
- Population : 15 plants/m^2
- Adopt a blanket recommendation of 70:35:35 kg/ha NPK for varieties and 80 :40: 40 kg/ha NPK for hybrids (Supplemental Irrigation)

Deficit rainfall condition

- Summer ploughing
- Seed treatment with 2% potassium chloride or 3% Nacl for 16 hours followed by 5 hours shade drying
- Adopt a spacing of 45 cm between rows and 15 cm between plants in the row.
- Population : 15 plants/m^2
- Adopt a blanket recommendation of 52.5 : 26 : 0 NPK kg/ha for varieties and 60 :30 : 0 NPK kg/ha for hybrids.
- Reducing 25% plant population during long dry spell

5. Small millets

Normal rainfall condition

- BBF in black soils and Compartmental bunding in red soils
- Seed hardening with 1% KCl solution.
- Spacing – 25 x 10 cm
- Plant population 4.0 lakh/ha.
- Azophos @ 2 kg/ha
- FYM / Compost / Composted coir pith : 12.5 t/ha
- Harvest at physiological maturity
- Intercropping of cowpea/ blackgram/lablab @ 8:2 or 4:1

Deficit rainfall condition

- Summer ploughing
- Ploughing across the slope
- Selection of early maturing varieties
- Seed hardening with 1% Kcl
- Adopt a spacing of 25 cm between rows and 10 cm between plants in the row.
- Adopt a blanket recommendation of 40 :20 : 0 NPK kg/ha.
- Potassium sulphate 1%spray during flowering
- PPFM @ 500 ml/ha as foliar spray during moisture stress
- Mulching with crop residues @ 5 t/ha
- Supplemental irrigation wherever possible
- Reducing 25% plant population during long dry spell
- Intercropping of cowpea/ blackgram/lablab @ 8:2 or 4:1

6. Pulses

i. Rice fallow pulses

Normal rainfall condition

Management Strategies for Blackgram and Greengram- Rice fallow pulses are given below:

- Maintaining optimum Plant population increased seed rate (30 kg/ha)
- Weed management: Grassy weeds: Quizalofop ethyl @50 g a.i./ha
- Broad Leaved Weeds: Imazethapyr @50 g a.i./ha
- Foliar nutrition through TNAU Pulse wonder @ 5 kg/ha at flowering (or) DAP 2% spray twice at flowering and 10 days there after

Deficit rainfall condition

- Supplemental irrigation through mobile sprinklers to mitigate moisture stress during crop growth stages.
- Foliar nutrition and PPFM spray

ii. Summer irrigated pulses

Normal rainfall condition

- **Weed management:** PE - Pendimethalin @ 0.75 kg/ha; for grassy weeds: EPOE Quizalofop ethyl @50 g a.i./ha on 15 DAE of weeds; for broad leaved Weeds: EPOE Imazethapyr @50 g a.i./ha on 15 DAE of weeds
- **INM**: 25:50:25:20 kg NPKS/ha + 25 kg $ZnSO_4$/ha; Foliar nutrition through TNAU Pulse wonder @ 5 kg/ha at flowering (or) DAP /urea phosphate 2% spray twice at flowering.

iii. Rainfed pulses (Blackgram and Greengram)

Normal rainfall condition

- **Weed management:** PE : Pendimethalin @ 0.75 kg/ha; Grassy weeds: EPOE Quizalofop ethyl @50 g a.i./ha on 15 DAE of weeds; Broad Leaved Weeds: EPOE Imazethapyr @50 g a.i./ha on 15 DAE of weeds
- **INM: 12.5:25:12.5:10 kg NPKS/ha;** Foliar nutrition through TNAU Pulse wonder @ 5 kg/ha at flowering (or) DAP /urea phosphate 2% spray twice
- **To mitigate drought:** 1% KCl spray

iv. Rainfed redgram

- **Weed management:** PE Pendimethalin @ 0.75 kg/ha on 3DAS; Grassy weeds: EPOE Quizalofop ethyl @50 g a.i./ha on 15DAE of weeds; Broad Leaved Weeds: EPOE Imazethapyr @50 g a.i./ha on 15 DAE of weeds
- **INM:** 12.5:25:125:10 kg NPKS/ha + 12.5 kg $ZnSO_4$/ha

7. Groundnut

Normal rainfall condition

- Hardening of seeds with 0.5 % Calcium chloride adopting the seed to solution ratio 1:0.5 with the soaking duration of 6 hrs and drying back to original moisture content.
- Seed drill sowing
- Maintaining plant population of 33 plants/m^2 (30 x 10 cm) (Seed rate @ 120 kg kernels/ha)
- Blanket application of 10-10-45 kg NPK/ha
- Application of 7.5 kg/ha of micronutrient mixture
- Seed treatment with biofertilizers, *Trichoderma* and *Pseudomonas*
- Pre emergence herbicide Pendimethalin @ 3.3 l/ha
- Gypsum application @ 400 kg/ha on 40^{th} DAS and earthing up.

Deficit rainfall condition

- Seed drill sowing
- Using mobile sprinklers for protective irrigation at critical stages of peg formation and pod filling stage.

Excess rainfall condition

- Medium duration semi spreading varieties - Co6, VRI (Gn)7
- Sowing with tractor drawn seed drill
- Gypsum application @ 400 kg/ha on 40 DAS
- Foliar spray of TNAU Groundnut Rich @ 2 kg/acre in 200 litres of water at peak flowering and at pod development stages

8. Sesame

Normal rainfall condition

- Seed rate of 5 kg/ha
- Spacing of 30 x 30 cm
- Blanket application of 23 -13- 13 kg NPK/ha
- Application of 5 kg /ha of Manganese sulphate
- Seed treatment with biofertilizers, *Trichoderma* and *Pseudomonas*
- Pre emergence herbicide Pendimethalin @ 3.3 l/ha
- Thinning to maintain single seedling

Deficit rainfall Condition

- Using mobile sprinklers for protective irrigation at critical stages

9. Sunflower

Normal rainfall condition

- Seed rate of 5 kg/ha
- Hardening of seeds with 2 % potassium dihydrogen phosphate adopting the seed to solution ratio 1:1 with the soaking duration of 16 hrs and drying back to original moisture content.
- Spacing of 60 x 30 cm
- Blanket application of 60-90-60 kg NPK/ha
- Application of 200kg / ha Gypsum
- Seed treatment with biofertilizers, *Trichoderma* and *Pseudomonas*
- Pre emergence herbicide Pendimethalin @ 3.3 l/ha
- Thinning to maintain single seedling

Deficit rainfall Condition

- Using mobile sprinklers for protective irrigation at critical stages

Pre-sowing seed invigouration technique

Sorghum

- Hardening of seeds with 2 % Potassium dihydrogen phosphate adopting the seed to solution ratio 1:0.6 with the soaking duration of 16 hrs and drying back to original moisture content.

Pearl millet

- Hardening of seeds with 2 % Potassium chloride adopting the seed to solution ratio 1:1 with the soaking duration of 16 hrs and drying back to original moisture content.

Ragi

- Hardening of seeds with 0.5% calcium chloride with seed to solution ratio 1:1 and the soaking duration of 6 hrs and drying back to original moisture content.

Maize

- Hardening of seeds with 2 % Potassium dihydrogen phosphate adopting the seed to solution ratio 1:1 with the soaking duration of 8 hrs and drying back to original moisture content.

Blackgram

- Hardening of seeds with 100 ppm zinc sulphate adopting the seed to solution ratio 1:0.3 with the soaking duration of 3 hrs and drying back to original moisture content.

Greengram

- Hardening of seeds with 100 ppm manganese sulphate adopting the seed to solution ratio 1:0.3 with the soaking duration of 3 hrs and drying back to original moisture content.

Redgram

- Hardening of seeds with 100 ppm zinc sulphate adopting the seed to solution ratio 1:0.3 with the soaking duration of 3 hrs and drying back to original moisture content.

Bengal gram

- Hardening of seeds with 1 % potassium dihydrogen phosphate adopting the seed to solution ratio 1:0.3 with the soaking duration of 3 hrs and drying back to original moisture content.

Integrated farming system (IFS models)

- Integrated farming system models have been developed for wetland, irrigated upland and rainfed eco-systems of Tamil Nadu for effective utilization of farm resources and for sustained income generation

Wetland ecosystem (1 ha)

- Cropping (0.75 ha) + Fodder Crop (0.12 ha) + Fishery (1000 nos.) + Mushroom (5kg/day) + Goat (20 female + 1 male) + Vermicompost (4tonnes production Capacity)

Irrigated upland ecosystem (1 ha)

- Cropping (0.70 ha) + milch cows (3 female + 2 male) + Goat (10 female+ 1 male) + Vegetables (0.06 ha) + Fodder Crop (0.20 ha) + Vermicompost (6tonnes production capacity)

Rainfed ecosystem (1 ha)

- Cropping (0.75 ha) + Silvipasture (0.20 ha) + Farm pond (0.04 ha) + Buffalo (2 Nos.) + Goat (10+1) + Bio-compost (8tonnes production capacity)
- Integrated farming system's cafeteria approaches have many options matching with farmers' preference, resource availability and affordability.

Cropping system for western zone

Evaluation of different cropping system for irrigated uplands of western zone of Tamil Nadu was carried out and among the different cropping system evaluated, cotton + green gram - maize - sunflower registered the highest production efficiency followed by beetroot - green gram - maize + cowpea over the existing system and these two systems also recorded higher economic efficiencies over the existing system.

Forage Crops - mechanized harvesting with Brush Cutter

- Increase tiller production as it facilitates harvesting close to ground.
- Induces healthy tillers
- Termites attack is avoided.
- Cuts grasses upto 2 tonnes/hour

Weather Based Agro Advisory Services

Agromet Advisory Services (AAS) bulletin is being prepared on every Tuesday and Friday of the week, based on the expert advice, forecast and crop information. The AAS is being prepared for Erode, Coimbatore and Tiruppur districts in both English and Tamil. The Agromet advisory bulletin are disseminated through mass media, Television and it is and also communicated through email to line department officials and KVK of the respective districts. It is also being placed in the IMD website www. imdagrimet. gov.in. Recently, dissemination of AAS was introduced through farmers portal website (www. farmer.gov.in) as SMS.

An impact assessment study was conducted with the rice farmers of Sathyamanagalam, Nambiyur and Gobichettipalayam blocks in Erode District who received and used the AAS bulletin for tactical decision making from August 2013 to December 2013. From each study block, ten AAS farmers and ten non-AAS farmers were randomly selected for collecting the information to perform the analysis.

Crop: Rice **Season: Samba (Aug. – Dec.)**

Crop Stage	Advisory given based on weather forecast	Actual observation	AAS farmers (Rs / ha)	Non AAS farmers (Rs/ha)
Nursery	27th August: Advised to maintain a thin film of water in the nursery to avoid seed displacement against expected rainfall	Received 22 mm of rainfall	Saved Rs. 450	Additional cost of Rs. 450 incurred by way of nursery re-sowing.
Main field preparation	6th September: As rainfall is expected main field preparation may be done	Received 45 mm of rainfall in 4 consecutive rainy days	Prepared main field and planting done on right time	Prepared main field but planting got delayed by 6 days due to re-sowing of nursery
Tillering	16th September: As heavy rainfall is expected, topdressing of N fertilizer may be postponed. Drain the excess rain water	Received 60 mm of rainfall in 3 rainy days	Postponed N fertilizer application	Applied first top dressing of N. incurred Rs. 900 Due to heavy rainfall water had been drained and fertilizer effect was not felt
Panicle initiation	5th November: Cloudy weather with drizzling would increase the leaf folder incidence. Hence watch for the pest and If crossed ETL, spray chlorpyriphos or dichlorvos @ 2 ml per liter of water	Cloudy weather observed	Plant protection chemicals sprayed. Cost: Rs. 600.	Plant Protection measures were not taken up

Flowering and grain formation	29th November Cloudy weather would induce false smut. Hence prophylactic spray with kocide @ 2 g/liter of water may be given	Cloudy weather with light drizzle experienced	Spayed against False smut Cost: 800	Prophylactic spray not given but due the disease incidence, additional 2 spays had been given Cost: 1600
Grain filling	As dry weather is expected regular irrigation may be given for maximizing the yield	Dry weather	Irrigation given	Irrigation given
Yield			5,400 kg / ha	4,800 kg/ha
Additional cost (Rs/ha)			Rs. 1400	Rs. 2950
Basic cultivation charges (Rs/ha)			Rs. 22,000	Rs. 22,000
Returns (Rs /ha)			Rs. 64,800	Rs.57,600
Net benefit (Rs/ha)			Rs. 41,400	Rs. 32,650
Additional benefit (Rs/ha)			Rs. 8750	-

- Economic benefit of Rs. 8750 / ha can be realized by following Agro-met Advisory Services in rice including inputs saving.

Crop Boosters

A tonic with nutrients and growth regulators for crops

1. TNAU Coconut Tonic

Benefits

- Increases chlorophyll content and greenness of leaves
- Improves photosynthetic efficiency of leaves
- Decreases button shedding
- Increases number and size of nuts
- Increases nut yield of 20 per cent
- Increases longevity and vigour of the palm
- Imparts resistance to pests, diseases and environmental stresses

Application

- Root feeding of the tonic @ 200 ml / palm twice a year at six months interval

2. TNAU Pulse Wonder

Benefits

- Decreases flower shedding
- Increases yield up to 20 per cent
- Increases drought tolerance

Application

- Dose : 2.0 kg / acre
- Spray volume : 200 litres
- Stage of spray : Peak flowering

3. TNAU Groundnut Rich

Benefits

- More flower retention
- Improves pod filling
- Increases pod yield up to 15 per cent
- Improves drought tolerance

Application

- Dose : 2.0 kg / acre
- Spray volume : 200 litres
- Stage of spray : Peak flowering and pod development

4. TNAU Cotton Plus

Benefits

- Reduces flower and square shedding
- Improves boll bursting
- Increases seed cotton yield up to 18 per cent
- Improves drought tolerance

Application

- Dose : 2.5 kg / acre
- Spray volume : 200 litres
- Stage of spray : Flowering and boll formation

5. TNAU Sugarcane Booster

Benefits

- Enhances cane growth and weight
- Improves internodal length
- Increases cane yield up to 20 per cent
- Improves sugar content
- Increases drought tolerance

Application

- Dose : 1, 1.5 and 2 / acre
- Stages of spray : 45,60 and 75 days after planting respectively
- Spray volume : 200 litres

6. TNAU Maize Maxim

Benefits

- Improves grain filling
- Increases grain yield up to 20 per cent
- Improves drought tolerance

Application

- Dose : 3 kg / acre
- Spray volume : 200 litres
- Stages of spray : Tassel initiation and grain filling stages
- Add adequate quantity of wetting agent

Technologies for enhancing for crop productivity under rainfed condition

***1. In-situ* water harvesting technologies and mulching**

- Board Bed Furrow (BBF) with coirpith incorporation @ 5.0 t ha^{-1} recorded for higher soil moisture retention, seed cotton yield and enhanced the carbon storage under vertisols, .
- Adoption of ridges and furrows (RF) with coirpith incorporation @ 5.0 t ha^{-1} is suitable for maize in Alfisols
- Adoption of BBF/RF/compartmental bunding with crop residue mulch @ 5.0 t ha^{-1} is recommended for groundnut in Alfisols

***In-situ* water harvesting technologies for dryland crops**

***2.* Recycling of harvested rain water in drylands**

- The experiment conducted at DARS, Chettinad revealed that adoption of minimum tillage with crop residues @ 5 t ha^{-1} and supplementary irrigation (3 times) through raingun / sprinklers increased soil moisture retention and pod yield of groundnut in alfisols.
- In dryland agriculture runoff is a major problem and it leads to water losses. This can be properly channelized by digging community based farm pond with polythene lining where ever is possible to reduce the percolation and seepage loss of collected water. Thus the stored water can be used for supplemental irrigation at critical stages of crop growth.

Farm pond

Supplementary irrigation with Raingun

IV. WATER MANAGEMENT STRATEGIES

Tamil Nadu has only about 4% of the geographical area and 2% of water resources potential of India while its population constitutes about 6% of the country. The total geographical area of the state is 13.019 M.ha of which 8.4 M.ha (74 taluks in 10 districts) is chronically drought prone area. Tamil Nadu has 34 basins which are grouped in 17 river basins. Of this, major basins (>20,000 Sq.km) = 1, medium basins (>2000 < 20,000 Sq.km) = 13 and minor basins (<2000 Sq.km) = 3. It has a per capita land holding of 0.95 ha as against the national average of 1.69 ha. The per capita sown area of the state is only 0.09 ha compared to all India average of 0.15 ha. The per capita water availability is only 700 m^3 $year^{-1}$ as against 2000 m^3 in the country. It has about 48% net sown area irrigated compared to 56.7% in U.P, 93.6% in Punjab and 75.2% in Haryana. The state's irrigation potential is only about 5 M.ha compared to all India potential of 140 M.ha. The mean annual rainfall of the state is 940 mm as against 1150 mm of national average. Being a monsoon country, the spatial and temporal variations are high both in India as well as in Tamil Nadu. It is more so in Tamil Nadu because major area of the state is dependent on retreating monsoon of North-East which is highly erratic.

Water resources of Tamil Nadu

The total surface water potential of river basins in Tamil Nadu calculated at 75% probability is 2.42 MHM or 853 TMC (Table 1). Cauvery, Tamiraparani, Vaigai, Palar and Agniar are the major river basins contributing more than 65% of total.

Table 1. Surface Water Potential of River Basins of Tamil Nadu

Sl. No.	River Basin	Surface Water Potential at 75% dependability	
		MCM	TMC
1.	Chennai	784	28
2.	From Krishna Water as per agreement	340	12
3.	Palar	1758	62
4.	Varaganadhi	412	15
5.	Ponnaiyar	1310	46
6.	Paravanar	144	5
7.	Vellar	963	34
8.	Agniyar	1084	38
9.	Pambar and Kottakaraiyar	653	23
10.	Vaigai	1579	56
11.	Gundar	568	20
12.	Vaippar	611	22
13.	Kallar	425	4
14.	Thamirabarani	1375	49
15.	Nambiar	204	7
16.	Kodaiyar	925	33
17.	Parambikulam and Aliyar as per agreement	864	30
18.	Cauvery in Tamil Nadu region	4655	164
19.	From Karnataka as per Tribunal order	5805	205
Total		**24159 or 2.42.MHM**	**853**

The ground water potential estimated by the State works out to 2.37 M. ha. M. (Table 2) while as per the Central Ground Water Board, it is only 2.24 M. ha. M.

Table 2: Groundwater Potential and its Utilization in Tamil Nadu

Agro climatic sub-region	Annual replenishable groundwater resource	Net Ground water availability	Annual ground water withdrawals			Stage of groundwater development
			Irrigation	Domestic and Industries	Total	
	mcm	mcm	mcm	mcm	mcm	%
North	24.8	22.3	27.8	1.0	28.8	129.1
Central	58.5	52.6	41.6	2.3	43.9	83.4
North-East coastal	89.4	80.4	75.7	3.0	78.7	97.9
Delta	13.8	12.4	9.5	0.8	10.3	82.8
South-East coastal	30.4	27.4	11.1	1.1	12.2	44.7
South	2.9	2.6	0.2	0.2	0.4	16.2
Hill	10.9	9.8	1.9	0.3	2.1	21.7
Tamil Nadu - Total	230.7	207.7	167.8	8.8	176.5	85.0

A comparison of rainfall, water available, cultivated and irrigated land, water and land available per person / year between India and TN is given in Table 3.

Table. 3: Rainfall, Water available, Cultivated and Irrigated Land in India and Tamil Nadu – 2010

Details	India	Tamil Nadu
Geographical area (M.ha)	329	13
Rain fall (mm)	1150	940
Total rain (MHM)	400	12
Surface Water (MHM)	195	2.42
Groundwater (MHM)	43	2.24
Tanks (Lakhs)	5	0.39
Well Open / Borewell (Million)	17	1.80
Water availability (per person/year)	2000	700
Cultivated Land (M.ha)	142	5.04
Land availability (per ha/ Person)	0.15	0.09
Irrigated Area at present (M.ha)	100	3.4
Irrigation potential (M.ha)	140	5.50
Water Storage Capacity (MHM)	36	1.67

Table 4 gives basin wise reservoirs and tank capacity in Tamil Nadu

Table. 4: Basin wise Reservoirs and Tank Capacity in MCM

Sl. No.	River Basin	Tanks		Reservoirs		Total Capacity
		Numbers	Capacity	Numbers	Capacity	
1.	Chennai	1519	1373	4	320	1693
2.	Palar	661	355	2	8	363
3.	Varaganadhi	1421	276	1	17	293
4.	Ponnaiyar	1133	240	7	311	551
5.	Vellar	457	70	5	115	185
6.	Agniyar	3975	560	-	-	560

7.	Pambar and Kottakaraiyar	1042	154	-	-	154
8.	Vaigai	1497	410	5	659	1069
9.	Gundar	649	331	-	-	331
10.	Vaippar	862	229	6	66	295
11.	Kallar	199	43	1	4	47
12.	Thamirabarani	880	196	7	367	563
13.	Nambiar	597	95	2	6	101
14.	Kodaiyar	2922	268	9	404	672
15.	Parambikulam and Aliyar	-	-	9	32	32
16.	Cauvery	21186	4910	21	4586	9496
Total		**39000**	**9510**	**79**	**6895**	**16405**

Table 5 : Total Water Potential in Tamil Nadu

Details of Water Potential	**MCM**	**TMC**
a. Surface water potential		
1. Within the State	16679	592
2. From neighboring States	7319	261
Total	24160	853
b. Ground water potential	22380	790
Total surface and ground water	**46540**	**1643**

The total water potential of Tamil Nadu is 46540 MCM which includes surface water potential of 24160 MCM and ground water potential of 22380 MCM. In Tamil Nadu, contribution of surface water potential was higher than the ground water potential.

Irrigation pattern

The total net irrigated area in the state was about 24.8 lakh hectares during 1960s, which has slightly increased to 28.63 lakh hectares at the year ending 2009-10 (Table 6) due to various major and minor irrigation projects. The area irrigated by tanks has decreased significantly from 36.8 per cent to 17.6 per cent of the net area irrigated over four decades.

Table 6. Trend in net area irrigated in Tamil Nadu (in lakh ha)

Sources	**1960s**	**1970s**	**1980s**	**1990s**	**2009-10**
Net area irrigated	24.79	26.96	24.96	26.18	28.63
Net area irrigated by canals	8.83 (35.6)	8.94 (33.1)	8.21 (33.0)	8.24 (31.3)	7.57 (26.4)
Net area irrigated by tanks	9.42 (36.8)	8.49 (31.5)	6.16 (24.7)	6.21 (22.3)	5.03 (17.6)
Net area irrigated by wells	6.45 (26.0)	9.18 (34.0)	10.38 (41.6)	13.14 (45.1)	15.93 (55.7)
Gross area irrigated	32.66	35.22	31.15	33.94	32.38
Irrigation intensity (%)	131.75	130.64	124.80	124.90	113.00

(Figures in parentheses are percentage to net area irrigated) (Source: TN Season and Crop reports, 2009-10)

On the other hand, the area irrigated by groundwater through wells has been increasing significantly both in absolute and relative terms. The decline in canals and tanks was more or less compensated by the significant growth in the area irrigated by

wells that leaped forward from about 26 per cent to about 55.7 per cent in the same period. Wells became dominant source of irrigation.

Ground Water resource potential in Tamil Nadu

Based on the groundwater potential the entire Tamil Nadu state has been divided into over exploited, critical, semi critical, safe and saline. The over exploited regions comprise the regions where the groundwater abstraction is more than 100 per cent.

Table 7. Status of groundwater in Tamil Nadu (2003)

Years	Groundwater characterization of Tamil Nadu					Total
	Safe blocks	Semi critical blocks	Critical blocks	Over exploited blocks	Saline	
1987	251	86	41	-	-	378
1992	209	86	89	-	-	384
1998	137	70	35	135	8	385
2003	97 (25.20)	105 (27.27)	37 (9.61)	138 (35.84)	8 (2.08)	385

(Source: Ministry of Water Resources, CGWB, SECR, 2003)

In the critical regions, the groundwater abstraction is between 90 to 100 per cent, semi critical regions the groundwater abstraction is 70 to 90 per cent and safe regions represents the regions where the groundwater abstraction is less than 70 per cent (Table 7). The trend in exploitation of ground water was more after 1990s and it was reflected in reducing numbers of safe blocks. The number of safe blocks reduced from 209 to 97 during 1992 to 2003. It was mainly due to exploitation of well water for irrigation and it was evidenced from the raise in area irrigated by the wells during 1990s to 2009-10 (Table 6). Of the total 385 blocks in the state, 138 blocks fall under the category of over exploited, 37 blocks under critical, 105 blocks under semi critical and 97 blocks under safe regions .

Demand for Water in Tamil Nadu

The domestic and industrial uses of water in the state at present claim a share of about 15 per cent of the total resources and this share is likely to be about 9.44 per cent in the year 2050 with increased industrialization, urbanization and growing needs of rural areas for improved facilities for drinking water (Table 8). The National Commission on Agriculture has indicated that although the percentage utilization for purposes other than irrigation is low at present, it is expected to rise significantly in the future with increase in industrialization and power generation through thermal and nuclear plants. By 2050 AD, the requirement of fresh water for non-irrigation purposes may be around 13.37 per cent of the available fresh water. Thus, the total demand for non-agricultural purposes will be 7745 MCM. As agricultural sector is consuming about 85 per cent of the available water resources at present, much attention should be given on the agricultural water need, its present and future utilization pattern etc. The compound growth rates of area under irrigated crops were worked out and projected for 2050 AD. Accordingly, the projected water requirements will be 57725 MCM, which is higher than the supply available for agricultural purposes i.e.49978 MCM.

Table 8. Sectoral water demand (MCM) from 2001 or 2050

Sl. No.	Details	2001	2010	2025	2050	% of the total in 2050
1.	Domestic	2222	2433	2791	3460	6.00
2.	Irrigation	49978	49978	49978	49978	86.58
3.	Industries	1555	1633	1757	1985	3.44
4.	Power	118	138	162	180	0.31
5.	Livestock	519	519	519	519	0.90
6.	Agriculture	2	2	2	2	-
7.	Recreation	1	1	1	1	-
8.	Navigation	-	-	-	-	-
9.	Minimum flows	-	-	800	1600	2.77
	Total	**54395**	**54709**	**56010**	**57725**	**100**

Supply-Demand Gap for Water

The supply demand gap by the year 2050 will be about 11185 MCM (24 per cent) (Table 9). It is important to bridge this gap either by reducing the demand or by increasing the supply level to match the growing demand in the future. It is appropriate to point out here that in Israel more than 75 per cent of the water is utilized for irrigation at present and it was observed that allocation of water for agriculture will be reduced to 65 per cent in another 10 to 15 years by efficient water management practices.

Table 9. Supply / demand and gap percent in 2001 and 2050

Supply / Demand	2001	2050
Total Water Resource	46540	46540
Agricultural demand	49978	49978
Total Demand	54395	57725
Gap	7855	11185
Gap percentage	16.88	24.05

Land Irrigability

Land irrigability classification is grouping of soil mapping units into land irrigability class and sub-classes based on the degree of limitation of soils for sustained use under irrigation and also physical and socio-economic factors. The soil criteria used for irrigability classification include soil depth, surface soil texture, permeability, coarse fragmentation, slope, erosion etc. Land irrigability classes identified were divided into sub-classes depending on the nature of limitation for irrigation viz., soil, topography and drainage. The land irrigability grouping of soils in Tamil Nadu have 16 associations of sub-classes. The classification showed that in the state, about 23 per cent of the area is not suitable for irrigation and 77 per cent lands are suitable for irrigation. Of the lands suitable for irrigation, 28 per cent have moderate limitation, 37 per cent have severe limitation and 12 per cent have marginal limitations.

Status of irrigation in Tamil Nadu

Out of 6.0 M.ha of cultivable area, only 3.0 M.ha area is irrigated normally. The major sources of irrigation are canals, tanks and wells. Surface method of irrigation is the traditional art of irrigation being adopted in all the districts of Tamil Nadu. Flood method of irrigation for transplanted rice, check basin or ridges and furrow method of irrigation for irrigated garden land crops are in vogue in major parts

of Tamil Nadu. Though, this method has got inherent drawbacks viz., less efficiency, wastage of water etc; this surface method is widely adopted because it is the easiest method and does not require any skill. Among the different crops under irrigated condition, rice occupies the major area of 18 – 20 lakh ha, followed by sugarcane (3.0 lakh ha) and coconut (2.3 lakh ha).

Challenges

The following issues are to be addressed for sustaining the water resources.

- Degradation of existing water supplies
- Degradation of irrigated cropped land
- Ground water depletion
- Increasing pollution / declining water quality
- Poor cost recovery
- Transboundary water dispute
- Increasing costs of new water
- Virtual water

Water management in Tamil Nadu

(i) Wetland Eco systems

The major art of irrigation for rice crop is flood method of irrigation. Normally rice crop is grown under submergence by maintaining 5 cm depth of irrigation water. Total water requirement under flood method of irrigation works out to 1100 - 1400 mm depending upon the seasons. Water requirement for rice grown under lowland land preparation is determined by the amount required for soil soaking, losses during operations and maintaining standing water in the field. Water requirement for soaking the land depends on the initial soil moisture content and surface conditions of the land and soil type. The requirement may vary from 200 to 400 mm. At present, about 3000-5000 litres of water are being used to produce 1 kg of paddy. Reducing this water use has been one of the major concerns for scientists and water managers and several new approaches like alternate wetting and drying, aerobic rice etc., were attempted to use irrigation water efficiently at farm level.

Table 11. Spatial and temporal variations in water productivity of rice under irrigation after disappearance of ponded water

Agro-climatic zones	Water productivity (kg m^{-3})		
	Kuruvai	Samba	Navarai
North eastern zone	0.44	0.48	0.47
North western zone	0.62	0.59	0.52
Western zone	0.58	0.49	0.41
Cauvery delta zone	0.42	0.33	0.39
Southern zone	0.41	0.35	0.39
High rainfall zone	0.47	0.58	-
High altitude zone	0.47	-	-

A study was conducted to work out the rice water productivity level in seven predominant agro-climatological regions of Tamil Nadu during the three distinct seasons of rice production, viz., samba, kuruvai, and navarai (Table 11). The results indicated that irrespective of the zones, the kuruvai season (June 12th to September 27th) registered the highest average water productivity at the rate of 0.48 kg m^{-3} followed by Samba (August 10th to December 23rd) at the rate of 0.47 kg m^{-3} and navarai 0.44 kg m^{-3} (December 22nd to April 21st). Erode District recorded the maximum rice water productivity of 0.65 kg m^{-3}, followed by Salem District (0.54 kg m^{-3}) and Namakkal District (0.53 kg m^{-3}). In order to overcome the low and high

variable water productivity of rice, water saving technologies viz., system of rice intensification, safe alternate wetting and drying irrigation and direct sown rice are available for farmers.

Water saving option like System of Rice Intensification (SRI) is available for the farmers to reduce the water requirement of rice cultivation. Around 50 percent of the total rice area is brought under SRI in TN. There is a great awareness prevailing among the farmers for SRI. Reports reveal that 40-50 percent of irrigation water is saved exclusively through SRI adoption.

Studies on water productivity with SRI were undertaken as a part of World Bank funded TN-IAMWARM project from 2010 to 2011. Studies were conducted in four locations, viz., Varaganadhi sub basin, Karumaniar sub-basin (Tirunelveli district, L1), Sevalaperiar sub-basin (Virudhunagar district, L2), Ongur sub-basin (Chengalpattu district, L3) and Nallavur sub-basin (Villuppuram district, L4) to compare the efficiency of SRI irrigation with the conventional practice (CP).

Table 10. Water use efficiency of rice in SRI demonstrations

Para-meters	L1		L2		L3		L4		Average	
	SRI	CP	SRI	CP	SRI	CP	SRI	CP	SRI	CP
Water used (mm)	923	1,252	973	1223	827	1,148	818	1,098	885	1,180
Productive tillers hill^{-1}	31	20	48	31	36	23	39	24	38	24
Productive tillers m^{-2}	470	350	612	505	720	580	780	704	646	535
Grain yield (kg ha^{-1})	5,810	4,450	5,982	5,032	7,046	5,965	6,784	5,689	6,406	5,284
Water use efficiency (kg ha^{-1}mm^{-1})	6.28	3.55	6.14	4.11	8.51	5.20	8.29	5.18	7.31	4.51
Water productivity (l kg^{-1})	1,588	2,813	1,626	2,430	1,174	1,924	1,205	1,930	1,398	2,274

L – Locations; CP – Conventional Practice (Annual Report,TN-IAMWARM, 2010-11)

The results indicated that SRI registered higher paddy grain yield and WUE of 6,406 kg ha^{-1} and 7.31 kg ha^{-1} mm^{-1}, respectively as compared to conventional practice (5,284 kg ha-^{1} and 4.51 kg ha^{-1} mm^{-1}) (Table 10). The water productivity in SRI was found to be 1,398 litres kg^{-1} as against 2,274 litres kg^{-1} in conventional irrigation.

A new concept of safe AWD Irrigation method is being experimented which saves around 30-40 percent of water. Instead of surface drying as the indicator for subsequent irrigation, depletion level of 15 cm is found to be safe AWD for irrigated rice. These levels can also go beyond 15cm wherever the yield penalty do not occur. All these techniques tend to keep in check the flow of water at the field level

either partially or completely. These new techniques also counteract the old conception of rice as an aquatic crop.

Direct sown rice using drum seeder and direct seeding in semi dry condition and converting to wetland condition after the receipt of canal water are the promising technologies which can be adopted during contingencies in the delta as well as non deltaic rice growing regions of TN. Direct seeding method of rice with improved practices (proper land leveling, drum seeding at solid row spacing of 25 cm and cono weeding on 20,30,40 and 50 days after sowing) is an easy method of crop establishment provided perfect leveling and water control are ensured. Direct seeding helped to achieve 15-20 percent of yield increment and 10-15 percent of water saving.

(ii) Garden land eco systems

The traditional gravity systems of irrigation conveyance and application structures involve mostly unlined channels and check basin or check furrow crop layouts, which are susceptible for significant proportions of water losses due to seepage, deep percolation and eventually resulting in low irrigation and water use efficiencies. The conveyance loss of water can be completely eliminated or minimized within safer limits by way of switching over to the pressure system of irrigation that comprises principally the drip and sprinkler systems with a network of closed conduits and controllable outlets.

Prospects of Drip Irrigation

Efficient use of irrigation water becomes an important means to increase crop productivity per unit quantity of irrigation water applied besides huge savings in water requirement. It has been proved that drip irrigation can result in more than 50 percent water saving with high levels of water use efficiency for wide range of crops. Drip irrigation systems are highly suitable for sandy, sandy loam and sandy clay loam terrains rather than clay or clay loam soils. Drip irrigation system also facilitates application of water-soluble fertilizers through the same piping network simultaneously. Fertigation is the best answer to achieve higher use efficiency of both water and fertilizers. Drip fertigation ensures that essential nutrients are supplied precisely at the area of most intensive root activity according to the specific requirements of crop and type of soil resulting in higher crop yields and enhances the quality of the produce. Drip fertigation is also picking up its momentum particularly under precision farming and controlled atmosphere cultivation like in green houses.

Table 12. Area under micro irrigation system in Tamil Nadu

Area (ha)	Total irrigated area (ha)	Potential for MIS		Under MIS	
		Area (ha)	% to irrigated	Area (ha)	% to potential
Banana	91,617	15,000	16	4,000	12
Mango	23,440	23,440	100	<1000	5
Vegetables	1,19,902	50,000	42	10,000	20
Coconut	3,10,314	2,00,000	64	1,25,000	63
Sugarcane	3,35,382	2,00,000	60	25,000	13
Tapioca	64,397	5,000	7	1,000	20
Turmeric	25,916	25,000	96	5,000	20
Misc.	19,826	10,000	50	3,500	35
TOTAL	**9,90,794**	**5,28,440**	**52**	**1,74,500**	**32**

In Tamil Nadu, about 9.9 lakh ha area is under irrigated dry crops and out of it, 1.74 lakh ha under microirrigation system (Table 12). Out of 8.16 lakh area of surface irrigated, 5.28 lakh ha area found to be the potential area for upscaling into micro irrigation system and includes crops viz., banana, mango, vegetables, sugarcane, coconut, tapioca and turmeric.

Potential areas suitable for drip irrigation

- Well irrigated areas which contributes more than 40 per cent of the irrigated area in the state
- Ideally suited for all row crops especially coconut, fruit trees, vegetables, flowers, commercial crops etc
- Waste lands by planting fruit trees
- Hilly and semi arid regions
- Water scarcity areas
- Command areas having community wells
- Coastal and saline sandy belts
- Areas having poor quality water resources

Table 13. Performance of drip fertigation technology on various crops

Crop	Method of cultivation	Water used (mm)	Water saving (%)	Yield (t/ha)	Yield increase (%)
Banana	Conventional	2300	30	75	36
	Drip fertigation	1600		55	
Sugarcane	Conventional	2500	36	100	25
	Drip fertigation	1600		125	
Tomato	Conventional	750	26	40	87
	Drip fertigation	550		75	
Chillies	Conventional	700	35	22	59
	Drip fertigation	450		35	
Turmeric	Conventional	1390	29	5.75	12
	Drip fertigation	980		6.45	

(Annual Report,TN-IAMWARM, 2010-11)

Large scale Demonstration of drip fertigation under TN-IAMWARM project resulted in increased the crop productivity in sugarcane and registered higher yield (125 t/ha) than conventional practices (100 t/ha) (Table 13). Further water saving to the tune of 46% when compared to conventional practice (2500 mm) by consuming lesser water (1600 mm) was also observed. Water use efficiency also increased under demonstration (78 kg/ha/mm) when compared to conventional practice (40 kg/ha/mm). Intervention of drip fertigation technologies increased the crop productivity in vegetables *viz*., tomato and registered higher mean yield of 75 t/ha which was 87.0 % higher than the conventional practice (40 t/ha). Drip fertigation consumed lesser (550 mm) water when compared to conventional practice (750 mm) and water saving was to the tune of 26 %. Water use efficiency also increased under demonstration (109 kg/ha/mm) when compared to conventional practice (57.6 kg/ha/mm). Demonstration of precision farming technologies increased the crop productivity in banana and registered higher yield (75 t/ha) than conventional

practices (55 t/ha). Drip fertigation consumed lesser (1600 mm) water than conventional practice and thus save the water upto 36% when compared to conventional practice (2300 mm). Water use efficiency also increased under demonstration (47.0 kg/ha/mm) when compared to conventional practice (24.0 kg/ha/mm).

Table 14. Impact of drip fertigation in Sugarcane

Particulars	Drip fertigation	Flood irrigation	Gain (%)
Yield (t/ha)	85	55	54.5
Water saving (mm)	1200	2200	45.5
Electricity saving (Kwh)	900	2100	58.5
Water used (mm) / tonne of cane production	14.1	44	64.7
Cost per tonne (Rs.)	379	541	29.9
Electricity used (Kwh) /tonne of cane	10.6	39.3	73

Adoption of drip fertigation in sugarcane enhanced the crop productivity over conventional flood irrigation besides considerable saving irrigation water (Table 14). Further, considerable saving in electricity was also noticed under drip fertigation system compared to flood irrigation. Thus large scale adoption of drip fertigation may lead to bring additional area under cane cultivation and considerable energy saving in agricultural sector.

Prospects of Sprinkler irrigation

Sprinkler irrigation refers to application of water to crops in the form of spray from above the crop like rain. It is also called as overhead irrigation as water is allowed to fall as spray from above the crop. Sprinkler irrigation is also called as pressurized irrigation as water under pressure is carried and sprayed into the air above the crop through a system of pipe network.

Advantages

- Sprinklers provide efficient coverage for small to large areas and are suitable for use on all types of soils
- Adaptable to nearly all-irrigable soils since sprinklers are available in a wide range of discharge capacity
- It is designed to ensure maximum water saving, combining high quality, affordability and ease of installation
- Suitable for almost all field crops like wheat, gram, groundnut, pulses as well as vegetables, soya bean, tea, coffee and other fodder crops.

Adaptability of sprinkler system

Sprinkler irrigation may be used for many crops and on all types of soil on lands of varying topography and slopes. However it is best suited to irrigate

(i) Sandy soils and soils having high infiltration rate

(ii) Shallow soils that do not allow proper land leveling required for surface irrigation methods

(iii) Areas with steep slopes having erosion hazards
(iv) For growing high priced crops
(v) Where water is scarce and costly

Raingun Irrigation

Rainguns are high performance impact sprinklers designed for a variety of uses and applications where relatively high flows and extended radius of throw are desired. A raingun may be permanent or portable. In a permanent raingun, the gun riser stands are permanently fitted on the pipeline network. It can also be supported by cement concrete block around the riser. One raingun can cover upto 4 hectare (10 acre) of land. With raingun, water saving of 30 to 50 per cent has been reported in different crops.

Advantages

- Saves more than 50% of the water used by flood irrigation.
- Reduction in labour need
- Saves electricity. In future, if farm motors come under unit rating, Rain Gun will save nearly 75% of the electricity. Increases life of motor / pump.
- As 1⁄2 acre could be irrigated within 1 1⁄2 hours, the total extend of area irrigated per day nearly doubles.
- Easier application of fertilizer and pesticides
- Easy intercultural operation
- Less Maintenance.

Scope of Dry Farming in Tamil Nadu

Tamil Nadu has a total geographical area of 13 m ha of which 6 m ha are cultivable. Dryland farming occupies a predominant place consisting nearly 56 per cent (3.19 m ha) of net cultivated area. Dry farming supports more than 50 per cent of the population of Tamil Nadu. Although a major constraint to dryland agriculture is deficient water, hazards such as insects, diseases, hail, high winds, and intensive rains can destroy crops in a matter of minutes or days. Making matters even more hazardous, farmers in dryland regions are often resource-poor and these regions are usually of low priority when national resources are allocated. Even when there is a knowledge base available for planning and managing crop and livestock systems in dryland regions, the most difficult task is to develop strategies *i.e*., technology packages comprising of necessary infrastructure and social and economic components together. Perhaps the toughest challenge for both farmers and governments will be to separate measures that is important from those that are practical.

In Tamil Nadu, 22 districts have been identified predominantly as rainfed farming districts which includes Vellore, Cuddalore, Villupuram, Thiruvannamalai, Dharmapuri, Salem, Namakkal, Coimbatore, Erode, Trichy, Karur, Perambalur, Pudukkottai, Madurai, Theni, Dindigul, Ramnathapuram, Sivagangai, Thanjavur, Virudhunagar, Thirunelveli and Thoothukudi

The distribution of total dryland area in different agro climatic zones of Tamil Nadu are: 26 per cent in North Eastern Zone; 24 per cent in North Western Zone; 12 per cent in Western Zone; 6 per cent in Cauvery Delta Zone; 24 per cent in Southern Zone and 7 per cent both in High Rainfall Zone and High altitude and Hilly Zone.

Since majority of the dryland area of Tamil Nadu fall under Semi Arid Tropics (SAT), these areas face higher incidence of solar radiation, more air and soil temperature and highly varying rainfall. In these areas conventional dry farming is risky one and farmers are reluctant to invest in crop production.

Rainfall variation

A good spatial and temporal distribution of rainfall is a pre-requisite for the growth of agricultural sector. The rainfall pattern in Tamil Nadu shows a wide fluctuation across space and time. The wide temporal variability is the major factor responsible for higher risk in achieving higher productivity in rainfed crops. Though the long term average over the last 40 years is around 900 mm which is close to the normal rainfall of the state, year-to-year variation in total amount of rainfall and skewed distribution of rainy days in a year are the major impediments in improving the productivity of rainfed crops. The long term coefficient of variation in the state shows that there is about 10-20 per cent deviation in normal rainfall. The district wise analysis of rainfall reveals that most of the predominantly rainfed districts show higher variability in rainfall than the state level variability.

The rainfall analysis indicated that dryland productivity is limited by the greater ET demand of the crops grown in dryland, unless the available soil moisture from rainfall is regulated through land configuration methods to meet the ET demand of the crop during dryspell period. The length of growing period, a product of weekly rainfall and weekly PET is the key factor that decides the potential of the crops to be grown. In most of these districts the length of growing period is less than and around 100 days and 64 days being the lowest at Thoothukudi district.

The following are some of the ways and means to conserve soil moisture and excess rain water and utilize the excess water for increasing the agricultural production. The treatment may be different with regard to red and black soils and the light and heavy rainfall areas. Based on the soil type and rainfall, the watershed plan can be prepared and implemented with cooperation of the farmers in the watershed.

- In-situ moisture conservation practices
- Soil conservation techniques viz. contour bunding or graded bunding, vegetative barriers, bench terraces, contour stone wall etc.,
- Construction of check dams and gully control structures
- Construction of farm ponds in the farmer's field
- Construction of percolation ponds
- Construction of irrigation tanks
- Maximum utilization of groundwater
- Application of water by sprinkler and drip irrigation methods
- Resources management
- Alternate land use
- Cultivation of land using agricultural implements and machinery.

MICRO LEVEL APPROACH

Check dam

Check dams constructed across gullies will serve as an effective water harvesting structure like mini percolation ponds. Even though their main purpose is for controlling the development of gullies, series of checkdams across a gully course will help augment the filling up of water in the existing wells nearby on both sides of the gully.

Percolation ponds

Percolation ponds are small ponds located mostly in low lying areas of poromboke lands and formed in order to store the run-off of rainwater and to allow it to percolate downwards and sideways. Deep ponds are preferred since evaporation of the stored water therein will be less. It has been observed that the percolation ponds are effective up to a distance of 1000 metres on the downstream side and wells within this range are benefited with more replenishment of water.

Farm ponds

Farm ponds are small water bodies formed either by the construction of a small dam or embankment across a waterway or by excavating or dug out. The water is usually harvested from a small catchment area and then used for irrigation during prolonged periods. Since a farm pond is formed in the low-lying area in an agricultural farm it will act as a collective drain.

Table 15. Farm pond with area, depth and uses

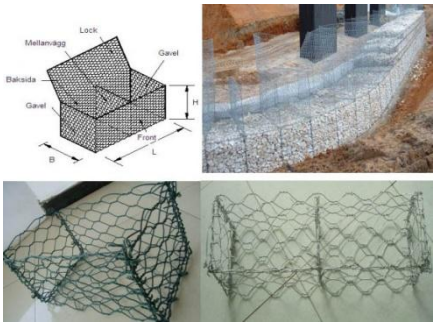
Water spread area	Standing water depth	Suitable uses
2000 to 10000m^2	2.5 to 3.0m	Supplemental irrigation, Fish culture and drinking water
2000 to 10000m^2	1.5 to 2.5m	Supplemental irrigation and drinking water
Less than 2000m^2	2.5 to 3.0m	Pot lifting irrigation for trees and seedlings, Fish culture and drinking water
Less than 2000m^2	1.5 to 2.5m	Pot lifting irrigation for trees and seedlings and drinking water

Maintenance of existing tanks and ponds

There are about 39,000 irrigation tanks in Tamil Nadu and more number of minor tanks under the control of Panchayat Unions. The water holding capacity of these tanks has been reduced by nearly 30 per cent due to siltation. In some tanks the water spread area has been encroached and their maintenance is also very poor. In order to increase the storage capacity and life of the tanks and ponds it is essential to control the deposition of sediments in the tanks and ponds.

Gabions

Gabions are wire mesh baskets filled with stones. The baskets are fastened together and piled up into a wall barring the passage of runoff water. The wire mesh holds the stones together and keeps them in place when the dam is built and the gabions are subject to water pressure. They are rigid bulky mass not easily shifted by water and responds well to spongy terrain. Cost of gabions is much cheaper than cement works. Transport cost is very minimal for gabions when compared to cement works. For gabion works, only galvanized steel wire needs to be transported and rocks available in the site itself can be exploited.



Artificial recharge of groundwater

Augmentation of groundwater resources becomes necessary, when, in a given area or basin the annual extraction of groundwater exceeds the annual replenishment. When the natural recharge is slow, we have to go in for artificial recharge of groundwater. Various methods of artificial recharge are given below.

- Check dams (Temporary and Permanent)
- Percolation ponds
- Irrigation tanks
- Individual well recharge
- Accelerated recharge technique

Rehabilitation of village ponds through community effects

The village ponds are silted up by 3 ft every year and thereby storage capacities are reduced. Encroachment is also one of the main reasons for reduction of storage capacity of ponds. Desilting of ponds once in 3 years may be carried out through village community organizations and it is the best way to increase the storage capacity of village ponds. It is very useful for recharging the groundwater of community wells.

Accelerated recharge technique

The general measure to sustain the ground water depletion is the construction of percolation ponds. But, the effectiveness of percolation ponds in recharging the aquifers are in question due to the siltation occurring in due course of time and associated costs of renovation. In order to increase the effectiveness of the percolation pond and for recharging the confined aquifers, recharge bore well technique is recommended. The evaluation study of this sub surface technique was carried out and it was found there is an appreciable amount of ground water recharge in all surrounding existing open well (27%) when compared to natural recharge (11%). It is also found that this technique is most efficient and cost effective structure to recharge the hard rock aquifer.

A study on recharge bore well in percolation pond was carried out with rechargeable components viz., silt detention tank, water collection and treatment chamber and filter cum bore well.

The results indicated that recharge during the North East Monsoon was 23% which was about 6% increase from maximum recharge due to the percolation pond. Percolation pond with recharge well has proven improvement in recharge of ground water.

Suggested plan of action for localized rainwater harvesting by farmers

Using abandoned/defunct wells on farmer holdings for rainwater harvesting

Tamil Nadu state has large number of abandoned open wells (about 1.6 lakhs) and their numbers is on the rise. The farmers may be encouraged to plan and execute structures on their farms to collect the rainwater, direct to the abandoned wells and thereby recharge the groundwater. This will help to harvest the rainwater in relevant areas besides utilizing the capital investments that have already been made by the farmers.

V. SOIL HEALTH MANAGEMENT

The average productivity of the major crops grown in Tamil Nadu is only 60 per cent of the potential yield. The main reason for low productivity is due to decline in soil organic matter and soil health status, lack of awareness on the latest technologies and lack of suitable advisory services. The adoption of suitable crop production techniques will pave way for enhanced crop productivity and sustained soil fertility.

Soil Organic Matter

Soil organic matter as a single entity, is the most important soil component for maintaining soil health fertility. Although the amount of SOC in soils of India is relatively low, ranging from 0.1 to 1.0 per cent and typically less than 0.5 per cent, its influence on soil fertility and physical conditions is of great significance. The cause of low level of organic carbon in Indian soil is primarily due to high temperature prevailing throughout the year. Considering the nutrient removal by crops and supply through different sources under intensive cropping systems, removal is far greater than supply. It is therefore extremely important to maintain SOC at a reasonable stable level both in quality and quantity by means of suitable addition of organic materials or crop residuals. Increasing soil organic matter content through Integrated Plant Nutrition System (IPNS) approach enhanced the soil quality, reduces soil erosion and degradation, improves surface water quality and increases soil productivity.

Soil organic matter has declined from 1.20 % in 1970 to 0.68% in 2002 and this decline in soil organic matter content impedes the crop response. The only solution to increase the organic matter content in soil is regular application of organic manures to soil by farmers. Now organic manures availability is very low and the quality is also very poor. The organic manure availability in Tamil Nadu can be improved through proper composting of biodegradable waste generated. This also need to be fortified to improve the quality of manures for which biofertilizer inoculum, biocontrol agents and rock phosphate can be used.

Recycling of waste for Agriculture

In soil health maintenance, organic manures play a major role. Addition of organic matter into the soil improves organic carbon content and also other nutrients in the soil. This supports the diversity of microbial flora in the soil, which plays a major role in nutrient transformation. In Tamil Nadu, 120 lakh tons of plant residues are available for recycling through composting which adds 0.70 lakh tons of nitrogen, 0.27 lakh tons of phosphorous, and 1.93 lakh tons of potassium. Through animal manure, we will get 3.36 lakh tons of nitrogen, 1.47 lakh tons of phosphorous and 20 lakh tons of potassium. The other good resource is vegetable waste generated from Uzhavar sandhai. All these biodegradable waste can be properly recycled through composting and more organic manure will be available for farmers use. TNAU has refined the composting technology through addition of efficient microorganisms.

Demand Driven Nutrient Supply

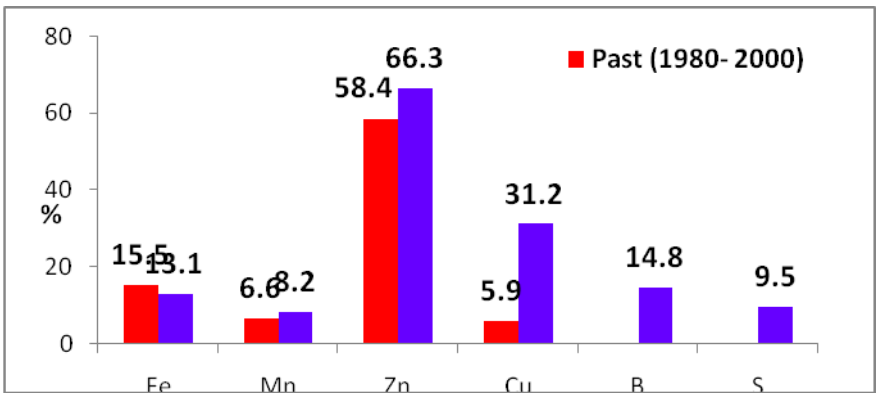
The estimated net negative balance of NPK is about 8-10 million tonnes per annum in India. Therefore, management of nutrients is to be given proper attention to maintain or increase yields and sustain productivity. The basic concept underlying the Integrated Plant Nutrition System (IPNS) is the maintenance of soil fertility, sustaining agricultural productivity and improving farmers' profitability through judicious and efficient use of fertilizers, organic manures and / or biofertilisers to the extent possible. Hence in the present context, Soil Test Crop Response based

Integrated Plant Nutrition System (STCR-IPNS) is one of the best nutrient management technologies which is based on demand driven nutrient supply for achieving yield enhancement of crops with sustained soil fertility.

STCR-IPNS is an improved technology over blanket or general fertilizer recommendation. In the experiments conducted so far, fertilizer prescriptions under IPNS have been developed for 25 crops *viz.*, cereals (rice and wheat), millets (maize, ragi and sorghum), pulses (greengram and blackgram), oilseeds (groundnut, gingelly and sunflower), commercial crops (cotton and sugarcane), vegetables (onion, bhendi, cabbage, cauliflower, potato, carrot, beetroot, radish, tomato and tapioca), spices (chilli and turmeric) and medicinal crops (ashwagandha) on 15 soil series *viz*.,Adanur, Ambasamudram, Gadillum, Irugur, Kalathur, low level laterite, Manakkarai, Noyyal, Ooty, Palathurai, Palaviduthi, Perianaickenpalyam, Pilamedu, Somayanur and Thulukkanur soil series. In addition, fertilizer prescriptions under IPNS have been developed for improved technologies *viz.,* rice under SRI (Noyyal series), drip fertigation for transgenic cotton (Perianaickenpalyam series) and for rainfed crops *viz*., transgenic cotton (Pilamedu series) and maize (Irugur series). These prescriptions were test verified and demonstrated at farmers' holdings for large scale adoption on similar and allied soil types. Being a site specific technology, STCR-IPNS ensures balanced nutrition, increased productivity and efficiency of applied NPK. In addition, fertilizer doses can be prescribed for desired yield targets based on resource availability of farmers.

Micronutrients status

The assessment of micro and secondary nutrients status in the soils of different districts of Tamil Nadu is highly essential to determine the nature and extent of nutrient deficiencies. A comparative analysis was made to find out the status of micronutrients and sulphur between 1980 -2000 assessment and present reassessment made between 2006 and 2013 from the soils collected in 16 districts. The data indicated that the deficiency of micronutrients in the soils of all 16 districts showed some spectacular changes. In general, average Zn deficiency is slightly increasing from 58.4 to 66.3 per cent, while Cu deficiency is emerging very fast from 5.9 to 31.2 per cent. There are no apparent changes in Fe and Mn status of the reassessed 16 districts. The B and S status in the previous assessment was not made for all the districts. However in the present delineation and reassessment, their average per cent deficiency was 14.8 and 9.5 per cent for B and S respectively. The deficiency of micronutrients can be managed by soil and foliar application of concerned micronutrient fertilizers depending up on the crop.



Management of Problem soils

Out of the total geographical area of 13.0 m.ha of the State, 4.69 lakh ha of land has been affected by sodicity/ salinity. The salt affected soils of Tamil Nadu based upon their geographical distribution have been classified into coastal saline soils (1.67 lakh ha) and inland saline or sodic soils (3.02 lakh ha).

Saline soils

In the areas of high salinity, it is essential to bring down the salinity by leaching the salts. It is also necessary to lower the water table if it is shallow and saline and maintain it below the critical depth to prevent resalinisation. Provision of lateral and main drainage channels of 60 cm deep and 45 cm wide and leaching of salts could reclaim the soils. Out of the various methods of drainage systems and reclamation of saline soils, subsurface drainage system will be most effective and long lasting particularly in heavy soils. This system includes laying of perforated PVC pipes underground and draining the accumulated salts along with water to a common outlets/well. The drained water will be tested for its quality and if found suitable, the same water will be recycled to the crop.

Sodic soils

Sodic soils containing excess sodium become extremely water-logged as the soil porosity is lost and water do not percolate down easily / quickly. Sodic soils are those which have an exchangeable sodium percentage (ESP) of more than 15. In case of excess sodium contents of the soil, it has to be treated with soil amendments such as gypsum, sulphur etc., and then the salts have to be drained.

Reclamation or improvement of sodic soils requires the removal of part or most of the exchangeable sodium and its replacement by the more favourable calcium ions in the root zone. The suitability of one or another amendment for sodic soil reclamation will largely depend on the nature of the soil and cost considerations. Gypsum is soluble in water to the extent of about one-fourth of 1 percent and is, therefore, a direct source of soluble calcium.

Tannery wastes contaminated soils

The tannery wastes (effluents and sludge) contain high concentrations of salts (sodium, chloride and sulfates, etc.) and chromium (Cr). The indiscriminate disposal of tannery wastes resulted severe pollution of soil and water in Vellore and Dindigul districts where most of the tanneries exist. Pollution of soil and water drastically reduced the crop yields (25 to 40%) over the years and total cropped area decreased significantly. Within 20 years, the total cropped area has fallen about 10.5% in Vellore district and 41% in Dindigul district. Assessment of Cr in contaminated soils in Vellore district showed that the soils around tannery industries are severely contaminated with Cr and in most places exceeded the maximum threshold limit prescribed in different countries. Currently, it has been estimated that more than 50,000 ha of productive agricultural lands are contaminated with Cr alone due to the disposal of tannery wastes in Vellore District. The Cr concentration in ground waters was also much higher than the normal average background value reported in different parts of India.

Management

- As part of bioremediation strategies, growing maize and sunflower with the application of poultry manure (10 t ha^{-1}) or vermicompost (5 t ha^{-1}) with or without microbial strains like *Pseudomonas fluorescens*, or *Trichoderma viride* is recommended.

- **Crops and varieties suitable for tannery waste affected soils**

  Based on the results of field trials conducted at Vellore district, the following crops, trees and their varieties are recommended for the tannery waste affected soils

  Cereals : Rice (TRY 1, CO 43, Paiyur 1, ASD 16)
  Millets : Ragi (CO 12, CO 13)
  Oilseeds : Sunflower (CO 4, Morden) and Mustard
  Sugarcane (COG 94076, COG 88123, COC 771)
  Vegetables : Brinjal, Bhendi, Chillies, Tomato (PKM 1)
  Flower crops : Jasmine, Neerium, Tuberose
  Trees : Eucalyptus, Casuarinas and Acacia

Textile and dye effluents contaminated soils

There are many textile and dyeing industrial hubs in India. Tirupur is one such hub located in Tamil Nadu. These industries generate large quantities of wastewater and solid wastes which are polluting land and water severely in and around Tirupur. There are about 3000 industries operating in the Tirupur District, of which about 750 are dyeing and bleaching units. About 75-100 million litres of effluent is being disposed onto the soil and water systems. Indiscriminate disposal of these effluent and solid wastes has affected more than 12000 ha of agricultural lands in Tirupur District alone. This effluent is discharged onto Noyyal River which has affected several thousand hectares of agricultural lands in Coimbatore, Erode and Karur Districts also. A reservoir was constructed at Orathuppalayam in Erode District by the Public Works Department of Tamil Nadu during 1992 across the Noyyal River downstream of Tirupur. It was constructed at a cost of Rs. 20 crores to store flood water for irrigation. However, in due course the Noyyal river water stored in Orathuppalayam Dam was contaminated and found unfit for irrigation owing to high electrical conductivity (EC) and total dissolved solid (TDS). The continuous storage of salt laden effluents in the Dam and its use for irrigation have resulted in the deterioration of soil and water in Tirupur, Erode, Karur and Coimbatore Districts. A research conducted by TNAU has shown that 6842 ha in Tirupur, 2353 ha in Erode, 8026 ha in Karur and 3717 ha in Coimbatore Districts were found affected due to textile and dye effluents (Table 1).

Table 1. Land area affected due to dye and textile effluents in Tirupur District (Classification based on well water EC)

District	Moderately affected EC 1.5 - 3.00 (dSm^{-1})	Severely affected EC 3.00 - 5.25 (dSm^{-1})	Very severely affected EC 5.25 - 7.5 (dSm^{-1})	Extremely affected EC > 7.5 (dSm^{-1})	Total area (ha)
Tirupur	3472.23	1742.26	886.59	740.61	6867.43
Erode	1398.78	610.24	173.53	170.60	2353.16
Karur	2814.04	2333.86	1185.19	1692.88	8025.97
Coimbatore	1144.76	2363.61	164.97	43.51	3716.85
Total	8829.81	7049.97	2410.28	2647.60	20937.66

Management

The soils affected due to textile and dye effluents can be managed by adopting appropriate technologies so that these soils could become productive and agriculture can be revitalized.

Following management practices are recommended:

- Irrigating the field with good quality water
- Providing adequate drainage system (development of either surface or sub-surface drainage)
- Blending (mix) good quality water with the contaminated water to reduce the concentrations of salts (dilution).
- The physical methods for reclamation of saline soils are deep ploughing, sub-soiling, profile inversion and scraping.
- Application of farm yard manure (FYM) at a rate of 5 t/ha, 10 to 15 days before sowing or transplanting of crops.
- Salt tolerance crops can be grown depending upon the EC of the irrigation water (Table 2).

Table 2. Relative salt tolerance of some important crops

Crop	Threshold salinity (dSm^{-1})	Crop	Threshold salinity (dSm^{-1})
Cotton	7.7	Sugarcane	1.7
Sorghum	6.8	Mung bean	1.0
Soybean	5.0	Cluster bean	8.8
Cowpea	4.9	Cucumber	2.5
Groundnut	3.2	Tomato	2.5
Rice	3.0	Onion	1.2
Maize	1.7	Carrot	1.0

GIS Nutrient Mapping

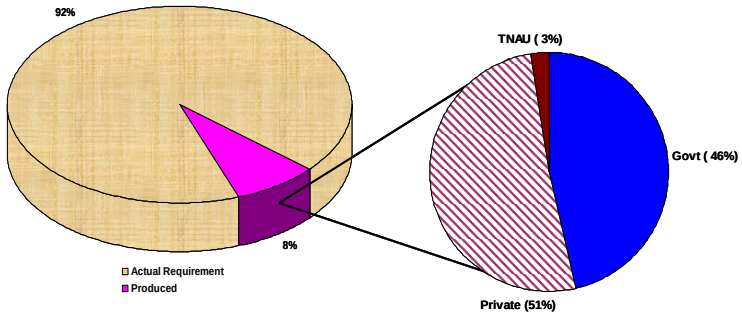
Soil test based nutrient application is an important concept centered around the principles of efficient and balanced fertilizer application and environmental safety. In Tamil Nadu, soil testing is taken up in a mission mode and a huge database on soil nutrient supply capacity is being generated. A much greater potential use of these results is to generate GIS maps of soil nutrients. The GIS nutrient mapping has been taken up in six blocks of Tamil Nadu comprising Kodavasal Block of Tiruvarur District, P.N. Palayam Block of Coimbatore District, Manikandam Block of Trichy District, Kaniyambadi Block of Vellore District, Sattur Block of Virudhunagar District and T.N. Palayam Block of Erode District, to create a digital village maps for generating base map for various mapping activities like soil nutrient mapping and to generate soil macro and micronutrient maps for Tamil Nadu.

Biofertilizers

Biofertilizer is one of the important component of integrated nutrient management, as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers. The nitrogen fixing bacteria, *Rhizobium, Azospirillum, Azotobacter, Gluconacetobacter,* cyanobacteria; P solubilizing bacteria, Phosphobacteria; P mobilizing fungi, Arbuscular mycorrhiza, pink pigmented facultative methylotrophs (PPFM) and N fixing green manure, Azolla are presently multiplied in large quantity and distributed to the farmers. The location, soil and crop specific strains maintained in the Department of Agrl Microbiology, TNAU, Coimbatore serve as mother cultures to various government and private biofertilizer production units. The total requirement of biofertilizer for entire crops in Tamil Nadu comes around 40,000 tonnes per year. Although Tamil Nadu ranks first in the production, it could meet only 20 percent of the total requirement of India. In Tamil

Nadu, there are 15 units under the Department of Agriculture and five units in TNAU (Coimbatore, Trichy, Madurai, Paiyur and Kilikulam).

Since the annual production of biofertilizer cover only 7-8% of the total cropping area of Tamil Nadu, there is a vast scope for large scale production and distribution of biofertilizers. The following fig. shows the annual biofertilizer requirement and coverage and different agencies contributing the biofertilizer production.



However, the popularization of biofertilizer among the farmers could increase the usage in Tamil Nadu for which, the quality of the biofertilizer is to be maintained. The key issues to be focused to increase the biofertilizer usage in the state are

- Crop / soil and location and stage specific inoculants
- High quality inoculants with more viable cells and nil contaminants
- Timely availability of biofertilizer to all the districts
- Suitable formulations for mechanized farming

Economically viable technologies developed are

1. Mixed bioinoculant - Azophos
2. Sugarcane biofertilizer – *Gluconacetobacter diazotrophicus*
3. Liquid biofertilizers
4. Arbuscular mycorrhizal biofertilizer production by rural women
5. Quality standards for AM biofertilizers
6. PPFM technology for drought mitigation

Liquid Biofertiizers

Liquid inoculants are available in broth culture or as frozen concentrates. Broth or frozen concentrates are treated to seeds or usually mixed with water and spread in to the seed furrows at planting. Liquid microbial inoculants are not only broth culture obtained from fermentors, but they contain polymers which primarily function as bacterial cell protectants. Liquid biofertilizer has certain advantages like

Advantages

- No contamination
- Better shelf life (12 – 24 months)
- Better survival on seeds and soil
- Cost saving on carrier material, pulverization, neutralization and sterilization
- Identified by typical fermented smell
- Easy quality control
- Dosages is 10 times less than carrier bio fertilizers
- Greater potentials to fight with native population

Preparation of liquid biofertilizer

TNAU has developed liquid biofertilizer technology for *Rhizobium, Azospirillum*, Phosphobacteria, and PPFM. Liquid biofertilizers production and application has been standardized. Based on this, already five biofertilizer production units (Cuddalore, Ramanathapuram, Trichy, Salem and Sakkottai) of the Department of Agriculture have been upgraded as liquid biofertilizer production units with technical advice and guidance from TNAU.

Biofertilizers through Drip

The State Government owned units can supply the liquid biofertlizers for drip irrigation. Liquid Biofertilzers and their application to different crops; For Annual Crops; Seed Treatment : 50 ml / acre seeds, Seedling dipping : 150 ml / acre seedlings, Main field application : 200 ml / acre.

Biofertigation for Precision Farming:

Liquid bioinoculant	:	To be mixed with water in the fertigation tank @ 1 ml / lit.
Time of application	:	15,30, 45 DAS
Precaution	:	A minimum time interval of one week to be maintained between biofertigation and fertigation

PPFM for drought mitigation

The PPFM liquid inoculant (diluted as 1% spray fluid with water) was applied on rice crops raised at Thanjavur, Thiruvarur and Nagapattinam districts of Tamil Nadu for mitigation of drought. A quantity of nearly 22,000 litres of PPFM inoculant was produced in June-Sep, 2012 and distributed to rice farmers. The drying crops regained its green color. This is the first report of large scale demonstration of saving the moisture stress affected crops using bacterial endophytes (PPFM). During 2013-14, with the financial assistance of GOI, Ministry of Agriculture, 1000 ha of paddy fields in Sivaganga and Ramand districts of Tamil Nadu were sprayed with PPFM to mitigate drought. **Precaution :** Do not mix with pesticide / fungicide / chemical fertilizers

Quality control to improve the biofertilizer production.

- Mother culture inoculants should be obtained from the Department of Agrl Microbiology, TNAU Coimbatore
- Quality microbiologists / plant pathologist should be engaged in the biofertilizer production centres.
- A centralized NABC accredited biofertilizer quality control laboratory may be established in coordination with TNAU.
- Already 5 Biofertllizer production units have been upgraded as liquid bioferliilzers production centers. To improve the quality of the bio inoculants, the remaining BFP units may also be upgraded as Liquid Biofertillizer units with advanced type fermentors.
- Only the quality control laboratories of the Department of Agriculture, Government of Tamil Nadu and the Department of Agrl Microbiology of SAU should be authorized to test the quality of biofertilizers and issue quality control certificates.
- A nodal centre for R & D and HRD in Biiofertlizer production and control may be established in TNAU to provide technical support to the BFP units.
- Periodical inspection by Additional Director of Agriculture and Experts from TNAU to monitor the functioning of BFP units and quality control laboratory of Department of Agriculture, Gov of Tamil Nadu.
- Quality control of biofertilizers should be made mandatory as per FCO.

VI. CROP PROTECTION STRATEGIES

The crop protection technologies developed by the TNAU for management of major pests (insects, diseases and nematodes) in various crops are compiled in the crop production guide, which serve as a ready reckoner for scientists and extension personnel. The technologies developed recently are included in this chapter for future reference.

INSECT PEST MANAGEMENT

Rice

Rice stem borer and leaffolder where predominant in rice growing areas of Tamil Nadu while planthopper in some areas of rice crop. As a consequence, the use of chemical pesticides increased phenomenally causing several ecocidal effects. The improper use of chemical pesticides resulted in adverse effects like resistance to insects, resurgence of sucking pests and residue problem in the treated surface leading to environment pollution. Integrated Pest Management (IPM) based on ecological principles is the best alternative to sole dependence on pesticides besides, IPM helps in efficient and sustainable rice production. Following effective IPM components developed have been validated in three centres in comparision with farmers' practice comprising chlorpyriphos and dimethoate and propiconazole application.

1. Wet seed treatment with *Pseudomonas fluorescens* TNAU *Pf* 1 @10g/kg of seed
2. Pest monitoring - TNAU indigenous pheromone for stem borer management @ 5/ac for monitoring and 8/ac for mass trapping
3. Release of *Trichogramma* egg parasitoids for stem borer and leaf folder management (5 cc/ha/release) based on pest monitoring *i.e.* pheromone catches and egg count
4. Foliar spraying of TNAU *Pf* talc formulation @ 5g/l two times from 45 DAP for disease management
5. ETL based application of profenophos 50 EC (400 ml/ac) or cartap hydrochloride (250 gm/ac)

Advantages of adopting IPM were reduced pest damage level, sustenance of biocontrol agents like coccinellids and spiders besides cost benefit ratio of 1:1.44 as against 1:1.05 in the farmers practice

MILLETS

Sorghum

Sorghum midge: Contarinia sorghicola, is one of the major pest attacking developing grains and causes pollen shedding due to egg laying, and chaffy grains are formed with holes due to feeding by developing maggots. Early results indicated that the pre-monsoon sowing reduces the midge damage than the post –monsoon sowing. Bio intensive pest management (BIPM) practices for sorghum midge were conducted with eight treatments and three replications of K8 sorghum. Among the BIPM treatments, neem oil 3 % recorded with the highest percentage of reduction over control (65.35) followed by NSKE 5 % (61.75), neem leaf extract 5% (58.18) and pungam oil 5% (51.49). The highest cost benefit ratio was obtained in NSKE 5% treated plot (1:2.19) followed by neem oil 3% treated plots (1:2.13).

Pulses

Among the pod borers of redgram, gram pod borer, *Helicoverpa armigera*, pod fly, *Melanagromyza obtuse* and pod bug, *Clavigralla gibbosa*, are the regular pests and in recent years, the spotted pod borer, *Maruca vitrata*, blister beetle, *Mylabris* sp. and pod wasp, *Tanaostigmodes cajani* are emerging as major pests. In TNAU research is being carried out on the identification of resistant sources for major pests and Integrated Pest Management. The variety LRG 41 is found to be tolerant against *H. armigera.* The mechanism resistance was found to be non preference for oviposition and tolerance under field condition. Number of eggs laid in LRG 41was less when compared to susceptible varieties possessing flower volatiles (Attractants) which might be the reason for more oviposition while LRG 41 lacks such volatiles. The flower volatiles were identified from susceptible varieties and synthesized for the field evaluation (to be used as attractant for females). This LRG 41 is also included in crossing program of TNAU (with CORG 7 of short duration & G 3 of long duration varieties) and that three crosses *viz*., CRG 2013- 107, CRG 2013- 109 and CRG 2013- 114 recorded low pod damage and further evaluation is in progress.

Need based application of insecticides is one of the components of IPM. Hence, newer insecticides were evaluated against pod borers. Among the newer insecticides evaluated, indoxacarb 15.8 EC @ 73g a.i/ ha and rynaxipyr 18.5 SC @ 30 g a.i./ ha were found to be highly effective against *Helicoverpa*. The per cent grain damage by pod fly was low (8.0) due to acetamiprid and rynaxipyr 18.5 SC @ 30 g a.i./ ha, as against the high damage in untreated control plots (25.3). The highest yield could be achieved with rynaxipyr 18.5 SC @ 30 g a.i./ ha (1063.3 kg/ha) followed by indoxacarb 15.8 EC @ 73g a.i/ ha (1060.0 kg/ ha) while the untreated plot yield only 510.0 kg/ha.

Use of botanicals is one of the IPM components. As there are certain practical difficulties in getting the NSKE and preparation of spray formulation, alternative to NSKE, the neem soap and pungam soap were evaluated by alternating with insecticides. The insecticidal combination with botanicals, the spraying of pungam soap (10g) followed by indoxacarb (0.5 ml/l) was found to be highly effective in reducing *Helicoverpa* larval population (1.5/plant), pod damage (6.3%) and pod fly grain damage (8.0%) resulting in an yield of 1163.3kg/ha while maximum pod damage (38.3%) and pod fly grain damage (24.6%) with minimum grain yield (565.0kg/ha) were observed in the untreated plot.

Major pests in redgram

Blister beetle

Spotted pod borer

Pod bug

Gram pod borer

Pod fly

OIL SEEDS

Ground nut

Application of novaluran 10 EC @ 1000 ml/ha is effective in managing the sucking pests *viz.,* thrips (4.2/ 3 compound leaves/ plant) and leaf hoppers (4.5/ 3 compound leaves/ plant) and also registered a maximum of 2.126 tonnes /ha pod yield and 8.5 tonnes /ha of haulm yield with a Benefit Cost ratio 1: 2.4 in kharif.

Sesame

Spraying chlorantraniliprole 18.5 S.C. @ 0.4 ml / l effected minimum damage both in vegetative (4.28 %) and capsule stage (2.82%) and minimum shoot webber population (0.4 on 7 DAT /plant) with the maximum yield (668 kg/ha) and cost benefit ratio (1:2.57) as against the untreated check having 16.12 per cent , 14.58 per cent damage and 4.24 larvae / plant respectively.

Damage

Larva

Adult

For the management of rust flour beetle, *Tribolium castaneum*, in stored sesame seeds, the seed treatment with spinosad 45 SC @ 0.5 ml/kg of seeds registered cent per cent mortality on 5 DAT with the highest seed germination percentage of 90.50.

Castor

Spraying of chlorantraniliprole 18.5 SC @ 0.3 ml/l recorded maximum reduction (67.7%) of defoliators *viz., Achaea janata, Spodoptera litura, Euproctis fraterna and Ergolis merione* and 60.5 % of reduction in capsule borer damage with maximum seed yield of 1414.12 kg / ha and high CBR (1: 2.23) as againt 572 kg/ha and 1.14 respectively in untreated check.

SUGARCANE

Assessment of certain insecticides against major pests of sugarcane under drip irrigated water management system

Micro irrigation aims to save considerable water and also efficient utilization of fertilizers through fertigation. This strategy also reduces labour involvement for flood irrigation as well as for fertilizer application manually. This technique also improves crop growth by minimizing wastage of precious water and costly fertilizers. Insect pests of sugarcane, especially borer pests cause considerable loss to sugarcane crop. Late planted sugarcane during summer months suffer heavily by shoot borer pest in Tamil Nadu and internode borer succeeds shoot borer in the later stages of the crop. Sucking pests are also a problem in the vegetative phase of the crop. Borer pests particularly shoot borer in the early stage of the crop are managed by chemicals either soluble concentrates or granular formulations of systemic nature. Topical applications are not so effective in view of the nature of the borer larvae living inside stem of the plants. Application of chemicals through drip irrigation just like

fertigation will certainly manage these borer pests effectively over the conventional system of spraying and also parasite/predator ecosystem will not be considerably altered. Hence, in the above context, pesticide application through drip irrigation was contemplated to reduce cost of pesticide application as well as prudent utilization of insecticides for the management of borers of sugarcane.

The treatments are to be done as pestigation via drip irrigation. The commonly used pesticides *viz.,* imidacloprid (17.8 SL), monocrotophos (36 SL), dimethoate (25 EC), chlorpyriphos (20 EC), neem seed kernel extract 5% @ 250, 1250, 1500, 1500 and 25 ml/kg/ha respectively, with systemic nature were selected, since pestigation was done through irrigation water and plants need to carry pesticides through systemic action to various plant parts. Neem product, a botanical insecticide, though non systemic was included as one of the treatments for comparison. Before pestigation, the drip irrigation is to be done for 15 minutes so as to drench the soil in the proximate root zone nominally, so that pestigation might be easily absorbed. The pesticide quantum is to be dissolved in 25 litres of water and allowed to be absorbed through ventury system and drip irrigation carried out for only 5-10 minutes initially and stopped. After two hours, normal drip irrigation to be continued for another two hours for moderate drenching of root zone and for effective translocation of pesticides through root system.

During 2012-2013 season, the cumulative incidence of shoot borer was the lowest in imidacloprid treatment (17.43%), followed by chlorpyriphos (24.85%), dimethote (26.14%) and monocrotophos (26.29%). Neem kernel extract has recorded high incidence of 46.27% shoot borer, while the untreated control has recorded 54.45% shoot borer, indicating the neem product non performance in pestigation technique and also its non systemic effects as against felt in other chemical pesticides. The mean cane yield per hectare was highest in imidacloprid treatment (130.04 t/ha), followed by monocrotophos (128.32 t/ha). Similar trend was observed during 2013 – 14. However, the standardisation of dosages and dilution factors and duration of pestigation have to be done by further studies. Besides, the residue analysis in juice and sugar for the best insecticide treatments has to be done to ensure quality for export purpose.

COTTON

Integrated Pest and Disease Management (IPDM) Technology for cotton

In recent years, sucking pest complex, *Alternaria* leaf blight and tobacco streak virus have become major constraints in cotton cultivation in Tamil Nadu. Hence, to mitigate the problem, IPDM practice was optimized.

IPDM Package

1. Seed treatment with imidacloprid 70 WS (10ml/kg seed)
2. Soil drenching with chlorpyriphos 20 EC (1.25 l/ha) on 25 days after sowing
3. Soil drenching with *Bacillus subtilis* (BSC5) on 30, 60 and 120 days after sowing
4. Foliar application of *B. subtilis* (BSC5) @ 0.1% containing 10^8 cells/ml (10g/l) on 30, 60 and 120 DAS
5. Monitoring with yellow sticky traps (12/ha)
6. Monitoring with pheromone trap(12/ha)
7. Need based application of insecticides - imidacloprid 17.8 SL (100ml/ha)
8. Need based application of fungicide 0.1% trifloxystrobin 25% + tebuconazole 50% WG or mancozeb 75 WP - 0.25%.
9. Raising of trap crop (castor and maize) along bunds.

Integrated Pest and disease management in cotton

Details	Tobacco streak Virus (%)	Root rot (%)	Whitefly Mean (No. /3 leaf)	Leaf hopper Mean (No. /3 leaf)	Thrips Mean (No. /3 leaf	Per cent Disease Index *Alternaria* Leaf blight (PDI)	Yield (Qtl/ha)	C/B
IPDM	5.75	5.44	3.0	6.0	5.0	11.9	27.0	1:3.56
Farmer's practice*	16.75	12.6	6.0	7.0	7.0	23.5	20.0	1:2.33

The IPDM package was effective in the suppression of both sucking insects and disease complex in cotton.

Management of stem weevil and root rot complex in cotton

In summer irrigated cotton, stem weevil and root rot complex is a serious menace in cultivation. Among the tested pesticides and bioagents imidacloprid seed treatment followed by drenching of monocrotophos (400 ml/acre) and carbendazim (0.2%) on 30, 60 and 120 DAS was effective in reducing stem weevil root rot complex.

VEGETABLES

Management of insect pests in vegetable crops using IPM components

- The IPM package in chillies *viz.,* seed treatment with *Trichoderma viride* (4g/kg), seed treatment with *Pseudomonas* (10 g/ kg), nursery + seedling dip treatment with *Pseudomonas* @ 10 g/ lit of water, soil application of neem cake @250 kg/ha, border crop (Castor/mustard/marigold), roguing virus infected plants, use of yellow sticky traps, pheromone traps (*Helicoverpa / Spodoptera /* Fruit fly) and parasitoid release (*Trichogramma),* resulted in reduced incidence of thrips, fruit borer, yellow mites, damping off, leaf spot, powdery mildew, leaf curl and fruit rot coupled with higher fruit yield and cost benefit ratio resulting in cost benefit ratio of 1:2.40 as against 1:1.98 in farmers' practice.
- IPM in gourds consisting of soil application of neem cake @ 250kg/ha, soil application of *Pseudomonas fluorescens* @ 2.5kg/ha, soil application of *Trichoderma viride* @ 2.5kg/ha, installation of yellow sticky traps, setting up of pheromone / fruit fly traps, release of biocontrol agents (*Trichogramma / Chrysoperla*), application of botanical pesticide (Neem formulations) and need based application of insecticide / acaricide / fungicide recorded lesser insect pests *viz.,* leafminer, leafhopper, whitefly, fruit fly and root knot nematode. Adoption of IPM resulted in C:B ratio of 1:1.80, 1:2.42 and 1:1.95 as against farmers' practice having only 1: 1.531: 1.68 and 1: 1.26 in bottle , bitter and snake gourds respectively.

Efficacy of insecticides for the control of spiralling whitefly *Aleurodicus dispersus* on cassava

Spiralling whitefly is becoming a major pest in many horticultural crops. In tapioca, it causes heavy yield loss and reported to attack the crop in almost all districts of Tamil Nadu. The incidence is very severe after the control of *Paracoccus marginatus* by release of *Acerophagus papayae*. Due to the reduction in competitive species, the problem is aggravated. Out of nine insecticides evaluated in two trials for the management, spraying acephate 75SP @ 1.5 g/l or triazophos 40 EC 2.5 ml/l. or acetamiprid 20 SP 0.4g/l is more effective for the control of spiralling whitefly on tapioca.


Field demonstration of BIPM package for the management of key pests of Tomato

Adoption of biointensive IPM package consists of seedling root dip with *Pseudomonas* 2% solution, African marigold as trap crop, installation of yellow sticky trap @ 50 No's /ha, installation of bird perches @ 10/ha, need based application of *Bt* and NPV based on pheromone monitoring, sucking pests management through azadirachtin spray, release of *Trichogramma pretiosum* @ 50,000 Nos /ha and release of *Chrysopa* grubs @ 50,000 Nos /ha. in tomato resulted in lower population of aphids, thrips, leafhoppers and whiteflies and lesser fruit borer *H. armigera* incidence (6.4 to 8.6%) when compared to farmers practice (14.2 to 15.8%) besides more fruit yield and higher natural enemy activity than the farmers practice with a high cost benefit ratio of 1:3.2. Higher natural enemies *viz*., *Chrysopa* and coccinellid activity was noticed in BIPM demonstration plot.

Fruits

The citrus or Lemon Butterfly, *Papilio demoleus* is an economically important pest whose larva cause serious damage by defoliating large quantity of the foliage. The caterpillars feed voraciously on the young foliage at the nursery stage and also on young flushes of grown up trees. In case of severe infestation, entire tree is defoliated and may cause 100 % defoliation in young plants. Foliar spray with *Bacillus thuringiensis* @ 1 g/l at 15 days interval was found to be effective for the management of lemon butterfly pest in acidlime both in nursery and also in main field.

Management of insect pests in sapota

Among the 25 insect pests attacking sapota, sapota bud worm, *Anarsia epotias* and sapota leaf webber *Nephopteryx eugraphella* are two major pests which are active throughout the year. The damage due to these insect pests varied from 2.0 to 15.0 per cent. Foliar spray with profenophos 50 EC @ 2ml/litre at 15 days interval was found to be effective for the management of the above pests

Coconut

Rhinoceros beetle and red palm weevil are the major pests of coconut causing economic damage. In recent years, pheromone lures are used to monitor and mass trap the rhinoceros beetle and red palm weevil population in coconut gardens. The efficacy of CPCRI nano-porous matrix (NPM) lure developed by CPCRI, Kasaragod with and without kairomone blends was evaluated during 2013-14 against these pests. The results indicated that NPM CPCRI lure attracted more number of rhinoceros beetles (51.3 / trap) and red palm weevils (23.5/ trap) as against nil catches in the control. The NPM CPCRI lures were found to be superior to the other lures.

Pheromone trap catches of rhinoceros beetles

Pheromone trap catches of red palm weevil

Efficacy of new iron cage trap on trapping Palm civets

Palm civet *Paradoxurus hermaphroditus* is an emerging problem in coconut It causes significant yield loss up to 25 to 30% in coconut and cocoa. A new iron cage was devised to trap palm civets. The number of palm civet trapped ranged from 2 to 34 / trap / year.

Modifications of the old trap

- Change of double compartment to single compartment cage.
- Reduction of overall weight of cage (from 14.00 kg to 8-10 kg)
- Permanent fixing of trapping rod on the roof of cage.
- Use of GI round rod instead of twister Iron rod.
- Reduction of size from 90 x 45 x 45 to 60 x 45 x 45 cm.
- Change of long size spring coil to medium size spring coil.
- Change of height of front side stand (leg) up to 8 cm and backside stand leg 4 cm (to get inclined position).
- No. of cross bar rods may be reduced up to 3 instead of 4 in mesh frame of front, back, roof and rear sides.
- Front door lock angle maybe used as GI instead of casting Iron metal.
- Setting up of new iron cage palm civet trap fastened with Karpooravalli banana kept in the coconut gardens intercropped with cocoa has attracted and trapped significantly more number of palm civets.

Imported palm civet trap

INTEGRATED DISEASE MANAGEMENT

Rice

Rice is severely affected by many fungal, bacterial and viral diseases. Among them blast, brown spot, sheath blight and false smut cause considerable yield loss in recent years. To manage these diseases the following fungicide molecules were tested for its performance in two places, Coimbatore and Aduthurai.

- Foliar spray of trifloxystrobin 25% + tebuconazole 50% 75 WG (0.4 g/l) resulted in the minimum blast severity of 33% as against 69% in control with a grain yield of 5321 kg/ha as against 3952 kg/ha in control.
- Spraying of Kresoxim methyl 44.3SC @ 1ml/lit reduced the sheath blight severity (16.53%) when compared to control (37.10%) and thereby could increase the yield of 1259 kg/ha.
- Spraying of Trifloxystrobin 25% + Tebuconazole 50%, 75WG at 0.4 g/lit brought down the brown spot severity to the minimum levelof 16.76%, followed by Kresoxim methyl 44.3SC @ 1ml/lit with 18.40%. as against 34.27% observed in the control.

For the false smut management the following fungicide molecules were tested for its performance in two places at three different growth stages of rice at booting, 50% panicle emergence and100% panicle emergence.

Applying propiconazole 25 EC (1ml/l) at booting stage lessened the infected smut spikelets / panicles (4.66%) compared to in control(18.66%) with yield increase of 1266 kg/ha,

Varagu

Kodomillet(also known kodo, haraka and arakalu) one of the small seeded grain cereal crops, predominantly grown in India being affected by various diseases. Among them, the sheath rot caused by *Sarocladium oryzae* is an emerging disease.

Sheath rot

The results of on farm trials revealed that seed treatment with *Pseudomonas fluorescens* (Pf1) @ 10 g /kg of seed recorded significantly lowered sheath rot disease incidence to 3.52% as against 14.4% in control and could increase the yield to the tune of 278 kg/ha with a cost benefit ratio of 1:2.0. Hence, the application of *P. fluorescens* as seed treatment @ 10 g /kg is recommended for the management of sheath rot in varagu.

Pulses

Sterility Mosaic Disease (SMD) caused by Pigeonpea Sterility Mosaic Virus (PSMV) is a major threat to redgram production as it causes 50-90 per cent yield loss. It is transmitted through eriophyid mite, *Aceria cajani*. The SMD infected leaves show yellow and green patches , malformation, severe cholorosis and reduction in leaf size. Eearly infection results in severe stunting and complete sterility and late infection leads to the partial sterility. Application of proporgite 57 EC @ 0.1% at 25 and 40 DAS resulted in the lowest SMD incidence of 11.5 per cent with the highest disease reduction of 83.7 per cent and increased the yield by 332 kg/ha with a C:B ratio of 1:2.5.

Under favorable environmental conditions the redgram wilt disease spreads very quickly and develops in a heavy proportion causing huge economic losses ranging from 10-100 per cent. Seed treatment with pre mixture of carbendazim +

mancozeb @ 2.5 g/kg seed+ basal application of *T.viride @ 2.5* Kg in 500 kg FYM/ha accounted for the disease reduction of 71.1 per cent with an yield increase of 196 kg /ha and C: B ratio of 1:2.1.

Oilseeds

Leaf spot, rust, collar rot, root rot and stem rot are the major diseases of groundnut and cause significant reduction in yield. In addition to resistant varieties, an integrated approach by using biocontrol agents, botanicals and less toxic chemicals is needed for effective management of diseases and to increase the yield.

Late leaf spot

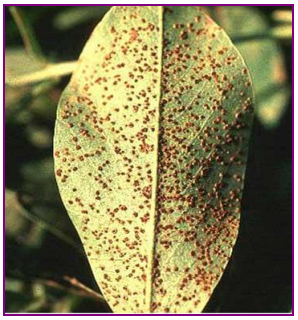
Rust

IDM module comprising of seed treatment with tebuconazole 1.5g/kg seed + soil application of *T. viride* @4kg enriched in 50kg FYM /ha + two spray of tebuconazole @1ml/l at 45 and 60 days was found to be the best in reducing late leaf spot (32.5 PDI), rust (25.2 PDI) and soil borne diseases collar rot (5.0 %), root rot (4.7 %) with higher yield of 2366 kg/ha when compared to control (91.2 PDI, 62.5 PDI , 9.2% &11.0%) and CB ratio of 2.72.

Disease management through organic practices in groundnut

Disease management strategies involving extensive use of fungicides have the disadvantage of residue problem in the produce. Since groundnut is used for edible purposes also, demand for organically grown produce is increasing. In order to address this issue, disease management through organic practices was developed in groundnut.

Stem rot



Rust

Stem necrosis

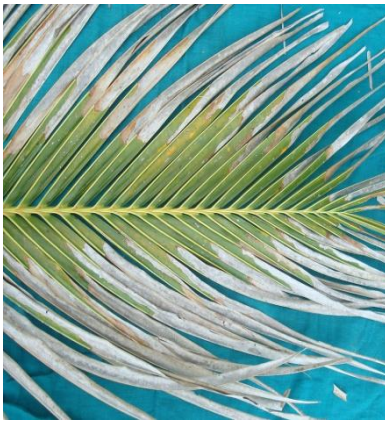
Organic practices *viz.*, seed treatment with *T. viride* and *P. fluorescens* mixture @ 10 g /kg + soil application of *T. viride* and *P. fluorescens*@ 2 kg each enriched with FYM 300 kg/ha + foliar spray of NSKE 5 % @ 30 and 45 DAS reduce the intensity of collar rot (7.6 %), stem rot (7.2 %) and foliar diseases late leaf spot (52.8 PDI) and rust (39.9 PDI) as against the diseases observed in the control (11.0% 8.9% 83.5PDI &68.1PDI) and increased the pod yield (627 kg/ha) with CB ratio of 2.06.

Coconut

The leaf blight disease of coconut caused by the fungus *Lasiodiplodia* (*Botryodiplodia*) *theobromae* is spreading at a faster rate in Coimbatore, Tirupur, Theni, Kanyakumari and other districts of Tamil Nadu. The affected leaflets start drying from the tip downwards and exhibit a charred or burnt appearance. Dark grey to brown lesions with wavy to undulated margins appear from the apex of the nuts. The affected nuts appear desiccated, deformed and dropped prematurely resulting in nut yield loss up to 10 to 25%. The incidence is noticed through out the year. Maximum incidence was observed during summer months. Soil application of microbial consortia consisting of *Pseudomonas fluorescens*, *Bacillus subtilis* and *Trichoderma viride* @ 300g (each 100g) along with FYM 5 kg/palm at quarterly interval was found to be effective in reducing the leaf blight disease incidence.

Leaf blight affected palms

Infection on nuts



Symptoms on leaves

Fruit crops

The fungal diseases like anthracnose caused by *Colletotrichum gloeosporioides* are of great economic importance as they cause heavy losses in mango even up to 100 per cent in severe cases. Almost, all the varieties are susceptible to anthracnose as the weather conditions during flowering are favourable for the buildup of pathogen inoculum. The post harvest losses account for 17-37 % in mango crop. Two foliar sprays of carbendazim (0.1%) starting from 30 days prior to harvest at 15 days interval followed by dipping of harvested fruits in hot water incorporated with carbendazim (500 ppm) were highly effective in reducing the anthracnose incidence (90.81 reduction over control).

The acid lime of canker caused by *Xanthomonas axonopodis* pv. *citri* affects the crop when there is windy rains followed by low temperature (25- 27□C) . Pruning followed by five alternate sprays of Streptocycline (100ppm) + COC (0.3%) and NSKE (5%) at 30 days interval was highly significant in reducing bacterial canker to 6.97 PDI whereas in control the disease incidence was 21.0 PDI with 71.13 % reduction in disease over control, while pruning followed by five alternate sprays of *Pseudomonas* (Pf1) (0.5%) + *Burkholderia gladioli* (0.5%) and NSKE 5% at 30 days interval was effective in reducing the canker incidence to 14.55 PDI with 59.25 % reduction in disease over control.

Vegetable crops

Purple blotch of onion caused by *Alternaria porri,* is one of the important diseases which affects the onion crop during the Kharif season (July – October), when the crop is at 30- 60 days. High relative humidity (80 to 90%) and optimum temperature (25 °C) favour the development of purple blotch disease causing yield

losses up to 20 %. Onion receiving mancozeb 0.25% (30 DAT) + tricyclazole 0.1% (45 DAT) + hexaconazole 0.1% (60 DAT) was effective for the management of purple blotch which had the least PDI of 14.41 and maximum yield of 20.9 t/ ha when compared with control having PDI of 39.7 and yield of 17.1t/ha.

BIOLOGICAL CONTROL OF NEMATODES

Castor

The reniform nematode, *Rotylenchulus reniformis,* wide in distribution in castor is causing 18 per cent loss in seed yield. Bioagents *viz., Pseudomonas fluorescens, Trichoderma viride* and *Paecilomyces lilacinus* evaluated in comparison with standard chemical check and untreated control in two different seasons at Yethapur revealed that soil application of *P. fluorescens* @ 2.5 kg/ha has resulted in significant reduction of soil and root population of *R. reniformis* with the highest yield (1097 kg/ha) and ICBR of 7.60.

Carrot

Root-knot nematode, *Meloidogyne hapla* is a major nematode parasite of carrot in Nilgiri and Kodaikanal hills of Tamil Nadu, significantly reducing the marketable yield and profitability causing yield loss up to 40 per cent. Treatment with *Paecilomyces lilacinus* @ 20g/kg seed + *P. lilacinus* @ 2.5kg + FYM 2.5t/ha was found to reduce significantly the final soil nematode population (240.3/200cm^3), root-knot index (3.0) and increase the yield of carrot (316 q/ha).

Carrots infested by *M. hapla*

Galled carrot

Forked carrot Healthy carrot

Cucurbits

Ashgourd and pumpkin are severely affected by root knot nematode, *Meloidogyne incognita*. The affected plants exhibit yellowing of leaves, wilting of plants with bigger size galls due to spongy nature of the root system. The estimated avoidable yield loss due to *M. incognita* is between 46 and 55 per cent. Integration of *P. fluorescens* as seed treatment and soil application @50 g / kg seed, 100 g/ pit with neemcake @ 500 g/ pit, farmyard manure @50 kg/ pit was found effective in enhancing the yield of ashgourd and pumpkin to 50.2 and 53.0 per cent with 44.0 and 52.2 per cent reduction in root-knot nematode population, respectively. However, with regard to Cost Benefit ratio, seed treatment with *P. fluorescens* @ 50g/kg is effective with high cost benefit ratio of 1:6.5.

Gourds affected by root-knot nematode

Ashgourd

Pumpkin

Crossandra

The area under crossandra is declining fast owing to the nematode disease complex in Tamil Nadu. The disease complex caused by the root-knot nematode, *Meloidogyne incognita* in association with *Fusarium oxysporum* is responsible for more than 50 per cent reduction in flower yield due to wilting. *Trichoderma viride* (2.5kg/ha) as soil application was found to be the most effective treatment for management of nematode fungal disease complex of crossandra and to increase flower yield (20.03%) with higher ICBR of 5.50.

SERICULTURE

Management of root rot disease in mulberry

Among the soil borne diseases of mulberry, root rot disease is alarming because of its epidemic nature and potential to kill the plant completely. The disease incidence ranges from 19.6 to 43.6 % in hot spot areas. Drenching with $ZnSO_4$ (0.1%) + carbendazim (0.1%) thrice at monthly intervals brought down root rot disease incidence to the lowest level of 9.65 per cent and with the highest leaf yield of 11,685 kg/ha compared to control having the maximum incidence of 59.10 per cent and the lowest leaf yield of 9,105 kg/ha.

ZnSO4 (0.1%) + carbendazim (0.1%) drenched plot

Untreated plot

APICULTURE

Management of *Varroa* mite, *Varroa jacobsoni* on *Apis cerana indica*

Varroa jacobsoni is an external parasite that feeds on the haemolymph (= blood) of adult and immature honeybees. *Varroa* mites reproduce solely on the immature stage of the bee, in the capped cells, where they are well-protected from any management measures. This parasitic mite is a serious pest on Italian honeybees and is recently reported to cause problem in Indian honeybees also. Survey conducted at Apiaries in Coimbatore and Erode districts in farmers' apiaries revealed presence of *Varroa* mites in almost all colonies during December 2013. Dusting the top of brood frames with sugar powder at 5 g per brood frame or sulphur dust at 2 g brood per frame

effectively controlled the mite and had lesser mites 15 days after treatment (18.0 and 7.7 mites in bottom board) and improved sealed brood area 30 days after treatment (435 and 511).

Management of *Varroa* mites on Indian honeybees using sugar powder and sulphur powder

Treatment	Mite population in bottom board (15DAT)	Sealed Brood area (cm^2) (30 DAT)	Percent increase in sealed brood area
Sugar powder – 5g per frame	18.0	435	20.5
Sulphur dust – 2 g per frame	7.7	511	41.6
Untreated control	22.1	361	-

Management of Thai Sac Brood Virus (TSBV)

Following preventive measures have to be taken up for keeping the virus under check as the causal organism of the TSBV disease is a virus, so far no effective agents has been reported for curing the colonies off the disease

1. Maintenance of apiary hygiene is absolutely essential. Washing hands with soap solution is a must after handling virus infected colonies and before touching healthy colonies as the disease can spread through contaminated hands of the beekeeper.
2. Avoid getting bee colonies and beekeeping equipments from unknown sources as they may harbor the pathogen.
3. Avoid exchange of brood combs and supers in diseased apiary.
4. Diseased colonies should not be used for colony multiplication. Use only healthy colonies for queen rearing or dividing.
5. Hives of deserted colonies must be closed immediately to avoid spread of disease through honey robbing by healthy worker bees. Melt the combs from diseased and deserted colonies and render wax. Deserted hives must be washed thoroughly with boiling water and sundried before reuse to kill the virus.

Management of bacterial disease

The preventive measures as mentioned for viral disease management (points 1 to 5) must be followed for managing the bacterial disease also. In addition, the bacterial disease can be managed by providing sugar solution mixed with antibiotic terramycin or tetracycline @ 500 mg per 5 litre solution and providing 250 ml of this solution to each hive affected by the disease twice at weekly interval. Care must be taken to minimize antibiotic residues in honey which can affect its quality.

TSBV infected larva dying prepupal stage

Typical symptom of Thai sac brood virus (TSBV) disease of Indian honeybee

VII. BRIDGING THE GAPS IN SEED CHAIN MANAGEMENT

The power of a seed is unlimited. As a powerful agent of change, seeds can be a means of overcoming production constraints, thereby making a difference in the lives of the poor and hungry. An effective seed supply system is necessary to make good quality seed available to farmers at the right time and at low cost. This requires seed demand and supply to be balanced by way of a secure seed supply system. This would give farmers access to adequate quantities of good quality seed of the desired type at the required time and at affordable cost.

India has long been aware of the role of high quality seeds of improved varieties in steering agriculture towards the path of higher productivity. Indian scientists and policy makers have also played a major role enacting and implementing a number of proactive policies to give the required importance to quality seed for the sake of achieving food production targets.

Tamil Nadu has a huge institutional framework for seed production in both public and private sector. Dominance of public sector in seed supply is necessary to guard the interest of the marginal and resource poor farmers who can access the valuable seeds at affordable price. Tamil Nadu Agricultural University has a fine track record of breeding high yielding varieties and hybrids across the crop spectrum, and also has well net work system to support and facilitate the seed production programme of the State by supplying required quantity of breeder seeds, which forms the first generation of the 'Seed Multiplication Chain'. The Department of Agriculture of Tamil Nadu also has well established infrastructural facilities and qualified manpower to accomplish the task of supplying high quality seeds to the farmers in seed supply chain. However, still there exists a certain gap between the seed demand and supply of the state in certain crops, thereby forcing the farmers to use farm saved seeds.

The need of the hour is to identify the lacuna and draw up strategies to tap the affluent resources and bridge the gap between seed demand and supply. Hence the analysis of supply chain management elucidates the technical details related to the seed multiplication and distribution, besides giving a strong back drop on Seed Replacement Rate, Seed Supply Mechanisms, Seed Multiplication Models, Seed Quality Control System etc., will provide the required clarity on the importance of seed multiplication, seed distribution and seed replacement to all concerned in seed planning, production and distribution.

Tamil Nadu comprises of seven agro climatic zones *viz.,* North Eastern, North Western, Western , Cauvery Delta, Southern, High Rainfall and Hill Zones. While tropical crops are being cultivated in six agroclimatic zones, the seventh zone *ie.,* hill zone is suitable for cultivation of temperate vegetables such as carrot, peas, beans, cabbage, cauliflower, radish, turnip, knoll khol etc., The total cultivated land accounts to 58.90 lakh ha. The major crops cultivated are cereals such as rice, maize, cumbu, sorghum and ragi; pulses such as red gram, black gram, green gram, bengal gram, cowpea and horse gram; oilseeds such as groundnut, sesame, sunflower, castor besides cotton, sugarcane and vegetables.

At present, the agricultural production of the state amounts to 61.92 lakh MT in rice, 37.77 lakh MT in millets, 3.69 lakh MT in pulses, 7.90 lakh MT in oilseeds, 4.42 lakh bales in cotton and 322.49 lakh MT in sugarcane. The world and national average yield (kg ha^{-1}) of rice is 3916 and 2393; for maize it is 4343 and 2478 while for cotton it is 1788 and 754 respectively. This reveals that there is tremendous

scope to improve the agricultural productivity of the state. Among the various factors that influence agricultural production *viz.,* irrigation, soil fertility, fertilizer application, pest and disease management *etc.,* sowing with quality seed registers a prominent contribution to the crop yield upto an extent of 15 to 20 percent. Thus the role of quality seed is prominent in boosting agricultural production of the state.

Currently, usage of quality seeds is high in rice, maize, ragi, cumbu, blackgram, greengram, redgram and sunflower, but very low in ground nut. Further, in crops such as sorghum, maize, redgram, green gram, bengalgram, horse gram, cowpea, sesame and castor also seed supply still needs further improvement. The present Seed Replacement Rate (SRR) is around 20-25 % for the various crops. This SRR level has to be increased to 25% (proposed 35%) in self pollinated crops, 33% in cross pollinated crops (proposed 50%) and 100% for hybrid crops, in order to increase sustainable agriculture production and productivity for achieving the food, nutritional and social security. Making quality seeds available is going to be one of the most important challenges before us.

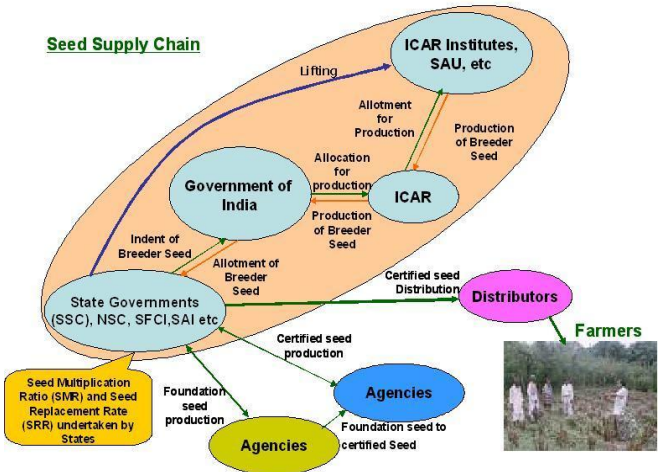
However, the current average SRR is less than the required for sorghum, maize, redgram, green gram, bengalgram, horsegram, cowpea, groundnut, sesame and castor. If the current SRR can lead to an agricultural production of 103 lakh tonnes, the increase in the SRR to the required levels will certainly result in increased production up to the tune of 15- 20 percent.

Seed programme and seed supply systems

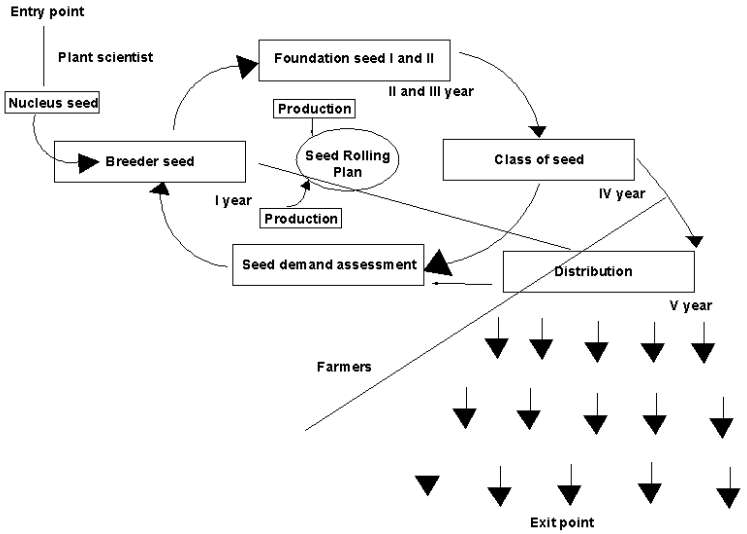
As per the seed supply system in Tamil Nadu, Breeder seeds for the public bred varieties are produced by the Tamil Nadu Agricultural University against the indents received from the State Department of Agriculture and Private seed companies. State Department of Agriculture and Private seed companies multiply the breeder seeds further into foundation and certified seeds. The analyses of data on breeder seed supplied by the Tamil Nadu Agricultural University and certified seed produced by the Department of Agriculture and private sector revealed that expected level of certified seed production has not been achieved in most of the crops. This throws light on the fact that the recommended ‘Generations of Seed Multiplication’ has not been followed strictly, resulting in lower certified seed production with ultimate negative impact on the Seed Replacement Rate.

Presently, the seed multiplication programme is handled by the Department of Agriculture and Department of Horticulture (by utilizing the State Seed Farms, State Oilseeds Farms and State Horticultural Farms) besides private sector. Since the supply of seeds needs to be improved in crops like millets, groundnut, sesame, pulses etc., there is much scope to improvise the existing seed supply system. Now it has been identified that the onus for improving the agricultural production of the state lies in formulating strategies to follow the ‘Generation System of Seed Multiplication’ rigorously without any missing link so that certified seed production is achieved up to the expected level.

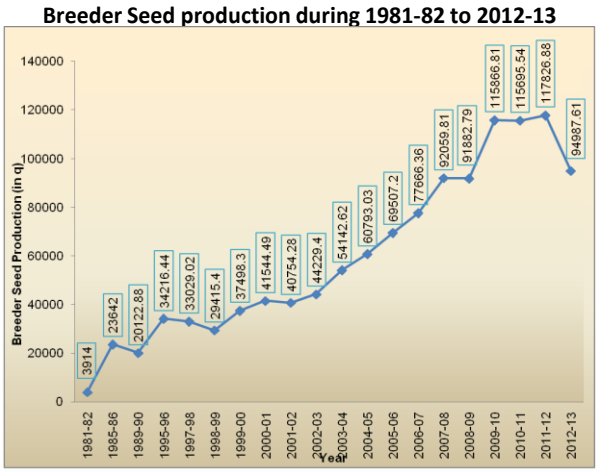
Current analysis is aimed at better understanding and appreciation of the existing set up of Seed Industry in Tamil Nadu, so as to arrive at logical seed plan and policy interventions.



Entry to exit ways of seed chain in rolling plan



Seed is an essential and basic input for crop production. Access of farmers to quality seed of improved varieties is key in increasing agricultural productivity and production. For any successful quality seed programme, it is mandatory to produce sufficient quantity of source seed with appropriate research backup on various aspects of seed technology *viz.*, production research, maintenance, quality assurance, processing, storage, seed protection, quality enhancement etc., In a bid to strengthen seed research in frontier areas and to facilitate instruction and coordination of pedestal for generation system of seed multiplication through the seed sector, contribution was phenomenal which has led to sea change and witnessed by increase from a meager breeder seed production of 3914 quintals during 1981-82 to a level of 94987.61 quintals during 2012-13, even though slight shortfall in few crops was observed due to climate vagaries in referred year as given below in graph. The ICAR-SAU system also continues to facilitate enhanced availability of breeder seed and other classes of seeds that constitutes the backbone of quality seed availability of notified varieties and parental lines of hybrids, which is sequentially multiplied to produce foundation and certified / quality seeds (Annual report, DSR, Mau, 2014).



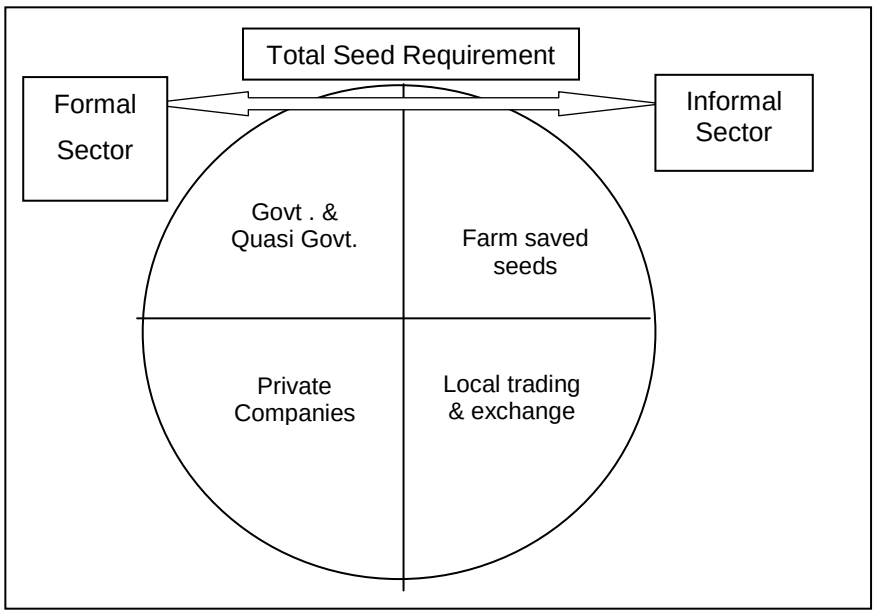
The seed production and distribution system

The Seed industry is a complete mix of formal and informal channels by which the total seed requirement of the farmers is satisfied.

i) **Formal sector:** Comprises of organized seed supply systems which may be Public or Private or Co-operative enterprises with local, national or global dimension.

ii) **Informal sector:** It is normally localized at the farm or community level and has relatively little organization. (Figure 1) eg., NGOs, Seed Villages and Farm saved / exchanged seeds.

Figure 1. Structure of Seed Industry
(Michael Turner **,** http://www.fao.org/docrep/005/Y2722E/y2722e1d.htm)



At one extreme is the traditional *Informal* (farmer- saved) system, in which part of the previous harvest is kept, and sometimes traded among local farmers, as planting material for the next crop. This is practiced by most of the small and resource – poor farmers. At the other extreme is the *Formal (*conventional) seed supply system, which serves the needs of large-scale commercial farmers who can afford to pay for quality seed (often of hybrid cultivars) produced by specialist seed growers and marketed by seed companies.

i) The Public Sector

Indian public sector constitutes giant players like National Seed Corporation (NSC), State Farms Corporations of India (SFCI) and 15 State Seed Corporations (SSC). These corporations produce and market varieties bred by the public sector institutions *i.e.,* the research institutes financed by the Indian Council of Agriculture Research (ICAR) and the State Agricultural Universities (SAU).

The public sector research to develop new varieties as well as breeder seed production is looked after by public research institutions, under the aegis of Indian Council of Agricultural Research (ICAR) and State Agricultural University (SAUs).

ii) The Private Sector

a) Private Seed Companies

The Indian private sector is a determinately growing enterprise. Altogether, there are around 500 seed companies catering mainly to the high value – low volume seed market.

The private sector focuses largely on hybrid seed. It is therefore, unimportant in the product segments of wheat and rice except as a seller of public varieties and hybrids. On the other hand, the private sector is a major player in the hybrid seed markets of maize, sorghum, pearl millet, oilseeds, cotton and vegetables. The composition of the seed industry, by volume of turnover, has reportedly reached a ratio of 60 : 40 between the private and public sectors.

b) Co-operatives

The co-operatives produce seeds of public varieties by procuring Breeder/ Foundation Seeds from the Public Sector seed producers. The seeds produced are mostly certified while truthfully labeled seeds are produced for varieties which not Notified as per the Seeds Act (1966). Mostly, all the Co-operatives have their own seed processing plants. If required, some small co-operatives, hire the processing facility from large co-operatives.

c) Non Governmental Organisations (NGOs)

Another form of decentralization is through the participation of private voluntary groups or Non Governmental Organizations (NGOs). Training is offered to these NGOs to take up hybrid seed of crops like maize and they will in turn train the farmers. The NGOs produce seeds of public varieties by procuring Breeder / Foundation seeds from the Public Sector seed producers. The seeds produced are mostly certified.

d) Farmer Saved, Exchanged and Sold seeds

For the seeds of crops like pulses and oilseeds (groundnut, sesame), farmers are not dependent on private or public sector but the farmers themselves save the seeds from the preceding crop supplies nearby 60% of requirements in these crops. In order to upgrade the farm saved seeds, one of the component of “Central Sector Scheme” is dedicated Seed Village Schemes.

The Scheme was initiated by Department of Agriculture in collaboration with the SAUs. The objectives of programme are: i) To sensitize the farmers about quality seed by involving them in seed production ii) To make quality seed available at a reasonable price within the village, iii) To decentralize the seed production.

Local seed systems can be used for the promotion of new varieties by some kind of scaling up of the minikit programmes for the newly released varieties. Farmer's transaction has the ability to secure seed which is described by the concept of seed security. It is important to ensure seed security by building local seed supply capacity through production and distribution of preferred varieties on timely basis at affordable price.

Seed supply system in Tamilnadu

The seed supply system involves scientific rising of seed crops, rigorous roguing, constant vigil to maintain field standards of seed crop, stage specific inspections, timely harvest, processing and seed testing / certification and labeling. The 'Generation System of Seed Multiplication' is followed to produce the quality seeds. The flow chart depicting the steps in crop improvement and seed multiplication is provided in Figure 2.

The seeds supplied to the farmers of Tamil Nadu are either Public or Private varieties. The seeds of Public varieties are multiplied and supplied to the farmers by the Department of Agriculture, Tamil Nadu Agricultural University and the interested seed companies. Irrespective of the agency that multiplies and supplies the seed, the indent for the breeder seeds from which further multiplication has to be made with the Tamil Nadu Agricultural University one year in advance.

The seed multiplication procedure and the quality control procedure followed for each class of seed is described below. The agencies involved and existing interface in the seed supply system of Tamil Nadu is depicted in Figure 3.

a) Public Varieties

For public varieties and hybrids, Tamil Nadu Agricultural University helps to meet breeder seeds of released varieties. Department of Agriculture, private seed companies or co-operatives that wish to obtain breeder seed should submit the indent to the University one year in advance. The indents are made once in a year; University then apportions the requests among its research stations.

Figure 2. Step – wise flow chart on crop improvement and seed multiplication

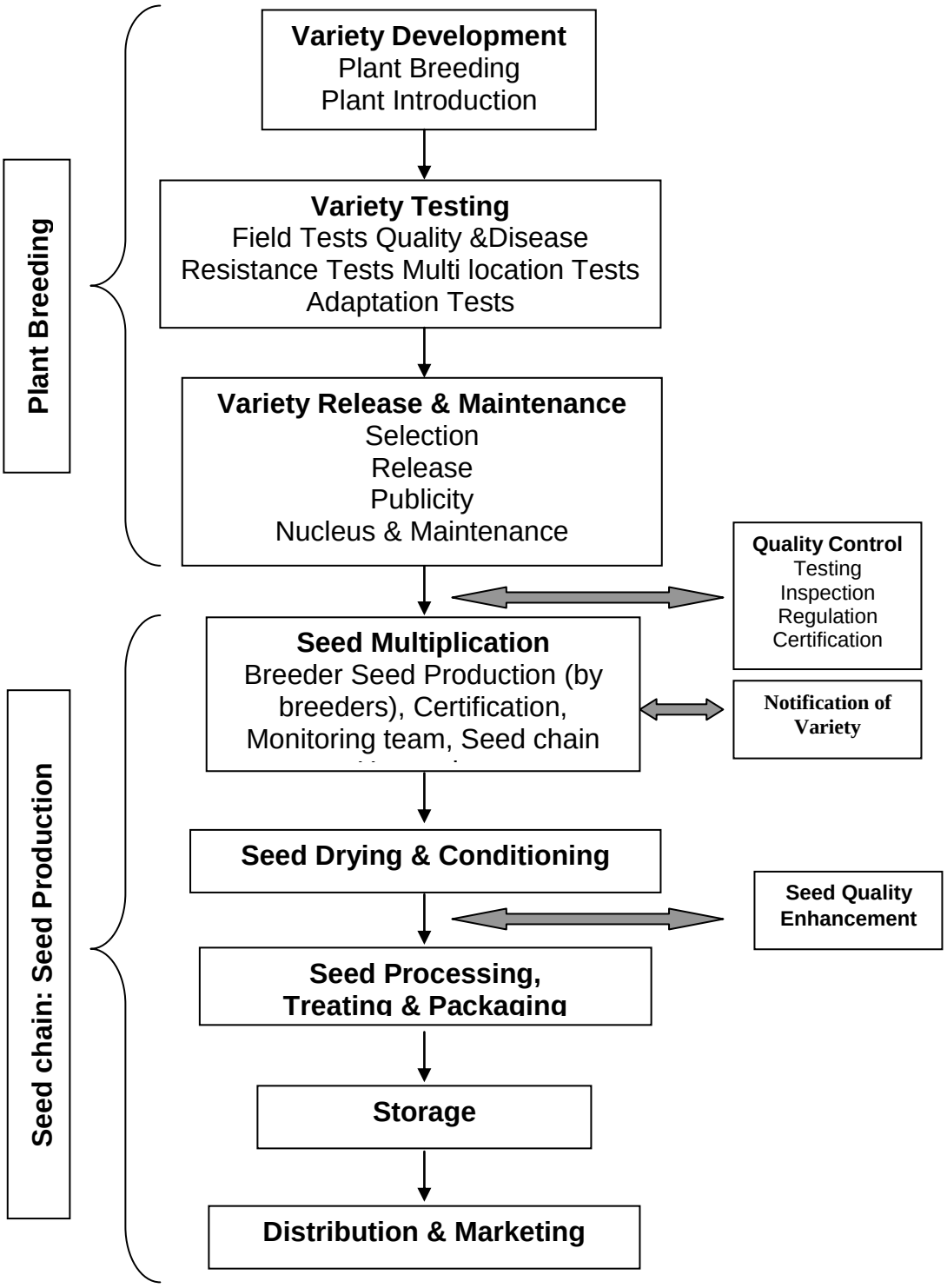
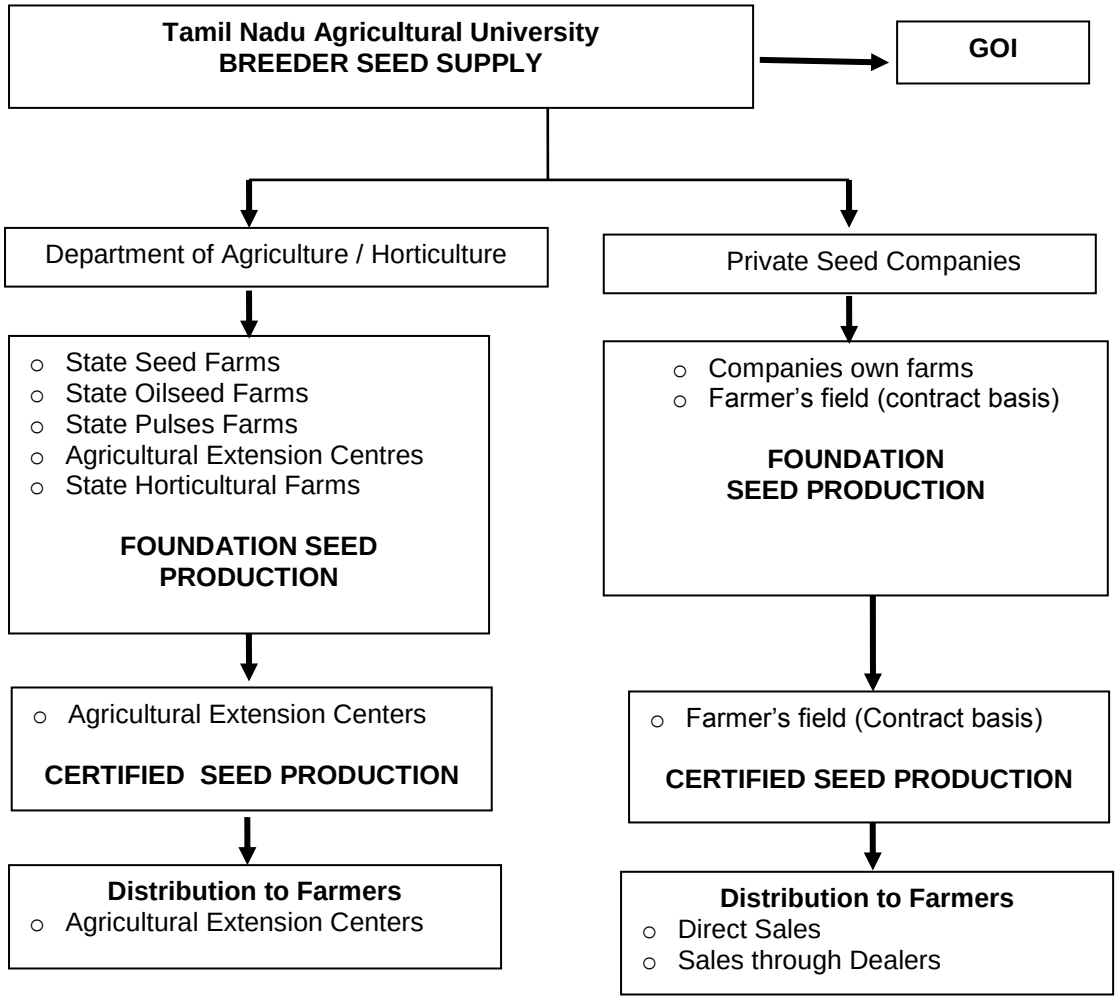


Figure 3. Seed Supply System for Public Varieties in Tamil Nadu



It takes approximately three years from the time of indent until the resulting commercial seed is ready for the market, since seed multiplication chain includes foundation and certified seed production. So seed producers need to plan their indents for breeder seed carefully and need to know which varieties are likely to be in demand.

b) Private Hybrids and Varieties

The company produces its own breeder, foundation and truthfully labeled seeds by entering into contract with the seed growers. At all stages of seed multiplication, the company maintains the seed quality standards at field level with their own staff followed by seed testing in their own laboratory and seeds sold as Truthfully Labeled seeds. Certified seeds of new varieties may be eligible for a subsidy from the State Government and this is an incentive for certification. However, some times the seed companies choose to forego certification and sell Truthfully Labelled seed since the time required for post harvest operations and testing after the seed crop is harvested seems to be inconvenient for the seed producers for ensuring timely marketing. In addition, there are some varieties (particularly newer ones) that have been released but not Notified and these are not eligible for certification as per the Seed Act (1966).

Seed quality control system

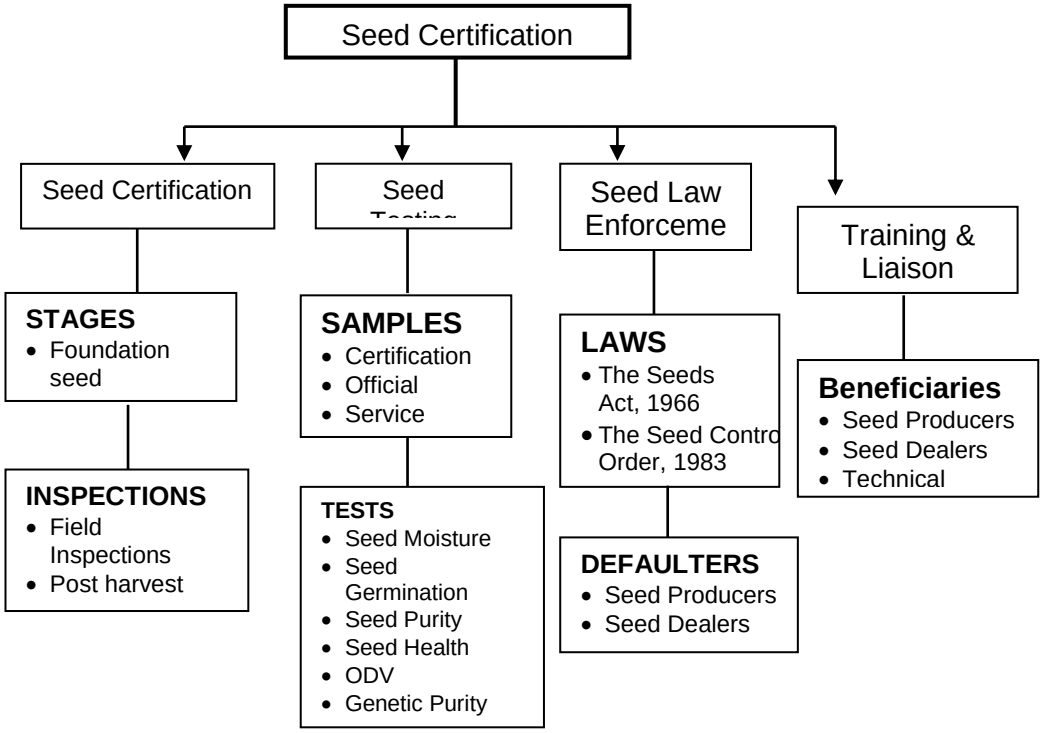
Traditionally, the seed quality regulation is the responsibility of the Government or Seed Certification Agency. But with entrance of competitive and mature players in seed industry, seed quality control has gained increasing importance. Therefore, public sector has adopted a facilitating role and enforces regulations to deal with unscrupulous firms or dealers supplying spurious seed.

The seed quality control is brought about by three functions

i) Seed Certification, ii) Seed Testing, and iii) Seed Law Enforcement.

ii) The seed quality control system in Tamil Nadu is depicted in Figure 4.

Figure 4. Organization set up and functioning of Seed Quality Control System in Tamil Nadu act as linkage in seed chain



Seed multiplication models

Each time a variety goes through the cycle of multiplication; there is chance of its deterioration through mechanical admixture, pollination by alien pollen or mutations. The possibility of contamination by alien pollen is greater in cross pollinated species than the self fertilized ones. However, even in species classified as self fertilized there can be small proportion of cross fertilization, for cross pollination in wheat occur with a frequency of 4 % while 1.1 to 8.7 % of out crossing takes place in oats.

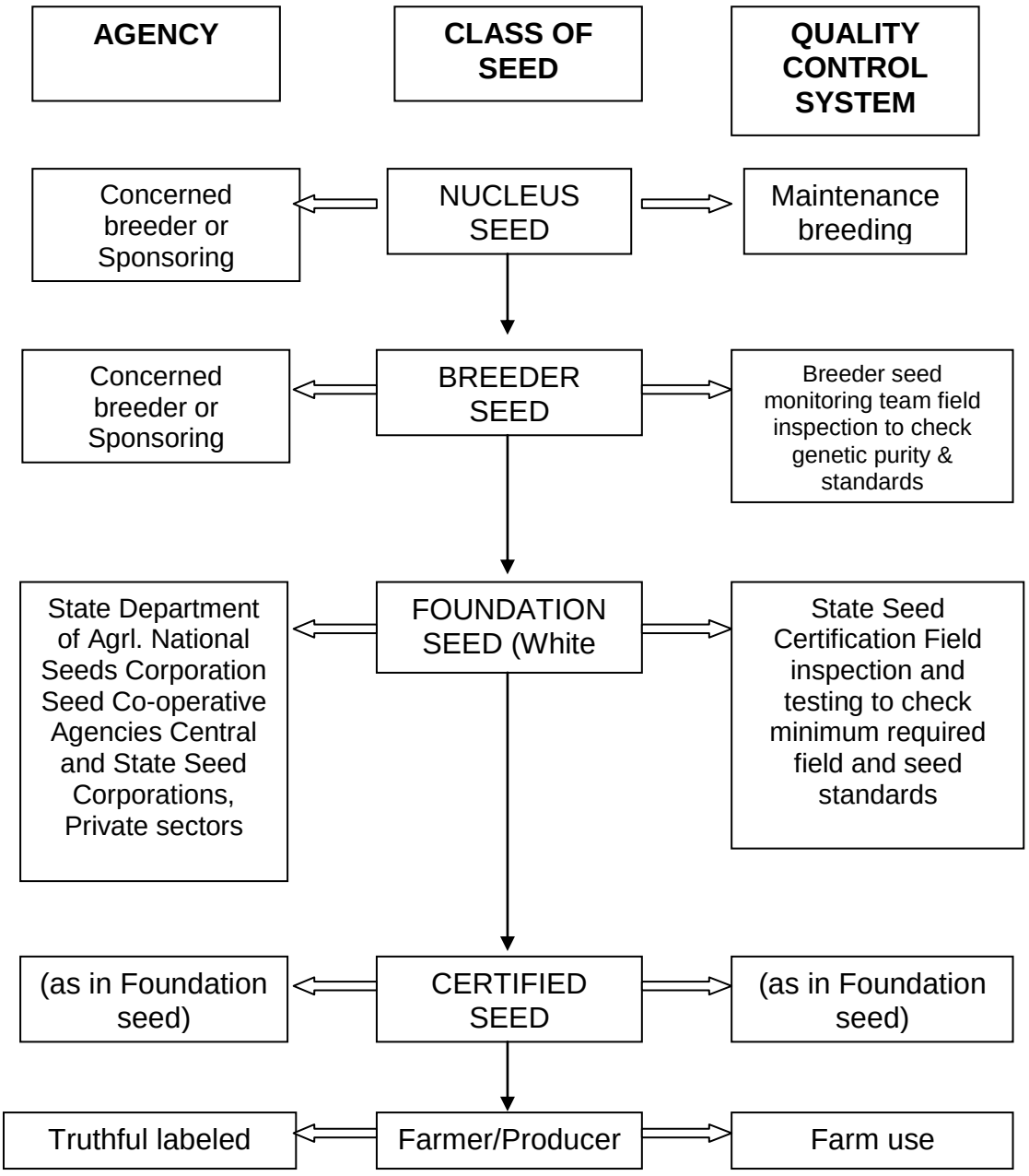
At the time of release of a variety, small quantity of seed normally known as nucleus seed is available with plant breeder. Commercial quantity of seed is produced from the nucleus seeds after a series of multiplication steps. Starting from maintenance programme in which nucleus seed is produced by the breeder or sponsored breeder, the seed is multiplied as breeder seed in the first generation, followed by foundation (second generation) and certified seeds (third generation).

This process of systematic multiplication of quality seed is called as *Generation System of Seed Multiplication* (Figure 5). In India, seed firms whether in the private or public sector, outsource the production of certified (commercial) seeds

to contract growers. These growers are supplied with the foundation seed that is used to produce certified (commercial) seed. The seed industry is one of the earliest examples of contract farming in India.

The objective designating the seed multiplication models for a crop is to enable quick supply of seed of a newly released variety to the farmer, without genetic deterioration up to the stage of certified seed. The choice of a seed multiplication model is the key to further the success of a seed programme, which basically depends on i) Rate of genetic deterioration, ii) Seed multiplication ratio and total seed demand.

Figure 5. Generation system of seed multiplication and quality control (notified varieties and hybrids)

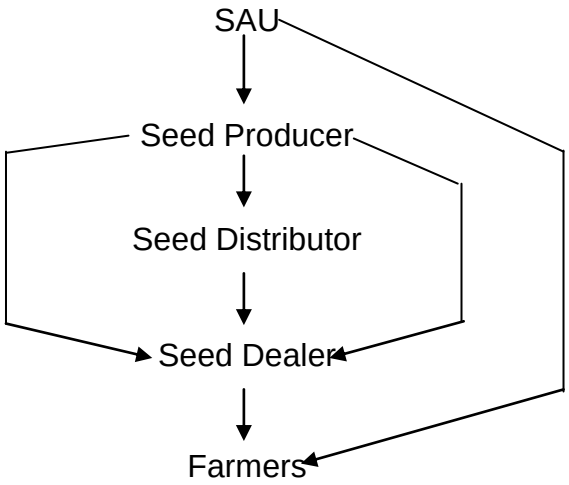


2 Generation model - (BS-FS-CS) - FOR CROSS POLLINATED CROPS
3 Generation model - (BS-FSI-FS II-CS) - FOR SELF POLLINATED CROPS such as Rice

In cross pollinated crops, there is always a danger of out-crossing leading to genetic deterioration of a variety. In self – pollinated crops, a larger number of generations may be permitted provided there is little chance for deterioration due to mechanical admixture or seed infection with designated seed borne diseases. Plants in which cross pollination may take place upto 5-50 % besides self pollination is categorized as often cross pollinated crops.

Box 1. Existing seed delivery chain in Tamil Nadu

(Post- Breeder seed)



Though the four generation model is prescribed for rice, groundnut often the private seed producers comprising of small to medium scale seed entrepreneurs buy the breeder seeds, multiply and sell as truthful seeds, bypassing the three stages in the middle (box 1). Through adoption of such a truncated generation model, the producers are guaranteed with the genetic purity of the immediate parent of the marketed produce. Besides, the seed farms need not be registered with the department of seed certification since the seeds are marketed as truthfully labeled. The participation of many such small private seed producers improve the spread of the varieties through quality seeds but cause an additional load on the public sector institutions to produce excess quantity of seeds than the projected target of breeder seeds which lead to missing link in seed supply chain.

Seed Multiplication Ratio

The *Seed Multiplication Ratio* (SMR) implies as to how much quantity of quality seeds can be produced from a unit quantity of seed. The Seed Multiplication Ratio of different crops is depicted in Table 1.

Table 1. Seed Multiplication Ratio of different crops

S.No	Crop	Multiplication Ratio
Cereals		
1	Rice	1:60
2	Bajra	1:250
3	Ragi	1:300
4	Maize - variety	1:150
5	Maize - hybrid	1:130
6	Sorghum	1:200

Pulses		
7	Black gram	1:40
8	Bengal gram	1:10
9	Cowpea	1:40
10	Green gram	1:40
11	Horsegram	1:40
12	Red gram	1:100
13	Soybean	1:30
Oil Seeds		
14	Castor	1:60
15	Groundnut	1:6
16	Sesame	1:150
17	Sunflower - variety	1:100
18	Sunflower - hybrid	1:75
19	Cotton- variety	1:100
20	Cotton- hybrid	1:60
Vegetables		
21	Brinjal	1:200
22	Bhendi	1:125
23	Bitter gourd	1:40
24	Snake gourd	1:60
25	Ribbed gourd	1:40
26	Chilli	1:100
27	French bean	1:25
28	Cluster bean	!:100
29	Tomato	1:200

In view of these basic factors, the chain of seed multiplication could be selected from the following three or four or five generation models of seed multiplication. The longer the sequence of multiplication, greater is the possibility that one or all the type of contamination may occur to erode the essential genetic qualities of a cultivar.

1. Three generation model
   BS – FS - CS

2.Four generation modal
   (a) BS- FS -CS I – CS II
   (b) BS- FS I - FS II – CS

3. Five generation model
   BS- FS I – FS II – CS I –CS II

The Generation System of Seed Multiplication is followed to accomplish multiplication of seeds upto required quantities without causing contamination in the different generations of seed multiplication so as to prevent serious reduction in yield potential due to genetic deterioration. It is also important to understand the types of contaminants and the basics of seed deterioration due to different types of contaminants that may occur in the seed production plots.

Seed replacement rate

Seed Replacement Rate (SRR) is defined as the percentage of area sown out of the total area of crop cultivated in the season by using certified/quality seeds other than the farm saved seed. The SRR is calculated considering the parameters like area under the crop, seed rate per unit area and total quantity of quality seed supplied. Seed Replacement Rate is an important factor in deciding the agricultural production of the country. The deterioration in the quality of seed results in loss in productivity per unit area. Therefore, the need for seed replacement necessarily arises from its economics, that is, the net incremental returns from the decision.

Now the question arises, how often the seed need to be replaced? Seed may be replaced when the deterioration in quality of seed results in loss of productivity such that the loss in value terms is higher than the incremental cost of using fresh seed. Such level of deterioration in quality seed may be noticed even in F_2 generation in case of hybrids. Hence, hybrid seeds need to be replaced every year. In case of varieties, the deterioration reaches the break-even level in the third or fourth year / generations. Obviously, seed replacement becomes due once in three years in the case of cross pollinated crops, once in four years for self pollinated crops and each year in the case of hybrids. Thus the recommended SRR is 25% for self pollinated crops, 35 % for cross pollinated crops and 100% for hybrid crops.

Influence of SRR on agricultural production

The seed sector is seen as a major driver of agriculture sector in the country and is expected to realize future growth due to increased seed replacement rate, higher conversion, wider use of proprietary hybrids etc. The influence of Seed Replacement Rate on agricultural production can be discussed under two aspects.

1. Shift from farm saved seeds to certified/ labeled quality seeds
2. Shift from varieties to hybrid

Thus, it is important to draw plans to demarcate the area of each crop well in advance and make arrangements to supply sufficient quantity of seeds of each crop giving due allowance for all sources of seed supply.

Note

The demand for different varieties must be based on a realistic assessment of the desirable and achievable levels of seed replacement rates (SRR). While projecting the levels of SRRs which are to be achieved, there must be a clear strategy and package of strategies worked out to reach the desired levels of SRRs separately for each crop for a particular state.

Seed production and supply scenario

Quality seed itself contributes yield increase upto 20 percent besides it also decides the performance and efficacy of other inputs. Availability and use of quality seeds is not a onetime affair. Sustained increase in agricultural production and productivity necessarily requires intensive efforts to continue the 'seed multiplication chain' to supply the seed of improved varieties and hybrids. Seed Replacement Rate is posting increasing trends in the past five years. With increasing awareness among the farmers to replace the farm saved seeds with fresh seeds of improved varieties and hybrids, the responsibility is now with the State Government to chalk out plans to meet the seed demand of the State through Public as well as Private Seed Sector.

As mentioned earlier, low value – high volume seeds (*e.g.,* cereals, pulses, oilseeds) are mostly dominated by public varieties while low volume – high value seeds (*e.g.,* hybrid cotton, hybrid sunflower and vegetables) are dominated by private sector. Both the sectors have to plan and go hand in hand to meet the seed demand of the entire State for the entire crop spectrum. Identification of lacuna and

formulation of strategies to salvage the system is the need of the hour to steer the State's agriculture sector towards prosperity. Hence, in this chapter efforts are taken to analyze the crop-wise area of cultivation the nature of the crops, the recommended seed replacement rate and flaws in implementing the seed multiplication chain.

Seed plan to supply different types of situations and weather proofing rice cultivation are detailed below in Box 2 and Table 2.

Box 2. Weather proofing rice cultivation area with Anna (R) 4 - Model

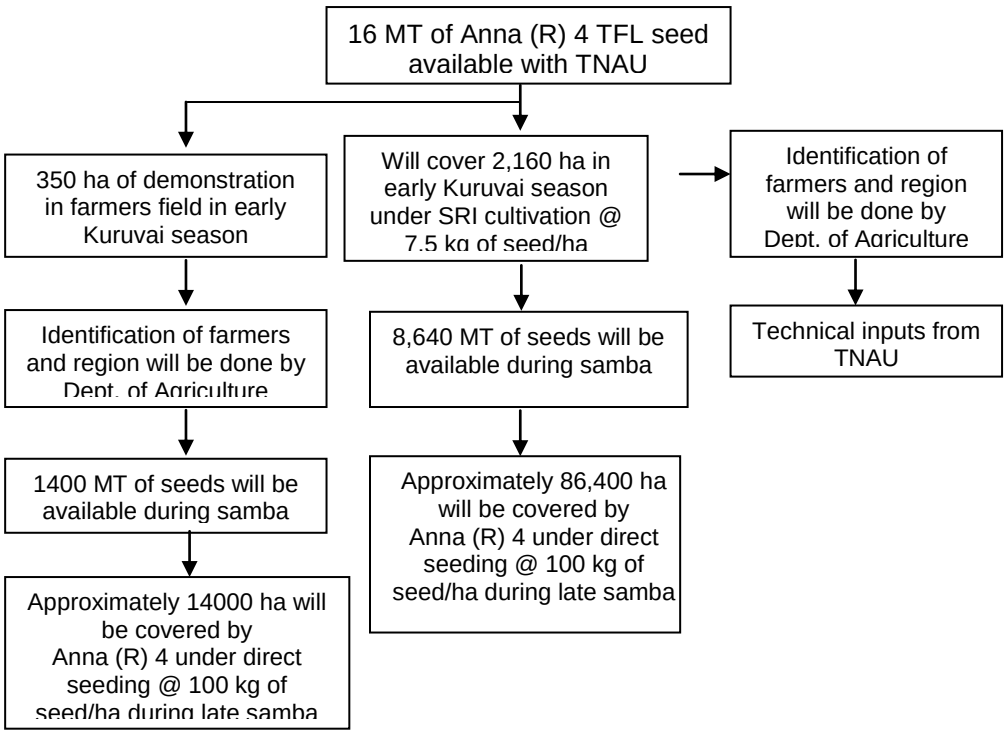


Table 2. Seed plan for TFL seed production during 12th and 13th Five Year Plan

Paddy

Unit : mt

Paddy	TFL Seeds		Foundation Seed		Budget (Rs. in Lakhs)	
	12th FYP (2014-2017)	13th FYP	12th FYP (2014-2017)	13th FYP	12th FYP (2014-2017)	13th FYP
Normal Season	1170	1950	360	600	123.75	230.00
Deficit year	369	615	-	-	42.00	80.00
Excess year	510	850	-	-	45.00	90.00
Total	**2049**	**3415**	**360**	**600**	**210.75**	**400.00**

Millets

Millets	Qty. of TFL Seeds (mt)		Budget (Rs. in Lakhs)	
	12th FYP (2014-2017)	13th FYP	12th FYP (2014-2017)	13th FYP
Normal year	42.0	70.0	9.0	16.5
Deficit year	55.5	92.5	12.0	22.0
Total	**67.5**	**162.5**	**21.0**	**38.5**

Pulses

Pulses	Qty. of TFL Seeds(mt)		Budget (Rs. in Lakhs)	
	12th FYP (2014-2017)	13th FYP	12th FYP (2014-2017)	13th FYP
Normal year	77.0	130.0	18.00	20.00
Deficit year	77.0	130.0	18.00	20.00
Total	**154.0**	**260.0**	**36.00**	**40.00**

Oilseeds

Oilseeds	Qty. of TFL Seeds (mt)		Budget (Rs. in Lakhs)	
	12th FYP (2014-2017)	13th FYP	12th FYP (2014-2017)	13th FYP
Normal year	25.5	42.5	9.00	17.00
Deficit year	25.5	42.5	9.00	17.00
Total	**51.0**	**85.0**	**18.00**	**34.00**

Breeder Seed Requirement and Supply

Tthe supply of required quantity of the quality seeds is ensured by the supply of sufficient quantities of breeder seeds by Tamil Nadu Agricultural University to the State Department of Agriculture and the Private Companies to facilitate further multiplication into Foundation and Certified seeds. In order to understand demand and supply gap of quality seeds, analyses of data on total seed requirement, actual seed requirement on recommended SRR and current seed supply achieved by both public and private sector (including certified and labeled seed). To understand the underlying causes of seed supply deficiency occurring in the State, an analysis of data on indent and corresponding breeder seed supplied for the past five years was attempted by perusing the data, revealed that in all the five years (2007-2012) the supply of breeder seeds by Tamil Nadu Agricultural University has been over and above the indent placed by both the State Government as well as the Private Sector. In sporadic cases, the breeder seeds have been supplied even when indents have not been received by the University. The data proved beyond doubt that, failure to meet the quality seed demand of the State is not caused by discrepancies in supply of Breeder seeds by Tamil Nadu Agricultural University which may due to various reasons for missing link in seed supply chain as discussed elsewhere in this analysis.

Analysis of Seed Multiplication Chain

Since the Breeder seed has been supplied over and above the indents placed, the failure to meet the seed demand of the State should be linked to the implementation of the rest of the Seed Multiplication Chain *ie.,* Foundation and Certified seed production which is taken up by the State Department of Agriculture and the Private Seed Sector. The data on the Foundation and Certified seed production against the breeder seed supplied has been provided in Tables 3 to 5 for both State Department of Agriculture and Private Seed Companies, for the year 2009-10 to 2010-11. The certified seed expected out of the breeder seed supplied is calculated based on the normal seed yield of the particular crop and number of generations allowed for that particular crop. The data arrived on expected shortfall in certified seed production is provided alongside in all the above tables. Unfortunately, in both Government and Private sector, the data for the past three years revealed that, there has been consistent shortfall in the certified seed production. Most of the foundation seeds produced by the private sector, especially in rice, are being directly sold as commercial seed instead of forwarding further multiplication into certified seeds. This reveals that the lesser than expected certified seed production has led to difficulty in meeting the seed demand of the farmers of Tamil Nadu. This underscores the necessity to implement the 'Seed Multiplication Chain', scrupulously.

Table 3 . Analysis of seed multiplication chain from the breeder seeds supplied during the year 2009-2010

Crops	Government					Private				
	Breeder seed supplied (kg) 2009-10	*Foundation seed produced (mt) 2010-11	*Certified seed produced (mt) 2011-12	** Certified seed expected (mt)	Shortfall in certified seed production (mt)	Breeder seed supplied (kg) 2009-10	*Foundation seed produced (mt) 2010-11	*Certified seed produced (mt) 2011-12	**Certified seed expected (mt)	Shortfall in certified seed production (mt)
Paddy	19933	2622.27	18238	71820	-53582	98911	40944	37764	356040	-37764
Sorghum	18	3.70	3.0	146	-143	63	8	0.6	510	-509.4
Ragi	20	-	107	800	-693	-	-	-	-	-
Bajra	64	13.40	46	1133	-1087	119	10.2	4.5	2120	-2115.5
Maize	233	9.40	13	9360	-9347	772	-	-	30880	-30880
Blackgram	7539	254.4	1355	6786	-5431	512	135.6	435	461	-26
Greengram	3078	128.0	362.	2872	-2510	117	27.1	8	106	-98
Cowpea	975	72.30	351	882	-531	24	1.20	-	22	-22
Redgram	409	21.0	109	2009	-1900	103	-	-	505	-505
Bengalgram	150	7.70	10.4	10	+0.4	25	-	-	1.4	-1.4
Horsegram	700	26.6	35	437	-402		-	-	-	-
Groundnut	24290	252.0	2695	9924	-7229	240	-	-	98	-98
Sesame	418	15.7	22	4180	-4158	184	-	1.4	1840	-1838.6
Sunflower	530	1.3	2.32	2333	-2330.68	80	-	2.0	353	-351
Castor	110	0.7	2	396	-394	-	-	-	-	-
Cotton	399	18.6	48.4	489	-440.6	526	88.4	86.7	644	557.3

* Directorate of Seed Certification (http://www.seedtamilnadu.com)

** Certified seed expected to be produced in 3 generations (groundnut in 5 generations)

Table 4. Analysis of seed multiplication chain from the breeder seeds supplied during the year 2010-2011

Crops	Government					Private				
	Breeder seed supplied (kg) 2010-11	*Foundation seed produced (mt) 2011-12	*Certified seed produced (mt) 2012-13	** Certified seed expected (mt)	Shortfall in certified seed production (mt)	Breeder seed supplied (kg) 2010-11	*Foundation seed produced (mt) 2011-12	*Certified seed produced (mt) 2012-13	**Certified seed expected (mt)	Shortfall in certified seed production (mt)
Paddy	15800	2334	11896	56880	-44984	120139	39456	17925.60	432540	-414615
Sorghum	135	3.26	-	1094	-1094	200	0.10	-	1620	-1620
Ragi	50	26.90	157.59	1000	-842.41	10	-	-	400	-400
Bajra	79	10.30	56.50	1400	-1343.5	80	1.20	-	1427	-1427
Maize	412	9.30	-	16480	-16480	126	-	-	5040	-5040
Blackgram	10726	282.80	1561.78	9653	-8091.22	2640	301.40	315.80	2376	-2060
Greengram	4737	147.90	185.40	4263	-4077.6	471	77.10	-	424	-424
Cowpea	970	72.30	415.00	873	-458	81	1.20	-	72	-72
Redgram	994	21.00	95.10	4871	-4775.9	286	-	-	1401	-1401
Bengalgram	150	7.70	7.80	9.60	-1.8		-	-	-	-
Horsegram	200	25.20	45.70	125	-79.3	20	-	-	12.5	-12.5
Groundnut	33125	359.30	2196.20	-	2196.2	7690	16.4	-	156	-156
Sesame	560	30.60	13.40	5600	-5586.6	179	-	2.40	1790	-1787.60
Sunflower	276	4.00	-	1227	-1227	6	-	-	-	-
Castor	40	0.50	-	144	-144		-	-	-	-
Cotton	450	17.1	146.64	551	-404.36	257	103.3	-	126	-126

* Directorate of Seed Certification (http://www.seedtamilnadu.com)

** Certified seed expected to be produced in 3 generations (groundnut in 5 generations)

Table 5. Model seed plan for seed supply chain in major crops of Tamil Nadu

Crop	* Total area (2011-12) (Lakh ha)	Total quantity of certified seeds required for 100 % SRR (mt)	** Recomm-ended SRR (%)	Seed Multiplication Ratio (%)	Quantity of different class of seeds required for recommended SRR (mt)		Quantity of Breeder seeds required (kg)	Quantity of Breeder seeds supplied (2011-12) (kg)
					Certified	Foundation		
Paddy	19.04	95200	25	1 : 60	23800	397	6600	119719
Sorghum	2.00	2000	35	1 : 200	700	7.8	87	7
Bajra	0.47	353	35	1 : 250	124	0.93	7	212
Ragi	0.83	415	25	1 : 300	104	0.52	3	28
Maize	2.81	5620	35	1 : 150	1967	9.84	49	325
Blackgram	3.08	6160	25	1 : 40	1540	51.34	1720	10462
Greengram	1.64	3280	25	1 : 40	820	27.34	920	6254
Redgram	0.36	360	35	1 : 100	126	1.8	26	1654
Bengalgram	0.09	675	25	1 : 10	169	21.12	2644	200
Horsegram	0.69	1380	25	1 : 40	345	13.8	552	600
Groundnut	3.86	77200	25	1 : 6	(C-II) 19300 (C-I) 4289	(F-II) 953 (F-I) 212	47200	29011
Cotton	1.36	1360	35	1 : 100	476	13.6	388	735

Source: * Season and Crop Report 2009-10.

** National Seed Plan (http://seednet.gov.in)

C-I – Certified Stage I; C-II - Certified Stage II; F-I – Foundation Stage I; F-II - Foundation Stage II

Seed supply chain dynamics

The Lacuna

In Tamil Nadu, the gap between requirements (demand) and production of quality (supply) seeds remain consistently high for many of the crops *i.e.,* 76 percent for agricultural crops and 50 per cent for horticultural crops. During the last decade, the share of government sector in seed production has come down heavily whereas the share of private sector has steadily increased. The need of the hour is to increase the participation of the Public Sector in catering to the seed needs of the farmers. A competitive Public Sector Organization / Agency are a must to guard unwarranted exploitation of farmers by private seed companies in the name of quality seeds. A vibrant Public Sector Organization / Agency is necessary to safeguard the interests of the marginal and resource poor farmers who cannot afford to purchase high cost seeds offered by the Private Sector. Deterred by the high cost of private company seeds, marginal and resource poor farmers may shun away from high yielding varieties/ hybrids leading to lower agricultural production. Thus, to bring social and economic development to farmers of all strata, it is important to nurture a efficient and effective Public Sector in seed supply system.

At present, the valuable breeder seeds supplied from the Tamil Nadu Agricultural University and ICAR Institutes are not fully utilized to produce the expected certified seeds as per Seed Plan to achieve the targeted SRR. Further, low Seed Multiplication Ratio is realized in the public and private sector, due to unknown reasons leading to consumption of more quantities of breeder seeds. Therefore, public and private sector have adopted the practices of placing indents for breeder seeds in higher magnitude than what is actually required. This situation not only increases the expenditure of seed production agencies on the purchase of excess breeder seeds but also causes stress on Tamil Nadu Agricultural University and ICAR Institutions to spend excessively on financial and human resources for breeder seed production.

As per the seed supply system in the State, the Department of Agriculture of State Government places the indent for the breeder seeds with Tamil Nadu Agricultural University and on procuring the breeder seeds from the University, further multiplication into foundation and certified seeds is carried out by the Department of Agriculture at the State Seed Farms ,State Oilseeds Farms, State Pulses Farms and in farmers field through Agricultural Extension Centers. Although the breeder seeds are supplied as per the indent by the University, the public and private sectors have not followed the *Seed Multiplication Chain* intensively to achieve the expected certified seed production. This is due to the operational constraints experienced in both public and private sector seed production agencies. The Tamil Nadu Agricultural University and Directorate of Seed Certification is engaged in offering number of trainings to the Agricultural Officers in the field of seed production. However, one of the major constraints experienced in the public sector is discontinuous engagement of trained staff in seed production activities. Similarly in private sector, except in very few seed companies, trained manpower is not available for seed production.

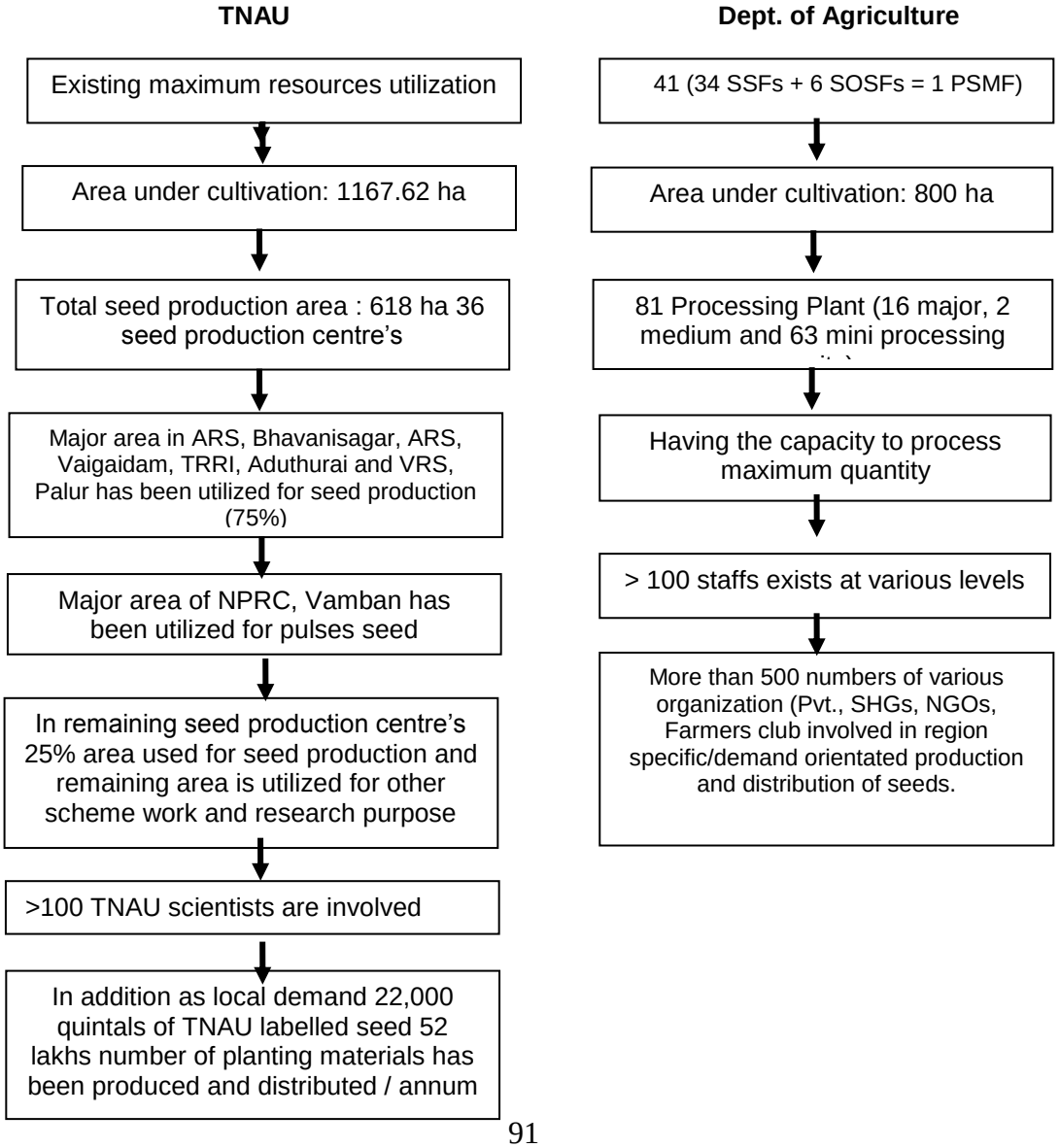
Discontinuation of the ‘Seed Multiplication Chain’ by supplying the foundation seeds as commercial seeds, instead of forwarding it to certified seed production.

1. Usage of excessive seed rate while sowing the breeder seed for foundation seed production resulting in lower than expected area of foundation seed production.
2. Poor management of seed production plots, improper agronomic practices resulting poor yield *i.e.,* less than expected foundation seed and certified seed.

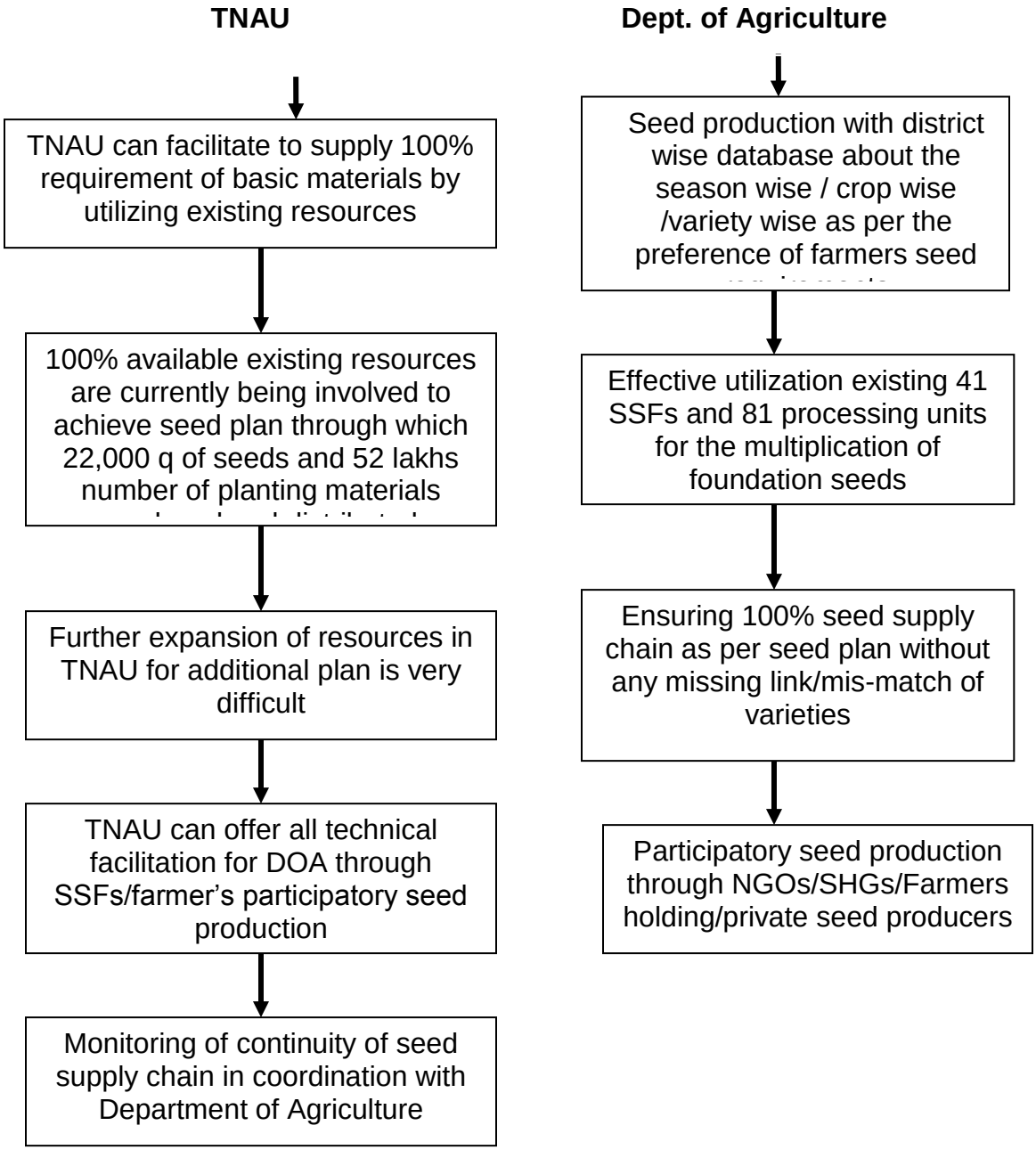
The above lacunae have to be addressed with conviction to assure that each breeder seed supplied by Tamil Nadu Agricultural University is multiplied in to foundation and certified seed so as to meet the entire seed demand of the State. The State Seed Producing Agency (DoA) should function with the following objectives.

1. To monitor the production of foundation seeds effectively in State Seed Farm.
2. To look after the production, procurement and distribution of quality seeds through contract seed production.
3. To ensure timely supply of quality seeds of improved varieties both during normal as well as off seasons.
4. To accelerate the spread of high yielding hybrids and varieties.
5. To co-ordinate with other State Seed Corporations and National Seed Corporations for seed production and distribution.
6. To develop the Human Resource in Seed Production by offering trainings to NGO's, private entrepreneurs and farmers.
7. To educate the farmers on the benefits of usage of quality seeds
8. To achieve the increased Seed Replacement Rate.

Infrastructure facilities and other support available for seed production



To achieve effective seed plan – seed supply chain system



Wrap up and outcome of the analysis on seed supply chain management

- Seed supply chain management will ensure production and distribution of high quality seeds of improved varieties.
- Necessary for varietal spread and derive the benefits of qualitative and quantitative traits.
- Keep continuity in seed chain (VRR Vs SRR) and conservation.
- Enhance production and productivity and livelihood of farmers.

Agencies responsible for seed chain

- Organizations / institute developed the variety (SAU's / ICAR / Private etc.)
- Development of department at respective State
- Seed corporations (NSC, SSC)
- Stake holders of seed industry
- Seed Certification Agencies
- End use farmers

Current status of seed supply chain

Seed planning and distribution	National / State level 100%
Production and distribution (By all agencies lifting)	Breeder seed 100%
Actual conversion in seed chain	Foundation seed 50-60%
	Certified seed 40-50%

Reasons for missing link in seed chain

- Excess indenting of breeder seeds.
- Diversion of foundation seeds for various scheme works and commercial multiplications.
  - Some time especially in pulses and oilseeds utilized for table and non seed purposes.
  - Rice, Pulses & Groundnut often the private seed producers comprising of small to medium scale seed entrepreneurs buy the breeder seeds, multiply and sell as truthful seeds, bypassing the three stages.
- Transport of foundation seeds for multiplication in other states.
- Change of preferences of consumers / farmers due to varietal mismatch.
- Unfavourable climatic conditions – moisture deficit situations.

Missing link Vs bridging the gaps in seed chain

- Database creation and online monitoring system (National / State level).
- Assessment of certified seed requirement with village level preferences / contingency seed plan.
- Indent and distribution of breeder seeds - Ensuring the traceability and continuity in seed chain through policy interventions.
- Effective utilization of all SSFs only for foundation seed multiplication.
- Tie-up with NSC / SSC / private stake holders in seed plan, production and distribution.
- Organizing demonstration with pre-release culture.
  - Organizing pre-season campaign cum awareness programme build the confidence.
- New variety seed distribution through mini-kit.
- Strengthening of post harvest seed dressing and handling facility, including seed delivery system.
- Farmers' centric market driven approach – corporate mode.
- Community based controlled seed storage go downs. (Conservation of resources and timely supply).
- Effective Co-ordination of staff and existing resources and infrastructure at all levels.
- Mission mode approach as food security through seed security for which need a suitable policy interventions for the vibrant seed supply chain.

Role of Department of Agriculture and TNAU in seed plan (Responsibility indicating the Department and TNAU)

Role of Department of Agriculture – Inputs

(a) Seeds

- State level assessment of the total requirement of seeds to meet out the target. Accordingly requirement of breeder seed indent should be given one year before.
- The Director of Agriculture will issue dispatch order for the entire quantity which was indented previous year.
- The onus of failure in lifting the indented quantity of seeds lies with Department of Agriculture.
- Utilization of the existing State Seed Farms for foundation seed production.

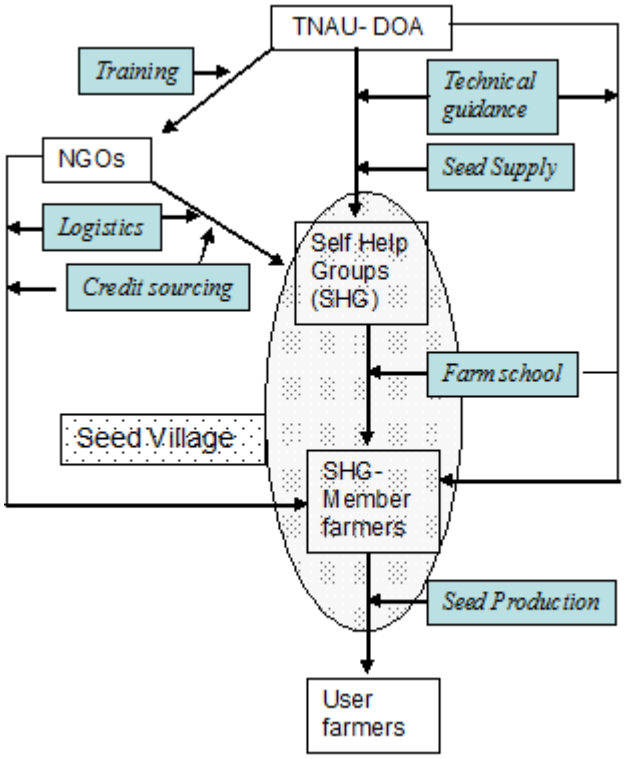
(b) Technology and Extension dissemination

- New varieties within the 3 years or until it gets notified, the Department of Agriculture will procure TFL seeds from TNAU and conduct adequate number of demos.
- The performance of new varieties and technologies in the farmer field should be jointly assessed by Department of Agriculture and TNAU.
- Pre-release cultures in the ART trials may be distributed under minikit programme with effective monitoring.
- An assessment of seed requirement should be made and suitable measures to the taken to procure either from TNAU or from TNAU licensed private manufactures.

Role of TNAU

- TNAU will produce genetically pure breeder seed materials of notified varieties against the indent of Department of Agriculture without any deviation.
- The quality of seeds supplied by TNAU should match with the respective crop seed standards.
- In case of non-compliance of adequate supply of breeder seeds against the indent of Department of Agriculture with respect to particular variety, TNAU will provide seeds of alternate variety.
- In addition, the Department of Agriculture can inform the requirement of TFL seeds of improved varieties one year before. Based on the resources, the TNAU will assess and supply the possible quantities.
- The possible quantity of TFL seed production also will be assessed and informed by TNAU based on indent of Department of Agriculture.
- Effective monitoring of multiplication of seeds in supply chain system by forming core committee comprising TNAU and DOA officials.

Box 3. A paradigm for improving seed delivery system in areas of resilient crops



The synergy between the SAU and Dept. of Agriculture through NGOs in addressing the problems of the downtrodden farmers is a new attempt based on the experiences in some of the crops. The proposed seed villages should have adequate support systems to have a reasonable crop even in the years of bad monsoon so as to sustain the seed production activities even year after year least affected by drought. The SHGs should be selected on the criteria that main occupation of the majority of the member farmers is farming so that they comprehend the system very well. The model farm school established by the SHGs with the help of NGOs comprising the materials supplied by TNAU would serve as an eye opener to the local and surrounding farmers to know the merits of the new varieties. Also the commitment of the member farmers in the group would attract the farmers unlike the private dealers who are active with profit motives. The proximity of these institutions to the farmers and their timely service would enable greater persuasion to utilize good quality seeds of improved varieties. The participating NGOs will interact constantly with the farmers assisting them to explore and execute the marketing of the produced seeds duly tested and certified by the Department of Seed Certification. This process is built upon the strong farmer to farmer contact which forms the most efficient seed channel. The proposed paradigm (box 3) with the committed active participation of all the partners is bound to reap rich dividends in terms of increased productivity and sustainable seed delivery mechanism established developed and can be implemented by the local groups.

Seed planning and monitoring

In order to have effective seed planning, co-ordination and monitoring in seed chain the following committee may be constituted.

1. **Institutional planning and monitoring committee**
   Director of Research, Director (CPBG), Special Officer (Seeds), Dean (Hort.), Heads of all seed production centres, Additional Director (Seeds), Department of Agriculture.

2. **District level Co-ordination and implementation**
   Vice-Chancellor, Director (CPBG), Special Officer (Seeds), Dean (Hort.), Director of Seed Certification, Joint Director of Agriculture, Deputy Director of Horticulture.

3. **State level monitoring and advisory committee**
   Agriculture Production Commissioner, Vice-Chancellor, Commissioner of Agriculture, Commissioner of Horticulture, Additional Director Seeds, JDAs of respective crops and SSFs, Director of Research, Director (CPBG), Special Officer (Seeds), Representative of TNSPA, NSC / SSC.

VIII. INVIGORATING EXTENSION SYSTEM IN TAMIL NADU – MECHANISMS AND MODALITIES

There is an immediate need of a vibrant, dynamic and innovative approach to be adopted for agricultural extension in order to achieve the targeted growth rate and serve the farmers of Tamil Nadu better. Research studies reveal that the present system of extension is constrained with the following:

- Existence of wide extension gap
- Low Extension: Farm family ratio
- Inadequate involvement of all stakeholders
- Inadequate operating resources for extension
- Weak Research-Extension-Farmer-Market Linkages

The Current major Challenges facing Tamil Nadu Agriculture are as follows:

- Climate Change
- Declining water availability
- Labour scarcity
- Marketing problems
- Lack of assured income
- Declining soil health
- Retaining youth in Agriculture

To overcome these constraints and achieve enhanced agricultural productivity in Tamil Nadu state, a ***participatory extension approach*** **or** ***hybridized extension approach*** comprising the following extension interventions /approaches are suggested:

- Lessons from earlier approaches
- Farmer to Farmer extension
- Market-led extension
- Public Private Partnerships in Extension
- ICT based extension
- Agriclinics and Agribusiness Centres
- Convergence of extension services
- Participatory Extension approach
- Conclusion

1. Lessons from earlier extension approaches

(a). IADP (1960)

Popularly named as package programme. The strategy adopted was the collective and simultaneous application of all practices of improved seeds, irrigation, fertilizer, plant protection, implements, credit, etc., in the potential areas to enhance the yield within a shorter time. However, two vital shortcomings of this approach were educational approach to reach farmers was lacking and the VLW were found below standard and were not able to impress farmers. If these two factors were taken care, the same approach could also prove to be a successful intervention.

(b). Training and Visit approach (1974)

The features of T & V approach included: (i) a rigid bi-weekly schedule of visits to a defined fixed list of contact farmers in specific villages within a village worker's area of responsibility. The contact farmers were expected to disseminate information further to other farmers within the community. (ii) Fortnightly regular training of village level workers, administered by superiors and subject matter specialists, and focused on the information to be delivered in the coming couple of weeks. The two important features namely the linkages between Farmer-Extension and research-extension are very well appreciated and this aspect need to be strengthened in the present system of extension (ATMA). This can be done by introducing the visit of extension worker to a group of farmers (say commodity groups or farmers' group) instead of visit to contact farmers for the purpose of technology transfer. By strengthening the linkage between the Extension – Research system, the knowledge of the extension worker can be updated with latest innovations. This can prove to be another effective intervention.

(c). Tamil Nadu Agricultural Development Project (TNADP)

TNADP was introduced in Tamil Nadu during 1991. The concept of BBES (Broad Based Extension System) was conceived for the first time in India. There was provision to disseminate the improved technologies in Agriculture and allied enterprises but functionally did not take- off. The programme was implemented in varied ways in different districts due to shortage of funds after the T&V system. The capacity building programmes of extension functionaries were limited to fund made available by the State Government. From 1991-2005, various development Departments were functioning in a compartmentalized manner resulting in duplication of activities and in many areas less relevant to the farmers' needs. However, there was enhancement of food grains production.

(d). ATMA

Agricultural Technology Management Agency Approach (ATMA) was introduced in Tamil Nadu in 2007. The extension system was reformed with new institutions in place at State, Districts, Blocks and village levels. There is provision for participatory planning, execution, monitoring and evaluation of the scheme involving various stakeholders, namely, Farmers, Extension functionaries of all Development Departments, scientists, NGOs, Farmers organizations, Banks etc. Decentralized Decision making process with more say by the farmers themselves is inbuilt in the scheme. Planning from below mechanism is possible for developing Strategic Research and Extension Plan (SREP) for each district for the holistic and integrated development of Agriculture and allied enterprises. Organizing the farming community into Farmers Interest Groups (FIGs), Commodity Interest Groups (CIGs), Farmers Registered Societies and Farmers Organizations (FOs) is the major functional approach of the new extension methodology. There is a great scope for all the stakeholders to work together for enhancing sustainable and profitable farming in Tamil Nadu State.

Gaps and Missing Links in ATMA

- Structurally reformed but functionally need to be improved a lot
- Synergy among various stakeholders is far from satisfactory
- More focused on "Targets" and "Achievements" (Physical and Financial) rather than "Results", "Deliverables" and "Outcome"
- Compartmentalized manner of functioning by the Development Departments

continues in most of the places

- The interventions are not fully need based
- There is a still a wide gap in addressing the problems and issues relating to effective production, value addition and marketing of agricultural commodities
- Multiplicity of schemes, projects and programmes hinder the systematic and concerted implementation
- More “File work” than “Field work”
- Inadequate man power
- Lack of proper facilities for the mobility of the extension functionaries.

The public extension system should be made more professional and accountable for which the following interventions are suggested:

- Delinking input supply function so that educational function becomes prominent convergence of resources and ideas
- Documenting and publicizing successes of Achiever Farmers and facilitating other farmers to replicate
- Taking full advantage of path breaking technologies
- Motivating farmers to get organized into groups, association, societies and federating for effective production, value addition and marketing of agricultural commodities
- Utilizing achiever farmers as para extension workers to educate other farmers, farmer friends and farmers’ groups
- Conducting SWOC Analysis for Agricultural Development at Block and District level.
- Extension functionaries to focus on reporting the ‘results’ and ‘outcome’ rather than mere activities like trainings and demonstrations.
- Intensifying exposure visits to successful farms
- Recognitions and awards to Achiever farmers and extension functionaries in each district, based on the results and outcome
- Displaying the details of government schemes in villages

2. Farmer – Farmer extension approach

Farmer Led Extension (FLE) may be promoted by identifying the Achiever/ Successful and progressive farmers from each crop/ commodity group / federation. These farmers will be trained in major commodity / enterprise. These trained farmers have to be used as resource persons in extension activities. Outstanding farmers may be recognized through awards at various levels and their services may be utilized through travelling seminars.

Large numbers of Farm schools have to be promoted on the farms of achiever farmers to demonstrate the critical agricultural production practices at village level. The services of such achiever/innovative and progressive farmers have to be utilized as change agents / para extension professionals which would also solve the problem of manpower shortage at field level through Farm schools.

Farm schools may be established in the fields of such achiever/innovative farmers, in order to spread their messages and methods. A cadre of grass root farmer trainers can be built up through such farm schools. The host achiever farmer may be utilized as a trainer in the respective crops / enterprises considering his area of

expertise. The farm schools will help to impart a sense of grass root realism to the capacity building programmes.

The FLE approach gives farmers the opportunity to share their experiences and practices through a method demo with fellow farmers in the area. It was proved that farmers who were successful in their farming venture have established credibility among their peers. Hence there is more chance of convincing other farmers of the commodity groups through these progressive farmer leaders.

In selecting the farmer extensionist, the primary consideration is highlighted as follows: He should be an innovative farmer, active, hardworking, honest, credible, interested in learning, accepted and committed to the community, and most importantly interested to share his knowledge and skills. He must also have the capacity and willingness to finance the cost of technology and must own and cultivate at least half hectare of land. The farm must be near his residence and he should have exhibited interest on critical technologies. As part of the FLE, demonstration will be established to serve as show window and learning site for the farmers. The farmer extensionist will train other farmers in his commodity group area via the method demonstration strategy.

3. Market-led extension

It has become absolute necessity to expand extension focus from production-orientation to market demand, aimed to increase farm income by adopting end-to-end approach. Market-led extension help the farmers to improve the quality of farm produce, increase the product value and marketability resulting in increasing of income to the farmers. Village based facilitation and Marketing Center need to be promoted for commodity groups engaged in agribusiness.

4. Public Private Partnerships in Extension

Extension interventions by a private sector should be in a project mode with quantifiable results and ensuring accountability aiming at profit maximization for farmers. Such private initiatives may be supported by government schemes, fiscal incentives and tax benefits to the extent of 100% of investment on Agricultural Extension. It has to be ensured that such intervention should result in bridging knowledge gaps, enhancing yields, protecting yield gains, minimizing Post Harvest losses, augmenting value-addition, increasing income and promoting critical technologies. Project based funding with clearly defined outlay-outcome matrix has to be promoted under Public Private Partnership for effective delivery of extension services on the targeted crops.

NGOs have potential to make significant contribution in implementation of extension activities with public funds. It is proposed that active and effective NGOs working in the field of agriculture would be involved in extension delivery mechanism. With a view to ensure quality implementation, steps need to be taken to identify and encourage NGOs having high performance. NGOs, agri-preneurs, etc. need to be provided some service charge for implementation of extension activities with public funds.

At present, many private companies are involved in providing extension services to farmers as a part of their business strategy, namely e-Choupal of ITC, TATA Kisan Kendra, Haryali Kisan Bazar, etc. Many of these initiatives are moving towards providing multiple services, each catering to about 40-50 villages. Such private investments could be accelerated with fiscal incentives in Tamil Nadu. Private sector could also be involved

in implementation of extension activities with public funds. Another option for Public Private Partnership is private management of public infrastructure. Each block has, on an average, about 20,000 farm holdings. It is, therefore, imperative that various services to the farmers are available at the block level or below. Agro-polyclinics at the block level are functioning in several districts in India. Agro-polyclinics/multiple service centres need to be promoted at the block level in Tamil Nadu. These could be set up by the private sector either on their own or in PPP mode. Necessary incentives need to be provided to the private sector for the purpose.

5. ICT based extension

Effective use of Mass media and ICT could be one of the possible means for bridging knowledge deficiency among farmers at a faster rate. TNAU has made pioneering attempt in utilizing the potentials of ICT in extension. Few such attempts include the opening of the TNAU Agritech Portal (http://agritech.tnau.ac.in/) for the dissemination of agricultural and allied technologies to the farmers of Tamil Nadu. The information about the path breaking critical technologies identified in various crops for achieving enhanced productivity could be uploaded in the portal for the benefit of farmers and extension officials of the state. The market information about the target crops can be fed and accessed through the DEMIC and Dynamic Market Information sites of TNAU.

Mass media can be used more creatively than at present to support farmers' decision-making - through increased coverage of the identified critical technological packages. Improved relevance of content to specific audiences, and use of programme formats could facilitate horizontal communication between users. Similarly, print and other extension material can support the adoption of path breaking /critical technologies more effectively if their form and content are tailored to the needs and characteristics of audience and give information on the economic and financial implications of the recommended critical technologies, including the uncertainties and known risks involved.

The mass media can be a powerful tool for exchange of views and sharing of information within a rural population, but are seldom used in this way. In both print and broadcast mass media, there is little attempt to involve the users in the design and production of media content, an essential step if agricultural information is to become more relevant, useful and accessible to farmers.

Though there are about 300 TV Channels in India, but none for agriculture. It is suggested to have a dedicated TV channel on agriculture in Tamil Nadu, subject to feasibility and usage to focus on location specific problems of farmers and technology transfer. Video lessons on the critical technologies may be produced for dissemination to the farming community by the Dept. of Agriculture.

The critical path breaking technologies could be disseminated through FM Radio. However, FM Radio should have a provision for advertisement while broadcasting of agriculture programme as a business model to generate revenue under Public-Private-Partnership mode.

There is a need to improve the awareness among farmers on Kisan Call Centres (KCC)- particularly its cost free services through toll free telephone so as benefit needy farmers. Emphasis on the critical technologies may be made by the Level I experts while they address the farmer’s queries on the target crops.

6. Agriclinics and Agribusiness Centres

The Agri-Clinics and Agri-Business Centres Scheme was launched in 2002 with the objective of better farming by every farmer and to supplement public extension by providing services of unemployed agricultural graduates by imparting training in entrepreneurship development and agri-business. The scheme would bridge the manpower inadequacy at grassroot level besides making available quality extension services, diagnostic facilities and infrastructure support. The scheme would help the state agriculture and line departments in providing better services to the farmers. Considering long-term benefits of the scheme, more active support of the state governments will help establishment of Agri-Clinics in rural areas. It is proposed to continue the scheme with strengthened training, handholding besides credit linked back ended capital subsidy. Awareness about Agri-Clinics and Agri-Business Centres scheme have to be increased through print, electronic, mass media, Banks and Agricultural Universities. The existing agriclinics in Tamil Nadu may be supplied with the information about the critical technologies for wider dissemination by the consultants in the state.

7. Convergence of extension services

There are many extension service providers in the field, providing different kinds of useful services like information and service support to farmers. They are state, central government agencies, agri-business companies, agri-preneurs, input dealers, manufacturing firms, NGOs, farmers' organizations and progressive farmers. There is duplication of efforts with multiplicity of agents attending extension work without convergence. There should be coordinated attempt to synergise and converge these efforts at the district and below to improve the performance of various stakeholders. It is essential to route all the state and Central Government extension funds through single agency like ATMA for effective utilization of crucial resources.

8. Participatory Extension Approach

The following interventions have been drawn to invigorate Extension in Tamil Nadu.

1. Eventhough much emphasis has been laid in ATMA for facilitating the farmers in getting organised into **Commodity Interest Groups** (CIGs) and other **User Groups** (UGs), the field reality remains dismal. The farmers need to be motivated and encouraged to establish CIGs at cluster level. One practical successful factor could be linking the technology delivery and capacity building programme, input supply, subsidy provision etc., to such **Registered Farmers Associations or Societies**. To begin within each block, the establishment of at least four or five **Commodity Interest Groups** representing different clusters (a group of two to four villages) should be facilitated by the Block Technology Team (BTT) and Farmers Advisory Committee (FAC) on a pilot basis. Later, upscaling may be done in other places also.
2. Currently Strategic Research Extension Plan (SREP) is prepared without adequate participation of all stakeholders. The planning process, therefore, needs to begin with the conduct of **SWOC analysis** involving all the stakeholders cluster wise and considering the technologies available, on-going schemes, projects resources, opportunities etc., the **Village Development Plan** (VDP for big village) or **Cluster Development Plan** (CDP, for a cluster of two or three small villages) have to be prepared. The consolidation of all the Village Development Plans and Cluster Development Plans will emerge as **Block Development Plan** (BDP). The **District Development Plan** has to be arrived at by consolidating all the Block Development Plans (BDPs).

3. The **Farmers Organizations,** namely **CIGs, Registered Farmers Societies** need to be given priority for capacity building programmes (Training, Demonstrations, exposure visits etc.,) establishment of community nurseries, provisions of subsidized inputs, supply of farm equipments and machineries for maintenance and hiring to nearby farmers, creating common storage and processing facilities, transporting and marketing agriculture produces and commodity collectively so as to get better price for the produces.
4. While implementing the extension interventions, beyond 'targets' and **'achievements'**, emphasis and focus needs to be on the **"results"** produced in the field. The 'actual results' produced in relation to production, value addition and marketing have to be documented and compared with the already determined 'expected results'. Special attention and efforts are to be jointly made by the Block Development Team and Farmers Advisory Committee for monitoring the activities and assessing the results and processes for continuous improvement.
5. Based on the "Strengths, Weaknesses, Opportunities & Challenges" and considering resources available, on-going schemes and projects etc., the Block Technology Team (BTT) comprising extension functionaries of various development departments and the Farmers Advisory Committee members can jointly facilitate the establishment of **Model Farms and Model Villages** adopting Integrated Farming Systems (IFS) approach blending economically viable and profitable combination of agriculture & allied enterprises in each block. Such model farms and model villages will serve as a training ground for other farmers to learn and replicate. Making such ventures mandatory would help infuse professionalism in the public extension system besides ensuring accountability of the extension system.
6. **Group Farming or Collecting Farming Approach** needs to be encouraged by channelizing the benefits and subsidies of the various development departments so as to facilitate the farmers to produce agricultural commodities in larger quantities with better quality so that collective marketing and higher income would be possible. The costs and income can be shared proportionate to the area, production and labour contribution by the individual farmers.
7. The Registered Farmer's Societies can be chosen to establish **Agricultural Processing Complexes** (APC) housing the agricultural equipments and machineries required by the farming community of the block concerned. The members of the societies willing to provide infrastructure facilities for the APC will have to be trained on the repair and maintenance of the equipments and machineries by the Department of Agricultural Engineering and TNAU Scientists. The Registered Societies can also rent the equipments and machineries to other farmers and get income. Government of India has funding provision for the establishment of such APCs. Further, this approach would immensy help the farming community to address the problem of labour scarcity effectively.

9. Extension Intervention For dry Farming

- Maximum and efficient use of monsoon rainfall in dry farming must be aimed on priority basis for which efficient land management technologies with mechanization should be promoted and maximizing yield per drop of rain water.
- Drought resistant high yielding varieties which could withstand intermittent stress need to be developed and popularized.
- Large area demonstration plots of dry farming should be taken up, Where in all possible technologies viz land management, seed hardening, seed drill sowing,

foliar nutrients, bio- fertilizer use, vermicomposting, rain water recycling etc. should be demonstrated.

- Contour cultivation Combined with mechanization should be emphasized in dry land farming.
- Dry land integrated farming system with annual crops, perennial fodders, arid zone fruit components with poultry, turkey, rabbit and goat rearing with additional enterprise of mushroom cultivation, value addition of millet products can be done on demonstration basis.
- Rain water harvesting structure and recycling units should be developed all runoff water used to collected in farm ponds and efficient use of these rain water with drip/ mini portable sprinkler should be aimed.
- Block level prediction of monsoon combined with short range weather forecast should be developed.
- Soil moisture conservation with mulch material, vegetative hedges and polythene sheets should be developed.
- Popularization of minor millets cultivation – preparation pamphlets – IEC activities.

Conclusion

While transfer of technology still has relevance, agricultural extension is now seen as playing a wider role by developing human and social capital, enhancing skills and knowledge for production and processing, facilitating access to markets and trade, organizing farmers and producer groups, and working with farmers toward sustainable natural resource management practices.

The critical path breaking technologies need to be identified in various crops and disseminated through the participatory approaches of extension detailed in this document. However the basis is to form commodity groups and form organizations at Block level and federate these commodity based farmer's organization at district and state level. Technology transfer by the state department of agriculture and line departments may consider disseminating critical production technologies and market information through the farmers' organization by adopting the Farmer to farmer extension and market-led extension approaches. The information about the critical technologies may be fed to the TNAU Agritech Portal, Kissan Call Centres, Agriclinics and Broadcast Media for wider dissemination to the farming community. ICT mode of extension may be adopted by the state department of agriculture to disseminate the critical and other agro technologies by the agricultural officer to the farmers directly using the ICT tools and through the village level extension officers. Use of achiever farmers to share their experiences through media, FM radio and video lessons/TV channels for dissemination of the critical technologies are suggested. Public private partnerships approach for delivery of extension services is suggested for high value crops. The lessons from IADP and T&V approach can be incorporated in the existing extension model (ATMA). Development of Block level, district level and state level agricultural development plans prior to the onset of a season in a year by involving all stakeholders is essential for achieving development in the agricultural sector of our state. The participatory extension approach with focus on Farmer to Farmer extension incorporating the positive lesson from earlier extension approaches will be pilot tested in two blocks namely Perinaickenpalayam and Kinathukadavu Blocks of Coimbatore District through action research process.

IX. FARM MECHANIZATION

Tractor operated pulse seeder

Salient features

- Results in 50.0 and 45.0 per cent saving in seed rate when compared with the existing inclined plate seeder and conventional method respectively.
- Results in 19.1 and 97.0 per cent saving in cost and time of opération respectively when compared with the conventional method of hand dibbling.
- Highest per cent hills with one or two plants (82%) with pulse seeder than the existing inclined plate planter (68%) and conventional hand dibbling (68%).
- Uniform hill to hill spacing closer to the recommended level of 10 cm
- Capacity – 1 ha per day
- Cost of the unit - Rs.50,000

Air assisted seed drill

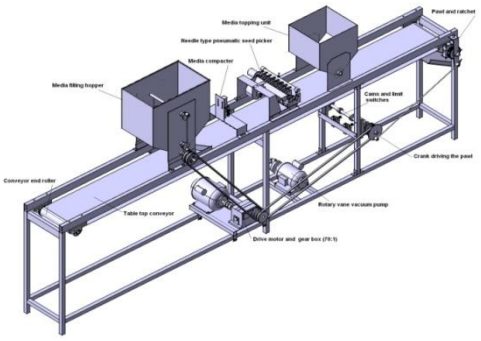
The unit consists of an air blower and drive, seed hopper and feeding device, seed distributor head, seed tubes, furrow opener ground wheel and furrow closer. The above components are mounted on a 9 tyne cultivator. Blower is used to blow air through a vertical distributor tube to the distributor head. Seed is metered by the ground wheel into the air stream at the required rate. The stream of seed is distributed to the 9 furrow openers by the distributor head. This ensures uniform drilling of fine seeds. Cost of the unit is Rs. 75,000/-

Hill drop planter

- ❖ Cost of the unit is Rs. 75,000
- ❖ Cost of operation of the unit is Rs.2000 per ha
- ❖ Coverage 0.3 ha /hour

Automated protray sowing machine for vegetable nursery production

In the past three decades, India has made commendable progress in vegetable production enabling it to become the second largest vegetable producer in the world. Recently, vegetable growers prefer pro-tray grown seedlings over conventional ones for manual transplantation. Simple cell type transplanters are now being developed which can transplant tray grown seedlings.



To mechanize the placement of seeds in the pro-tray cells, an automated protray sowing machine has been developed in the Agricultural Machinery Research Centre, Tamil Nadu Agricultural University, Coimbatore. The device has an automated needle picker, which can handle a queue of protrays. A flat conveyor belt is moved in steps on a table top to cater the inter cellular distance of a standard 98 celled protray. A media filling mechanism with a media hopper and a feed roller are provided along with regulating shutters, so that the volume of media metered correspond to fill each row of the protray cells. Similarly another feed hopper for dispensing media to top up the tray after the sowing operation is also provided. The device has a solenoid actuated tray compacting device, that press the media down a single row at a time of the media filled protray. The seed picking arm having a row of 7 needle pickers alternately dip into a vibrating seed tray and shuttles back to drop the seed into each row of the protray below. An electrical drive and appropriately mounted limit switches control the above action. This is integrated to the main control circuit operating the compacter and the vacuum release solenoid. Since the seed pick/drop mechanism needs to be stopped when the seed tray is not present below it, an optical sensor is incorporated in the circuit to sense the tray's presence. A rotary vane vacuum pump is provided from which the vacuum is sourced to the picking array. A solenoid valve as coupled on the line between the pump and the picker manifold, makes and breaks the vacuum supply to the pickers, so as to pick and drop the seeds at the appropriate locations. Cams as mounted to actuate limit switches control the seeding/ compacting actions appropriately.

The protrays once fed on the conveyor are automatically filled with growth media, compacted, sown, topped up with media and passed out to the other side of the conveyer, thus fully automating the process. About 80 sown trays can be prepared in an hour. Cost of operation works out to Rs 350/ day for sowing 600 trays /day, which is its maximum capacity. The savings in cost and labour is about 117 per cent and 60 per cent respectively. The cost of the unit is Rs. 50,000 only.

Tractor drawn turmeric rhizome planter

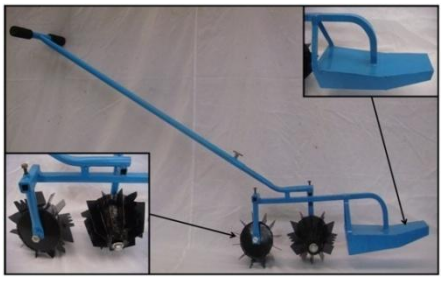
Salient findings

A three row tractor drawn turmeric planter was developed. Preliminary trial was conducted in the presence of Horticultural Officers of state department during the Zonal workshop. Evaluation of the unit will be conducted in the ensuing season. The cost of unit is Rs. 60,000/-

Ergo refined women friendly conoweeder

Weeding roller design configuration

- apex angle - 360
- height of blade - 35 mm and
- number of blades - 10



Ergo designed values

- handle height - 910-970 mm ,
- cross handle bar length - 400 mm
- handle length - 1170-1270 mm and
- handle grip diameter - 26-43 mm

The cost of the unit is Rs. 1500/-

Mechanized intercultivation

Option 1

The whole intercultivation machinery should proceed between the crop rows - would not be possible if crop row is smaller than the weeder's minimum working width.

Power weeder –garden land

The lightweight power weeder is powered with 8.3 / 10 hp diesel engine. The engine power is transmitted to ground wheels through V –belt pulley. A tail wheel is provided at the rear to maintain the operating depth. The rotary weeding attachment does weeding. The rotary weeder consists of three rows of discs mounted with 6 numbers of curved blades in opposite directions alternatively on each disc. These blades help in cutting and mulching the soil. The width of coverage of the rotary tiller is 500 mm and the depth of operation can be adjusted to weed and mulch the soil in the cropped field. It is for mechanical control of weeds in crops such as tapioca, cotton, sugarcane, maize, tomato and pulses whose rows spacing is more than 450 mm. Attachments like sweep blades, ridger, trailer can be used with the machine. The lightweight power tiller can also be used for tillage under hill agriculture and terrace farming. It can also be used for weeding in arecanut and coconut groves and orchards. The capacity of the machine is 0.5 ha per day. The cost of the unit is Rs. 1,20,000/-.

Option 2

Or the tractor should straddle the crop with its wheels and the soil working tool is made to work between the crop rows

- The first requirement is to set up the tractor with a set of row crop rear wheels.
- The row crop wheels are thin wheels (8" x 36")

– 8" rim (tyre) width - unlike the regular traction wheels which are about 16"- 18" wide used for ploughing

Front mounted weeding tools

- A front mounted ridger /earthing-up / weeding tool has been developed and tested
- The implement frame is carried on a three point hitching system supported by a front mounted frame
- It is raised up and lowered using a separate remote hydraulic cylinder coupled to the tractor's hydraulics.
- The depth of cut is maintained by a simple pair of restraining/ adjustable chains. (More precise hydraulic controls are contemplated for future development)

Multi-row power weeder for paddy

The motorized power weeder comprises of engine, gearbox, main frame, rotary wheel, float, handle and controls. When used for weeding three rows simultaneously, 60 per cent and 75 per cent of weeding efficiencies are achieved for one and two way operations respectively. Similarly while using it for two row passes, it yields 65 and 90 per cent weeding efficiencies for one and two way operations respectively. The treading of weeds by the operator as well as by the float provides the middle row to be weeded effectively making it into a three row weeder. The wide bladed weeds are effectively trampled by the float in the middle row while the weeding rotors weed the extreme rows. When the weed intensity is more, the weeder can be used as two row weeder. The capacity of the machine while used as a three row weeder is 1 ha per day. The cost of the unit is Rs. 35,000/-.

Twin row precision organic manure cum fertilizer applicator

Priorities in agriculture research are gradually moving from a focus on individual crop performance to a total system productivity with due attention on product quality and environment safety. The popularity of organic farming is gradually increasing and now organic agriculture is practiced. In traditional rain fed agriculture (with low external inputs), organic agriculture has shown the potentials to increase yield. Deep tillage loosens the subsoil layers that remain moist. Presence of organic mulch material in the subsoil could also make the subsoil biologically active and enhance the root growth in to subsoil layers. Subsoil placement of mulch would prevent it from dispersed during subsequent tillage operations. Control of the application rate of mulch/manure in the field can contribute to make management of mulch a more technologically and economically interesting alternative for soil and crop growth. For precise application of the limited available organic manures/mulch in the soil at desired application rate and depth, a tractor operated twin row precision organic manure cum fertilizer applicator has been developed in the department of Farm Machinery, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore.

The unit is built around a chisel plough. The functional components include chisel plough, manure and fertilizer hopper with metering device and agitator for the organic mulch/manure. Two chisel plough bottoms are mounted on a main frame with adjustable cross rail through which the spacing can be adjusted to suit the row spacing of crops. The mainframe is attached to the tractor through three point linkage. Two trapezoidal shape feed hoppers are mounted on the main frame for holding the organic mulch/manure. An agitator is provided in the hopper to prevent clogging of the mulch/manure. The mulch/manure form the hopper is metered precisely by a screw auger assembly and dropped into the furrow opened by the furrow wings attached with the chisel shank. Two trapezoidal shapes feed hoppers are attached with the manure

hopper to hold the fertilizer. The fertilizer is metered by an orifice and agitating type device and placed above the manure. The manure and fertilizer metering devices are driven by a ground wheel unit. The agitator is driven by PTO of the tractor through chain and sprocket transmission system. The cost of the unit is Rs. 75,000. The unit can cover one ha per day.

- Suitable for application of organic mulch / manure directly below the root zone of the crop.
- Application rate of manure can be precisely controlled.
- The manure can be placed at desired soil depth.
- Adjustable spacing between the furrows enable the use of the unit for different crops.
- Simultaneous precise placement of organic manure/mulch and inorganic fertilizer.
- Accurate and controlled application of organic manure/mulch at desired depth improves the soil nutrient use efficiency, lowering production costs while improving crop yields and soil quality.
- The versatility of the unit extends its use for the application of farm yard manure, enriched FYM, compost, vermi-compost etc.
- Deep loosening of soil and placement of organic mulch/ manure in subsoil layers as mulch directly below the crop helps in improving the moisture and nutrient availability of root zone.

Groundnut harvester

It consists of a digging blade, an elevator /shaker, idlers, driving sprockets; two gauge wheels, and gearbox. The front end of the picker elevator is adjusted in accordance with the depth of working of the blade. The soil engaging tool is a 50 mm thick x 100 mm wide x 1800 mm long straight steel blade with 15 degree rake angle and is fixed to a main frame through shanks at both ends. The pickup conveying mechanism of length 1200 mm is made of two 600 mm endless strip chains spaced 1800 mm apart. The angle of the shaker conveyor is 45 degree with horizontal and has a length of 1200 mm. The digger is operated by a tractor of 35 hp or higher. The PTO through a telescopic shaft supplies power to the gearbox of the machine. It digs the groundnut vines below the pod zone and elevates them by an elevator picker for dropping on the ground. The soil attached to the vines is shaken off in the process and a windrow is formed with the help of deflector fenders. The cost of the unit is Rs. 75,000/-.

Impact type groundnut stripper

The unit consists of a 1.2 m long peg type stripping cylinder fitted with rigid stripping fingers. The fingers are mounted on eight bars (Fig. 2. 13). The fingers are made of 70 mm long 6 mm diameter mild steel rods and are spaced at a spacing of 50 mm. The fingers on alternate bars are staggered. The cylinder revolves at 200 rpm and is powered by 2 hp / petrol start kerosene run engine. The drive is transmitted to

the thrashing drum through V belt reduction. The drum is enclosed all-around except for the feeding window. A feeding platform is provided for the operator to conveniently hold and thrash the crop. The vines are held by the operator and the root zone with the pods is exposed to the beater fingers for stripping the pods. The machine is designed for two operators to work simultaneously. The machine is supported on wheels for transporting in the field.

Specifications

i. Stripping efficiency	:	100%
ii. Damage to pods	:	Less than 2%
iii. Saving in labour	:	37%
iv. Saving in cost	:	17%
v. Capacity of the tool	:	1 acre can be stripped per day
vi. Power source	:	2 hp electric motor / 2.5 HP kerosene engine
vii. Cost of operation	:	Rs.833 per ha
viii. Cost of the unit	:	Rs.30, 000/-

Hydraulic brake system of two wheel tractor trailer

The farm tractor has become a very important part of the food production chain. Tractor - trailer combination plays a significant role in agricultural goods transportation. Many accidents, mainly longitudinal or lateral overturning, occur with the tractor-two wheel trailer system due to lack of important safety features. The two wheel tipping trailers are not provided with any separate brake arrangement for the trailer. They are stopped by the braking action of the tractor alone. When brakes are applied to a tractor with a loaded two wheel tipping trailer, the tractor first stops and then the trailer rams into the tractor and stops due to its inertia. This causes potential jack knifing situation leading to subsequent over turning. Keeping the above factor in view, a a hydraulic brake system has been developed for the two wheel tractor trailer.

The hydraulic brake system of the two wheel tractor trailer can be mounted on the tractor and powered by the electrical and hydraulic system of the tractor. The developed hydraulic brake system consists of following components:

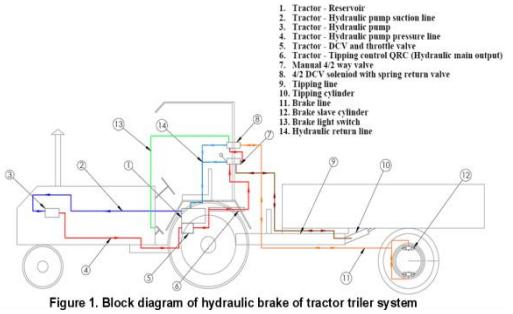


Figure 1. Block diagram of hydraulic brake of tractor triler system

- Tractor - Hydraulic gear pump
- Pressure relief valve
- Manual operated spring loaded 4/2 Direction control valve (for tipping of trailer)
- Solenoid operated spring loaded 4/2 Direction control valve (for brake system)
- Tank or reservoir
- Pressure gauge
- Trailer wheel Brake unit with hydraulic slave cylinder
- Tipping control

The hydraulic brake system was actuated by brake light switch attached to the brake pedal of the tractor through a solenoid operated spring loaded 4/2 Direction control valve. When the operator applies tractor brakes, the brake light switch is actuated and energizes the solenoid which in turn opens the DCV to supply the hydraulic oil at the set pressure to the slave drum of the brake mounted on the trailer wheel and

the braking of the trailer is accomplished. The brake pedal play and the position of the brake light switch is set in such a way that the trailer brake will react before the tractor wheel brake reacts. A pressure gauge is provided in the hydraulic lines to measure and set the pressure of the hydraulic oil.

Salient findings

A hydraulic brake system has been developed for the two wheel tractor-trailer system.

Trailer mounted steering for power tiller

The power tillers are being used extensively in rice and sugarcane cultivation. The power tiller is a multi-purpose hand tractor designed primarily for rotary tilling, transportation and other farm operations. The operator sits on the seat of the trailer and controls the power tiller during transport operation. The steering controls of the power tiller swings out around the power tiller trailer hitch point axis. Hence the operator seated on the trailer seat has to extend his hands sideways and at the same time moves away from seat. The operator has to cope up with the forward speed of the power tiller while doing so. This results in unstable operator posture apart from inducing considerable strain on the operator. The risk taking behaviour of the operator some time leads to accidents.

For enhanced safety, comfort and ease of operation, the existing steering system of power tiller – trailer system was improved. In the new steering system, the two handle bars attached to the body of the power tiller are removed and fitted on the tow bar of the trailer with a bracket. The handle bars are supported with fixtures from the tow bar of the trailer. The main clutch-brake lever from the handle bar of the power tiller is connected to the clutch assembly through a rod and cable supported by clamps mounted on the left side handle bar. The two steering cables are extended in linear mode through coupling clamps fixed on the two sides of the bracket which is mounted on tow bar of the trailer. The steering cable consists of two portion *i.e.,* one is connected between the steering clutch and the coupling and the other connected between the coupling clamps and steering lever in the body of the power tiller.

In the existing design, the trailer is attached with the power tiller through a single point hitch. The handle bar attached with the body of the power tiller swings up and down while riding with the trailer. Accordingly, the height of the handle varies from 610 to 950 mm from ground level and this causes discomfort to the operator. In the new steering system, the handle bars are attached to the tow bar of the trailer and hence the height remains constant.

Presently to negotiate turns, the operator has to lean side ways to hold the handle which swings to right or left as the turn may be. The handle swings out of reach (Location of handle grip from the seat rest of trailer is 1700 mm and the handle is inclined at 46º from the axis of trailer at extreme turning condition) and the operator jumps out of the seat and steers the power tiller by holding the handle in standing posture from ground level . With improved steering system, the lateral swing of the handle is arrested and the operator can steer the power tiller with trailer from the seat of

the trailer when negotiating turns. The new steering system in power tiller-trailer arrested the relative motion of the operator between the trailer seat and steering handle and the up and down swing motion of the handle bar. Controls *viz.,* steering clutch, main clutch lever, brake lever, main gear shift lever and rotary gear shift lever are well within the reach of the operator and hence the operator feel secure, more comfortable and ease of handling the power tiller- trailer. The turning radius for the power tiller-trailer with new steering system is shorter by 60 per cent than that of conventional power tiller-trailer.

Salient features

- With new steering system, the operator feels safe and secure.
- Ease of handling makes the worker comfortable.
- Shorter turning radius, enable the operator to take turns in narrow space.
- Controls *viz.,* steering clutch, main clutch lever, brake lever, main gear shift lever and rotary gear shift lever are well within the reach of the operator,
- Reduced body part discomfort of the operator through elimination of lateral and vertical swing of the handle.
- Reduces the health risk of operator with reduction in hand transmitted vibration.
- Cost of the new steering system is Rs.1,000/-

X. POST HARVEST MANAGEMENT AND VALUE ADDITION TO CROP PRODUCTS

Agriculture production in the country has increased considerably during the past three decades, due to the introduction of improved agricultural technologies. However, this has produced a lot of problems, commonly referred to as 'second generation' problems. For example, the crops harvested during rainy season place a heavy demand on drying and storage facilities. The combination of more intensive cropping seasons and more production inputs increase the demand for labour at critical times. Increased productivity has also led to the failure in the existing infrastructure to cope with the large marketable surplus resulting in the inability of the farmers to retain them. Once the crop is harvested, the quality starts deteriorating due to the attack by the microorganisms, insects and rodents. A bulk of produce is also lost due to improper handling and storage. A reduction in food supply after harvest is considered a "post harvest loss". It has been estimated that about 10 percent of durable and 20 percent of perishable crops are lost due to improper post harvest operations.

The post harvest processing solutions are not unique. They vary with the commodity and are also location specific. The various processing operations for application at farm level, village level, and organised industrial level have to be different. While there are number of technologies available to cater to the needs of industrial level operations, the processing technologies at rural threshold, namely, farm, and village level technologies are lacking. By improving handling, processing, storage and preservation, the loss can be reduced significantly. However the potential for preventing losses greatly depend on the cost and benefits involved.

Many improved technologies/processes have been developed for the various unit operations during the past as summarized below, and their popularization for processing and preservation of food material and adoption will go a long way in increasing the food availability.

Mini dhal mill

The dhal mill is suitable for splitting all kinds of legumes into dhal. Farmers cultivating legumes can split them into dhal and get good prices for their produces. This unit is more suited for redgram, green gram, black gram and also for pulverising of cereals by making simple adjustments in the unit. The unit has a capacity of 30 kg/h and operated by 1 hp motor. The cost of the unit is Rs.25,000/-. This can also be mounted in the same frame of the domestic wet grinder making the unit suitable for wet grinding also with the same prime mover.

Improved dhal mill

In the existing mini dhal mill, no provision is available for pitting, cleaning and grading the dehusked pulses. Hence, to have pitting operation and to have a cleaner cum grader, an improved TNAU dhal mill has been developed. The unit consists of a pitting unit, a milling unit, a blower, grading sieves and a motor are operated by one horse power single phase motor. The milling efficiency for red gram, back gram and green gram were found to be 90, 92 and 93%. The cleaning efficiency of the blower and the grading efficiency of the sieves were found to be 92 and 95%, respectively. The cost of the unit is Rs.50,000/-.

Improved dhal mill

Mini dhal mill

House hold level paddy parboiling unit

The paddy parboiling unit developed is of house hold type with a capacity of 125 kg/ batch. The water filled in the unit is boiled and from the steam produced, paddy is parboiled. For the subsequent batches of paddy, the same hot water is used resulting in saving in time and fuel. The time taken for the first batch of paddy is 45 minutes and for the subsequent batches, it is only 25 minutes. The cost of the unit is Rs.20,000/-.

Turmeric boiler

The turmeric boiler is used to boil the turmeric rhizomes under controlled and hygienic condition. The boiler capacity is 150 kg/ batch and operated by 2 men . The cost of the boiler is Rs.25,000/-. In this boiler, the same water is used for the subsequent batches which save the time and fuel.

Paddy parboiling unit

Improved farm level Turmeric boiler

Chilli seed extractor

The chilli seed extractor is used for extracting seed from dried chilli. The capacity of the extractor is 50 kg of dry fruits per hour and operated by 0.5 hp electric motor. The cost of the unit is Rs. 30,000/-.

Adhesive from tamarind kernel powder

The materials used for preparing adhesive are tamarind kernel powder (TKP), glucose, sodium carbonate, soybean meal and chloroform. The process involves the preparation of TKP after roasting and decortication and mixing with chemicals. The adhesive can be used in paper industries and carpentry works.

Dehydration of mushroom

A fluidised bed dryer of batch capacity of 6 kg has been developed. The mushroom dipped in 0.5% of Potassium Meta bi sulphite (KMS) solution can be dried in 2 hours at 50°C for 2 hours. The quality of the dehydrated mushroom was good without loss of any nutrients.

Brinjal seed extractor

The unit consists of a macerator assembly and a separation unit. And suitable for the extraction of seeds from ripened brinjal fruits. The unit is operated by a 3 hp motor and has a capacity of 120 kg of fruits per hour. The cost of the unit is Rs. 40,000/-.

Fluidised bed dryer for mushroom

Chilli seed extractor

Pulper cum washer for coffee

Brinjal seed extractor

Pulper cum washer for coffee

A pulper cum washer has been developed for coffee which combine the both pulping and demucilaging of coffee. The water requirement for pulping of coffee berries and washing of parchments are reduced to 4 litres of water against 15 litres required per kg of fruits by the conventional process. The cost of the unit is Rs. 75,000/-.

Tomato seed extractor

A tomato seed extractor has been developed for extraction of seed from tomatoes. The unit has a squeezing and separation assembly. The unit is operated by 1 hp motor and the capacity is 180 kg of fruits per hour. The cost of the unit is Rs. 35,000/- and the cost of operation is Rs. 100/- per kg of seeds extracted.

Tomato seed extractor

Arecanut dehusker

Arecanut dehusker

The unit consists of a mainframe on which a rotary shelling drum having 8 Nos. of solid rubbers on its periphery is mounted (like rasp bar threshing cylinder). Below this, a concave is placed to aid shelling and to pass the dehusked material down. After dehusking kernels and husk flow to the duct and reach the air stream, produced by a blower. The husk is thrown out and the kernels / nuts are collected at the bottom. Depending upon the size of fruits, the concave has to be changed for higher efficiency and minimum breakage. Grading the dried fruits before dehusking will also help to increase the dehusking efficiency and reduce the breakage. The cost of the unit is Rs.50,000/-.

Ground nut decorticator (Power Operated)

It consists of a hopper, double crank lever mechanism, an oscillating sector with sieve bottom and a blower assembly, all fixed on a frame. A number of cast iron peg assemblies are fitted in the oscillating sector unit. The groundnut pods are shelled between the oscillating sector and the fixed perforated concave screen. The decorticated shells and kernels fall down through the perforated concave sieve. The blower helps to separate the kernels from husk and the kernels are collected through the spout at the bottom. The shells are thrown away from the machine. Cost of the unit is Rs.40,000/-

Ground nut decorticator (Power Operated)

Ground nut decorticator (Hand operated)

Ground nut decorticator (Hand operated)

It consists of an oscillating sector with sieve bottom and a handle. Number of cast iron peg assemblies is fitted in the oscillating sector unit. The groundnut pods are shelled between the oscillating sector and the fixed perforated concave screen. The decorticated shells and kernels fall down through the perforated concave sieve. The kernel and husk are collected at the bottom of the unit and separated manually. Cost of the unit is Rs.12,000/-

Hand operated pepper thresher

Pepper thresher consists of a metallic drum provided with rasp bars, concave, power drive with a handle and a sieve for separating the empty spikes. Through the handle provided, the unit is operated. The unit has provision to adjust the clearance between the rotor and the concave to minimize damage to the berries. The empty spikes need to be fed second time for threshing depending on the berries present in the vines. Cost of the unit is Rs.15,000/-

Power operated pepper thresher

The unit consists of a metallic drum provided with rasp bars, concave, power drive and oscillating sieve. The pepper spikes fed through the hopper reaches the threshing drum and undergoes threshing. The empty spikes and berries reach the oscillating sieve

mechanism and the empty spikes are separated. The clearance between the drum and rotor can be adjusted to minimize the breakage. Cost of the unit is Rs.35, 000/-

Hand operated pepper thresher

Power operated pepper thresher

White pepper peeler cum washer

Rotary type garbler for cardamom

White pepper peeler cum washer

White pepper pulper cum washer consists a feed hopper, rotor and shaft, inner perforated drum, blade and brush, water distribution system, discharge system and motor. The rotor shaft is the key component of pepper pulper cum washer unit. The unit is kept at an inclination of 15° to facilitate flow of washed skin after pulping. Mild steel blade and nylon brushes were mounted on the shaft. The rotor shaft was mounted on gunmetal bush at both ends. The inner perforated cylinder is placed over a bottom trough. The perforation size was 2x20 mm, so that only washed skin is collected. Nylon brushes are provided in the opposite sides of blades, to avoid clogging of perforated screen. Water for washing the pulped berries is supplied by 0.5 hp mono block self-priming pump through pipe at the center of the water distribution pipe. The wash water collected in the trough is allowed to fall in perforated bottom, where the water is drained to the bottom trough and recirculated.

Rotary type garbler for cardamom

This type of garbler consists of a feed hopper, rotating drum, discharge chute and handle. A shaft placed at the centre of the drum is provided with 4 numbers of beaters radially mounted. With the help of a suitable handle the beater assembly is rotated. In this garbling unit, about two to three minutes is required to garble one batch

of about 5 kg of cardamom. The capacity of the unit was found to be 100 kg/h and the efficiency was 98%. The broken capsules were found to be less than 5%. The cost of the unit is approximately Rs.10,000/-.

White pepper peeler cum washer

Rotary type garbler for cardamom

Rotary sieve multi crop cleaner cum grader

The cleaner cum grader consists of a rotor provided with three numbers of sieves and the sieves can be changed according to the crop to be cleaned and graded. A handle is provided to operate the rotor at 15 to 30 rpm speed. For easy conveying of the material, a screw auger is provided inside the rotor. Below each sieve, outlet is provided to collect the graded output. Cost of the unit is Rs.15, 000/-

Rotary sieve multi crop cleaner cum grader

Insect trap

TNAU Insect trap

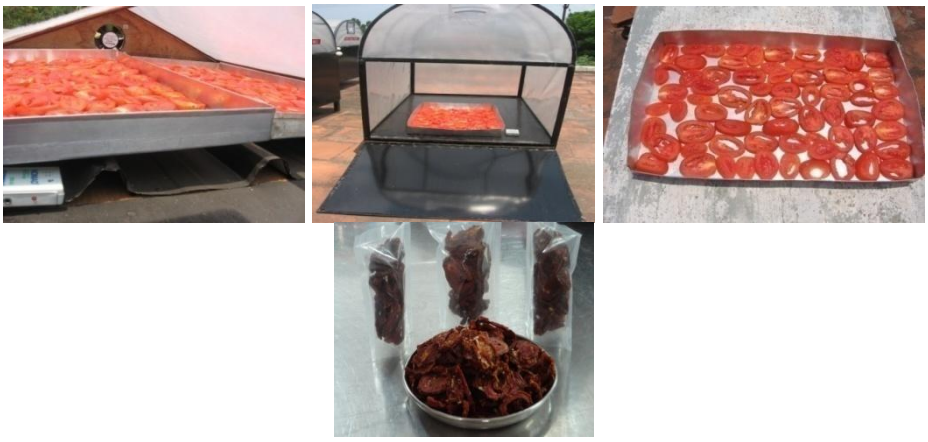
The basic characteristics of the stored product insects, viz., affinity towards air, tendency to move towards aerated region, wander in the grain and active during dusk and dawn have been exploited in the development of the trap. The stored grain insects, like red flour beetle, saw toothed beetle, rice weevil, paddy moth, turmeric beetle, drug beetle, pulse beetle, groundnut bruchid, dermestid beetles, flat grain beetles, etc with the behaviour of wandering in the bulk grain, reach the insect trap. These insects will enter the trap through the perforations and reach the stem of the trap. In the stem, as the insects cannot move upward and escape, they move towards the bottom and reach the pit fall placed at the bottom.

Process for sun dried tomatoes

Tomatoes have been domestically grown in many parts of the world and popularly grown throughout India. The varieties cultivated are nadu and plum tomatoes. Sometimes tomatoes were as expensive as apples at Rs.40 to 50 / kg whereas the high yield of tomatoes has brought down the prices of crop to Rs.7/basket which lead to

heavy loss to the farmers and lead to post harvest losses tomatoes. Studies indicated fresh produce losses ranged from 10 to 40% globally, with losses in India at the high end. One of the best ways to reduce post harvest losses is converting them in to value added products. Based on these a study was undertaken to develop sun dried tomatoes. Red fully matured plum tomatoes were selected, washed and cut in to 2 cm thickness slices approximately. The slices were pretreated in soaking in 2 % salt, 2% sugar and 2% sodium benzoate solution for ½ an hour and drained. The slices were spread on an aluminum tray and kept for drying under open sun and two different types of solar driers. Dried slices were packed in polyethylene bags and stored in dry cool place. During storage, drying constant, rehydration ratio, moisture, acidity, ascorbic acid, water activity, lycopene and microbial enumeration were evaluated.

The shelf life of the sun dried were 180 days in all pretreated samples whereas the control samples were deteriorated within 2 days. In the pretreatments, 2 % sugar solution was best both in nutrient composition like retention of lycopene and vitamin C were high compared to 2 % salt treated and 2 % sodium benzoate treated samples. The solar dries samples were good compared to open drying method in the case of quality and time taken for drying. There is no difference between the two types of solar driers. The water activity (aW) of the fresh tomatoes was 0.95 and sun dried tomatoes was 0.57.The moisture (6.5% and 6.2%), total sugar (4.80, 4.81 and 4.87g/100g) reduced and acidity(4.27,4.21 and 4.86 g/100g), lycopene (86 and 90mg/100g) and vitamin C(27.43, 45.53, and 25.02 mg/100g) increased in salt, sugar and sodium benzoate treated samples respectively during storage from its initial value of 90.36 % moisture, 6.62 g of total sugar, 0.45 g acidity, 10.86 g of lycopene and 16.50 g of vitamin C . Sensory evaluation studies showed that Soup prepared from fresh tomatoes (8.0) followed by sugar (7.0), salt and sodium benzoate treated (6.8) sun dried tomatoes in all characteristics. During storage, the bacterial and fungal count was decreased. The results concluded that 2% sugar solution treated sun dried tomatoes were good in all characteristics, nutrient composition and sensory evaluation up to six months.



Value addition to sorghum

The sorghum varieties CO (S)28, CO (S) 30, COH4, TNSH 482 and local varieties were standardized for the preparation of Quick cooking Sorghum. The variety CO(S)28 was found to have low cooking time (5 min.) in pressure cooking, (10 min.) in open cooking and (15 min.) in conventional method than the other varieties. Sorghum varieties CO (S) 28, CO (S) 3 and TNSH 482 were high in Carbohydrate and

Protein content. The anti-nutritional factor like tannin content in raw sorghum was found to be decreased during processing.

The quick cooking sorghum was standardized for the preparation of instant food mixes. The quick cooking sorghum products were packed in two types of packaging materials. Products packed in P2 (400 gauge) polyethylene bags had maximum retention of nutrients, during storage than in P1 (200 gauge). The shelf life of the optimized quick cooking sorghum grains was highly acceptable up to six months. The cost of the quick cooking sorghum products ranged from Rs.60/- to Rs.130/ Kg.

Sorghum composite biscuits

Value added Plmyra tender fruit products

Sorghum variety CO (S) 28 was selected for preparing sorghum flour instant food mix as it was identified to be the best variety. Twenty instant food mixes were prepared, standardized and studied for their nutrient content. The developed quick cooking sorghum products were packed in two types of packaging materials viz., LDPE 200 gauge thickness and LDPE 400 gauge thickness. The products prepared using CO (S) 28 were identified to be the best based on the criteria of nutrient content and the anti nutritional factor. The products were found to be highly acceptable and fairly good sources of iron and calcium. The shelf life of the sorghum flour instant food mixes was found to be six months. The cost of the sorghum flour instant food mixes ranged from Rs.70 to 95/- per Kg.

Value added products from palmyra tender fruits and tuber

Sugar based value added products, *viz.,* squash, ready to serve beverage, jam, jelly, candy, preserve and peda from palmyra tender fruits and value added products using palm tuber were standardized and analyzed for their physic- chemical characteristics, sensory evaluation and storage studies. The palmyra tender fruit squash and blended squash were standardized using different proportions of palmyra tender fruit pulp and in combination with grapes, pineapple and mango. It is possible to prepare squsn, RTS beverages and jam by blending various pulpy fruits like grapes, pineapple and mango at 20 percent incorporation level with palmyra tender fruit pulp.

The shelf life of the squash, and RTS beverages were highly acceptable up to six months and jam jelly ,candy and preserve was highly acceptable up to one year based on the storage study and sensory evaluation . Palm tuber was incorporated for the standardization of rotti, puttu and upma, snack recipes such as murukku, pakoda and ribbon pakoda, sweet recipes such as laddu, kesari, payasam, soya laddu and porridge . The Standardized products were found to be acceptable at 10-30 percent incorporation levels and bakery products such as bread and cookies and extruded products like vermicelli prepared from palm tuber flour were

found to be highly acceptable at 30 percent incorporation level. The cost of the all the recipes ranged between Rs.6.00 to Rs.14.00.

Value addition of small millets

Small millet based value added foods including breakfast recipes, sweet and snack recipes based on traditional methods commonly prepared by farmers were standardized. breakfast recipes like idli, dosa, idiappam, rotti, pittu, upma, vermicelli, adai, porridge, khakra and chappathi. Sweets like halwa, leaf kolukattai, adhirasam, kesari, nutritious ball, kheer and sweet paniyaram. Snack items like vadai, pakoda, ribbon pakoda, omapodi, murukku, thattu vadai, hot kolukattai and vadagam. All the above recipes were developed with small millets replacing rice flour and other cereal grains. The products were standardized and evaluated for their sensory attributes by a panel of trained members using a nine point Hedonic scale. In India, different kinds of traditional foods are made from small millet grains and they form the staple diet for many rural and urban households.

Value added products from millets

The developed recipes were analyzed for their nutrients using standard procedures. The developed traditional products were found to be rich in protein, calcium and phosphorus. The protein content of adai prepared from little millet was found to be 13.74 g/ 100 g. The iron content of kodo millet and barnyard millet adhirasam was 16.3 mg and 17.4 mg, respectively. The overall acceptability of the developed products

ranged between 8.1 to 8.6 for barnyard millet, 8.3 to 8.7 for kodo millet, 8.1 to 8.7 for finger millet and 8.3 to 8.6 for little millet products.

Millets were used for the preparation pasta products, puffed foods, bakery products and instant food mixes. Small millets were incorporated in different variations from10% to 50% level to standardize bread, cake and cookies. Bakery products like soup sticks and khari using small millets were standardized and analyzed for their nutritive value. Vermicelli and Macaroni were prepared at various substitution levels of small millet flour. The products were found to be acceptable up to an incorporation level of 30 per cent. The developed products were highly acceptable and on the whole, the incorporation of millet flour improves the nutrient content and the millet composite products are economically feasible which may provide variety with high nutrient content and partially replaces the consumption of cereals.

Novel food products from sago

Plain sago has been enriched with pulses, vegetables, roots and tubers were used to prepare pulse sago, vegetable sago, potato sago, coconut sago, lime sago and tomato sago. Snacks like ladoo, vada and kheer were prepared and its organoleptic characteristics and nutritive values were analysed.

Sago vadai

Tomato- sago

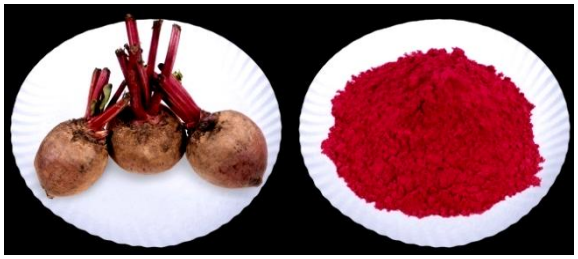
Sago laddu

The studies have showed that sago is very much suitable for preparing sago pulav, potato sago, pulse sago, lemon sago, tomato sago and coconut sago as that of rice. The plain sago food with various combinations has proved that the products from sago were highly nutritious and acceptable. As these sago foods are highly nutritious this may meet 1/3 nutrient requirement (RDA) of the growing children if introduced in appropriate programmes. The results of this study are giving scope for an experimental intervention in the noon meal centers.. The product diversification of cassava and development of value added product is very important for industries as well as farmers. Hence the nutrient enriched sago products will enhance the economic value of the cassava which ultimately will help in sustained growth of the sago industry in Tamil Nadu.

Biocolour from beetroot

Technology for the production of biocolour from beetroot has been developed. The powder obtained by spray drying has a storage period of 180 days. This biocolour was foud suitable for use in colouring the foods *viz.,* beverages (milk shake), jam, jelly, candies (jujups and lollipop), sweetmeats (halwa and kesari), icings and icecream and the level of incorporation of biocolour was optimized. Incorporation of biocolour in processed foods was ranged from 0.2 to 0.9 per cent and the synthetic colour was between 0.01 and 0.03 per cent. The organoleptic characteristics viz., colour and appearance, flavour, texture, taste and overall acceptability of the prepared products

were done by using 9 -1 hedonic scale of ten untrained judges initially and at the end of storage period (180 days). Organoleptic evaluation studies showed that the overall acceptability the processed products ranged from 8.0 to 8.6 initially and from 7.5 to 8.0 at the end of 180 days. For 100 kg of fresh beetroot yielded 19.0 kg of biocolour. The cost of the biocolour from beetroot powder was Rs. 56/- per 100 gram.

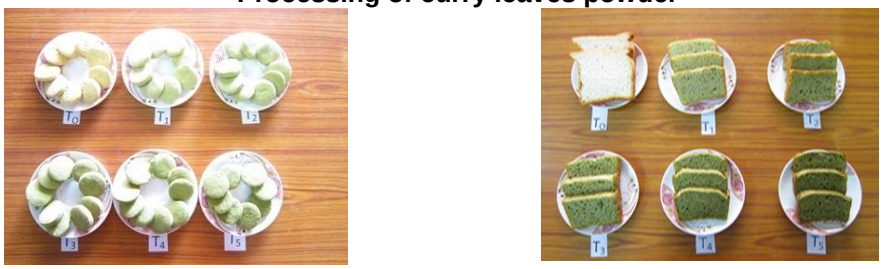


Biocolour from beetroot

Production of curry leaves powder

Dehydration of curry leaves in cabinet drier at 50◦ C for 3 hours and 30 min. was found to be more suitable than drying in shade, sun and solar drier for the preparation of curry leaves powder. The optimum pretreatment to retain the green colour in the processed curry leaves powder was standardized. Curry leaves are dipped in the cold solution containing 0.1 % magnesium oxide, 0.5% potassium metabisulphite and 0.1% sodium bicarbonate for 15 minutes. Packaging in 300 gauge thick polyethylene bags stored well. Value added products viz., cookies, bread, *paruppupodi, and adaimix* were formulated by incorporating curry leaves powder at different combinations. Results showed that curry leaves powder incorporated at a level of 4.0, 4.0, 25 and 15 per cent respectively in cookies, bread, *paruppupodi* and *adai* mix was found to be highly acceptable by the judges and the score card ranged between 8.0 and 9.0.For 100 kg of fresh curry leaves yielded 19.0 kg of powder. The cost of the prepared curry leaves powder was Rs. 21 per 100 gram.

Processing of curry leaves powder



Cookies **Bread**

Curry leaves powder incorporated products

XI. SOCIOECONOMIC ISSUES IN AGRICULTURAL DEVELOPMENT IN TAMIL NADU

Although the share of agriculture sector in gross domestic product has declined over the period of time, still it is continued to be the main source of livelihood for majority of the rural population. A much desired growth of agriculture is critical for inclusiveness. Important structural changes are taking place within the sector and there are definite signs of improved performance. Even though agricultural development increasingly becomes technology propelled, innate and extraneous factors continue to hamper agriculture. As a result the development programmes implemented have not brought in desired results, emphasizing the need for focusing the attention on key issues and rendering cost effective agricultural technologies so that their net profit in agriculture motivate the people to continue in the agriculture. The determinants of profit are income and cost. The income depends on production and price of produce. The cost is influenced by efficient management of the resources and input prices. An attempt has been made to relate the issues in agriculture and possible strategies derived from the socio-economic studies of the university.

Land

Land and water are the resources which play a critical role in achieving the production. The net area zone has declined from 53 lakh hectares in 2000-01 to 48 lakh hectares in 2012-13. It indicates that any further increase production could be possible through intensive adoption of technologies. Besides the wastelands are also increasing year by year. The current fallow is around 10 lakh hectares. The land put to non agricultural uses (22 lakh hectares in 2012-13) continue to increase in the future also. Hence the strategies for effective utilization of wastelands are the need of the hour. A recent study on the evaluation of distribution of 2 acres land suggests that investment on irrigation sources with agro-forestry may be a viable option.

A study on techno-Economic Feasibility of Wood Based Agro Forestry Models in Tamil Nadu is conducted and the results are as follows: International Wood Pulp price is to be included to study the impact on demand and supply of wood materials under the project “Techno-Economic Feasibility of Wood Based Agro Forestry Models in Tamil Nadu. The raw material demand for pulpwood is 9.5 lakh tonnes. There is a short supply of 1.5 lakh tonnes from paper industries. About 90 per cent of farmers adopted monocropping of agroforestry based pulpwood models.The net income from casuarina+ black gram agroforestry model was 37.00 per cent higher than mono-crop agroforestry models. The cost of pulpwood production from casuarina plus black gram model was Rs. 1561 per tonnes and followed by eucalyptus (Rs.1646 per tonnes) and casuarina (Rs.1691 per tonnes) model.

Water

The net area irrigated by all sources of irrigation was 29.64 lakh hactares in 2012-13. The major source being the wells accounting for 13 lakh hectares of net area irrigated. The next major source of irrigation forms the canals (7.5 lakh hectares) and tanks (5.28 lakh hectares). The irrigation study revealed that still uncertainty prevails not only in tank irrigated areas but also in the canal irrigated areas. The extraction of ground water sources is higher than the recharge. The impact assessment of watershed programmes suggests that the water harvesting structures are aiding the groundwater recharge. However it is not able to balance the extraction. The study on impact

assessment of micro-irrigation programmes proved the technical and financial feasibility of the technology. Hence it is suggested to go for increased adoption of micro-irrigation in the water intensive crops.

Crop Production

The major crop of Tamil Nadu state is rice occupying 33 per cent of the gross cropped area. In Tamil Nadu SRI Technology is introduced in the year 2007-08 and efforts were taken to popularize the technology as well as for adoption in a larger extent. The results from the evaluation study are furnished.

Technical change in SRI farms

Zone	2009	2010	2011	% change from 2009 to 2011
Cauvery Delta Zone	0.895	0.943	0.981	**9.61**
Central zone	0.968	0.920	0.975	**0.72**
North eastern zone	0.950	0.983	0.980	**3.16**
Southern zone	0.816	0.916	0.983	**20.10**
Tamil Nadu	0.942	0.935	0.980	**3.93**

- Only 44 % of SRI farms used recommended seed rate
- Age of seedlings, modified mat nursery and single seedling technologies were followed by only 1/3rd of SRI farms
- Single seedling, square planting and Cono-weeding → the highest yield
- Lack of availability of skilled labour, suitable conoweeder and shorter planting time for large scale adoption are the major constraints
- Issues to be addressed for large scale SRI adoption:
  - Intensive training and establishment of SRI farmers association,
  - Improvement in cono weeder
  - Supply of cost effective power weeder
  - Promotion of laser leveler

Pulses

Pulses occupy nearly 10 per cent of gross cropped area in the state. Of which 6 per cent is irrigated. Nearly 50 per cent of the requirement is being met. Hence increasing the area and productivity is the need of the hour. One of the studies revealed that use of combine harvester in paddy harvesting has reduced the plant population in rice fallow pulses and consequently reduced the yield.

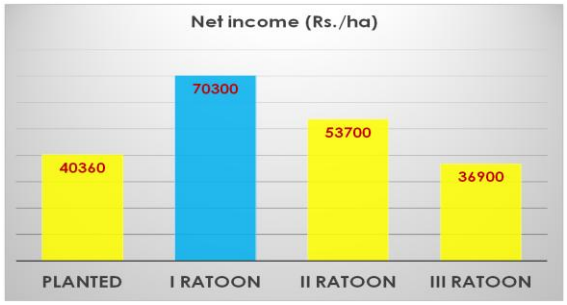
- The use of combined harvester in Thaladi/Samba resulted in strong negative effect on pulses area and productivity.
- The combined harvester was used in 30% of marginal farms, 71 % of small farms, while 92 % of large farms used combined harvester in 2010 -11 as compared to only 19, 12 and 22 % in the respective farm size classes in 2008-09 indicating the expansion of machine harvesting by all size groups due to severe labor scarcity in paddy harvesting.
- However, the actual pulses area to potential pulses area (area harvested in Samba/ thaladi) has declined from 77 % in 2009 to 64 %.
- The declining productivity of blackgram and greengram was observed in 2010-11

- In machine harvested rice field, farmer increase the seed rate by one-fourth from 24 kg/ha to 30 kg/ha and reduced the sowing days before the harvest from one week before harvest to 3-4 days to increase the soil moisture availability. However, the germination percentage has declined from 83 % labour-harvested fields to 68% in machine-harvested.

The yield from machine-harvested fields was 366 kg/ha from 523 kg/ha in labour-harvested fields. However, the negative effect could be managed to some extent by using belt-type combined harvester which will reduce soil compaction and improve soil moisture for pulses germination.

Sugarcane

A study on productivity of ratoon sugarcane was conducted. The results of project on productivity on ratoon sugarcane revealed that ratooning in sugarcane is profitable for two crops which have not been supported by actual data. If it is so, it can be test verified at Stations / Farmers holdings. Quality parameters can also be recorded. What are the problems associated with marketing of ratoon sugarcane and how they can be overcome by suitable technological interventions? Are there any interventions that can be recommended for minimizing the yield loss in ratoon compared to the main crop.



Risk analysis

The study of Vulnerability, Production risk and Farm Technology Adoption in Climate Change Prone Irrigated Eco-system in Coimbatore District of Tamil Nadu was conducted and the results are as follows,

- Farmers in different production environments have encountered different shocks in the last ten years. The per cent of farmers' perception about the different climate related shocks, effects of shocks and coping and adaptation strategies followed are discussed here. The major shocks are drought (99.2% of farmers), animal disease (76.2%), untimely rains (42.3%), irregular weather (52.2%) and temperature fluctuation (62.8%).
- The major effects of these climate related shocks are manifold. They include changes in soil salinity and decrease in soil moisture (53.5%), major changes in cropping pattern (28.17%), major changes in livestock asset (34.68%), major changes in farm investment (45.9%), crop failure (74.2%), depletion of groundwater (68.4%), loss of income (27.7%) and death of livestock (4.9%).
- In order to manage the changes in the climate, farmers in different production environments adopt various coping and adaptive measures. The farm based coping strategies include leaving lands fallow (48.6%), selling livestock (32.9%),

investing on farm ponds (34.4%), changes in cropping pattern (51.6%), growing perennial trees (57.2%), change in planting date and varieties (59.4%), adopting of drip irrigation (57%) and drilling new bore wells (36.6%). Similarly, the non-farm based coping strategies followed by farmers are involvement in non-farm employment activities, migration to urban areas, borrowed money etc.In order to prepare for the climate variability, each production environments will require a specific set of adaptation measures addressing various scales of intervention and vulnerable groups. Hence, policy measures such as watershed development programmes, demand side management of water technologies like drip and sprinkler irrigation, System of Rice Intensification, changes in land use like shifting towards rain fed cultivation, farm diversification such as inclusion of livestock, monitoring and forecasting (weather forecasts, automatic weather forecast station) and risk sharing and spreading (crop insurance, weather based crop insurance, micro insurance).

Marketing

A case study on pearl millet for poultry feed value chain and the value chain of chickpea in Tamil Nadu was conducted. The results revealed that there are three main market channels were identified for pearl millet used in poultry feed production in Tamil Nadu. In view of the raw product required for poultry feed industry there is very limited scope for value addition in any segment of the value chain before the feed plants. Hence, the various market functionaries merely play the role of transferring the produce from farmer to the ultimate users (feed industry). Further, most of these traders / commission agents are also engaged in the trading of other agricultural commodities such as rice, maize, other cereals and pulses and hence their commercial interest in pearl millet is lower. In addition, limited and uncertain production of pearl millet and its diminishing area over period have not provided the required impetus for increased commercial interest in this crop.

An analysis of price trends of maize and pearl millet over a period of 17 years reveal that there is a high correlation between these two prices suggesting that these two commodities are very close substitutes for each other. Though pearl millet supply is limited, sharp increase in prices of pearl millet is effectively cushioned by relatively huge supplies of maize and hence the prices of these two commodities move in tandem with each other.

Presently, there is almost no role for farmers in value addition for realizing a better price for pearl millet due to two main reasons: a) the possibility for higher price of pearl millet for poultry feed industry is effectively cushioned by shift in demand towards maize and hence price premium for pearl millet cannot be expected to arise from increased demand for pearl millet from poultry feed sector; and b) there is very minimal scope for value addition at farm level as far as poultry feed use is concerned as pearl millet is only a minor component contributing for less than one-fifth of the total quantity of poultry feed produced. Given the minuscule role of pearl millet in poultry feed production and the dominance of maize in influencing the demand price of pearl millet for poultry sector, there is very limited scope for realizing additional benefits for farmers. However, the potential for better price realization could be explored by motivating farmers to take up direct sale of pearl millet to feed mills instead of through commission agents and/or wholesalers. The possibility of adjusting the pearl millet sowing season such that harvest of pearl millet coincides with off-season for maize supply may be explored.

The functioning of the regulated market was studied and the results are as follows,

- In Tamil Nadu only 26.16 percent of the RMs handles more than 10,000 tonnes of arrival, around 51.25 percent of RM had the arrivals of 1,000 to 5,000 tonnes of arrivals and 22.58 percent of RM have arrivals less than 1,000 tonnes.
- The storage structure utilization in Coimbatore marketing committee is only 67.66 per cent. The Arrivals stored in Coimbatore District RM during 2011-12 is only 17.72 per cent
- The major reason for low performance of RM in different locations were inappropriate location, distance from production centers, inadequate infrastructure facilities, inefficient management, inadequate human resources and poor regulations.
- Among the farmers major factors contributing to the marketable surplus is total production of the crop, size of holding, education status of the farmers
- Total arrivals to the regulated market are influenced by the total production in the District and number of farmers using the regulated market rather than the trader's participation, and price.
- The factors such as the age, experience in marketing, size of holding, distance from the regulated market, difference between farm gate price and regulated market price and contact with the officials influences the farmers in using the regulated markets to sell the agricultural products
- The major problem faced by the farmers in using the regulated markets were low quantity of produce, transport expenditure, lack of crop loan in needy times which make them to go for pre harvest contract etc.
- The major advantages felt by the regulated market using farmers were the higher price, storage facilities, competitive trader's price, pledge loan facilities and correct weight.

The traders also have the advantage in using the regulated markets; the advantages are concentrated assembling of produce, low transport cost / assembling cost, adequate infrastructure, banking and financial facilities.

Price forecasting

- DEMIC generated 26 price forecast advisory on Turmeric, Coconut, Groundnut, Gingelly, Potato, Small onion, Maize, Cotton, Copra, Potato, Cumbu, Coriander, Chana & Sunflower.
- Price forecasts given were periodically validated.
- The forecasts were disseminated through various modes like hardcopy, news paper & magazines, radio and through TV.
- Forecast advisories through text SMS were sent to 768440 farmers.
- Final report draft was prepared including 10 consortium partners technical and financial progress and sent to NAIP.
- DEMIC generated 27 forecast advisory on Banana, Tapioca, Bhendi, Brinjal, Tomato, Sorghum, Ragi, Carrot, Beetroot, Turmeric, Chana, Cumbu, Coriander & Chillies.
- Price forecasts given were periodically validated.
- The forecasts were disseminated through various modes like news paper & magazines, radio and through TV.
- Around 180072 SMS were sent to farmers on the forecast given.

Credit

The causes and consequences of credit gap in major crops was studied and the results revealed that the credit gap was estimated for seven crops grown in Tamil Nadu viz., paddy, maize, sugarcane, banana, cotton, groundnut and coconut. The Credit Gap I, i.e., the difference between the credit requirement and scale of finance and Credit Gap II (credit requirement less the credit sanctioned) were estimated. It was found out that the Credit Gap II was higher in paddy (44 per cent) followed by sugar cane (39 per cent), groundnut (36 per cent), coconut (32 per cent), cotton (30 per cent), banana (22 per cent) and maize (19 per cent). The major problems faced by the borrowers in availing the loan amount were lack of flexibility in loan repayment schedule, provision of a part of the loan amount in terms of fertilizers by the PACS, inordinate delay in sanctioning the loan, and so on.

Policy suggestions

- The banking sector might consider all the crops cultivated by the farmers while fixing the crop loan amount in order to bridge the credit gap.
- The scale of finance needs to be fixed considering the costs of cultivation for different crops which vary across time and space. The scale of finance may be fixed based on the estimates of the cost of cultivation survey - similar to the present study - to be taken up every year covering all the major crops in all the districts.

The repayment schedule might be made flexible wherever the crop is affected by the natural calamities. The interest rate subvention may be uniform and it should be extended to all categories of farmers without any capping on the loan amount.

Adoption of technologies

Adoption of TNAU released Varieties and Management Technologies in Oilseeds-Groundnut and Sunflower was studied.

Adoption level

- Varieties: Sunbred hybrid (Syngenta): 53.33%, NK (Pioneer): 23.3%, CO 2 (hybrid) / CO 4 (Var.): 6.66%.
- Sowing: Manual: 80.0%, Seed Drill: 20%.
- Fertilizer (60:60:90 / ha): Blanket: 20.0 %, Less adoption: 80 %.
- Appln. of MN mixture: Nil. Adoption.
- Weeding: Manual: 80.0%, Pre-emergence herbicide: 20.0%.
- Leaf Hopper control: Chemical (Methyl Dematon): 50%.
- Harvest: Machine: 93.3%.

Constraints

- Non-availability of TNAU hybrid / var. in time (80.0%); Lack of awareness on MN mixture (73.33%); Bird damage (70.0%).

Involvement of women in production of pulses – Blackgram
Adoption Level
Seed

- 42% of farm women grow Vamban 3, 23.6% Vamban 6, 17.8% Vamban 4 and 16.6% grow Vamban 5.
- 40% of farm women use their own seed for two seasons.

- 42.2% purchased seeds from SDA, 37.8% from KVK and NPRC, and the rest 20% from input dealers.

Biofertilizer seed treatment: 40% treated seeds with biofertilizers.
Planting: Irrigated farm women (73%) formed ridges and furrows for planting, while rainfed farmers (27%) did not do so.
DAP spray: 71% of farm women spray 2% DAP
Impact of Farm Schools operated under ATMA Extension Reforms Programme.
ICM in Maize
Knowledge gain: 60%
Extent of adoption: 65%
ICM in Bengalgram
Knowledge gain: 63.3%
Extent of adoption: 56.67%
ICM in Groundnut
Knowledge gain: 58.0%
Extent of adoption: 84.62%
Training Needs assessment of Extension Workers for effective implementation of Extension Reforms

Training Needs Assessment
Extension methods

- Preferred areas were training on conduct of demonstrations, Farmers Field Schools and leadership development (80%).

Use of ICT

- Mobile applications, use of Tablets, portals, video-conferencing, e-Velanmai, Village Knowledge Centers and Information Kiosks (75%).

Marketing

- Knowledge on DEMIC, and use of mobile phones for marketing of farm produce (92%).

Allied areas

- Apiculture, sericulture, agro-forestry, public private partnership, and Commodity Interest Groups (61%).

Methods of Training

- Most preferred methods were lecture with AV aids, followed by field visit, group discussion, demonstration, and study tour (70%).

Training Venue

- TNAU main campus and Research Stations was the most preferred training venue for 90%, followed by STAMIN (60%), and farmers' holdings (37%)

Conclusion

The vision of achieving second green revolution in Tamil Nadu is possible by focusing on crop specific and location specific technology adoption. Besides resource conservation and optimum utilization is the need of the hour for achieving sustainable production. Linking the farmers in production, marketing and value – addition will increase the income of the farm families.

ACTION TAKEN REPORT FOR THE 79th SCIENTIFIC WORKERS CONFERENCE 2013 HELD AT TNAU, COIMBATORE DURING 1-2 MARCH, 2013

1. For launching uzhavar peruvizha, appropriate planning need to be done in discussion with the sister departments using appropriate budget (Action: Deputy Director of Agriculture, (ATMA), Chennai).

In Karur district, uzhavar peruvizha was conducted in 203 revenue villages from 14.4.2013 to 17.5.2013 with co ordination of all sister departments to meet the input distribution to farmers, refreshment charges and facilitating farm level plan through data collection and entry in FCMS portal. An expenditure of Rs 76.23164 lakhs was incurred with a share of Rs.28.38014 lakhs from ATMA and Rs. 54.85060 lakhs from NADP. Similar type of event was organized in other districts as well.

2. The ATMA functionaries should be trained for effective involvement in the ensuing uzhavar peruvizha 2013. (Action: Commissioner of Agriculture and Director of Animal Husbandry).

As per the revised guidelines of the ATMA scheme, the functionaries are going to get the following training from 2014-15 onwards.
a) Induction training of ATMA functionaries
b) Refresher training of all ATMA functionaries.
and these functionaries are to be paid Rs.1000/- day as incentive during training.

3. For comprehensive ICT intervention, the procedures should be brought out in a logical and implementable level. (Action: Commissioner of Agriculture).

- Basic details about farmers have been collected and entered in FCMS portal for all farm holdings (146051) in Karur.
- Soil samples have been collected and analysed ; results have been uploaded in portal for crop plan development to all farm holdings
- For fastening FIHB cards distribution, separate printers for printing of cards through portal have been supplied.

4. The compilation of strategies for increasing paddy cultivation at district and block levels may be done. (Action: All JDAs)

Namakkal district has prepared the compendium of statistics including strategies for all crops at district and block levels. That mode has been approved. Like wise, other districts are preparing the compendium. In this regard, the meeting for compilation, correction etc., is being conducted at frequent intervals at the Office of the Director of Agriculture.

- In Namakkal district, paddy is covered in an area of 9180 ha during 2013-2014. SRI method of cultivation was followed in an area of 7199 ha which accounts for 78% of SRI coverage.

- Soil health improvement was made through heavy dose organic manure application to maintain the soil health. Green manure and green leaf manures were applied to maintain the soil fertility status.
- Improved and quality certified seeds were distributed in the paddy growing area to increase the productivity.
- In East bank canal area of Pallipalayam block, paddy cultivation in 4236 ha was taken up. Exclusively 3385 ha of paddy cultivation was brought under SRI method.
- Power weeders were used periodically to increase the number of productive tillers in SRI area.
- Split application of nitrogenous fertilizers, management of the pest and diseases resulted in an increased paddy production. Timely application of potash also increased the resistance against pest and diseases.
- Adoption of the optimum spacing in SRI cultivation reduced the incidence of pest and disease problems especially false smut, BPH and leaf folder.
- The ruling short duration variety IR 20 was gradually replaced by ADT 49 in east bank canal areas.
- The low yielding long duration variety “Vaynadu 2” grown in hilly track of Kolli hills block is gradually replaced by IWP and IR20.
- In Namakkal district, under paddy food grain mission, total production of 48,000 Mt was achieved during the year 2013-2014.

5. Food grain production in mission mode should be given importance to draw implementable strategies. (Action: Director, CPBG).

A detailed Plan of work was prepared by TNAU involving Dept of Agriculture officials by organizing three discussion meetings for effective implementation of food grain mission in rice, pulses and millets and the same was sent to the Director of Agriculture, Chennai vide Lr. Dt. 07.11.2013 through the Director of Research.

6. For enhancing productivity in sugarcane, effective implementation of SSI needs to be done. (Action: Commissioner of Agriculture and Sugarcane).

During 2013-14, all efforts had been taken to implement SSI and an area 7522 ha (4463+3059=7522 ha) was covered by supplying single budded seedling through sugar mills, critical inputs and drip irrigation system by Agriculture Department. Training to 7000 farmers was also imparted regarding SSI techniques. During 2014-15, it is programmed to cover SSI in 5000 ha.

7. The comprehensive input supply management system has to be given some insight by way of including micro irrigation component. (Action: Commissioner of Horticulture).

The special purpose vehicle for supply of quality inputs has been formed. As per the G.O.Ms.No.227 Agriculture (H1) Department, Dated 14.11.2013. Government issued orders that TANHODA will serve as special purpose vehicle for procurement. Rs.50.00 crores revolving fund have been drawn towards special purpose vehicle and issued to Managing Director, TANHODA. The Technical Committee has been formed for purchase of inputs.

8. For developing integrated farming system for maximum profitability, co-ordinated schemes may be formulated. (Action: Commissioner of Agriculture, Director of Animal Husbandry, NABARD).

The Integrated farming system as a district saturation model in Villupuram district would be implemented with the co-ordination and cooperation of all the departments with the convergence and integration of all possible schemes implemented by the departments involved with focused attention on development of rural areas so that holistic development could be achieved.
The Agricultural Department would co-ordinate the activities of Agricultural Engineering Department, Agricultural Marketing and Agricultural Business Department and other development departments and organize Integrated Farming System development.
The NABARD consultancy services would be taken up on the pre project and fund requirement on implementation of Integrated Farming System in Villupuram as district saturation model and the project would be implemented based on the report.
A Proposal for RS 22.25 lakhs was sent to government vide Lr. No. G2/18221/13 DT: 12.02.2014 for the cost of consultancy service which is under the active consideration of the Government.

9. New orientation has to be given for vegetable cultivation through mission mode approach. (Action: Dean, Hort.).

Under NADP, the following training programmes were conducted to the farmers and extension officials to increase the profitability of vegetable cultivation and hybrid seed production during the year 2013-14.

- **NADP scheme on "Farmers participatory approach for maximizing the profit of hybrid cucurbit vegetable crops with coriander intercropping".**

Training programmes on advances in production technology of cucurbits were conducted by the Department of vegetable crops, HC&RI, TNAU, Coimbatore under NADP scheme. Fifteen training and demonstration programmes at ten villages of Coimbatore and Tirupur districts were conducted where cucurbitaceous vegetables are cultivated.
Eight field days were conducted at selected villages of Coimbatore and Tirupur districts. About 600 nos. of pandal growers of Coimbatore and Tirupur districts were sensitized about the latest technologies on use of F_1 hybrids, transplanting with protray technique, training, fertigation with water soluble fertilizers, use of ethrel for production of more female flowers and thereby increased yield in cucurbits. Further, the farmers were explained and demonstrated about the integrated pest and disease management like use of pheromone traps for control of fruit fly in cucurbits.

- **NADP scheme on "Capacity building of extension officials to transfer hybrid seed production technologies in vegetable crops (Tomato and okra) to improve the entrepreneurial skill for uplifting the socio-economic status of rural farmers.**

Four training programmes on hybrid seed production technologies in tomato and bhendi were conducted to extension officials of Department of Horticulture from Coimbatore, Tirupur, Karur and Erode. Three demonstrations programmes on hybrid seed production technologies in tomato and bhendi were conducted at Kinathukadavu block of Coimbatore district. About 40 extension officials of Department of Horticulture were sensitized about the F_1 hybrid seed production technologies in tomato and bhendi. Hybrid seed production technology of tomato and bhendi was demonstrated in three farmer's field. During the demonstration, 60 farmers of Kinathukadavu block got benefited.

10. For enhanced farm mechanization, agro service and for bringing fallow land to agriculture, comprehensive approaches may be formulated. (Action: Chief Engineer, AED, Chennai).

- **Massive promotion of farm mechanization- approaches to ensure availability of machinery, equipments to carry out all type of agricultural operations**

  For promoting agricultural mechanization in a massive way, the Agricultural Engineering Department has proposed the scheme of "Agricultural Mechanization in Tamilnadu" under National Agricultural Development Programme during the year 2013-14 with an amount of Rs 7000.00 lakhs and for which the Government order has been issued vide G.O.(Ms)No. 90 Agriculture (AP1) Department, Dated 10-05-2013. The Government in its G.O.(Ms)No.160 Agriculture (AP1) Department Dated 02-08-2013 has restricted the amount to Rs 4800.00 lakhs. Out of the sanctioned amount of Rs 4800.00 lakhs, an amount of Rs 4799.82 lakhs was spent towards the distribution of 54083 Nos. of Agricultural Machinery / implements during 2013-14.

- **Establishment of agro service centre to train on machinery operation and maintenance**

  To create a highly professional and motivated group of manpower dedicated to betterment of agriculture and to reduce the labour shortage by providing labour and machinery to ensure timely farm operations and also to promote the farm mechanization by using the farmers group , a proposal entitled "Formation of Farmers Group (Rural, Youth ,small and Marginal farmers) including package of machinery and training" was sent to Government for an amount of Rs.750.00 lakhs for which the Government Order was issued vide G.O.(Ms).No.88 Agriculture (AP1) Department Dated:10-05-2013. The Government in its G.O.(Ms) No.160 Agriculture (AP1) Department Dated:02-08-2013 has reduced the amount to Rs.10.00 Lakhs towards the formation of 30 Nos. of farmers group and for imparting training to the farmers group. Out of the sanctioned amount of Rs.10.00 Lakhs, an amount of Rs.9.652 Lakhs was spent under NADP during the year 2013-14.

  The Agricultural Engineering Department has also sent a proposal to Government of India for the Agricultural Mechanisation programme under the Sub Mission on Agricultural Mechanization incorporating the components viz., 1) Subsidy for selected Agriculture Machinery and Equipments 2) Establishment of Farm Machinery Banks for Custom Hiring 3) Procurement subsidy for establishment of Hi Tech Hub 4) Enhancing Farm Productivity at Village Level by

introducing appropriate farm mechanization in selected villages for a total amount of Rs 5472.00 lakhs during the year 2013-14. But the Government of India has not sanctioned the scheme not only for Tamil nadu but for the entire country. Now the Government of India has issued the operational guidelines for implementing the Sub Mission on Agricultural Mechanization (SMAM) scheme. The Annual Action Plan for the year 2014-15 is to be prepared for implementing the SMAM scheme and the proposal for the year 2014-15 is to be sent to Government of India shortly.

- **Strategies to bringing fallow land back to Agriculture**
  The proposal for reviving 12500 acres of fallow lands back to Agriculture was sent to Government by the Agricultural Engineering Department and subsequently a revised proposal was sent to Govt for reviving 100 acres of fallow lands back to agriculture in Villupuram district for which the Government order was issued vide G.O.(Ms) No.165 Agriculture (AP1) Department Dated:13-8-2013 with an allotment amount of Rs.4.00 Lakhs. The entire sanctioned amount of Rs.4.00 lakhs was spent towards the implementation of Agricultural Engineering interventions for reviving 100 acres of fallow lands back to agriculture in Villupuram district during 2013-14.

11. The detailed plan may be worked out at the earliest for micro and macro analysis of 32 lakh number of soil samples for GIS mapping. (Action: Commissioner of Agriculture and SO, NRM).

To speed up the implementation of GIS mapping by completing the micro and macro analysis of soil sample, a project under NADP was proposed for employing temporary staff for quicker analysis of soil samples, uploading the analytical results in FCMS site. The project of GIS soil mapping by fast tracking soil sample analysis was implemented during 2013-14 through which 45.51 lakh soil samples were analysed and the analytical results of 6 pilot blocks namely Kaniyambadi (Vellore), Sattur (Virudhunagar), Manigandam (Trichy), P.N.Palayam (Coimbatore), T.N.Palayam (Erode) and Kodavasal (Thiruvarur) had been sent to Tamil Nadu Agricultural University, Coimbatore and the GIS soil mapping for the above 6 pilot blocks is being worked out.

12. Apart from green manure seed production, the other requirements like maintaining the supply chain of seed by replacing the old varieties with the new varieties have to be worked out. (Action: Special Officer, Seeds).

In the seed plan of 2013-14, in addition to the plan for production and distribution of green manure seeds to the level of 30 tonnes, the strategies for inclusion of new varieties in seed supply chain in all major crops have been included. The new varieties replacing the old varieties in the different crops are as follows.

The new varieties of TNAU replacing the old varieties during 2013-14

Crop	New variety popularized-alternate	Pre release/ if released – year of release and/or notification	Replacement of variety (year of release)	Quantity of seed Produced (qtl)
Paddy	ADT (R) 49	Released 2011/S.O. 1708(E)	BPT 5204	275
	ADT (R) 50	Released 2012/S.O. 1708(E)	CR 1009 & ADT 44	10
	CORH 4	Released 2011/S.O. 1708(E)	ADT 39, I.W. Ponni	400
	CO (R) 50	Released 2010/S.O. 2187(E)	ADT 38, CO 43 & IR 20	200
	CO (R) 51	2013	IR 50, IR 36, ADT 43 & ADT (R) 45	200
Greengram	CO (Gg) 8	2013	CO (Gg) 7 (2005)	80
Blackgram	VBN (Bg) 6	Released 2011/S.O. 1708(E)	VBN (Bg) 5 (2007)	105
Sorghum	CO (S) 30	Released 2010/S.O. 1708(E)	CO (S) 28 (2001)	5
Maize	CO (MH) 6	Released 2012/S.O. 1708(E)	CO (MH) 5 (2006)	47
Cumbu	TNAU Cumbu Hybrid CO 9	Released 2011/S.O. 1708(E)	CO (Cu) 9 (2004)	7
Ragi	CO (Ra) 15	2013	CPU 28	100
Sunflower	Sunflower Hy. CO 2	Released 2010/S.O. 1708(E)	TCSH 1	100
Groundnut	CO (Gn) 7	2013	CO (Gn) 4	300
	TMV (Gn) 13	Released 2006/S.O. 1178(E)	TMV 7	420

13. Under food processing and value addition, the activities for revenue generation have to be thoroughly listed including coconut and grapes. (Action : Professor and Head, PHTC).

Post harvest activities, food processing and value addition are for revenue generation by processing agricultural produces. The major crops and the possible products are listed below.

Crop	Products
CEREALS	
Rice	Rice flour, snack foods, extruded foods, rice flour noodles, extruded foods from broken rice flour, brown rice flour incorporated instant south Indian food mixes, quick cooking rice, rice bran incorporated extruded foods, traditional Indian breakfast foods, beverages, flaked rice, puffed rice and puffed rice products and confectionaries.
Corn	Corn flour, puffed corn, corn flakes.

MILLETS	
Finger millet Little millet Kodo millet Barnyard millet Proso millet Pearl millet.	Parboiled dehulled finger millet rice, millet flour and popped millet, incorporated bakery items - bread, bun and cookies, Soupsticks, Instant mixes of traditional Indian breakfast foods, health mixes.
PULSES	
Red gram Green gram Bengal gram Black gram	Dhal flour, snack food, ready to cook dhal based Indian foods, curries and gravies, chutney mix and rice mixes, fried gram snack food, roasted gram dhal, vada mix, jalebi mix, idli and dosa mix.
OILSEEDS	
Ground nut Sesame	Edible oil, refined oil, oil cake, oil cake incorporated confectionaries and oil cake incorporated instant food mixes.
Coconut	Tender coconut water jelly, desiccated coconut , grates, coconut flour, coconut flour chocolates, coconut flour cookies, canned/ bottled tender coconut water.
FRUITS	
Mango, pine apple, papaya, grapes, orange, citrus, etc.	Jam - all fruits- single or blended, jelly, marmalade, squash, ready to serve beverage, fruit pulp and nectar, carbonated fruit beverages, candy and preserve, conserve, dehydrated fruits, fruit powder, osmo dried fruits, canned fruits and fruit pulp, fermented fruit beverages, raisins, etc.
Vegetables	
Carrots, drum stick, cluster beans, okra, tomato, greens	Dehydrated vegetables, pickles, sauce and ketchup, brined vegetables, vegetable powders, vegetable powder incorporated instant mixes and snack foods, dehydrated greens, greens powder, greens powder incorporated instant mixes and snack foods, greens pickle, etc.
Roots and Tubers	Dehydrated foods, roots and tubers powder, tubers incorporated bakery and extruded foods, tubers incorporated convenience foods.
Spices and condiments	Spice powders, dehydrated spices and spice oleoresins.