A Decade of Agronomy Research in Southern Districts of Tamil Nadu

1987 - 1997

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FOREWORD

Agricultural research being primarily an applied research, must have a region-specific and location-specific focus to ensure rapid adoption of developed technologies. With this view, the third Agricultural College of Tamil Nadu Agricultural University at Killikulam was upgraded as a Research Institute in 1989 to conduct research relevant to the southern districts of Tirunelveli and Tuticorin. Much needed research man power was made available when this college was upgraded as a post-graduate institution in 1990. It is gratifying to note that the research programmes contemplated and conducted by scientists and post-graduate scholars of this Institute during the last decade (from 1987 to 1997) have helped greatly to develop technologies relevant to the southern agro-climatic zone.

The realisation of the genetic potential of improved crop varieties is influenced by environment and management. The interactive effect of environment and management on growth and yield of the major crops of the southern zone has been investigated through an array of research projects by Agronomists at Agricultural College and Research Institute at Killikulam. Rice being the dominant crop of this region, most of the research results presented in this bulletin relate to the various aspects of management of rice culture only. The detailed description of the agro-climatic features and resource availability in the region provides ample scope for better comprehension of the utility and applicability of the results. This compilation of the results of Agronomy research is a timely effort to publicise the findings. It is hoped that the momentum thus far generated will be carried forward to fully meet the agronomic research requirements of the region in the future.

The efforts taken by Dr. A. Mohamed Ali, Dean and Dr. V. Veerabadran and Dr. B.J. Pandian of Department of Agronomy in compiling this bulletin deserve commendation. I believe that this will serve as a source of reference for future research as well as to motivate the scientists for greater efforts.

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CONTENTS

LIST OF ABBREVIATIONS

AT	-	Active Tillering
B:C	-	Benefit Cost Ratio
BF	-	Biofertilizer
CEC	-	Cation Exchange Capacity
CCC	-	Chloro Choline Chloride
CCP	-	Composted Coir Pith
CD	-	Critical Difference
C:N	-	Carbon:Nitrogen
DAP	-	Diammonium Phosphate
DAS	-	Days After Sowing
DAT	-	Days After Transplanting
DMP	-	Dry Matter Production
DLSM	-	Deep Litter Sheep Manure
DPM	-	Dried Poultry Manure
FYM	-	Farm Yard Manure
GLM	-	Green Leaf Manure
GM	-	Green Manure
HYV	-	High Yielding Variety
HW	-	Hand Weeding
ICAR	-	Indian Council of Agricultural Research
IFS	-	Integrated Farming System
INM	-	Integrated Nutrient Management
IW/CPE	-	Irrigation Water/Cumulative Pan Evaporation
KCl	-	Potassium Chloride
LER	-	Land Equivalent Ratio
MSL	-	Mean Sea Level
MOP	-	Muriate of Potash
MD	-	Medium Duration
NAA	-	Naphthline Acetic Acid
NARP	-	National Agricultural Research Project
NEM	-	North East Monsoon
PB	-	Phospho Bacteria
PM	-	Pig Manure
PR	-	Paired Row
PPM	-	Parts Per Million
PWD	-	Public Works Department
RP	-	Rock Phosphate
SD	-	Short Duration
SEY	-	Sesamum Eequivalent Yield
SSP	-	Single Super Phosphate
STL	-	Soil Testing Laboratory
SWM	-	South West Monsoon
TOT	-	Transfer of Technology
WCE	-	Weed Control Efficiency
WUE	-	Water Use Efficiency

A DECADE OF AGRONOMY RESEARCH IN SOUTHERN DISTRICTS OF TAMIL NADU 1987-1997

INTRODUCTION

Agricultural College, Killikulam was established in 1984-85 as the third constituent agricutural college of Tamil Nadu Agricultural University in the then undivided Tirunelveli District (now in Thoothukudi District). The institution was upgraded as Agricultural College and Research Institute in 1989. Since then, this Institute has been engaged in fundamental and applied research in various disciplines of agriculture to cater to the needs of farming community in Tirunelveli and Thoothukudi Districts. The thrust on research received a further filip when the college became a post-graduate institution in 1990. The Department of Agronomy functioning since the inception of the college has planned and conducted many research programmes on various aspects relevant to the farming systems of these two southern districts. The research results provided solutions to many existing problems and generated or modified the production technologies for most of the crops in this region.

The research programmes were carried out by the scientists as well as post-graduate students of the Department of Agronomy during the decade from 1988-1997. The objectives of the research projects aimed at solving the various problems as identified by the scientists or indicated by extension officials or informed by the farmers. The project proposals were formulated after extensive review of literature and in depth discussion with scientists of the Department of Agronomy as well as from allied disciplines. Rice being the major crop of this region, many projects were in this crop.

Infrastructure available for Agronomy research at Killikulam is more than adequate. Technical man power was provided in the form of highly qualified scientists, assisted by the post-graduate students majoring in Agronomy. Land and water facilities available in the campus rank among the best in Tamil Nadu Agricultural University. The College Farm with an area of 426 ha is the largest in the University. The three major farming systems viz. wetland farming, irrigated dryland farming and dryfarming are well represented in the land features of this college. Irrigation is provided through a canal pumping system to supply 2.5 cusecs of water from the Maruthur East channel of Tambiraparani Irrigation system. Wetlands under both direct and indirect ayacut are available. The indirect ayacut is irrigated by the

Killikulam tank which is a nonsystem rainfed tank which gets its water supply through run-off from the foothills of the Vallanad Hills. Open wells provide water supply for irrigated drylands.

The college is located at 8° 46' N latitude and 77° 42' E longitude at an altitude of 40 m above MSL. Funds for research have come mostly from Plan Schemes of Tamil Nadu Agricultural University. A few projects were funded from NARP Phase II. Some of the post-graduate research received financial support through ICAR Junior Fellowship. The guidance from the Vice-Chancellor, Deans and Directors benefitted the scientists of the Department of Agronomy immensely to produce valuable research findings which are presented in the ensuing pages.

AGROCLIMATIC FEATURES OF TIRUNELVELI AND THOOTHUKUDI DISTRICTS

Research programmes at the Department of Agronomy at Killikulam mainly cater to the needs of farmers in Tirunelveli and Thoothukudi Districts which are located in the Southern Agroclimatic zone of Tamilnadu. The two southern districts have a semiarid tropical climate except in a small section of Western Ghats in Tirunelveli District bordering Kerala state. The agroclimatic features of the two districts described below will enable better appreciation of the reserch results.

TIRUNELVELI DISTRICT

CLIMATE

The mean annual rainfall in Tirunelveli District is 888.7 mm. However, wide variation exists in rainfall behaviour in the various taluks of the District. North East monsoon accounts for 55 per cent of annual rainfall with November being the peak rainy month. Rainfall during South West monsoon, summer and winter seasons constitute 15.8, 19.0 and 10.2 per cent of annual rainfall respectively. The annual mean maximum and mean minimum temperature are 33.2°C and 23.4°C respectively. The evapotranspiration demand is high for a major part of the year. Relative humidity is generally low during most months except during north east monsoon season. The month of July is characterised by strong winds.

SOIL

Alfisols constitute the major soil group in Tirunelveli District. A brief description of the various soil types found in the district is given below.

TYPIC USTIPSAMMENTS

These are very deep soils but sandy in texture with very low waterholding capacity. They have a low cation exchange capacity and poor organic matter content.

TYPIC USTORRENTHS

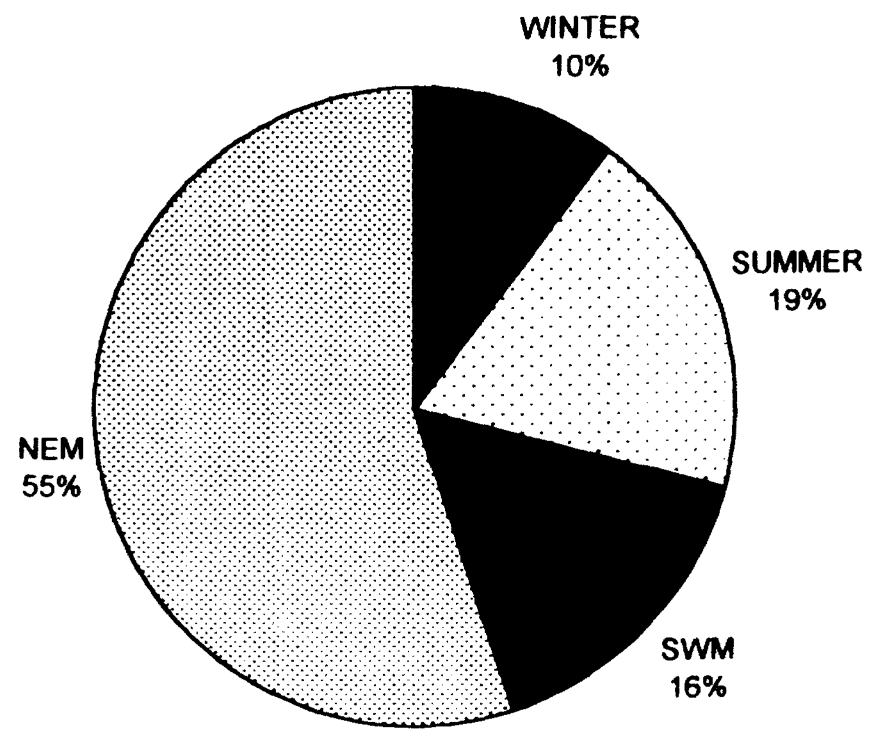
These are deep noncalcareous and well aerated soils. Surface crusting, low organic matter content and low CEC are the major limitations.

PARALITHIC USTORRENTHS

These are well drained noncalcareous soils. The main limitations are shallow depth, low water holding capacity, poor fertility status and sheet erosion.

Rainfall in Tirunelveli District

Month/Season	District		Taluks					
	mm	% to Total	Sankarankovil	Ambasamudram	Tenkasi	Radhapuram	Nanguneri	Tirunelveli
January	58.4	6.6	23.1	51.3	37.8	15.7	36.5	36.1
February	32.4	3.6	29.1	53.8	39.9	17.0	33.9	35.8
Winter	90.8	10.2	52.2	105.1	77.7	32.7	70.4	71.9
March	49.7	5.6	38.8	55.6	84.1	25.1	38.3	39.5
April	72.6	8.2	76.2	77.4	107.5	62.0	59.4	60.6
May	46.7	5.2	42.8	55.0	73.7	36.7	35.5	39.9
Summer	169.0	19.0	157.3	188.0	265.3	123.8	133.2	140.0
June	41.0	4.6	8.5	25.7	76.2	37.8	28.3	8.8
July	42.2	4.7	15.2	26.0	84.2	28.4	18.3	6.4
August	25.5	2.9	15.1	14.5	43.8	14.5	21.8	20.0
September	31.8	5.8	35.0	34.7	48.3	19.8	34.1	34.8
SWM	140.5	15.8	71.8	100.9	252.5	100.5	102.5	70.0
October	163.5	18.4	147.8	151.2	166.9	114.2	136.0	139.4
November	215.9	24.3	178.5	248.3	237.0	169.1	192.8	181.6
December	109.0	12.3	60.5	155.5	106.0	78.5	96.1	91.9
NEM	488.4	55.0	386.8	555.0	509.9	361.8	424.9	412.9
Annual	888.7	-	668.1	949.0	1105.4	618.8	731.0	694.8



SEASON-WISE RAINFALL DISTRIBUTION IN
TIRUNELVELI DISTRICT (mm)

TYPIC USTROPEPTS

These are deep to very deep soils with medium water holding capacity, medium CEC and high base status. The main limitations are slight calcareousness, low organic matter content and low fertility status.

VERTIC USTROPEPTS

These are deep to very deep soils with high water holding capacity, high CEC and high base status. Because of high CEC, the holding and release of nutrtients are more.

FLUVENTIC USTROPEPTS

These are very deep soils with medium cation exchange capacity. Since these soils occur on almost flat lands, erosion hazard is minimised. The main limitations are calcareousness and poor organic matter content.

TYPIC RHODUSTALFS

These are very deep, medium textured red soils with medium water holding capacity. The main limitations are calcareousness, low CEC and poor organic matter content.

TYPIC HAPLUSTALFS

These are vey deep, medium textured moderately well drained soils with medium water holding capacity.

TYPIC CHROMUSTERTS

These are deep to very deep soils with shrink and swell clays. These soils have high water holding capacity and high CEC. They develop deep cracks during summer. The main limitations are heavey texture, poor drainage and accelerated erosion even in flat lands.

WATER RESOURCES

Tirunelveli District is better endowed with irrigation facilities than Thoothukudi District. The gross irrigated are is 1,37,060 ha constituting 67.4 per cent of total sown area. Canal irrigation accounts for 15.1 per cent of net irrigated area, tanks irrigate 43.9 per cent area and wells provide irrigation for 41.0 per cent of area. The major source of surface irrigation is the Tambiraparani irrigation system. Other river irrigation projects in the district include Manimuthar, Gatananathi, Karuppanathi, Ramanadhi, and Gundar. In terms of ground water potential and utilisation in Tirunelveli District, two out of 19 panchayat unions have been classified as 'dark' (< 85% utilisation), four unions are classified as 'grey' (65 - 85% utilisation) and the remaining 13 unions are categorised as white (less than 65% utilisation).

IRRIGATION SOURCES

1.	Tambiraparani system Papanasam Reservoir		Ayacut (ha)
	i) Advance kar		14,399
	ii) Kar		34,440
	iii) Pishanam		34,440
2.	Manimuthar Manimuthar Main Canal		8,090
3.	Gadana Reservoir	- Kar - Pishanam	400
4.	Karuppanadhi	- Kar	1,170
		- Pishanam	3,800
5.	Ramanathi		210
6.	Gundar Reservoir		40

Source: i) AGROSTAT, 1993, Directorate of Agriculture, Madras. p.25-29.

ii) Statistical Hand Book of Tamilnadu. Director of Statistics, Madras p.158-165.

LAND UTILISATION

In terms of total geographical area, Tirunelveli district extends over 6.8 lakh hectares which is 5.2 per cent of total state area. Net cultivated area is 1.66 lakh hectare which is just 24.4% of total area of the district. A large section of land area (24.8%) remains as culturable waste or as other fallow lands (1.69 lakh hectare). This district has 13.7% of total wastelands in the state. Area under forests is only 18.4% of total district area, much less than the optimal requirement. The area sown more than once is 31.7% of net area sown.

CROPPING PATTERN

Rice with 99000 ha is the dominant crop in Tirunelveli District, followed by cotton (22800 ha) and pulses (21200 ha). Millets are grown in 8000 ha with major area under sorghum (4000 ha). Among the pulses, blackgram is the major crop (15800 ha). Groundnut (7000 ha) and sesamum (4000 ha) are the important oilseeds in the district. Sugarcane area is about 5000 ha. Productivity of most crops is higher than state average except in oilseeds.

GROUND WATER POTENTIAL AND UTILISATION IN TIRUNELVELI DISTRICT

S. No.	Panchayat Union	Potential	Utilisation	Balance	Classification
1.	Ambasamudram	2014	435	1579	White
2.	Alangulam	9095	8759	336	Dark
3.	Cheranmadevi	2755	610	2145	White
4.	Kuruvikulam	8685	6092	2593	Grey
5.	Kilapavur	4270	2800	1470	Grey
6.	Kadayanallur	4842	2609	2233	White
7.	Sankarankovil	5761	4018	1743	Grey
8.	Senkottai	2728	781	1942	White
9.	Melanilithanallur	4491	3905	586	Dark
10.	Pappakudi	2829	1176	1653	White
11.	Kadayam	3801	1985	1816	White
12.	Vasudevanallur	11293	7251	4042	White
13.	Tenkasi	4417	239	4178	White
14.	Manur	7426	2681	4795	White
15.	Palayamkottai	5670	1653	4017	White
16.	Kalakkadu	3888	2090	1798	White
17.	Nanguneri	7482	1829	5653	White
18.	Radhapuram	3724	2726	998	Grey
19.	Valliyoor	5447	2761	2686	White
20.	Total	100618	54350	46263	

Note: Utilisation above 85% : Dark
65 - 85% : Grey
below 65% : White

Source:Ground water in Tirunelveli District, Public Works Dept.(Groundwater) 1992.

LAND UTILISATION IN TIRUNELVELI AND THOOTHUKUDI DISTRICTS (1990-91)

S.No.	Feature	Tirunelveli			Thoothukudi		
		Ha	%	% to State level	Ha	%	% to State level
1	Total geographical area	681629	-	5.2	459054	-	3.5
2.	Forests	125508	18.4	5.8	11002	2.4	0.5
3.	Barren & uncultivable land	25165	3.7	4.9	19944	4.3	3.9
4.	Land put to non-agricultural use	94814	13.9	5.2	68593	14.9	3.7
5.	Cultivable waste	39901	5.8	13.7	20137	4.4	6.9
6.	Permanent pasture and other grazing lands	10919	1.6	8.9	5052	1.2	4.0
7.	Miscellaneous tree crops and groves	9231	1.4	3.9	24852	5.4	10.6
8.	Current fallows	80385	11.8	6.4	38150	8.3	3.0
9.	Other fallow lands	129581	19.0	12.4	40468	8.8	3.9
10.	Net area sown	166125	24.4	3.0	230838	50.3	4.1
11.	Area sown more than once	51593	7.6	4.9	14058	3.1	1.3
12.	Gross area cropped	217718	32.0	3.3	244896	53.4	3.7

Source: AGROSTAT, 1993. Directorate of Agriculture, Madras p.91-97.

THOOTHUKUDI DISTRICT

CLIMATE

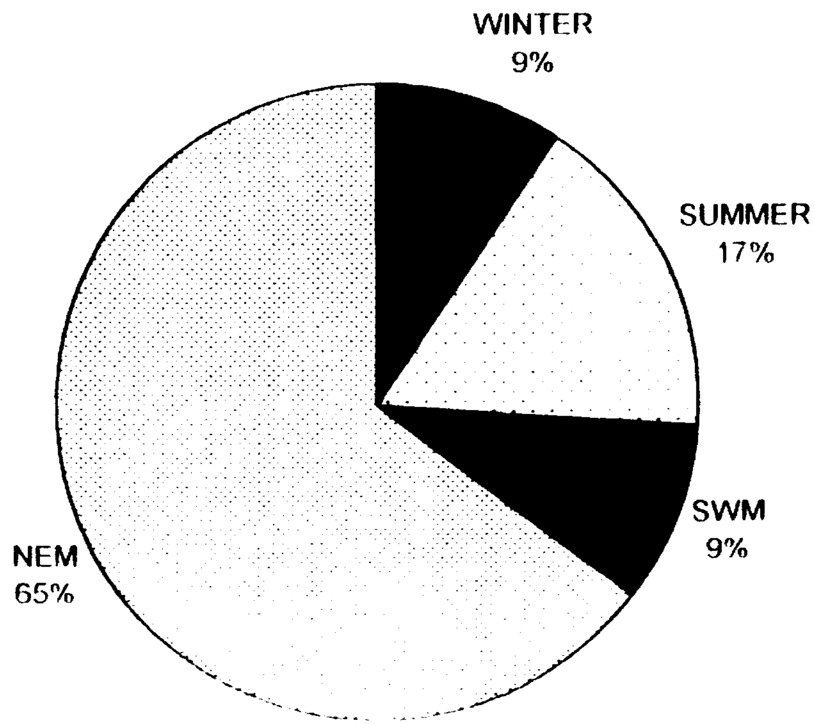
The mean annual rainfall of Thoothukudi District is 662.2 mm. In the various taluks, the annual rainfall ranges from 595.5 to 794.7 mm. North East monsoon contributes a major share (65%) of annual rainfall. The annual mean maximum and mean minimumtemperatures are 33.4°C and 23.9°C respectively. Relative humidity is low for most part of the year. Evapotranspiration demand is also higher during most months.

SOIL

Red soils, black soils and sandy soils are found in the district. The important soil types are described below.

RAINFALL IN THOOTHUKUDI DISTRICT

Month/Season	District		Taluks						
	mm	% to Total	Kovilpatti	Tiruchendur	Thoothukudi	Vilathikulam	Ottapidaram	Sathankulam	Srivaikundam
January	38.9	5.9	65.5	66.8	28.2	32.3	36.3	40.6	40.6
February	23.1	3.5	19.4	37.0	28.7	18.3	21.1	25.1	23.1
Winter	**62.0**	**9.4**	**84.9**	**103.8**	**56.9**	**50.6**	**57.4**	**65.7**	**63.7**
March	30.5	4.6	13.7	35.6	34.7	25.7	24.6	25.9	32.3
April	54.3	8.2	56.6	49.3	44.5	55.6	49.3	46.7	48.9
May	26.1	3.9	76.3	14.0	17.8	31.5	30.2	23.5	31.9
Summer	**110.9**	**16.7**	**146.6**	**98.9**	**97.0**	**112.8**	**104.1**	**96.1**	**113.1**
June	6.1	1.0	18.7	4.8	4.3	6.9	3.3	10.2	6.9
July	10.0	1.5	19.5	3.6	4.1	12.7	6.8	8.1	7.1
August	18.5	2.8	27.2	6.6	6.6	36.8	25.1	17.0	21.1
September	25.3	3.8	67.4	5.8	15.5	52.3	36.8	23.4	26.2
SWM	**59.9**	**9.0**	**132.8**	**20.8**	**30.5**	**108.7**	**72.0**	**58.7**	**61.3**
October	150.7	22.7	147.6	135.1	135.4	172.2	188.2	162.8	146.3
November	184.7	27.9	174.8	232.4	188.5	154.7	157.0	202.4	183.1
December	94.0	14.2	76.5	154.7	94.5	68.6	78.5	208.7	100.1
NEM	**429.4**	**64.9**	**398.9**	**522.2**	**418.4**	**395.5**	**423.7**	**573.9**	**429.5**
Annual	**662.2**	-	**763.2**	**745.8**	**602.8**	**667.6**	**650.0**	**794.4**	**667.5**



SEASON-WISE RAINFALL DISTRIBUTION IN THOOTHUKUDI DISTRICT (mm)

Typic Ustipsammets

These soils are red, very deep, sandy, non calcareous and excessively drained. They occur in very gently sloping lands of the coastal belt and the 'therilands' are subject to moderate wind erosion. The texture is sandy to loamy sand.

Paralithic Ustorrenths

These soils are red, shallow, fine loamy, non calcareous and well drained.

Typic Ustropepts

These soils are dark grey, moderately deep to deep, fine loamy, calcareous and moderately well drained. The depth varies from 50 to 110 cm and the texture ranges from sandy loam to sandy clay loam.

Vertic Ustropepts

These soils are brown to dark brown, very deep, fine loamy, calcareous, poorly drained and mildly alkaline soils. They develop cracks of more than 1 cm width to a depth of 50 cm. These soils occur mostly in the rainfed drylands.

Fluventic Ustropepts

These are dark grey, deep to very deep, moderately well drained, alkaline soils with coarse textured layer in the subsurface.

Typic Haplustalfs

These are deep to very deep soils, calcareous, well drained and medium to coarse textured. They occur on comparatively elevated land and are subjected to sheet and gully erosion.

Typic Chromusterts

These soils occur generally in lower elevation and develop deep cracks during summer.

Water Resources

The percentage of irrigated area to net area sown is only 18.2% in Thoothukudi District.. Four canals of Tambiraparani irrigation system constitute the major source of surface irrigation. The proportion of net area irrigated by canals, tanks and wells constitute 18.7, 46.8 and 40.5% respectively.

Regarding ground water potential, three out of 12 panchayat unions in the district are classified as 'grey' and the rest are 'white' areas. Despite a reasonably good availability of ground water, its utilisation for agriculture is handicapped by the poor quality of water in many places.

NET AREA IRRIGATED BY SOURCES (1989-90)

Source	Tirunelveli			Thoothukudi		
	No.	Area (ha)	%	No.	Area (ha)	%
Canals	261	15146	15.1	4	4565	12.7
Tanks	2170	43695	43.9	628	16847	46.8
Wells	84584	40941	41.0	29182	14611	40.5
Total net area irrigated	99788			36023		
Area irrigated more than once	37281			9302		
Gross irrigated area	137069			45325		
% of Gross irrigated area to total sown area	67.4			17.2		

Source: AGROSTAT, 1991, Directorate of Agriculture, Madras, P 18-19.

LAND UTILISATION

Thoothukudi District extends over a land area of 4.59 lakh hectare which corresponds to 3.5% of State area. Net area sown is 2.31 lakh hectare equal to 50.3% of the total district area. Culturable waste and other fallow lands occur in 0.60 lakh ha constituting 10.3 per cent of total waste land and fallow land area in the state. The area sown more than once is very low at 6.1% of net area sown, indicating the low intensity of cropping. Rainfed drylands occupy a major part of net sown area.

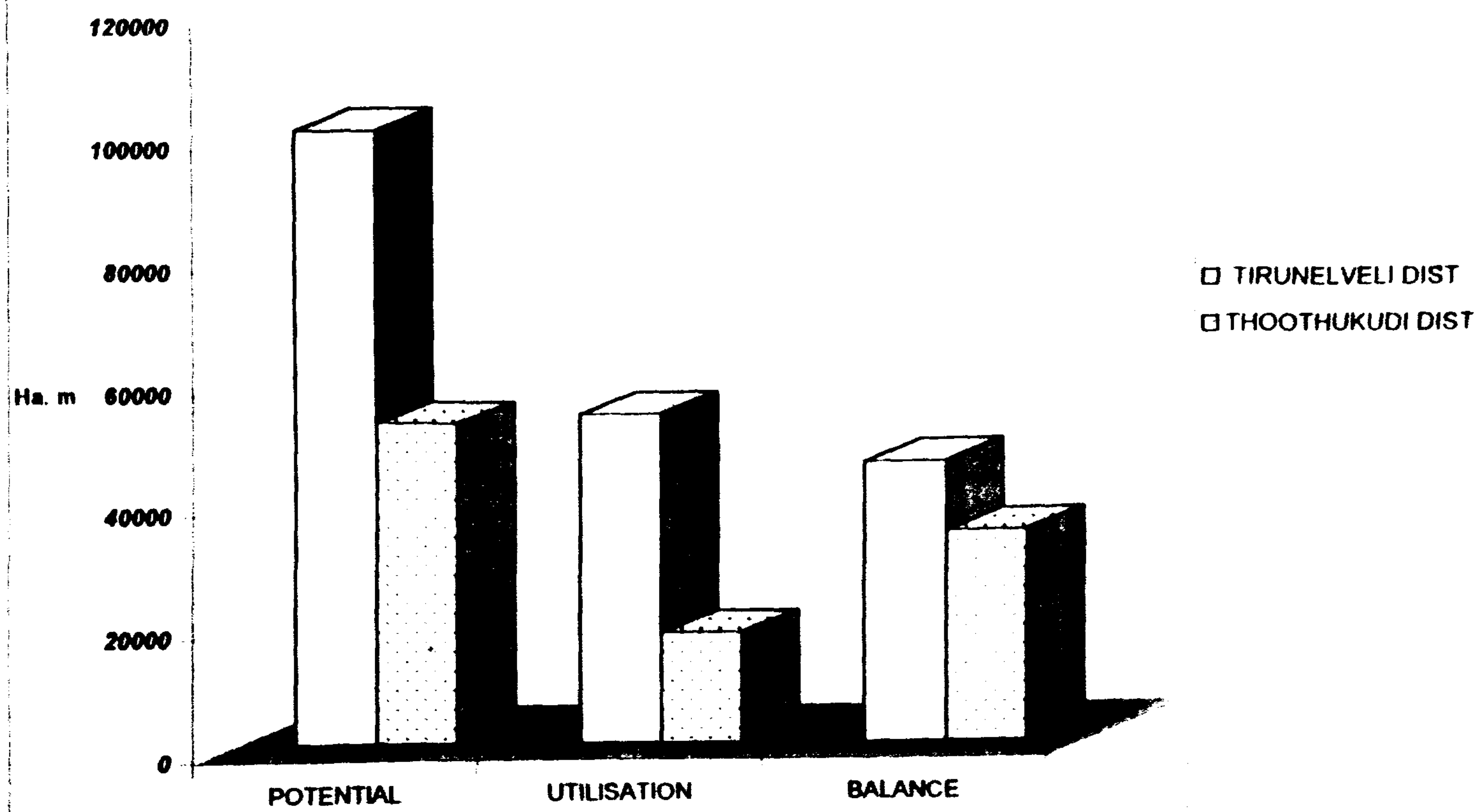
CROPPING PATTERN

In Thoothukudi District, cotton was the major crop (52500 ha) until recently but the area under cotton is declining in the past few years. Pulses occupy a large area of 37400 ha, among which blackgram is the major crop (25200 ha) followed by greengram (10700 ha). Rice is grown in an area of 32000 ha and millets in 28000 ha. Among the millets, cumbu occupies a larger area (18000 ha). Groundnut, sesamum and sunflower are the important oilseed crops of the district. Area under sugarcane is very meagre (200 ha). Banana is a dominant crop in the canal command area in the district. Productivity of most of the crops is higher than state average except oilseeds and cotton

GROUND WATER IN THOOTHUKUDI DISTRICT (1992)

S.No.	Panchayat Union	Potential	Utilisation (Ha m)	Balance	Classification
1	Kovilpatti	4105	2618	1487	White
2	Kayathar	5357	2649	2708	White
3	Ottapidaram	5981	2685	3296	White
4	Alwarthirunagari	7258	1090	6168	White
5	Srivaikundam	2258	511	1747	White
6	Karunkulam	4570	1524	3046	White
7	Vilathikulam	8494	883	7611	White
8	Puthur	3735	991	2744	White
9	Tuticorin	4581	544	4037	White
10	Santhankulam	3218	2446	772	Grey
11	Thiruchendur	926	643	283	Grey
12	Udangudi	2338	1534	804	Grey
	Total	52821	18118	34703	

Source: Ground water in V.O.Chidambaranar District, Public Works Dept. (Ground Water), 1992.



GROUNDWATER POTENTIAL,UTILISATION AND BALANCE

AREA, PRODUCTION AND PRODUCTIVITY OF CROPS (1991-92)

Crop	Tirunelveli District				Thoothukudi District				State average Kg/ha
	Area (lakh ha)	% to State	Production (lakh tonnes)	Productivity (kg/ha)	Area (lakh ha)	% to State	Production (lakh tonnes)	Productivity (kg/ha)	
1. Paddy	0.99	4.7	3.19	3227	0.32	1.5	1.09	3393	3114
2. Sorghum	0.04	0.7	0.10	2540	0.09	1.5	0.16	1824	1210
3. Cumbu	0.02	0.8	0.04	1730	0.18	7.4	0.27	1520	1070
4. Ragi	0.01	0.5	0.05	3380	0.01	0.5	0.02	2086	1876
5. Other millets	0.01	0.7	0.01	1000	0.02	1.4	0.01	600	593
Total Millets	0.08	0.7	0.19	2375	0.28	2.3	0.45	1607	1223
6. Redgram	0.002	0.1	0.002	777	0.002	0.1	0.002	738	726
7. Blackgram	0.158	5.0	0.086	547	0.252	8.0	0.140	555	440
8. Greengram	0.022	1.6	0.016	725	0.107	7.9	0.086	806	462
9. Horsegram	0.008	0.7	0.003	332	0.001	0.1	0.005	414	396
10. Bengalgram	-	-	-	-	0.004	9.5	0.001	550	543
11. Other pulses	0.022	1.9	0.035	158	0.012	1.0	0.021	245	193
Total Pulses	0.212	2.6	0.110	519	0.374	4.5	0.231	617	448
12. Groundnut	0.07	0.7	0.08	1239	0.04	0.4	0.05	1160	1280
13. Gingelly	0.04	3.1	0.01	120	0.04	3.1	0.02	227	254
14. Sunflower	-	-	-	600	0.04	17.4	0.01	336	525
15. Castor	-	-	-	310	-	-	-	232	316
16. Coconut	7288 (ha)	4.0	841 lakhs	-	3276 (ha)	1.8	379	-	-
17. Cotton	0.228	8.6	0.507	378	0.525	19.8	0.565	183	281
18. Sugarcane	0.034	1.5	0.455	-	0.002	0.1	0.021	-	-

Source: AGROSTAT, 1993. Directorate of Agriculture, Madras p. 6-78

STATE OF ART IN RICE PRODUCTION IN TAMBIRAPARANI COMMAND AREA

The dominance of Rice in the cropping pattern of Tirunelveli and Thoothukudi Districts is a gift of one of the oldest irrigation systems in Tamilnadu. The river Tambiraparani with its many tributaries of Chittar, Ramanadhi, Gadananathi, Manimuthar, and Pachaiyar has its origin in the high rainfall Western Ghats of Pothigai hills and drains into the Gulf of Mannar in the Bay of Bengal. It transverses through a length of 120 km. The Tambiraparani irrigation system consists of eight anaicuts and eleven channels with an authorised ayacut of about 34850 ha of which 47% is direct ayacut and 53% is indirect ayacut, fed through many tanks (Table).

The average drawal of irrigation water through the eleven channels of the Tambiraparani Irrigation Project is 844 million cubic meters. This water is utilised for rice cultivation in the three main seasons viz. advance Kar (April - July), Kar (June - September) and Pishanam (October - February).

RICE GROWING SOILS

The soils of the rice growing area in Tirunelveli District fall under the subgroups of Typic Ustropepts, Vertic Utropepts, Typic Haplustalfs, Aquic Haplustalfs and Fluventic Ustropepts. In Thoothukudi District rice soils come under the subgroups of Vertic Haplustalfs, Typic Ustropepts, Vetric Ustropepts, Aquic Haplustalfs and Fluventic Ustropepts. The physicochemical properties of these various soil subgroups are presnted in tables.

R ICE BASED CROPPING SYSTEM

The main rice growing seasons are Kar (June - September) and Pishanam (October - February). An advance Kar season rice from April - July is in vogue in a small area of Thoothukudi District, mainly for the utilisation of water released from Papanasam Dam into the river during April - May for the hydel power generation.

Pishanam rice is followed by rice fallow blackgram, gingelly and greengram during March - May. In advance Kar rice areas, blackgram/gingelly is raised during August - October in between the advance Kar and Pishanam seasons.

The total production of rice in Tirunelveli District was 4,17,700 tonnes during 1992-93. The productivity varied with the locations from 3237 to 8731 kg/ha. During the same period, rice production in Thoothukudi District was 66179 tonnes with an average productivity of 3947 kg/ha.

COMMAND AREA OF TAMBIRAPARANI IRRIGATION SYSTEM

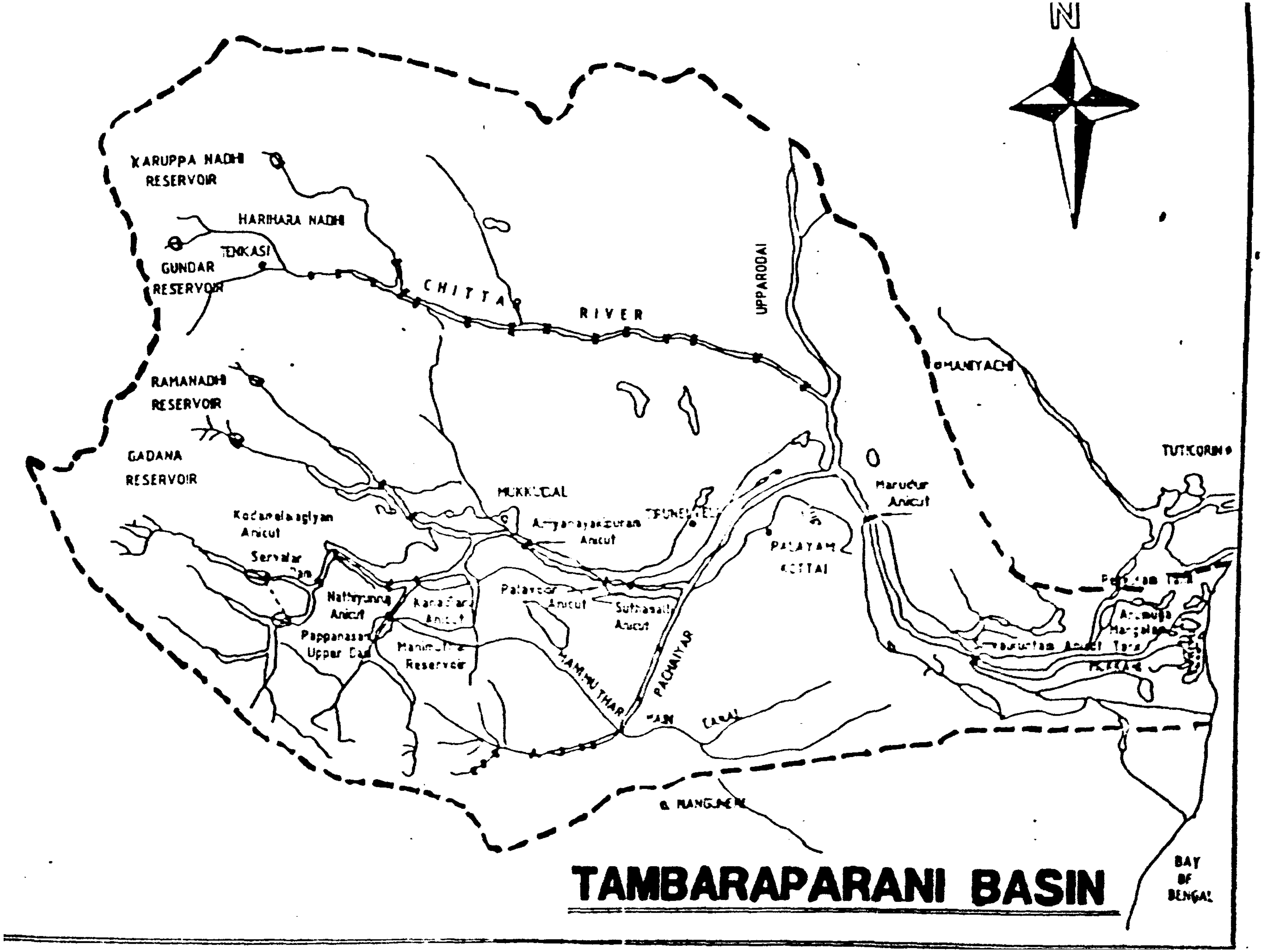
Sl.No.	Anicut/Channel	Command Area (ha)		
		Direct	Indirect	Total
1.	Kodaimelalagan Anicut			
	a) North Channel	783	132	915
	b) South Channel	352	-	352
2.	Nadhiyunni Channel	996	-	996
3.	Kannadian Canal	4182	877	5059
4.	Ariyanayagipuram Anicut Kodagan Channel	1214	1214	2428
5.	Palavoor Anicut Palayam Channel	2509	1336	3845
6.	Suthamalli Anicut Tirunelveli Channel	1022	1572	2594
7.	Maruthur Anicut			
	a) West Channel	1202	1949	3151
	b) East Channel	1843	3322	5185
8.	Srivaikundam Anicut			
	a) North Main Canal	1331	3849	5180
	b) South Main Canal	1090	4074	5164
	Total	16524	18325	34849

Source: Records of Superintendent Engineer (PWD), Tambiraparani system

The Tambiraparani Command Area is endowed with the agroclimatic resources for achieving higher productivity of rice than the present level. On-farm trials on yield maximization realised yield level of upto 8100 kg/ha in Tirunelveli District and 9840 kg/ha in Thoothukudi District during 92-93 (Veerabadran and Rangarajan, 1994).

EFFICIENT RICE CROPPING ZONE

Based on the soil properties of solum depths, texture, puddlability, permeability, soil reaction, type of clay, CEC, lime status, alkaliity , salinity, drainage and slope, Dhanapalan Mosi et al. (1970) suggested a classification of soil suitability for rice cultivation. The soil subgroups in the Tambiraparani Project Area are accordingly classified as below:



TAMBARAPARANI BASIN

Highly Suitable	Fairly Suitable	Poorly Suitable
Udic Haplustalfs	Typic Ustropepts Typic Haplustalfs Aquic Haplustalfs Fluventic Ustropepts	Vertic Ustropepts

Such classification, if perfected, will enable the development of soil specific technology package for high productivity.

Another approach for identification of efficient rice cropping zones was based on average yields recorded in Kar and Pishanam season over the years. Accordingly the rice area under the different channels has been grouped into Ecologically stable Rice Production Zone, Ecologically Potential Rice Production Zone and Ecologically risk prone rice production zone ([redacted]). Agroclimatic characterisation of rice growing environment through in-depth surveys will enable the recommendation of appropriate technologies for eachof these zones.

RICE PRODUCTIVITY RATING OF TAMBIRAPARANI COMMAND AREA

S.No.	Zone Description	Channel Command	Yield kg/ha	
			Kar	Pishanam
I	Ecologically Stable Rice Production Zone	Kodaimelalagan Nadhiyunni Kannadian	5928	4940
II	Ecologically Potential Rice Production Zone	Kodagan Palayam Tirunelveli	4500	4300
III	Ecologically Risk Prone Rice Production Zone	Marudur Srivaikuntam	4250	3950

CONSTRAINTS IN RICE PRODUCTION

The high potential productivity of rice in Tambiraparani Command Area has not been achieved due to many constraints. These include the limitations imposed by seasonal factors, irrigation water availability and soil related constraints apart from the constraints in adoption of improved production technologies and socio economic factors.

A) SEASONAL EFFECTS

A relatively large area of rice in the Command Area is raised during Pishanam season from October to February. The percentage of rice area in Pishanam to total area under rice during 1992-93 was 77% in Tirunelveli District and 62% in Thoothukudi District. The Pishanam season, though blessed with adequate water availability, is characterised by cloudiness and low solar radiation, low temperature and high rainfall. The productivity of rice during this main season is severely limited by the above climatic constraints.

B) IRRIGATION WATER AVAILABILITY

The advance Kar (April - July) and Kar (June - September) seasons are climatically more favourable for rice cultivation. But uncertainity in the onset and distribution of South West monsoon in the catchment area of Tambiraparani Project affects water release as well as water quantity for these two favourable seasons. As a result, the area covered in these seasons is subjected to wide fluctuations over the years ([redacted]). In many years, late release of water beyond the stipulated period has resulted in yield reduction during Kar season.

Even during Pishanam season, failure of North East monsoon rainfall leads to late season water stress in tail end areas. On the contrary, in lower reaches of the project, poor drainage and water stagnation have led to salinisation and consequent yield reduction by 25-50%.

C) SOIL RELATED CONSTRAINTS

In Thoothukudi District, saline and alkaline soils occur in an area of 1200 ha and the productivity of rice in this tract is low. Alkalinity problem is noticed in the soil subgroups of Vertic Ustropepts, Typic Haplustalfs and Typic Ustropepts. The problem of impeded drainage and salinisation is associated with aquic haplostalfs. Strong calcareousness is present in the soils of typic haplustalfs and Vertic Ustropepts. Deficiency of zinc and iron, non availability of applied P, volatalisation loss of broadcast nitrogen and water stagnation affect rice yield in these soils.

The problem of soil acidity is present in the upper reaches in Tirunelveli District in the soil subgroup of typic ustropepts and aquic haplustalfs. Deficiency of P and lesser use efficiency of K are problems associated with acid soils. Generally, the rice growing soils are low in organic matter content and low in cation exchange capacity (less than 7 C mol/kg).

WATER DELIVERY AND RICE AREA DURING ADVANCE KAR, KAR AND PISHANAM SEASONS

Year	Water Delivery (m cu m.)		Rice Area (ha)		
	Advance Kar and Kar	Pishanam	Advance Kar	Kar	Pishanam
1971-72	458	598	1563	25127	31328
1972-73	428	531	10336	16354	31328
1973-74	327	470	3076	19891	31328
1974-75	477	481	5768	20922	31328
1975-76	346	352	944	22026	31328
1976-77	100	407	nil	6464	31328
1977-78	275	346	11694	11276	31328
1978-79	309	512	4570	18400	31328
1979-80	456	473	6866	19824	31328
1980-81	363	434	4623	18347	31328
1981-82	551	566	1509	25181	31328
1982-83	275	459	3288	19682	31328
1983-84	144	525	nil	22970	31328
1984-85	613	536	18660	7830	31328
Mean	366	478			
C.V.%	36	15			

Source: Records of Superintending Engineer (PWD), Tambiraparani Project.

SOIL RELATED CONSTRAINTS FOR RICE PRODUCTION

S.No.	Constraint	Location	
		Tirunelveli District	Thoothukudi District
1.	Strong Calcareousness	All Taluks	All Taluks
2.	Alkalinity	-	Ottapidaram, Vilathikulam taluks
3.	Salinity	Nanguneri, Radhapuram, Sankarankovil, Sivagiri	Vilathikulam, Ottapidaram, Tuticorin, Tiruchendur, Sathankulam
4.	Acidity	Ambasamudram	-
5.	Impeded internal drainage	Ambasamudram, Tirunelveli	Srivaikuntam

D) CONSTRAINTS IN TECHNOLOGY ADOPTION

The important constraints in the adoption of improved production technologies for rice by farmers of Tambiraparani Command Area were identified as noted below:

S.No.	Technology	Reasons for poor or non-adoption
1.	Seed rate and Nursery area	Risk factor, non-awareness
2.	DAP application to Nursery	Fear of root snapping while pulling out seedlings
3.	Furadon application	Non-awareness, high cost
4.	Azospirillum	Non-awareness
5.	Zinc sulphate	Non-awareness, lack of finance
6.	Herbicide	High cost, lack of finance
7.	Plant Population	Non-cooperation of labourers
8.	Organic manure	Non-availability
9.	Inorganic fertilizer	Lack of finance

Source: Records of Department of Agrl. Extension, AC & RI, Killikulam

TECHNICAL & ADMINISTRATIVE REQUIREMENTS FOR HIGHER RICE PRODUCTIVITY

- Stability rice area during Kar season
- Research on HYV for Kar, Pishanam and late Pishanam
- Technology for Pishanam
- Regulating water release and distribution
- Reclamation of problem soils
- Identification of constraints in rice production in High, medium and low productivity zones
- Strengthening TOT
- Adequate supply of quality seeds
- Infrastructure improvement for credit, input and output market
- Promoting cost reduction technologies
- Revival of green manuring
- Substitution of inorganic fertilizers through locally available organic manures and organic wastes
- Stabilising income through IFS.

RICE VARIETIES AND THEIR YIELD POTENTIAL

Rice is grown during two seasons viz Kar (June - September) and Pishanam (October - February) in Tirunelveli District. In Thoothukudi District, besides the above two seasons, rice is also raised during Advance Kar season (April - July). Many varieties with varying yield potential are raised during these seasons.

The Rice Research Station at Ambasamudram in Tirunelveli District has released many high yielding varieties suitable for diterent seasons. Varieties released from other rice research centres also are widely cultivated. The varieties recommended for advance Kar and Kar seasons include the short duration varieties such as ASD 16, ASD 17, ASD 18, ASD 20, ADT 36, ADT 37, ADT 42, IR 50, IR 64, TKM 9 and Rice hybrid CORH 1. for Pishanam season medium duration varieties such as IR 20, Ponni, ASD 19, ADT 38, ADT 39 and CO 43 are recommended. For late pishanam season, short duration varieties like ASD 16, ADT 36 are recommended.

The Rice Research Station at Ambasamudram was established in 1937 with the objective of developing high yielding rice varieties suitable for Tambiraparani Command Area. Until 1997, this centre has released 20 rice varieties. The variety ASD 16 released from this centre has been christened by farmers as "Super Rice" because of its high yielding ability and wide adaptability . In State Level Crop yield competition during 1988-89, ASD 16 recorded a high yield of 20.13 t/ha in Alwar Thirunagari in Thoothukudi District. In Kanyakumari, this variety was grown in 90% of rice area during 1995-96. It is a medium tillering variety with more grains per panicle and greater grain weight with a duration of 110-115 days.

The variety ASD 17 with a duration of 100 days is a red grained variety, tolerant to drought and suitable for direct sowing. It is preferred by farmers in Kanyakumari District and in the tail end areas of Thoothukudi District. Variety ASD 18 was released in 1991 and suitable for all rice growing seasons in the Southern Districts. It is a medium fine white grained rice with a high yield potential of 7.3 t/ha.

Rice ASD 19 released in 1995 is a medium duration variety of 130 days duration. It is a fine grained white rice type suitable for Pishanam (Rabi) season in the place of IR 20 in the Southern Districts. Variety ASD 20 was released in 1997 and has a duration of 110 days with yield potential of 6.7 t/ha and is recommended as a substitute for IR 50 during Kar and late Pishanam seasons (Vivekanandan et al., 1997).

Varietal evaluation studies during advance Kar season at AC & RI, Killikulam indicated that variety ASD 16 exhibited better growth and produced higher grain yield than IR 50 and TKM 9 (Palanivelayutham, 1997). During Kar season also variety ASD 16 produced higher yield over ASD 18 and ADT 36 and provided higher economic returns (Velayutham, 1993).

YIELD POTENTIAL OF RICE VARIETIES UNDER DIFFERENT DATES OF SOWING DURING ADVANCE KAR

Variety	Yield (kg/ha)			
	Apr.1	Apr.15	May 15	Mean
IR 50	4253	3516	4031	3933
ASD 16	5536	4107	5216	4953
TKM 9	5102	4182	4816	4700
Mean	4964	3935	4688	
	SEd	CD		
Variety	59	128		
Date of sowing	30	84		
V x D	102	. 222		

YIELD POTENTIAL OF RICE VARIETIES DURING KAR SEASON

Variety	Grain (Kg/ha)	Straw (Kg/ha)	B:C
ADT 36	3889	4760	1.89
ASD 16	4657	5815	2.38
ASD 18	3367	3920	1.39
SEd	30	21	
CD (P=0.05)	62	54	

Variety ADT 38 proved to be suitable for both Kar and Pishanam seasons, recording 4928 and 5989 kg/ha respectively during the two seasons (Velayutham, 1993). In an experiment to identify varieties suitale for late Pishanam, Arumainathan (1997) reported that varieties ASD 18 and ASD 16 performed better over ADT 36 and ADT 39 at different dates of sowing from Nov. 1 to Dec. 1. Variety ADT 39 performed poorly when sown beyond Nov. 20.

To assess the scope for ratooning of rice after late pishanam crop. Varieties ASD 16, ADT 36, CO 37 and PMK 1 were compared in an experiment. Variety CO 37 was best suited for ratooning by maturing in 77 days after harvest of plant crop and yielded 2590 kg/ha (Balasubramanian, 1991).

VARIETAL PERFORMANCE IN KAR AND PISHANAM SEASONS

Variety	Grain (Kg/ha)		Straw (Kg/ha)		B:C	
	Kar	Pishanam	Kar	Pishanam	Kar	Pishanam
ASD 16	4080	5496	5540	7588	1.29	1.92
ADT 38	4928	5989	6728	8347	1.79	2.18
CD(P=0.05)	99	66	150	90		

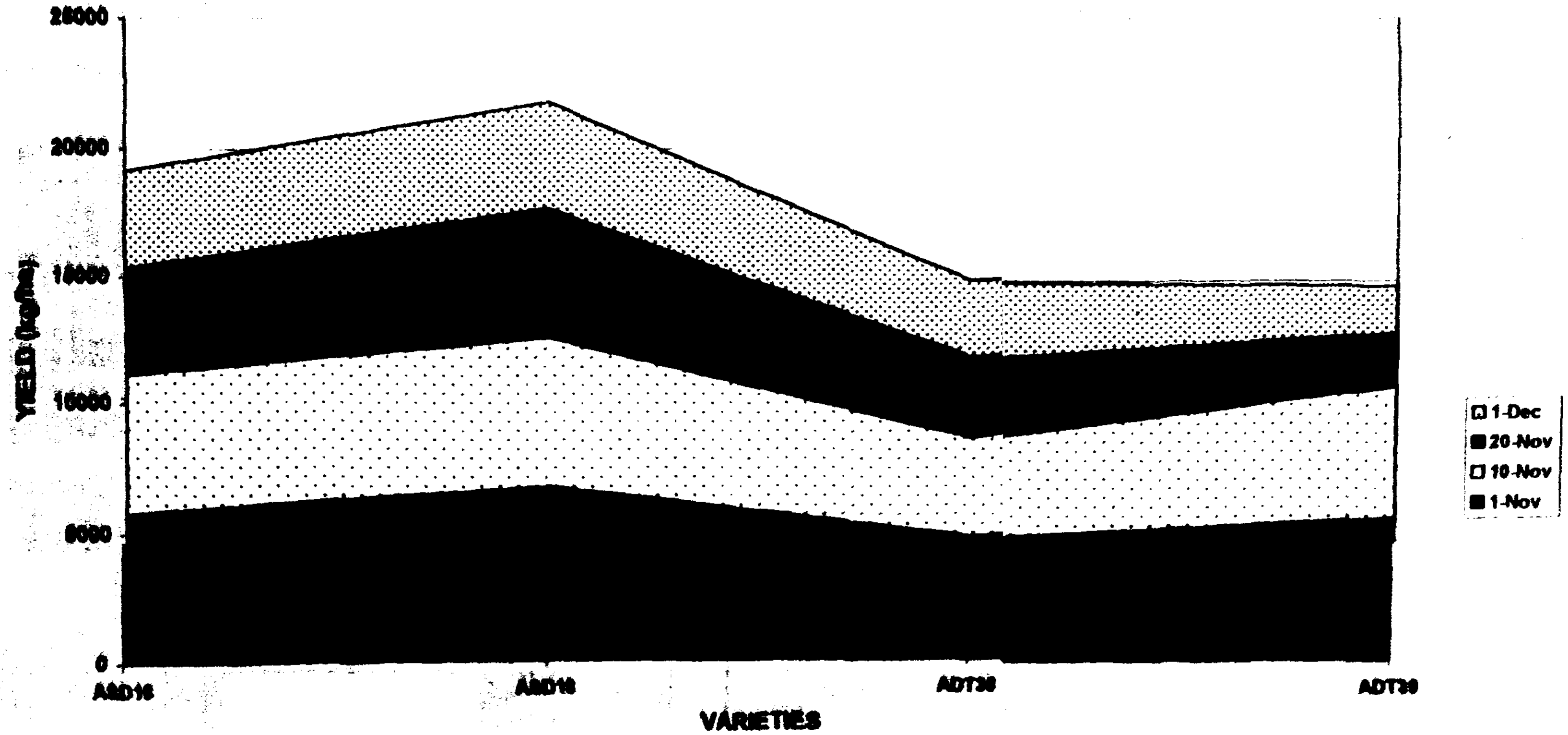
YIELD POTENTIAL OF RICE VARIETIES UNDER DIFFERENT DATES OF SOWING DURING PISHANAM

Variety	Grain Yield (Kg/ha)				
	Nov. 1	Nov. 10	Nov. 20	Dec. 1	Mean
ASD 16	5764	5375	4232	3788	4790
ASD 18	6860	5809	5047	4105	5455
ADT 36	4920	3808	3205	2983	3729
ADT 39	5714	5100	2124	1841	3964
Mean	5814	5023	3652	3179	

	SEd	CD (P=0.05)
Date	152	371
Variety	97	200
V at D	194	400

RATOONING ABILITY OF RICE VARIETIES

Variety	Days to maturity	Grain (Kg/ha)	Per day productivity (kg/ha)
ADT 36	79.0	1470	18.6
ASD 16	79.8	1370	17.0
CO 37	77.2	2590	33.1
PMK 1	77.4	2313	28.2
CD (P = 0.05)	0.4	17	



YIELD POTENTIAL OF RICE VARIETIES UNDER DIFFERENT DATES OF SOWING DURING PISHANAM SEASON

EFFECT OF TIME OF SOWING IN RICE

Rice is raised during Kar (June - September) and Pishanam (October - February) in Tirunelveli District and during advance Kar (April - July), Kar and Pishanam seasons in Thoothukudi District. Many experiments were conducted to study the effect of time of sowing on rice growth and yield during the different seasons.

During advance Kar season, all the growth attributes of lowland planted rice registered higher values in the crop sown early on 1 April than the late sown crop in 15 April and 1 May. Among the yield attributes, number of panicles, number of filled grains per panicle and thousand grain weight were higher in 1 April sown crop and panicle length was more in 15 April sown crop. Higher grain yield (5102 kg/ha) was associated with early sowing on 1 April (Palanivelayutham, 1997).

EFFECT OF TIME OF SOWING ON RICE YIELD DURING ADVANCE KAR SEASON

Date of sowing	Grain yield (Kg/ha)	Straw Yield(Kg/ha)
1 April	5102	7065
15 April	4182	5294
1 May	4816	6417
SEd	30	166
CD (P=0.05)	84	322

Yield potential of hybrid rice ASRH 11 during advance Kar season under varying dates of sowing viz., 10 April, 10 May and 10 June was evaluated in another study by Prabhakara Rao (1997). Sowing on 10 June was found to be favourable for higher yield of 7312 kg/ha in hybrid rice.

YIELD OF HYBRID RICE UNDER DIFFERENT DATES OF SOWING

Date of sowing	Grain (Kg/ka)	Straw (Kg/ha)
10 April	6364	8375
10 May	6446	8524
10 June	7312	9388

Scented rice variety ADT 41 (JJ 92) was raised during Pishanam season under different dates of sowing from 25 September to 4 November at 10 days interval. Though growth attributes during vegetative phase of the crop were better in the crop sown early on 25 September, the yield attributes recorded higher values in the crop sown late on 4 November, which gave higher grain yield 5272 kg/ha (Saravanan, 1995).

EFFECT OF TIME OF SOWING ON SCENTED RICE ADT 41

Date of Sowing	Grain (Kg/ha)	Straw (Kg/ha)
25 September	3643	8865
5 October	4161	8896
15 October	5034	8706
25 October	4640	8990
4 November	5272	8812
SEd	23	16
CD (P=0.05)	75	52

In another study, the yield potential of rice varieties during late Pishanam season under different dates of sowing, was assessed. Sowing on 1 November enabled better growth of planted rice in terms of height, tiller production, leaf area and dry matter accumulation than delayed sowings on 10 November, 20 November and 1 December. Various yield attributes such as panicles per m2, panicle length, grains per panicle and test grain weight were also favourably influenced by sowing on 1 November. Delay in sowing by 20 November or 1 December caused reduction in all the growth and yield attributes. Favourable range of maximum and minimum temperature during critical stages of the crop sown on 1 November enabled higher grain yield (5814 kg/ha). Grain yield declined by 791 to 2635 kg/ha as the sowing was delayed to 10 November, 20 November and 1 December (Arumainathan, 1997).

EFFECT OF TIME OF SOWING ON RICE IN LATE PISHANAM

Date of sowing	Grain (Kg/ha)	Straw (Kg/ha)
1 November	5814	8033
10 November	5023	7055
20 November	3652	5277
1 December	3179	4631
SEd	152	168
CD (P = 0.05)	371	412

PLANT POPULATION STUDIES IN TRANSPLANTED RICE

TRANSPLANTED RICE

Optimum plant density is a key determinant of yield in rice. Studies on ASD 16 and ADT 38 varieties during Kar and Pishanam seasons revealed that adoption of a high density of 100 hills m^{-2} resulted in maximum grain yield under high nitrogen fertilisation (Velayutham, 1993).

EFFECT OF PLANT DENSITY ON RICE YIELD

Density Hill m^{-2}	Grain (Kg/ha)		Straw (Kg/ha)		B:C	
	Kar	Pishanam	Kar	Pishanam	Kar	Pishanam
66	3917	5226	5392	7204	1.24	1.79
80	4467	5516	6190	7959	1.55	1.88
100	5019	6299	6906	8737	1.84	2.32
CD (P=0.05)	119	83	187	110	-	-

However, in another study during Pishanam season of 1995-96, the results showed no distinct advantage with higher density of 80 hills m-2 over 66 hills m^{-2} in rice varieties ASD 16, ASD 18, ADT 38 and ADT 39. Plant density of 66 hills m^{-2} was found optimum in all these varieties during Pishanam season (Arumainathan, 1997).

EFFECT OF PLANT DESNSITY ON YIELD OF RICE VARIETIES DURING PISHANAM SEASON

Variety	Grain (Kg/ha)		Straw (Kg/ha)	
	66 hills	80 hills	66 hills	80 hills
ASD 16	5454	4125	7729	5802
ASD 18	5433	5477	7920	7496
ADT 38	4576	2882	6449	4154
ADT 39	3179	4209	4650	6000
CD(P=0.05)	253		448	

Optimal plant density for scented rice ADT 42 (IJ 92) during Pishanam season was determined to be 80 hills m^{-2} in a trial by Saravanan (1995). With 80 hills m^{-2}, grain yield was 4597 kg /ha as against 4503 kg/ha at 66 hills m^{-2}.

EFFECT OF PLANT DENSITY ON YIELD OF SCENTED RICE

Density Hills m^{-2}	Grain (Kg/ha)	B:C
66	4503	3.37
80	4597	3.42
SEd	18	-
CD (P=0.05)	51	-

Plant density studies in hybrid rice ASRH 11 revealed that adoption of wider spacing (20 x 10 cm) to provide a population of 50 hills m^{-2} was found to be optimum to realise higher grain yield potential of 7050 kg /ha during Kar season (Prabhakara Rao, 1995).

PLANT DENSITY FOR HYBRID RICE

Plant density hills m^{-2}	Grain (Kg/ha)	Straw (Kg/ha)
50	7051	9123
66	6849	8717
80	6360	8451
SEd	18	24
CD (P=0.05)	62	67

PULSES

Pulses, especially blackgram, constitute a major component of the cropping systems in Tirunelveli and Thoothukudi districts. Maintenance of optimum plant density is an important non-monetary input for yield maximisation in pulses.

PLANT DENSITY IN BLACKGRAM

Plant desnity experiment on blackgram during Kar (Kharif) season under irrigated condition revealed that higher density of 40 plants m^{-2} resulted in more grain yield than the recommended density of 33 plants m^{-2} under adequate nutrient supply. Protein content, however, was higher at the density of 33 plants m^{-2} (Subramanian, 1995).

PLANT DENSITY IN IRRIGATED BLACKGRAM

Plant Density m^{-2}	Grain (Kg/ha)	Protein Content (%)
33	1141	23.97
40	1169	22.09
50	1156	22.26
SEd	4	0.01
CD (P=0.05)	11	0.03

SOYBEAN

Soybean is gaining acceptance among farmers of the region as an irrigated dry crop and as a rice fallow crop. In irrigated soybean, closer spacing of 20 x 10 cm was found to be necessary for higher yield and return (Moh ammed Sabeer, 1995).

EFFECT OF SPACING IN IRRIGATED SOYBEAN

Spacing (cm)	Grain (Kg/ ha)	B:C
30 x 10	1175	0.95
20 x 10	1396	1.24
SEd	16	-
CD (P=0.05)	32	-

WATER MANAGEMENT

Tambiraparani Irrigation System is the major source of sustenance for rice farming system in the two districts. Yet, in the past few years, erratic monsoon behaviour in the catchment area of Papanasam Reservoir has led to uncertaintyin release of water and availability of water in the canals, especially during advance Kar and Kar seasons, affecting rice area and production. Studies on irrigation management were conducted in the research station as well as farmers' fields to evaluate the effect of various irrigation regimes on rice growth and yield.

In experiments conducted in transplanted rice during 1986-87, the conventional practice of continuous submergence to 5 cm depth was compared with irrigation to 5 cm depth at various intervals after disappearance of ponded water. Continuous submergence registered higher grain yield (5754 kg/ha) but recorded a high water use of 1770 mm with low water use efficiency (3.25 kg/ha mm-1). Irrigation at various intervals after disappearance of ponded water led to reduction in water use and higher water use efficiency but absolute yield was reduced to varying degree. The least reduction in grain yield was associated with irrigation immediately after disappearance of ponded water but with a saving in water use (1261 mm) and higher WUE (4.33 kg/ha mm-1) compared with continuous submergence. The results also enabled an understanding of the effect of limited water supply during scarcity conditions (Wahab, 1994).

EFFECT OF WATER MANAGEMENT PRACTICES ON YIELD OF RICE IR 20

	Irrigation Management	Mean of two years			
		Grain (kg/ha)	Straw (Kg/ha)	Water use (mm)	WUE (Kg/ha mm-1)
1.	Continuous submergence	5754 ✓	6942	1770	3.25
2.	Irrigation to 5 cm immediately after disappearance of ponded water	5469	6417	1261	4.33
3.	Irrigation to 5 cm 2 days after disappearance of ponded water	5291	6183	1175	4.51
4.	Irrigation to 5 cm 4 days after disappearance of ponded water	5054	5921	1130	4.47
5.	Irrigation to 5 cm 6 days after disappearance of ponded water	4955	5704	990	5.00
	CD (P = 0.05)	158	252		

In order to assess the effect of irrigation after disappearance of ponded water in rice-rice-pulse crop sequence, Asokaraja (1994) conducted experiments for two years during 1992-1993. The results revealed that in both years, higher rice grain yield in Kar as well as Pishanam seasons resulted from irrigation on the day of disappearance of ponded water. Though irrigation at 3 or 6 days after disappearance of ponded water saved irrigation water by 13.5 to 15.7 per cent, grain yield was reduced by 5.3 - 6.7 per cent. The benefit-cost ratio was also higher with irrigation on the day of disappearance of ponded water in all the four rice crops during the two year period.

ONFARM RESEARCH IN WATER MANAGEMENT FOR RICE

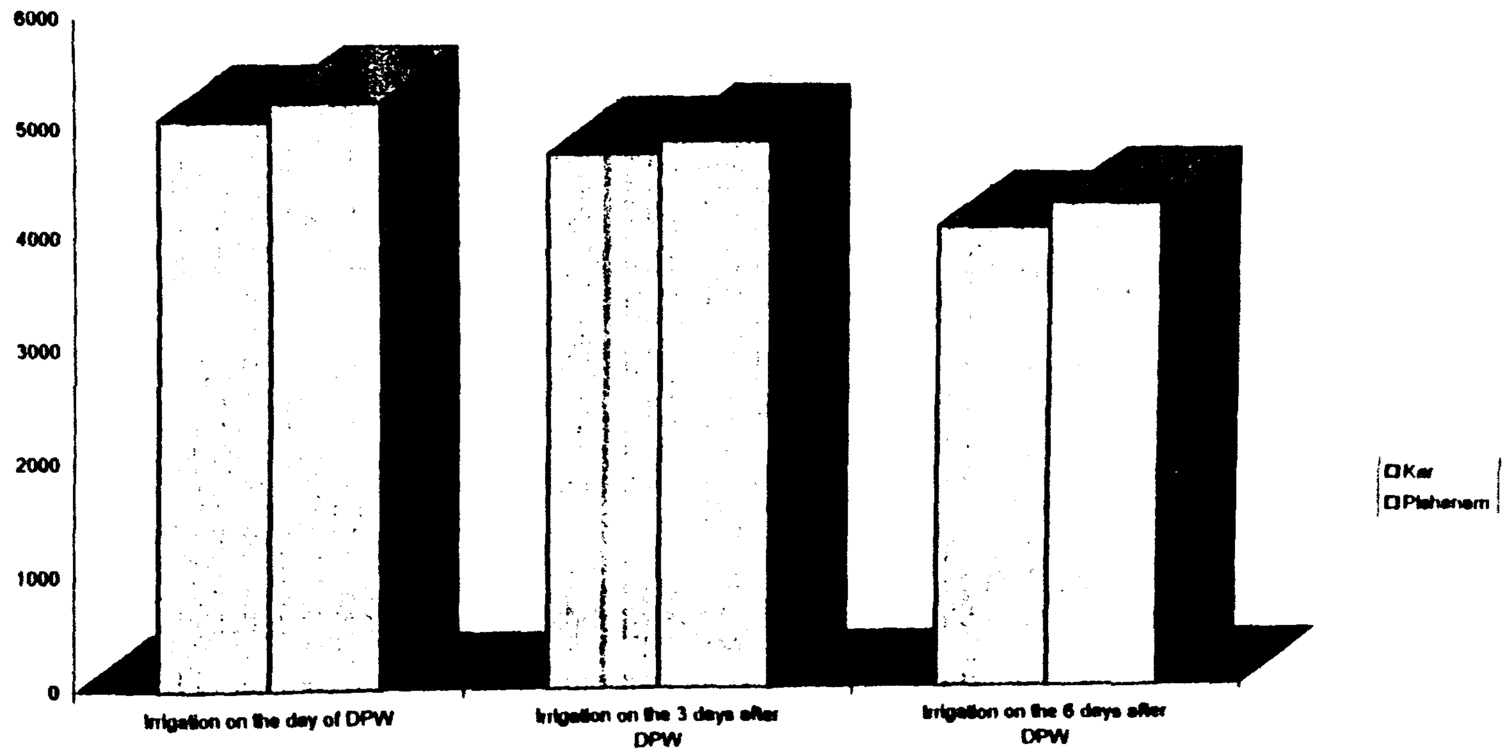
To enable the effective transfer of the technology of improved irrigation management in transplanted rice, onfarm research was conducted in farmers' fields for five years (1991-1995) in different locations. The research was financed under NARP II. In all the locations, the improved method of water management viz. irrigation to 5 cm depth after disappearance of ponded water was compared with the traditional method of continuous submergence to 5 cm depth. The experiments were conducted during Kar as well as Pishanam seasons.

During Kar season, rice varieties ASD 16, IR 50 and ADT 36 were raised. The results from different locations over various years confirmed the effectiveness of irrigation to 5 cm depth after disappearance of ponded water over continuous submergence. Mean grain yield with improved water management was 5605 kg/ha as compared to 5150 kg/ha with traditional method of continuous submergence. The per cent increase in grain yield was 8.9. Irrigation water requirement with improved method was 84.6 cm as against 100.3 cm with continuous submergence, thus resulting in a saving of 15.8 per cent. Water use efficiency was also higher (66.3 kg/ha mm-1) with irrigation after disappearance of ponded water.

During Pishanam season, the varieties raised were IR 20, ADT 36 and ASD 16 in the different locations. The pooled data for various locations during the period of study indicated that the improved method of irrigation not only increased the grain yield but also conserved irrigation water by 13.8 per cent over continuous submergence (Narayanan, 1996).

WATER MANAGEMENT IN WETSEEDED RICE

Late release of water coupled with shortage of labour and high labour costs have rekindled the interest in lowland wetseeded rice among the farmers. Studies on irrigation management in wetseeded rice during Kar season showed that irrigation immediately after disappearance of ponded water gave comparable yield with



IRRIGATION REGIMES AND RICE YIELD

Particulars	Kar		Pishanam	
	Continuous submergence	Irrigated after disappearance of ponded water	Continuous submergence	Irrigated after disappearance of ponded water
1. Yield kg/ha	5150	5605	3988	4636
2. Per cent increase	-	8.9	-	16.25
3. Total irrigation water requirement (cm)	100.3	84.5	102.3	88.16
4. Per cent saving	-	15.8	-	13.8
5. Water use efficiency kg ha^{-1} mm^{-1}	51.5	66.3	38.98	52.58

continuous submergence but saved 200 mm of water. Irrigation 3 days after disappearance of ponded water resulted in considerable yield reduction during Kar season. There was no significant difference in yield between continuous submergence and irrigation immediately or three days after disappearance of ponded water. Water requirement under continuous submergence was high at 1076 to 1200 mm as compared with 866 to 970 mm with irrigation immediately after disappearance of ponded water (Marimuthu and Srinivasan, 1997).

EFFECT OF IRRIGATION MANAGEMENT IN LOWLAND WETSEEDED RICE

Irrigation regime	Kar		Pishanam		Late Pishanam	
	Grain (Kg/ha)	Water use (mm)	Grain (Kg/ha)	Water use (mm)	Grain (Kg/ha)	Water use (mm)
Continuous submergence to 5 cm depth	4490	1102	4548	1076	4503	1200
Irrigation to 5 cm immediately after disappearance of ponded water	4167	902	4393	866	4625	970
Irrigation to 5 cm 3 days after disappearance of ponded water	3079	652	4583	646	4103	705
CD (P = 0.05)	614		NS		NS	

MILLETS

IRRIGATION SCHEDULING IN FINGER MILLET

A comparison of various irrigation regimes based on climatological approach showed that irrigation at 0.8 IW/CPE ratio favoured better growth and higher yield in finger millet (3347 kg/ha) and it was comparable with the higher regime of irrigation at 0.8 IW/CPE (3371 kg/ha). Higher water use efficiency and benefit cost ratio were associated with irrigation at 0.6 IW/CPE ratio (Balasubramanian, 1996).

EFFECT OF IRRIGATION REGIMES ON YIELD OF FINGER MILLET

Irrigation Regime	Grain Yield (Kg/ha)	WUE (Kg/ha mm^{-1})	B:C
1. 0.4 IW/CPE throughout crop growth	2159	6.00	1.77
2. 0.6 IW/CPE throughout crop growth	3347	7.28	2.67
3. 0.8 IW/CPE throughout crop growth	3371	6.02	2.66
4. 0.4 IW/CPE during vegetative phase and 0.6 IW/CPE during reproductive stage	2391	5.84	1.94
CD (P = 0.05)	45		

COTTON

WATER MANAGEMENT IN WINTER IRRIGATED COTTON

In winter irrigated cotton, land shaping for irrigation and mulching may influence crop growth when irrigation intervals are prolonged due to limited water supply. In an experiment conducted for two seasons during 1993-1995 in cotton MCU 11, irrigation at 12 days interval throughout crop growth was compared with irrigation at 20 days interval upto vegetative phase and at 12 days interval thereafter under different land shaping practices and mulching. Adoption of irrigation interval of 12 days uniformly throughout growth recorded higher seed cotton yield over irrigation at varying intervals during vegetative and reproductive stages.

Mulching with coir dust at 30 t/ha or rice husk at 10 t/ha enabled a significant increase in seed cotton yield over no mulching. Among the two mulching materials, rice husk was more effective than coir waste.

Land shaping practices influenced water use and cotton yield. Irrigating the crop through every furrow irrigation in ridges and furrow system recorded higher seed cotton yield over check basin, alternate furrow irrigation in ridges and furrows and bed furrow. However, when irrigation is scheduled at wider intervals of 20 days during vegetative phase due to limited water supply, the consequent reduction in seed cotton yield was minimised by adoption of alternate furrow irrigation in ridges and furrows or bed furrow irrigation along with mulching with rice husk. Higher water use efficiency could be ensured with these practices (Nalliah Durairaj, 1996).

WATER MANAGEMENT IN RICE FALLOW COTTON

Cotton is raised as rice fallow crop after Pishanam rice in areas where supplemental irrigation facilities exist. An experiment was conducted during 1988-89

INFLUENCE OF LANDSHAPING, IRRIGATION REGIMES AND MULCHES ON SEED COTTON YIELD AND WATER USE EFFICIENCY

	Seed Cotton Yield (kg/ha)			Water Use Efficiency (kg ha^{-1} mm^{-1})		
	Coir Waste	Rice Husk	No Mulch	Coir Waste	Rice Husk	No Mulch
	Irrigation Regime I			Irrigation Regime I		
Check basin	2257	2316	1948	2.73	2.80	2.35
Ridge - Furrow (every)	2276	2345	1988	3.06	3.09	2.62
Ridge - Furrow (alternate)	2209	2273	1794	3.74	3.85	3.04
Bed Furrow	2179	2229	1735	4.05	4.14	3.22
	Irrigation Regime II			Irrigation Regime II		
Check basin	2212	2276	1876	3.12	3.22	2.64
Ridge - Furrow (every)	2229	2297	1910	3.43	3.54	2.94
Ridge - Furrow (alternate)	2128	2184	1704	4.16	4.27	3.33
Bed Furrow	2085	2131	1650	4.51	4.61	3.57
	CD (P = 0.05)					
Landshaping	16			Irrigation I	Uniform irrigation interval of 12 days throughout crop	
Irrigation regime	33					
Mulch	60			Irrigation II	Varying irrigaion interval of 20 days during vegetative and 12 days thereafter	
Irri - Mulch	74					
Irri - Landshaping	66					
Mulch - Landhaping	116					

to identify suitable stress management strategies when irrigation to rice fallow cotton has to be limited due to restricted water supply. The irrigation regime based on 0.6 IW/CPE ratio was found ideal for higher yield and return than the restricted regime of 0.4 IW/CPE ratio. However, adoption of stress management strategies such as seed hardening with 2% potassium chloride, seed and soil inoculation with azospirillum and foliar spray of 6% Kaolin heped to minimise yield loss due to limited irrigation at 0.4 IW/CPE ratio (Alwar Arunachalam, 1995)

EFFECT OF STRESS MANAGEMENT PRACTICES ON RICE FALLOW COTTON MCU 7

Stress Management	Yield (Kg/ha)		WUE (Kg/ha mm-1)		Net Return (Rs/ha)	
IW/CPE	0.4	0.6	0.4	0.6	0.4	0.6
Control	1773	1851	3.12	2.47	7711	8492
Azospirillum (Seed + Soil)	1819	2006	3.20	2.72	8263	9758
Kaolin Spray 6%	1812	1896	3.18	2.53	8144	8687
Seed hardening with 2% KCl	1874	1975	3.29	2.66	8673	9468
Seed hardening with Cycocel	1964	2048	3.45	2.73	9292	9841
Azospirillum + Kaolin	2067	2150	3.63	2.87	9879	10415
Azospirillum + CCC	2092	2206	3.68	2.94	10144	10897
Azospirillum + KCl	1951	2039	3.43	2.73	9162	9796
KCL + Kaolin	1921	2110	3.38	2.82	8884	10155
CCC + Kaolin	2111	2192	3.71	2.93	10207	10729
Azospirillum + KCL + Kaolin	2200	2291	3.87	3.06	10785	11377
KCl + CCC + Kaolin	1922	2099	3.38	2.80	8854	10053
CD (P = 0.05)	32					

IRRIGATION MANAGEMENT IN TOMATO

In tomato, varying irrigation regimes were evaluated with and without mulching during 1994 in a post-graduate study by Nagarajan (1995). Yield attributes such as number of flowers and fruits per plant were significantly higher with irrigation at 0.9 IW/CPE ratio throughout crop duration. The fruit yield of 36.3 t/ha at this higher regime was however comparable with the yield of 35.4 t/ha obtained with the lower regime of irrigation at 0.6 IW/CPE during vegetative phase followed by irrigation ·t 0.9 IW/CPE ratio during reproductive phase. Further lowering of irrigation regimes caused significant reduction in fruit yield.

Mulching with banana sheath at 10 t/ha improved the growth and yield attributes and increased the fruit yield by 4 t/ha over no mulching. Quality attributes of tomato fruits such as total soluble solids and ascorbic acid content were also improved by mulching.

INFLUENCE OF IRRIGATION REGIMES AND MULCHING ON TOMATO FRUIT YIELD AND WUE

Irrigation regimes		Fruit Yield (t/ha)			WUE (Kg/ha/mm)		
IE/CPE		No mulch	Banana Sheath, mulch 10 t/ha	Mean	No mulch	Banana Sheath mulch 10 t/ha	Mean
Veg.	Repro.						
0.5	0.5	17.2	18.9	18.1	31.57	39.37	35.47
0.6	0.6	22.3	26.0	24.1	33.79	43.75	38.77
0.7	0.7	30.4	34.2	32.3	42.13	51.96	47.05
0.8	0.8	31.6	36.5	34.1	37.72	47.19	42.46
0.9	0.9	33.1	39.5	36.3	37.39	48.11	42.75
0.5	0.6	20.9	23.0	22.0	34.75	42.76	38.76
0.5	0.7	27.5	30.7	29.1	42.40	52.24	47.32
0.5	0.8	29.5	33.1	31.3	43.83	53.06	48.44
0.5	0.9	31.3	36.4	33.8	40.50	51.28	45.89
0.6	0.7	29.9	33.2	31.5	42.02	51.56	46.79
0.6	0.8	31.2	35.6	33.9	40.03	49.76	44.90
0.6	0.9	32.8	38.3	35.4	39.49	50.10	44.80
Mean		28.1	32.1	38.74		46.17	
		CD (P = 0.05)					
Irrigation		1.20					
Mulch		0.80					
I x M		NS					

NUTRIENT MANAGEMENT

Crop nutrition plays an important role in yield maximisation. Nutrient management experiments were conducted to optimise nutrient levels, to evolve integrated nutrient management system, to evaluate various organic sources for their potential to substitute inorganc sources and to evolve nutrient management strategies for cropping systems.

RICE

OPTIMISATION OF NPK REQUIREMENT IN RICE

Results of experiments on yield maximisation in transplanted rice ADT 38 during Kar and Pishanam seasons of 1990 - 92 showed that a dose of 200 kg N/ha was needed to get maximum yield in both seasons. Economic returns also increased with increasing N levels (Velayutham, 1993).

EFFECT OF N LEVELS ON RICE ADT 38

N level (kg/ha)	Kar			Pishanam		
	Grain (kg/ha)	Straw (kg/ha	B:C	Grain (kg/ha)	Straw (kg/ha	B:C
100	4013	5500	1.30	5303	7339	1.85
150	4477	6159	1.46	5763	8001	2.07
200	4942	6829	1.48	6159	8552	2.23
CD (P=0.05)	241	205		215	175	

Response of three short duration rice varieties to N levels was evaluated during advance Kar season of 1996 by Palanivelayutham (1997). All the three rice varieties viz., IR 50, ASD 16 and TKM 9 responded linearly upto 150 kg N/ha.

EFFECT OF N LEVELS ON YIELD OF RICE VARIETIES DURING ADVNCE KAR SEASON

N level (kg/ha)	Grain Yield (kg/ha)			
	IR 50	ASD 16	TKM 9	Mean
100	3776	4770	4558	4368
125	4071	4827	4353	4408
150	3980	5262	5187	4653
CD (P = 0.05)	V = 128	N = 185	V x N = 291	

Nitrogen management studies in scented rice ADT 41 (JJ 92) indicated that applicaton of 150 kg N/ha was optimum for high rice grain yield (4846 kg/ha) during Pishanam season (Saravanan, 1995).

EFFECT OF N LEVELS IN SCENTED RICE ADT 41

N level (kg/ha)	Grain (kg/ha)
100	4207
125	4445
150	4846
SEd	22
CD (P = 0.05)	63

In hybrid rice ASRH 11, application of 175 kg N/ha recorded higher grain yield than 150 and 200 kg/ha. The B:C ratio was, also high at 175 kg N/ha (Prabhakara Rao, 1995).

EFFECT OF N LEVELS IN HYBRID RICE

N level (kg/ha	Grain (kg/ha)	Straw (kg/ha)	B:C
150	6293	8469	4.49
175	7119	9047	4.68
200	6717	8775	4.37
SEd	32	30	-
CD (P = 0.05)	66	62	-

INTEGRATED NUTRIENT MANAGEMENT

Environmental concerns associated with use of inorganic fertilisers and escalation of cost of fertilisers warrant efforts to reduce levels of inorganic fertilisers and to increase fertiliser use efficiency. Integrated nutrient management studies conducted at Killikulam clearly established the potential of organic nutrient sources such as green manures, livestock waste, crop residues, wasteland weeds, industrial wastes and biofertilisers in rice nutrition.

Organic wastes such as banana waste and palmyrah leaves, green leaf manures viz. subapul, neem leaves, *Cassia nigricans* (wasteland weed) and biodigested slurry were applied at 5 t/ha along with recommended NPK fertilisers and compared with the fertilisers alone. All the integrated nutrient management treatments gave high grain yield over inorganic alone, the yield increase ranging from 488 to 986 kg/ha. The benefit:cost ratio was higher (2.06) with subapul application (Velayutham, 1993).

In another study, the beneficial effect of rice straw incorporation was investigated. Rice straw contains about 0.5% N, 0.1% P and 1.5% K and 40% carbon. The experiment conducted on rice IR 20 revealed that incorporation of rice straw at 2 tonnes/ha along with recommended inorganic fertilisers registered higher rice grain yield of 6200 kg/ha (Krishnarajan, 1988).

Incorporation of composted coir pith was compared with green manure (*Sesbania aculeata*) and no organics. Application of composted coirpith at 12.5 t/ha to rice variety ASD 16 registered significantly higher grain yield (4910 kg/ha) over green manuring and no organics control (Karunakaran, 1994).

Crop residues constitute an important source of nutrition for many crops. Composting of these crop residues with chemicals or micro organisms reduced their C:N ratio, increased their nutrient content and improved their manurial value. The effect of incorporation of raw cane trash, composted cane trash, composted banana pseudostems, raw cotton stalks, composted cotton stalks, and turmeric waste was compared with green manuring and no organiccs in Kar season rice during 1995 (Sundaram, 1996). The residual effect on Pishanam rice was also studied. Cane trash was composted with addition of rock phosphate, gypsum and urea. Banana pseudostems and cotton stalks were composted with Pleurotus sojorcaju and urea.

The grain yield of first season rice crop was improved by 19 to 38 per cent by the addition of organic wastes over control. Of the various organic sources, green manure and turmeric waste recorded higher grain yield followed by composted cane trash and composted banana pseudostems. Addition of raw cane trash and raw cotton stalks was not advantageous over no manuring. The beneficial residual effect of crop residue incorporation during first season was seen in the succeeding rice crop also. Turmeric waste, composted cane trash, raw cane trash and green manure showed better residual effect.

Various methods of composting of cane trash were evaluated to identify the most effective method. Cane trash composting with urea + superphosphate + muriate of potash in 1:2:2 ratio at 25 kg mixture per tonne of cane trash produced compost with higher nutrient content and lesser C:N ratio (Ravisankar, 1997).

Intercropping and incorporation of green manure Sesbania rostrata was compared with basal incorporation of green manure/green leaf manure. Raising Sesbania rostrata as intercrop in 2 rows all around rice plot at 2.5 m interval and incoporation at preflowering stage yielded on par with basal incorporation of 12.5 t of Sesbania rostrata or Sesbania speciosa or *Cassia nigricans*. Soil test based NPK levels were applied in all green manuring treatments (Alwar Arunachalam, 1996).

EFFECT OF ORGANIC WASTES ON GRAIN YIELD OF TRANSPLANTED RICE (MEAN OF TWO YEARS)

Organic Waste @ 5 t/ha	Nutrient Content (%) on dry basis			Grain Yield (kg/ha)	Straw Yield (kg/ha)	B:C
	N	P	K			
Subapul	2.67	0.17	-	4295	5270	2.06
Biodigsted slurry	1.20	0.70	0.80	4103	5045	1.97
Banana pseudostem	2.70	0.21	4.50	4184	4955	1.99
Cassia nigricans	2.73	0.18	0.50	4189	4980	2.00
Palmyrah leaves	0.65	0.50	0.70	3797	4700	1.83
Neem leaves	2.40	0.37	-	3917	4810	1.88
Control	-	-	-	3309	4050	1.62
CD (P = 0.05)	-	-	-	58	62	

COMPARISON OF COMPOSTED COIR PITH WITH GREENLEAF MANURE IN PLANTED RICE

Treatment	Grain yield (kg/ha)	Net return (Rs/ha)
No organics	4296	7738
Sesbania aculeata	4643	8540
Composted coirpith	4910	9311
CD (P = 0.05)	26	-

EFFECT OF CROP RESIDUES ON YIELD OF RICE

Crop Residue	Direct Effect - Yield of First Season Rice (Kg/ha)	Residual Effect - Yield of Second Season rice (Kg/ha)
No organics	3498	3509
Green leaf manure	4880	4962
Raw cane trash	3565	4855
Composted cane trash	4488	4900
Composted banana waste	4473	3513
Raw cotton stalks	3553	3591
Composted cotton stalks	4129	3855
Turmeric haulms	4834	4935
CD (P = 0.05)	193	81

Evaluation Of Methods Of Composting Sugarcane Trash For Rice Nutrition

Treatment	Grain yield (kg/ha)		B:C
	I Season	II Season	
No trash	4456	1997	2.49
Raw trash	4948	2864	3.12
Anaerobic compost without additives	4692	2464	3.00
Trash composted with MRP, gypsum and urea	5094	3292	3.41
Trash composted with Azospirillum, phosphobacteria	5177	2951	3.30
Trash composted with Pleurotus and urea	5629	3591	3.95
Trash composted with urea, superphosphate and potash	5991	3984	4.00
CD (P = 0.05)	89	67	

Integration of greenmanure, biofertiliser and inorganic fertilisers proved more effective than either organic sources alone or fertiliser alone The INM system of daincha + azospirillum + fertiliser recorded additional grain yield of 715 kg/ha over fertilisers alone and 2523 kg/ha over organic alone (Velayutham and Balasubramanian, 1996).

The efficiency of applied phosphatic fertiliser was enhanced and higher grain yield obtained when superphosphate application was accompanied by green leaf manuring than when the phosphatic fertiliser alone was applied at various levels from 30 to 60 kg/ha. Application of 45 kg P2O5/ha at the time of green leaf manure incorporation well before transplanting or application of 60 kg P2O5/ha at the time of transplanting preceded by green lef manure incorporation recorded significantly higher grain yield over 60 kg P_2O_5/ha applied at planting without green leaf manuring (Sindhu, 1995).

Substitution Of Inorganic Fertilisers Through Organic Sources

Environmental concerns and escalating cost of fertilisers have warranted reduction in the quantity of inorganic fertilisers applied to rice which is the major consumer of fertilizers used today. Green manures, livestock waste, crop residues, biofertilisers and some industrial wastes have exhibited the potential for full or partial substitution of inorganic fertilisers without any yield reduction. This was confirmed in many of the experiments on rice conducted at Killikulam during the decade from 1987-1997.

EFFECT OF GREENMANURING ON RICE YIELD

Method of green manuring	Rice grain yield (kg/ha) (mean of two seasons
Sesbania rostrata in 2 rows all around plot and incorporation	6100
Sesbania rostrata one row all around plot and incorporation	5500
Sesbania rostrata - basal incorporation @ 12.5 t/ha	6500
Sesbania speciosa - basal incorporation @ 12.5 t/ha	6200
Cassia nigricans - basal incorporation @ 12.5 t/ha	6300
CD (P = 0.05)	135

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD OF TRANSPLANTED RICE

Treatment	Yield (kg/ha)	
	Grain	Straw
Danicha @ 6.25 t/ha + Azospirillum @ 2 kg/ha	2996	5697
Inorganic fertilizers 120:60:60 kg NPK/ha	4804	8163
Danicha + Azospirillum + Inorganic fertilizer	5519	8822
CD (P = 0.05)	554	769

INTEGRATED USE OF GREENLEAF MANURE AND PHOSPHORUS IN RICE

Level of P and GLM	Time of Application of P	Yield (kg/ha)		
		Grain	Straw	B:C
60 kg P + GLM	AT GLM incorporation	5554	8187	1.79
45 kg P + GLM	"	5520	8128	1.92
30 kg P + GLM	"	4975	7779	1.62
60 kg P + GLM	At rice planting	5529	8142	1.80
45 kg P + GLM	"	5230	8053	1.73
30 kg P + GLM	"	4775	7789	1.61
60 kg P + GLM	Half at GLM incorporation and half at rice planting	5362	8093	1.72
45 kg P + GLM	"	5005	8034	1.65
30 kg P + GLM	"	4685	7627	1.56
60 kg P + GLM	-	4698	7644	1.59
45 kg P alone	-	4667	7299	1.61
60 kg P alone	-	4633	7245	1.65
Control (No P, No GLM)	-	4613	7216	1.75
CD (P = 0.05)		71	450	

NITROGEN SUBSTITUTION THROUGH GREENLEAF MANURE AND BIOFERTILISER IN RICE

Nitrogen Source	Yield (kg/ha) (Mean of 3 seasons		B:C
	Grain	Straw	
Control	3261	3492	3.43
100% N - inorganic	4563	4603	2.82
75% N - inorganic + 25% N through Cassia nigricans	4473	4530	3.21
50% N inorganic + 25% N through Cassia nigricans + Azospirillum	4162	4260	3.20
75% N inorganic + 25% N through Ipomoea cornea	4878	4910	3.50
50% N inorganic + 25% N through Ipomoea cornea + Azospirillum	4570	4620	3.52
75% N inorganic + 25% N thorugh daincha	5496	5553	3.94
50% N inorganic + 25% N through daincha +Azospirillum	5868	5890	4.52
CD (P = 0.05)	92	101	

Experiments conducted over three years (1993-1995) revealed that application of 50 per cent N as inorganic fertiliser + 25 per cent N through green manure (daincha) + biofertiliser (azospirillum) or application of 75 per cent N through fertilisers + 25 per cent N through green manure recorded significantly higher grain yield over 100 per cent N through inorganic fertiliser alone. The results also showed that substitution of inorganic N upto 25 per cent was possible through the incorporation of weed biomass without any yield reduction (Velautham and Balasubramanian, 1996).

In a field experiment conducted during 1996 by Ramesh (1997), the substitution potential of various livestock manures was evaluated. The resuits showed that inorganic N could be substituted fully by pig manure or upto 75 per cent through dried poultry manure or upto 25 per cent through deep litter sheep manure without any yield loss. However, higher grain yields over 100 per cent N through inorganic fertilizers alone could be realised through 50-75 per cent substitution with pig manure or 25-50 per cent substitution through dried poultry manure. Highest benefit-cost ratio (3.41) was realised when 50 per cent N through pigmanure and 50 per cent through fertiliser was applied.

Rice husk ash, a waste from rice hulling mills, contains about 2.0 per cent potassium. It has been found to be an effective substitute for inorganic potassic fertilisers in rice nutrition. Karunakaran (1994) reported that application of 2 t/ha of rice husk ash can effectively substitute inorganic potassic fertiliser without any yield loss.

In another experiment with rice husk ash, 50 per cent substitution of inorganic potassic fertiliser (at 50 kg K_2O level) without any yield loss was found to be feasible. Besides rice husk ash, application of composted coir pith and green leaf manure enabled 25 per cent substitution of inorganic potassium without any yield loss (Srinivasan and Velayutham, 1998).

NITROGEN SUBSTITUTION POTENTIAL OF LIVESTOCK MANURES IN RICE

Treatment	Yield (kg/ha)		B:C
	Grain	Straw	
100% inorganic N	4890	6357	2.43
100% N as FYM	3657	4698	2.16
75% N as FYM + 25% N inorganic	3903	5200	2.36
50% N as FYM + 50% N inorganic	4362	5845	2.53
25% N as FYM + 75% N inorganic	4456	5971	2.63
100%N as dried poultry manure (DPM)	4578	6000	2.95
75% N as DPM + 25% N inorganic	4998	6397	3.13
50% N DPM + 50% N inorganic	5273	6887	2.96
25% N as DPM + 75% N inorganic	5649	7249	3.06
100% N as pig manure (PM)	4830	6327	2.95
75% N as PM + 25% N inorganic	5339	6802	3.24
50% N as PM + 50% N inorganic	5735	7340	3.41
25% N as PM + 75% N inorganic	5825	7456	3.38
100% N as deep litter sheep manure (DLSM)	4072	5417	2.33
75% N as DLSM + 25% N inorganic	4113	5580	2.41
50% N as DLSM + 50% N inorganic	4538	5990	2.60
25% N as DLSM + 75% N inorganic	4990	6402	2.74
Control (No N)	3060	4407	2.01
CD (P = 0.05)	134	279	

SUBSTITUTION OF INORGANIC POTASSIC FERTILISER THROUGH RICE HUSK ASH IN RICE

Source of K	Grain yield (kg/ha
No potassium	3998
50 kg K2O/ha as muriate of potash	4750
25 kg K2O/ha as MOP + 25 kg K2O/ha through rice husk ash	4772
37.5 kg K2O/ha as MOP + 12.5 kg K2O/ha through rice husk ash	4780
50 kg K2O through rice husk ash	4781
CD (P = 0.05)	27

Substitution of Inorganic Potassic Fertiliser through Organic Sources in Rice

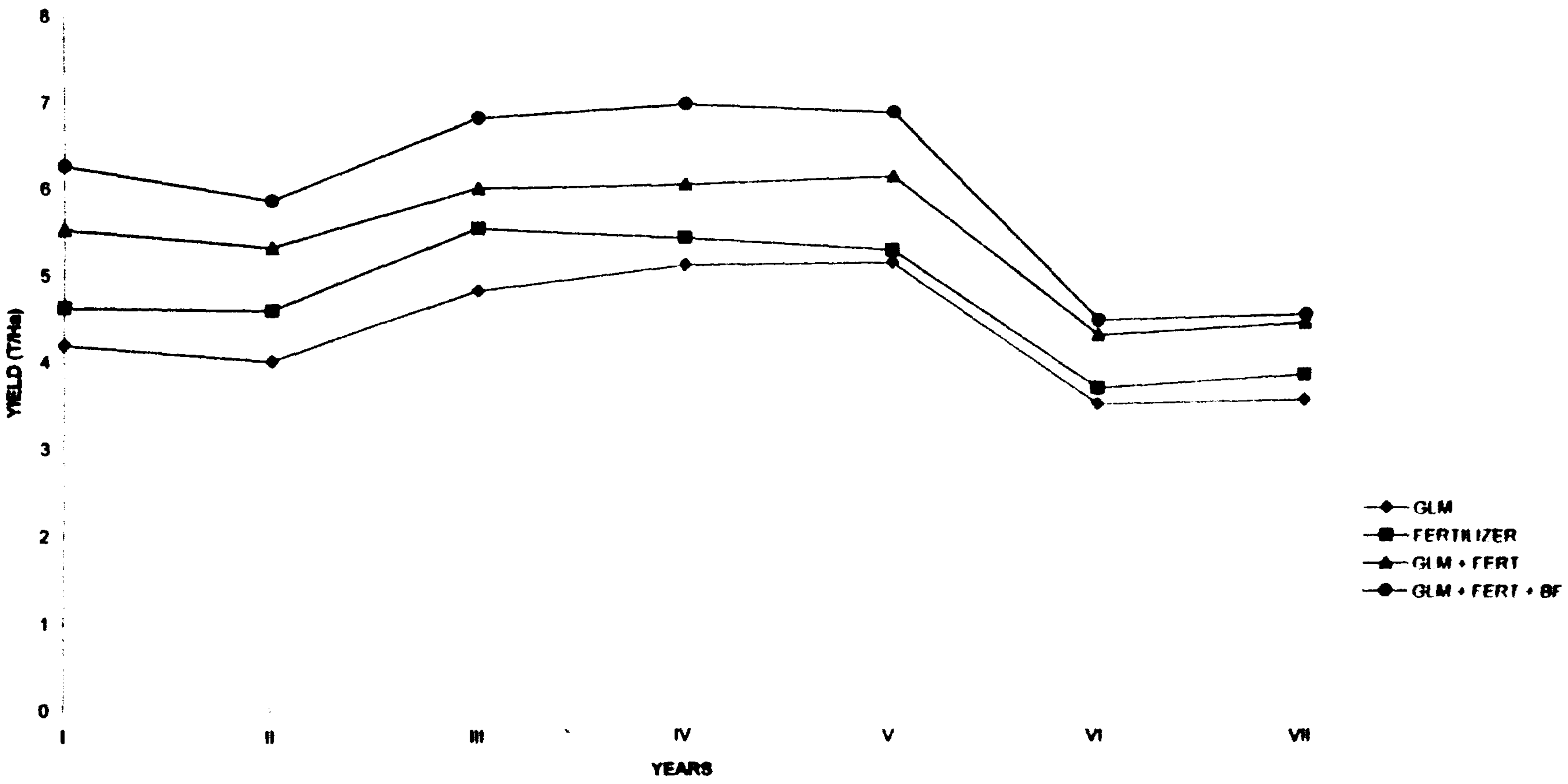
Source of K	Grain Yield (kg/ha)	B:C
Control (No K)	4525	2.96
100% K (50 kg/ha) as muriate of potash	5251	2.51
25% K as rice husk ash + 75% K as MOP	5666	3.17
50% K as rice husk ash + 50% K as MOP	5383	2.90
75% K as rice husk ash + 25% as MOP	5174	2.73
100% K as rice husk ash	4928	2.59
25% K as coir pith + 75% K as MOP	5474	3.03
50% K as Coir pith + 50% K as MOP	5166	2.72
75% K as Coir pith + 25% K as MOP	5109	2.58
100% K as Coir pith	4795	2.29
25% K asGreen leaf manure + 75% K as MOP	5381	2.95
50% K as Green leaf manure + 50% K as MOP	5083	2.74
75% K as Green leaf manure + 25% K as MOP	4858	2.59
100% K as Green leaf manure	4622	2.32
CD (P = 0.05)		

Nutrient Management in Rice Based Cropping Systems

Cropping system approach in nutrient management is a component of integrated nutrient management. It often enables efficient use of applied fertilizers and also makes possible reduction in fertilizer levels to succeeding crops.

In continuous cropping of rice over seven seasons, consistently higher grain yields were recorded with the integrated nutrient management system, of green leaf manure + fertiliser + biofertiliser over continuous use of inorganic fertilisers alone. Sustainable Yield Index was high at 0.70 with INM as against only 0.57 with inorganics alone (Ganesan, 1997).

In a two year study by Manoharan (1997) involving rice-rice-sesamum sequential cropping, application of organic manures such as green manure, farm yard manure, poultry manure and biodigested slurry increased the yield of rice during both seasons by 5.9 to 19,2 per cent over no organics. Higher net returns in rice-rice-sesamum crop sequence was realised through the incorporation of green leaf manure at 6.25 t/ha prior to planting of first rice crop, addition of 120 kg N/ha



CONTINUOUS USE OF ORGANIC MANURES, INORGANIC FERTILIZERS AND INM IN RICE NUTRITION

to first and second season rice crops and application of recommended NPK/ha to rice fallow sesamum.

In rice-cotton sequential cropping, cotton crop raised after rice which received integrated nutrient supply through green manure, fertiliser and biofertiliser performed better than the cotton crop following rice which received only inorganic fertilisers or organic manures alone. When INM was adopted for the preceding rice crop, cotton crop which received only 50% of recommended NPK yielded on par (1375 kg kapas/ha) with the crop receiving 100% recommended NPK and following rice crop which received only inorganic fertilisers (1349 kg kapas/ha). When 100% NPK was applied to cotton following rice with INM, the kapas yield was significantly increased (1606 kg/ha) (Jeya Selvin Inbaraj, 1995)

In rice-blackgram sequence, green leaf manure incorporation at 10 days before planting rice and application of recommended N to rice resulted in higher grain yield in rice as well as in the following blackgram crop. Grain yield of blackgram was significantly higher when preceding rice crop received green leaf manure incorporation than after rice which received no green leaf manure (Deepthi, 1995).

EFFECT OF CONTINUOUS APPLICATION OF ORGANIC AND INORGANIC NUTRIENT SOURCES ON YIELD AND SUSTAINABLE YIELD INDEX IN RICE

Treatment	Grain Yield (t/ha)							Sustainable Yield Index
	Crop I	Crop II	Crop III	Crop IV	Crop V	Crop VI	Crop VII	
Biofertilisers (BF)	2.73	2.95	3.59	3.63	3.55	2.86	2.93	0.39
FYM @ 25 t/ha	2.93	3.01	3.66	3.83	4.11	3.23	3.29	0.42
GLM @ 10 t/ha	4.20	4.01	4.86	5.17	5.21	3.56	3.62	0.52
Inorganic fertilisers(fert)	4.63	4.60	5.59	5.49	5.36	3.75	3.92	0.57
Fert + BF	4.57	4.59	5.55	5.72	5.77	3.87	4.03	0.58
FYM @ 12.5 t/ha + Fert	4.73	4.68	5.60	5.83	5.93	4.05	4.23	0.60
GLM @ 6.25 t/ha + Fert	5.53	5.33	6.06	6.12	6.23	4.37	4.53	0.66
FYM + BF	3.00	3.05	3.76	3.92	4.10	3.33	3.38	0.44
GLM + BF	3.73	3.66	4.33	4.45	4.62	3.50	3.58	0.50
FYM + Fert + BF	4.80	4.79	5.64	5.89	6.03	4.18	4.33	0.61
GLM + Fert + BF	6.27	5.88	6.88	7.06	6.98	4.55	4.63	0.70
Control	2.67	2.85	3.15	2.97	2.47	2.45	2.53	0.35

Effect of Organic Manures in Rice-Rice Sesamum Sequence

Organic Manure	Total Rice Grain Yield t/ha	
	I Crop Cycle	II Crop Cycle
No organic manure	13.16	12.66
Green manure	15.44	15.09
Farm yard manure	14.35	14.50
Poultry manure	13.94	13.54
Biodigested slurry	14.36	13.79
SEd	0.31	0.29
CD (P = 0.05)	0.71	0.67

Effect of Nutrient Management to Rice on Kapas Yield of Succeeding Cotton in Rice-Cotton Sequence

Nutrtient applied to cotton	Kapas yield of cotton kg/ha *Nutrient management to rice*		
	Green manure + Azospirillum	Inorganic NPK alone	Inorganic + Green manure + Azospirillum
Control	493	656	721
100% NPK	931	1349	1606
75% NPK	876	1264	1478
50% NPK	794	1177	1375
75% N + FYM + Azospirillum	800	1233	1468
50% N + FYM + Azospirillum	738	1099	1348
100% N + FYM + Azospirillum	628	802	873
SEd	28		
CD (P = 0.05)	77		

NITROGEN APPLICATION AND GREEN MANURE INCORPORATION IN RICE-BLACKGRAM SEQUENCE

Nutrient management to rice	N levels to rice (kg/ha)					
	60		90		120	
	Rice	Black gram	Rice	Black gram	Rice	Black gram
	kg/ha					
No green leaf manure - N at transplanting	4162	390	4304	414	4248	420
No green leaf manure - N at 15 DAT	4235	419	4347	425	4387	440
GLM incorporation - planting rice immediately - N at planting	4241	426	4459	456	4678	476
GLM incorporation and immediate planting of rice - N at 15 DAT	4538	492	4807	504	4964	514
GLM incorporation - planting rice 10 days later - N at GLM incorporation	4521	432	4555	450	4560	464
GLM incorporation -planting rice 10 days later - N at planting	4828	439	5404	479	5523	500
GLM incorporation - planting rice 10 days later - N at 15 DAT	4549	460	5048	490	5202	505
	SEd			CD (P = 0.05)		
Rice yield	196			399		
Blackgram yield	250			NS		

NUTRIENT MANAGEMENT IN WETSEEDED RICE

Wetseeding of rice is advocated in the Command Areas when water release is uncertain and labour for transplanting is scarce. The alternate wetting and drying in the early stages of crop establishment in wetseeded rice is likely to increase the leaching loss of N applied basally at sowing. Experiments conducted at AC & RI, Killikulam confirmed the advantage of skipping basal nitrogen at sowing and commencing N application from 15 - 20 DAS.

Venkatachalapathy (1997) observed that application of 120 kg N/ha in four equal splits i.e. 25 DAS, active tillering, panicle initiation and heading stage, increased the grain yield of wetseeded rice by 556 to 708 kg/ha over the same level of N applied in 3 splits including one at sowing.

In another experiment on suitable time of application of nutrients to wetseeded rice Marimuthu and Srinivasan (1997) reported that application of 120 kg N and 60 kg K_2O/ha in four equal splits at 15/25 DAS, 35 DAS, 50 DAS and 65 DAS registered significant increase in rice grain yield over 3 or 4 splits including the basal application at sowing. One late split application of N and K proved to be more beneficial for higher yield of grain as well as straw.

EFFECT OF SPLIT APPLICATION OF N IN WETSEEDED RICE

N Splits (120 kg/ha)					Yield (kg/ha)	
Sowing	25 DAS	AT	PI	Heading	Grain	Straw
50%	-	25%	25%	-	3786	6703
-	50%	25%	25%	-	3634	6541
-	25%	25%	25%	25%	4342	7469
SEd					33	18
CD (P = 0.05)					66	37

EFFECT OF SPLIT APPLICATION OF N AND K IN WETSEEDED RICE

N and K splits kg/ha							Grain yield kg/ha			
DAS	0	15	25	35	50	65	Kar	Pishanam	Late Pishanam	Mean
N	60	-	-	30	30	-	3228	4389	4178	3994
K	30	-	-	-	30	-				
N	60	-	-	30	30	-	3238	4306	4067	3917
K	20	-	-	20	20	-				
N	-	60	-	30	30	-	4137	4333	3650	3943
K	-	20	-	20	20	-				
N	-	-	60	30	30	-	3928	4000	4542	4253
K	-	-	20	20	20	-				
N	30	-	-	30	30	30	4078	4500	4697	4493
K	15	-	-	15	15	15				
N	-	30	-	30	30	30	4233	5194	4649	4682
K	-	15	-	15	15	15				
N	-	-	30	30	30	30	4550	4833	5067	4880
K	-	-	15	15	15	15				
CD (P = 0.05)							550	459	641	

NUTRIENT MANAGEMENT IN IRRIGATED DRYLAND CROPS

SORGHUM

Studies on nutrient management with different organic sources, varying levels of N and biofertiliser (Azospirillum) in irrigated sorghum emphasised the need for integrated nutrient management. Even at 50% of soil test based N recommendation, inclusion of FYM/composted coir pith resulted in grain yield on par with 100% of soil test based N level without any organics. Seed and soil inoculation of azospirillum further enhanced the sorghum grain yield. Highest grain yield of 5218 kg/ha was recorded with FYM/composted coirpith @ 12.5 t/ha + 100% STL based N level + azospirillum as against only 4296 kg/ha with 100% inorganic N alone (Gomathinayagam, 1996).

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT IN SORGHUM

	Grain Yield (kg/ha)			
	No Manure	FYM	CCP	Mean
100% N	4296	5210	5170	4892
100%N + Azospirillum	4378	5281	5218	4952
75% N	4181	5070	5030	4760
75% N + Azospirillum	4328	5241	5199	4923
50% N	3534	4948	4835	4431
50% N + Azospirillum	4027	5035	4995	4686
Mean	4124	5128	5075	
	N	Manure	N x M	
CD (P = 0.05)	109	116	212	

GROUNDNUT

In an experiment on yield maximisation in irrigated groundnut TMV 7 application of 12.5 t/ha FYM, 34:17:54 kg NPK/ha at sowing, 17 kg P_2O_5/ha at 30 DAS and 400 kg Gypsum/ha at 40 DAS increased the pods per plant, pod weight and pod yield. With this nutrient management system, high pod yield of 2198 kg/ha in summer and 2067 kg/ha in winter were realised (Kumaran, 1996).

INFLUENCE OF LEVEL OF N, TIME OF P APPLICATION, FYM AND GYPSUM IN GROUNDNUT

FYM t/ha	Basal N kg/ha	Basal P kg/ha	P at 30 DAS kg/ha	Gypsum at 40 DAS kg/ha	Pod Yield (kg/ha)	
					Summer	Winter
-	17	34	-	-	1732	1641
-	17	17	17	-	1741	1650
-	17	17	17	400	1819	1715
12.5	17	34	-	-	1885	1793
12.5	17	17	17	-	1925	1814
12.5	17	17	17	400	1987	1837
-	34	34	-	-	2014	1872
-	34	17	17	-	2051	1901
-	34	17	17	400	2080	1932
12.5	34	34	-	-	2091	1967
12.5	34	17	17	-	2104	1978
12.5	34	17	17	400	2198	2067
CD (P = 0.05)					15	23

SESAMUM

In irrigated sesamum raised during Feb. - May, application of 40 kg N/ha in two equal splits, half as basal and the rest at 30 DAS recorded higher seed yield of 870 kg/ha besides registering a high B:C ratio of 4.88 (Natarajan, 1996).

EFFECT OF N LEVELS AND TIME OF APPLICATION IN IRRIGATED SESAMUM

N Level kg/ha	Basal	30 DAS	Grain Yield kg/ha	B:C
20	100%	-	761	4.31
20	50%	50%	777	4.40
40	100%	-	809	4.53
40	50%	50%	870	4.88
60	100%	-	861	4.72
60	50%	50%	868	4.81
CD (P = 0.05)			17	-

BLACKGRAM

The significance of micronutrient nutrition to blackgram was brought out in a study by Subramanian (1995). Seed treatment with ammonium molybdate 25 ppm + $ZnSO_4$ 10 ppm + $FeSO_4$ 100 ppm and foliar application of DAP 1% + urea 0.5%+ $MgSO_4$ 05% + $ZnSO_4$ 0.25% was the most effective nutrient management system, yiedling 1420 kg/ha of blackgram grain.

NUTRIENT MANAGEMENT IN BLACKGRAM

Treatment	Grain kg/ha	Protein %
DAP 2% + NAA 40 ppm Spray	1067	23.52
Seed treatment with 25 ppm Am.molybdate + 100 ppm $ZnSO_4$ + 100 ppm $FeSO_4$	1233	22.63
DAP 1% + 0.5% urea + 0.5% $MgSO_4$ + 0.25% $ZnSO_4$ spray	1066	23.01
Seed treatment with 25 ppm Am. molybdate + $ZnSO_4$ 100 ppm + $FeSO_4$ 100 ppm and spray of 2% DAP + 40 ppm NAA	1250	22.92
Seed treatment with 25 ppm Am.molybdate + 100 ppm $ZnSO_4$ + 100 ppm $FeSO_4$ and spray of 1% DAP + 0.5% urea + 0.5% Mg SO_4+ 0.25% $ZnSO_4$	1420	24.1
Control	894	21.4
CD (P =.005)	120	

SOYBEAN

In irrigated soybean, phosphorus at 80 kg/ha was needed to maintain high yield level. Regarding form of P source, at any level of P application, a combination of single superphosphate + Mussorie Rock Phosphate in 1:1 ratio (nutrtient basis) along with soil application of phosphobacteria was the best phosphorus management practice (Mahalingam, 1994).

EFFECT OF LEVELS AND SOURCES OF P IN SOYBEAN

P Source	P level (kg/ha)					
	40		60		80	
	Yield kg/ha	B:C	Yield kg/ha	B:C	Yield kg/ha	B:C
Single Superphosphate	-	-	-	-	1770	2.72
Rock Phosphate + Phosphobacteria	1321	2.41	1421	2.47	1406	2.33
SSP + RP (1:)	1387	2.50	1633	2.77	1592	2.55
SSP + RP (1:1) + PB	1407	2.51	1678	2.82	1729	2.75
CD (P = 0.05)	51					

FODDER SORGHUM + COWPEA INTERCROPPING

Fertiliser management studies were conducted in fodder sorghum + cowpea intercropping sown in different proportions. Application of 60 kg N/ha to sorghum + cowpea sown in 2:1 proportion resulted in high green fodder yield of 62.08 t/ha (Sornamanickam, 1994).

EFFECT OF N LEVELS ON TOTAL GREEN FODDER YIELD IN FODDER SORGHUM + COWPEA INTERCROPPING

Cropping System	Total green fodder yield (t/ha) under N levels (kg/ha)				System Mean
	0	20	40	60	
Sorghum + Cowpea 1:1	24.09	29.92	34.77	37.62	31.60
Sorghum + Cowpea 2:1	33.36	44.83	58.17	62.08	49.61
Sorghum + Cowpea 2:2	31.62	37.08	44.62	53.43	41.74
Sole Sorghum	43.04	46.38	49.90	56.60	48.98
Sole Cowpea	20.71	22.33	27.56	33.41	26.00

	SEd	CD (P = 0.05)
System	0.35	0.71
N	0.28	0.58
S x N	0.77	1.62

COTTON + BLACKGRAM INTERCROPPING

In cotton + blackgram intercropping application of 60 kg N/ha + Azospirillum seed and soil inoculation produced yields of cotton and blackgram that were comparable with 80 kg N/ha applied to the system. Net returns were higher when cotton was sown in paired rows and blackgram as intercrop in two rows between pairs of cotton rows and supplied with 60 kg N + azospirillum than the same cropping system applied with 80 kg N/ha alone. Soil organic carbon and available N status were higher after cotton + blackgram intercropping and this residual effect increassed the yield of succeeding rice over the crop following sole cotton (Krishnasamy, 1993).

N Management In Cotton + Blackgram Intercropping System

Cropping System	Kapas Yield (kg/ha)					
	40 N	40 N + Azo	60 N	60 N + Azo	80 N	80 N + Azo
			1990			
Cotton Sole Crop	1828	-	2142	-	2410	2127
Cotton in Uniform row + 1 row blackgram	1718	-	1840	-	1920	1826
Cotton in paired row + 1 row blackgram	1767	-	1910	-	2019	1899
N Mean	1771	-	1964	-	2122	
			1991			
Cotton Sole Crop	1950	2197	2222	2395	2438	2240
Cotton in Uniform row + 1 row blackgram	1705	1843	1932	1970	2018	1894
Cotton in paired row + 1 row blackgram	1695	1920	2006	2074	2120	1963
N Mean	1783	1987	2054	2123	2192	
		1990			1991	
System	73		156	41		102
N	73		149	47		95
S x N	99		200	84		205

MAIZE + PULSES INTERCROPPING

Cowpea, soybean and redgram were intercropped with maize under normal row and paired row planting systems. Grain yield of maize was increased with cowpea and soybean as intercrops in either system of planting. Maize yield with redgram was comparable to sole maize yield in paired row planting only. When intercropped with pulses, application of 75% N and 125% P recommended to sole maize produced maize yield on par with 100% N and P. However, the overall yield advantage and economics of intercropping system were the highest when 100% N + 125% P of recommended level to sole maize was applied to the intercropping systems (Seenivasan, 1997).

Nutrient Management in Maize + Pulse Intercropping Systems

Cropping System	Maize grain kg/ha					Intercrop grain kg/ha					B:C Ratio			
	100%NP	75%N 100%P	100%N 125%P	75%N 125%P	Mean	100%NP	75%N 100%P	100%N 125%P	75%N 125%P	Mean	100%NP	75%N 100%P	100%N 125%P	75%N 125%P
Maize sole crop	4446	4195	4670	4436	4437	-	-	-	-	-	1.77	1.71	1.81	1.76
Maize + cowpea (UR)	4611	4559	4884	4612	4666	374	362	391	380	377	2.09	2.11	2.16	2.09
Maize + cowpea (PR)	4837	4587	5013	4782	4805	425	405	448	431	427	2.23	2.16	2.26	2.20
Maize + soybean (UR)	4720	4623	4908	4752	4751	465	438	496	475	468	2.12	2.11	2.16	2.13
Maize + soybean (PR)	4983	4779	5103	4870	4933	524	507	558	530	530	2.26	2.22	2.27	2.22
Maize + redgram (UR)	4339	4275	4548	4336	4374	321	303	345	326	324	2.04	2.03	2.09	2.03
Maize + redgram (PR)	4426	4270	4596	4420	4428	251	233	275	256	254	1.96	1.93	2.01	1.96
Mean	4623	4470	4817	4601	-	-	-	-	-	-		-	-	-
	SEd	CD				SEd	CD							
System	17	37				-	-							
Fertilizer	17	35				5	12							
S x F	46	92				-	-							

WEED MANAGEMENT

Weed management was a major field of research at Killikulam during the decade from 1987 to 1997. The weed management research programmes enabled the identificationn of major weed species associated with different crops and the recommendation of economic and efficient weed management technology for many crops and cropping systems practised in Tirunelveli and Thoothukudi districts.

WEED FLORA AT KILLIKULAM

A total of 43 different species of weeds grouped under grasses, sedges and broad leaved weeds as listed below were found to occur at Killikulam.

Echinochloa colonum	*Coccinia indica*
Echinochloa crusgalli	*Solanum nigrum*
Panicum sp.	*Gomphrena decumbens*
Cyperus rotundus	*Parthenium hysterophorus*
Cyperus iria	*Celosia argentea*
Cyperus difformis	*Cleome viscosa*
Fimbristylis miliacea	*Gynandropsis pentaphylla*
Eclipta alba	*Chloris barbata*
Rotella densiflora	*Dactyloctenium aegyptium*
Sphenoclea zeylonica	*Achyranthes aspera*
Ludwigia parviflora	*Boerhaavia diffusa*
Commelina benghalensis	*Croton sparsiflorus*
Alternanthera echinata	*Euphorbia hirta*
Centella asiatica	*Lantana camara*
Ammannia baccifera	*Leucas aspera*
Lippia nodiflora	*Ocimum sanctum*
Cynodon dactylon	*Clitoria ternata*
Phyllanthus maderaspatensis	*Calotropis gigantea*
Phyllanthus niruri	*Corchorus olitorius*
Acalypha indica	*Tribulus terrestris*
Amaranthus viridis	*Solanum xanthocarpum*
Abutilon indicum	*Vernonia cinerea*

WEED MANAGEMENT IN TRANSPLANTED RICE

Summer ploughing twice or application of paraquat at 2 lit/ha one week before puddling helped to reduce the weed density to a greater degree than puddling alone in transplanted rice. Preemergence application of anilofos 0.3 kg/ha + 2, 4 - DEE 0.5 kg/ha provided more effective control of weeds over handweeding twice (Alwar Arunachalam, 1992)

Neemcake powder proved to be an effective herbicide carrier. Preemergence application of butachlor at 1.5 kg/ha mixed with 30 kg of powdered neemcake controlled the weeds more effectively and improved the rice grain yield in a three season trial (Mohamed Ali, 1991).

EFFECT OF HERBICIDE CARRIER ON WEED CONTROL IN TRANSPLANTED RICE

Herbicide Carrier On Weed Control For Planted Rice	Rice grain yield t/ha		
	85-86	86-87	87-88
Neem cake powder 15 kg	5.15	4.96	5.07
Neem cake powder 30 kg	5.21	5.09	5.18
Neem cake powder 45 kg	5.17	4.97	5.14
Neem coated urea 15 kg	4.98	4.71	4.78
Neem coated urea 30 kg	4.99	4.72	4.79
Neem coated urea 45 kg	5.00	4.74	4.71
Sand 50 kg	4.94	5.00	4.92
Hand weeding twice	4.72	4.66	4.71
Unweeded check	4.20	4.13	4.21
CD (P = 0.05)	0.18	0.17	0.21

A new, low dose, high efficiency herbicide, metsulfuron methyl was evaluated to determine optimal dose and time of application during late pishanam and early Kar seasons with transplanted rice IR 20 and ASD 16 respectively. Metsulfuron methyl applied at 0.008 kg/ha at 3 to 9 DAT recorded high weed control efficiency of 87-90% during late Pishanam and 77-82% during early Kar season. Metsulfuron methyl was more effective than anilofos and butachlor and resulted in grain yield comparable with handweeding twice (Narayanan, 1994).

A study on continuous use of same herbicide and rotation of herbicides was undertaken for five seasons during 1994 - 1996 by Balasubramanian (1996). The effect of summer tillage and preplant application of glyphosate on weed incidence and control in rice - rice - blackgram sequence was also evaluated. Glyphosate application prior to planting of first season rice increased the grain yield of rice by 6.9 to 10.4 per cent over tillage at planting. Summer tillage also increased the grain yield by 4.7 to 8.6 per cent over conventional puddling at planting. Among the herbicide treatments, continuous use of pretilachlor or rotation of thiobencarb and pretilachlor in alternate seasons (followed by one handweeding) provided the most effective weed control and recorded grain yield on par with handweeding twice. Continuous application of butachlor or anilofos resulted in lower grain yield than the above treatments.

METSULFURON METHYL FOR WEED CONTROL IN RICE

Herbicide	Dose kg/ha	At DAT	Weed dry weight at 40 DAT (kg/ha)		Rice grain yied kg/ha		WCE %	
			1992	1993	1992	1993	1992	1993
Metsulfuron methyl	0.004	3	265	276	4762	4325	79	69
Metsulfuron methyl	0.004	6	201	291	4676	4272	77	68
Metsulfuron methyl	0.004	9	163	277	4639	4196	74	68
Metsulfuron methyl	0.006	3	271	283	4736	4669	81	61
Metsulfuron methyl	0.006	6	218	297	4715	4303	85	66
Metsulfuron methyl	0.006	9	202	271	4719	4552	83	70
Metsulfuron methyl	0.008	3	112	151	5132	5175	90	81
Metsulfuron methyl	0.008	6	127	124	5607	5214	89	77
Metsulfuron methyl	0.008	9	186	157	5521	5392	88	83
Anilofos	0.4	3	270	316	4554	4387	85	62
Anilofos	0.4	6	260	298	4976	4436	86	69
Anilofos	0.4	9	268	296	4589	4582	71	61
Butachlor	1.5	3	160	233	4857	4952	84	72
Butachor + 2, 4 DEE	1.0 + 0.5	3	218	258	4653	4955	89	69
Hand weeding	Twice	20 & 40	98	93	6090	5871	86	87
Unweeded check	-	-	481	603	3440	3190	-	-
CD (P = 0.05)			62	10	496	522		

Note: All the herbicide treatments were followed by one hand weeding

Effect of Continuous Use and Rotation of Herbicides in Rice

Weed Management		Grain yield kg/ha			
First Crop (*Kharif*)	Second Crop (Rabi)	1994		1995	
		Kharif	*Rabi*	*Kharif*	***Rabi***
Thiobencarb	Thiobencarb	5228	4505	5641	**4743**
Butachlor	Butachlor	4951	4246	5386	**4466**
Pretilachlor	Pretilachlor	5260	4548	5674	**4800**
Anilofos	Anilofos	4859	4168	5369	**4415**
Thiobencarb	Butachlor	5214	4310	5450	**4608**
Thiobencarb	Pretilachlor	5226	4548	5688	**4827**
Thiobencarb	Anilofos	5210	4296	5371	**4528**
Butachlor	Pretilachlor	4940	4540	5632	**4808**
Butachlor	Anilofos	4944	4280	5380	**4491**
Anilofos	Pretilachlor	4860	4520	5653	**4781**
HW twice	HW twice	5214	4544	5651	**4835**
Unweeded	Unweeded	2201	1763	2335	**1920**
SEd		138	123	119	**123**
CD (P = 0.05)		276	246	238	**246**

In another study by Asokaraja (1994), preemergence application of pretilachlor 0.5 kg/ha + 2, 4 - DEE 0.5 kg/ha followed by one handweeding was more effective than handweeding twice or butachlor followed by hand weeding. In a two year study on rice-rice sequence, the combination of pretilachlor + 2, 4 - DEE + one hand weeding recorded the highest total marginal return.

WEED DENSITY AND DMP UNDER PRE- AND POST-PLANTING WEED MANAGEMENT IN RICE

Weed Management	Mean of Two Seasons	
	Weed Density (no. m^{-2})	Weed DMP (kg/ha)
Preplanting		
Summer ploughing	96.8	102.7
Paraquat 2 lit/ha	111.7	112.3
Farmer's method	122.4	109.1
Post-planting		
Butachlor 0.75 kg + one HW	75.0	82.2
Butachlor 1.25 kg + one HW	62.5	60.4
Anilofos 0.3 kg + one HW	38.8	38.0
Anilofos 0.4 kg + one HW	53.2	44.0
Hand weeding twice	95.4	76.2
Unweeded check	312.8	361.4
CD (P = 0.05)		
Pre-plant	2.6	1.3
Post-plant	3.0	2.8

WEED MANAGEMENT IN RICE-RICE-BLACKGRAM SEQUENTIAL CROPPING

Weed Management	Rice grain yied (kg/ha)			
	1991-92		1992-93	
	Kharif	Rabi	Kharif	Rabi
Pretilachor 0.75 kg fb HW	5044	5329	5215	5113
Pretilachlor 0.5 kg + 2, 4 DEE 0.5 kg fb HW	5271	5847	5422	5443
Butachlor 1.00 kg fb HW	4331	4543	4485	4598
Butachlor 1.00 kg + 2, 4 DEE 0.5 kg fb HW	4607	4764	4745	4844
Hand weeding twice	4887	5059	5022	5020
Unweeded check	3642	3843	3524	3754
SEd	196	166	117	184
CD (P = 0.05)	406	331	238	375

WEED MANAGEMENT IN WETSEEDED RICE

In wetseeded rice culture where sprouted seeds are direct sown in puddle, weed competition is a major constraint for higher yield. An effective integrated weed management routine is of paramount importance in wetseeded rice.

Application of thiobencarb at 1.25 kg/ha on 6 DAS or propanil at 1.5 kg/ha on 10 DAS followed by one hand weeding at 35 DAS was very effective in checking weed growth and increasing the grain yield of wetseeded rice. These integrated weed management treatments were as effective as hand weeding twice. However, thiobencarb applied at last puddling before sowing reduced the yield considerably. Integrated weed management or hand weeding twice improved the rice grain yield by 1.55 - 1.61 t/ha during Kar and by 1.57 - 1.61 t/ha during Pishanam season over unweeded check (Krishnasamy, 1992).

In another experiment to evaluate various herbicides in wetseeded rice, pre-emergence application of pendimethalin at 1.25 kg/ha / thiobencarb at 1.5 kg/ha / anilafos at 0.4 kg/ha followed by one hand weeding proved to be as effective as hand weeding twice in controlling weed growth and increasing the grain yield (Ramakrishnan, 1992).

Grain yield reduction due to unchecked weed competition was to the tune of 2084 to 2160 kg/ha. Hand weeding twice or pre-emergence application of butachlor followed by one hand weeding considerably increased the benefit cost ratio. Herbicide + hand weeding was more economical than hand weeding twice under broad casting whereas hand weeding was more effective under drill sowing (Venkatachalapathy, 1997).

A comparison of herbicides viz., cinmethyline, pretilachlor + safener and thiobencarb in wetseeded rice revealed that pretilachlor + safener applied at 0.45 kg/ha at 4 DAS followed by one hand weeding at 25 DAS was the most effective integrated weed management routine for wetseeded rice. Grain yield increase with the above IWM practice ranged from 37 to 110 per cent over unweeded check during two seasons of study . Cinmethylin at higher dose of 0.06 kg/ha was slightly phytotoxic to wetseeded rice. Weed control efficiency of pretilachlor + safener was 82-86% on par with hand weeding twice (Ramesh Babu, 1994).

EVALUATION OF HERBICIDES FOR WEED CONTROL IN WETSEEDED RICE

Treatment	Weed density m-2		Weed DMP kg/ha		Grain yield t/ha	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Unweeded check	42.6	69.8	780	893	3.65	3.35
Handweeding twice	9.7	12.7	291	252	5.26	4.96
Thiobencarb 1.25 kg/ha at last puddling + HW	26.5	27.7	648	437	3.63	3.29
Thiobencarb 1.25 kg/ha on 6 DAS + HW	20.4	21.9	390	270	5.25	4.94
Thiobencarb 1.25 kg/ha on 8 DAS + HW	19.0	18.4	400	283	5.25	4.96
Propanil 1.5 kg/ha on 10 DAS + HW	15.2	20.2	386	293	5.20	4.92
CD (P = 0.05)	0.03	0.1	111	50	0.11	0.63

EVALUATION OF HERBICIDES IN WETSEEDED RICE

Treatment	Rice grain yield (t/ha)				
	89-90	90-91		91-92	
	Rabi	Kharif	Rabi	Kharif	Rabi
Unweeded check	4.45	4.29	4.51	4.16	4.27
Handweeding twice	5.53	5.41	5.47	5.46	5.29
Thiobencarb 1.50 kg + HW	5.41	5.01	5.04	6.07	5.94
Pendimethalin 1.25 kg + HW	5.45	5.27	5.18	6.21	6.16
Thiobencarb 1.5 kg + 2, 4 - DEE 1 Kg + HW	5.05	5.73	5.71	5.65	5.69
Pendimethalin 1.25 kg + 2, 4 - DEE 1 kg + HW	6.40	6.13	6.11	5.48	5.44
Anilofos 0.4 kg + HW	-	-	6.30	5.30	4.78
Anilofos 0.4 kg + 2, 4 - DEE 1 kg + HW	-	-	5.45	5.37	4.84
CD (P = 0.05)	0.86	0.16	0.10	0.11	0.11

EFFECT OF WEED MANAGEMENT UNDER DIFFERENT METHODS OF SOWING OF WETSEEDED RICE

Method of sowing	Grain yield kg/ha			B:C ratio		
	Un-weeded check	HW twice	Herbi-cide + HW	Un-weeded check	HW twice	Herbi-cide + HW
Broadcasting	2150	4700	4719	1.20	2.68	3.06
Seed drill sowing at 2 cm intrarow spacing	3083	5243	5167	2.23	3.13	3.54
Seed drill sowing at 3.5 cm intrarow spaciing	2100	4883	4767	1.24	2.92	3.38
Seed drill sowing at 4.7 cm intrarow spacing	3183	3600	3500	0.41	3.06	2.68
Mean	2167	4927	4667			
	SEd			CD (P = 0.05)		
Sowing method	37			76		
Weed management	33			66		
M x W	57			114		

EFFECT OF SEED RATE ON WEED INCIDENCE IN WETSEEDED RICE

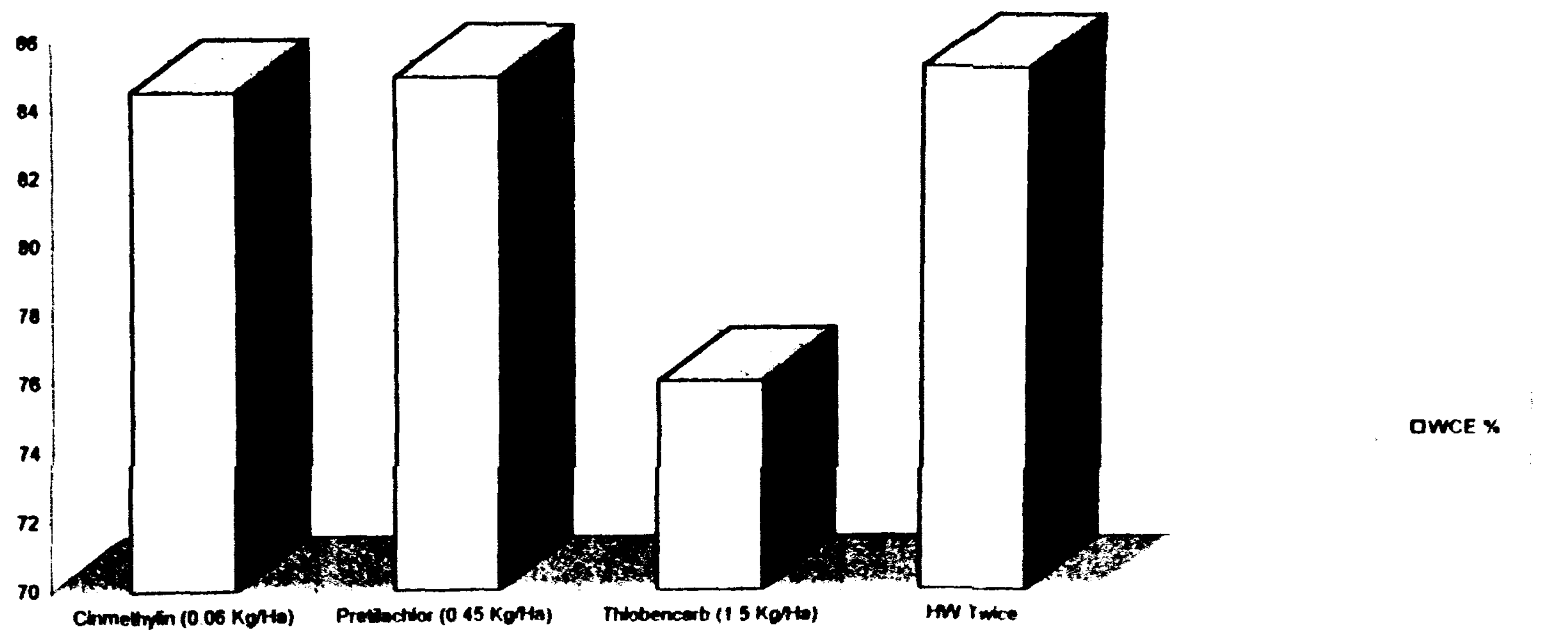
Seed rate kg/ha	Weed DMP kg/ha	Grain Yield t/ha
75	2067	5.31
100	1583	5.42
125	1500	5.41
CD (P = 0.05)	132	0.08

EVALUATION OF HERBICIDE DOSE AND TIME OF APPLICATION IN WETSEEDED RICE

Herbicide	Dose kg/ha	Time of appli-cation	Weed Control Efficiency (%)		Grain Yield kg/ha		Net return per rupee
			Rabi	Kharif	Kharif	Rabi	
Cinmethylin	0.02	6	74.7	69.7	4360	4444	1.14
Cinmethylin	0.02	8	79.2	72.7	4254	4741	1.09
Cinmethylin	0.04	6	69.8	78.9	4487	4874	1.15
Cinmethylin	0.04	8	77.7	77.9	4444	4906	1.13
Cinmethylin	0.06	6	84.7	83.8	4003	4021	0.92
Cinmethylin	0.06	8	84.6	87.1	4063	4423	0.92
Pretilachlor + safener	0.30	4	86.6	76.6	4655	4910	1.15
Pretilachlor + safener	0.30	6	83.3	79.4	4719	5079	1.18
Pretilachlor + safener	0.30	8	82.5	79.8	4762	4952	1.20
Pretilachlor + safener	0.45	4	85.9	85.3	5116	5333	1.27
Pretilachlor + safener	0.45	6	83.4	84.1	5079	5122	1.26
Pretilachlor + safener	0.45	8	85.1	84.7	4973	5037	1.21
Pretilachlor + safener	0.60	6	82.7	83.5	4978	5269	1.13
Pretilachlor + safener	0.60	8	84.9	86.6	4994	4995	1.14
Thiobencarb	1.50	6	77.7	77.6	4656	4698	1.10
Handweeding	Twice	25 & 45	85.5	83.2	4952	4974	1.26
Unweeded check			-	-	2433	3894	0.37
SEd			-	-	132	156	-
CD (P = 0.05)			-	-	268	317	-

Note: In all herbicide treatments, one handweeding was given on 25 DAS

Seed rate and sowing method also influenced weed incidence in wetseeded rice. Ramakrishnan (1992) observed that adoption of a seed rate of 100 - 125 kg/ha reduced the weed DMP to 1500 - 1583 kg/ha as against 2067 kg/ha with a seed rate of 75 kg/ha. Sowing with TNAU Drum Seeder in lines 20 cm enabled a significant reduction in weed DMP (1587 kg/ha) compared to 2363 kg/ha in broadcast method of sowing (Venkatachalapathy, 1997).



WEED CONTROL EFFICIENCY OF HERBICIDES IN WET SEEDED RICE

WEED MANAGEMENT IN RICE FALLOW CROPS

After the harvest of rice crop, blackgram, greengram, sesamum and cotton are raised as rice fallow crops in Tambiraparani Command Area. The major weed flora observed in rice fallow conditions are the following:

Echinochloa colonum, Cyperus rotundus, Cynodon dactylon, Phyllanthus niruri, Eclipta alba, Cleome viscosa, Spaeranthus indicus, Phyllanthus maderaspatensis, Euphorbia hirta, Paspalum sp

Application of pendimethalin at 0.75 kg/ha effectively controlled annual grasses and broadleaved weeds in rice fallow crops. Post-emergence application of Fluazifop-p-butyl at 0.5 kg/ha was able to control emerged grasses only (Mohamed Ali, 1993)

WEED MANAGMENT IN IRRIGATED DRY CROPS

In chillies, preemergence application of fluchloralin at 0.75-1.00 kg/ha followed by a hand weeding at 35 DAS or isoproturon at 0.25-1.00 kg/ha followed by one hand weeding caused considerable reduction in weed DMP. The IWM practice of preemergence application of fluchloralin at 1.00 kg/ha on 3 DAP followed by one hand weeding at 35 DAP resulted in pod yield of chillies comparable to the conventional method of hand weeding twice on 20 and 35 DAP. Border crops of redgram, castor, gourds, sesbania and onion were not affected by fluchloralin and isoproturon (Mohamed Ali, 1991).

EFFECT OF WEED MANAGEMENT IN CHILLIES

Weed Management	Weed DMP (g m^{-2})		Dry pod yield kg/ha	
	1989	1990	1989	1990
Hand weeding twice	21.6	59.8	1358	1353
Isoproturon 0.25 kg/ha + HW	14.0	46.8	1228	1223
Isoproturon 0.50 kg/ha + HW	9.6	33.9	1296	1320
Fluchloralin 0.75 kg/ha + HW	10.8	42.0	1281	1271
Fluchloralin 01.00 kg + HW	6.8	28.3	1362	1355
CD (P = 0.05)	1.6	1.7	5.6	2.7

The suitability of herbicides for control of *Cyperus rotundus* in chilies was evaluated by Mohamed Ali (1991). Preemergence application of metolachlor at 1.0

kg/ha followed by one hand weeding at 40 DAT was more effective in controlling *Cyperus sp.* than oxyflourfen which also caused phytotoxicity in chillies and onion.

In sorghum + blackgram / cowpea intercropping system preemergence application of metolachor 1.0 kg/ha followed by one hand hoeing on 40 DAS effectively controlled all categories of weeds and improved the yield of both base and inter crops. There was no adverse residual effect due to metolachlor on the succeeding crops of groundnut, soybean and ragi (Solaimalai, 1996).

EVALUATION OF HERBICIDES IN SORGHUM + PULSES INTERCROPPING

Weed Management	Sorghum Yield kg/ha		Blackgram Yield kg/ha		Cowpea Yield Kg/ha	
	Summer	Winter	Summer	Winter	Summer	Winter
Unweeded check	2570	2520	394	393	309	299
Handweeding twice	5140	4550	577	526	429	390
Butachlor + HW	5040	4460	560	510	416	378
Fluchloralin + HW	4930	4380	493	489	366	341
Pendimethalin + HW	5410	4790	656	597	486	443
Metolachlor + HW	5690	5300	668	621	496	461
Isoproturon + HW	-	5040	-	610	-	452
SEd	60	50	12	10	9	1.5
CD (P = 0.05)	120	100	27	23	20	4

Field experiments were conducted during 1993 to 1995 to evaluate the efficiency of preemergence herbicides and their application techniques in cotton based intercropping systems. Cowpea and soybean were raised as intercrops in cotton. Preemergence application of metolachlor 1.0 kg/ha through herbigation followed by one hoeing at 40 DAS effectively checked most of the weeds and recorded weed control efficiency ranging from 86-87%. Yield of cotton kapas as well as grain yield of the inter crops - cowpea and soybean - were considerably improved over unweeded check. Metolachlor application to cotton did not affect the germination and growth of succeeding sorghum crop (Velayutham, 1996).

EFFECT OF HERBICIDES AND THEIR METHOD OF APPLICATION IN COTTON BASED INTERCROPPING SYSTEM

Herbicide	Dose kg/ha	Method	Kapas Yield (kg/ha)							
			1992-93				1994-95			
			Cotton sole	Cotton + Cowpea	Cotton + Soybean	Mean	Cotton sole	Cotton + Cowpea	Cotton + Soybean	Mean
Unweeded check			786	735	763	761	666	632	658	652
Hand weeding twice			1816	1730	1806	1784	1679	1577	1667	1641
Metolachlor	0.75	Herbigation	2226	2070	2182	2159	2073	1929	2006	2006
Metolachlor	1.00	Herbigation	2363	2200	2292	2287	2194	2010	2129	2111
Metolachlor	0.75	Spray	2135	1995	2103	2078	1985	1822	1930	1912
Metolachlor	1.00	Spray	2275	2115	2202	2197	2117	1938	2044	2033
Pendimethalin	0.75	Herbigation	1907	1804	1885	1865	1766	1649	1742	1719
Pendimethalin	1.00	Herbigation	2044	1920	2004	1989	1897	1757	1823	1826
Pendimethalin	0.75	Spray	1839	1740	1821	1800	1700	1595	1686	1660
Pendimethalin	1.00	Spray	1952	1844	1925	1907	1810	1685	1780	1758
			CD (P = 0.05)				CD (P = 0.05)			
System			19				25			
Herbicide			64				54			
S x H			102				90			

Weed management experiment in soybean also established the efficiency of metolachlor. Preemergence application of metolachlor at 0.75 kg/ha followed by one hoeing at 35 DAS recorded weed control efficiency of 86% on par with hand weeding twice and increased the grain yield of soybean by 711 kg/ha over unweeded check (Rajaram, 1993)

EFFECT OF WEED MANAGEMENT IN SOYBEAN

Weed Management	Weed Control Efficiency (%) at 60 DAS	Soybean Yield kg/ha
Unweeded check	-	799
Handweeding twice	86.8	1432
Fluchloralin 1.00 kg + HW	83.7	1259
Metolachlor 0.5 kg + HW	80.8	1176
Metolachlor 0.75 kg + HW	86.6	1510
Metolachlor 1.00 kg + HW	87.0	1498
SEd	0.13	45
CD (P = 0.05)	NS	92

In transplanted ragi, an integrated weed management practice involving the preemergence application of Oxadiazon 0.5 kg/ha at 3 DAT followed by one hand weeding at 30 DAT proved to be more effective in controlling weeds and increasing the grain yield of ragi. Pendimethalin at 0.75 kg/ha and pretilachlor with safener at 0.45 kg/ha also provided effective weed control in transplanted ragi. None of the three herbicides applied to ragi showed any adverse residual effect on blackgram (Balasubramanian, 1996).

EFFECT OF WEED MANAGEMENT METHODS IN TRANSPLANTED RAGI

Weed Management	Grain Yield kg/ha	B:C
Unweeded check	1749	2.14
Handweeding twice	2969	2.76
Pendimethalin 0.75 kg + HW	3107	2.63
Oxadiazon 0.5 kg + HW	3198	2.94
Pretilachlor with safener 0.45 kg + HW	3066	2.81
SEd	63	-
CD (P = 0.05)	133	-

In egg plant (brinjal), mulching with polythene, banana trash or coir pith helped to smother weeds effectively. Herbicides such as pendimethalin, metribuzin and metolachlor were found to be selective for brinjal. Preemergence application of metolachlor at 1.0 kg/ha at 3 DAT followed by one hand weeding at 60 DAT recorded high fruit yield of 44.0 t/ha as against 24.5 t/ha u nder unweeded check and 37.5 t/ha with hand weeding twice (Saravanan Babu, 1994).

EFFECT OF MULCHING AND WEED MANAGEMENT ON FRUIT YIELD OF BRINJAL

	Fruit Yield t/ha				
	Polythene mulch	Banana trash mulch	Coir pirth mulch	No mulch	Mean
Unweeded check	29.3	31.7	27.2	9.6	24.5
Handweeding twice	39.7	46.7	35.8	27.6	37.5
Pendimethalin + HW	43.3	47.6	39.4	30.8	40.3
Metribuzin + HW	39.9	46.2	35.4	26.1	36.9
Metolachlor + HW	46.7	49.8	43.1	36.5	44.0
Mean	39.8	44.4	36.0	26.1	
	SEd		CD (P = 0.05)		
Mulch	0.33		0.80		
Weed Management	0.30		0.61		
M x W	0.60		1.22		

DRY FARMING

Red soils dominate in the dry farming regions of Tirunelveli and Thoothukudi Districts. With their inherent poor water holding capacity coupled with erratic rainfall behaviour, the capability of red soils to support remunerative crop production under rainfed conditions is declining. Uncertainty in yield and unremunerative returns have forced the farmers to abandon annual cropping as a result of which a large stretch of redsoil drylands in the two districts have become degraded wastelands. An immediate revival of efforts to develop vegetative cover to reclaim these wastelands is imperative. The economy in the two districts being predominantly agriculture oriented, concerted research to develop the considerable area under dryfarming is needed. Towards this objectiv, research programmes were undertaken at Department of Agronomy, Killikulam.

In an experiment conducted during 1991-93 to evaluate the suitability of various *in situ* soil moisture conservation practices, for rainfed crops such as horsegram, cowpea, tenai, castor and samai, Velayutham (1993) concluded that contour ploughing was most effective and on par with broad based ridging but distinctly superior to contour bunding. The yield of the crops ranged from 11.5 to 12.13 q/ha in tenai, 9.04 to 9.56 q/ha in cowpea, 7.92 to 7.98 q/ha in horsegram, 7.39 to 7.42 q/ha in castor and 8.75 to 9.02 q/ha in samai (Velayutham, 1993).

EFFECT OF IN SITU MOISTURE CONSERVATION PRACTICES IN RAINFED REDSOILS

Moisture Conservation	Mean Yield of Crops (q/ha)	
	1991-92	1992-93
Contour bunding	8.68	8.05
Contour ploughing	9.74	9.65
Broad based ridging	9.32	9.08
CD (P = 0.05)	0.73	0.40

Surface soil crusting is a serious problem in the rainfed red soils. Apart from reduction in rainfall infiltration and increased runoff, soil crusting also inhibits germination and emergence of seedlings. To assess the relative tolerance of crops to crusting and to evaluate the efficacy of amendments to minimise the effect of crusting on seed germination, an experiment was conducted during 1993-95. The results showed that application of raw or composted coirpith, FYM and gypsum improved the germination and population of the various crops tested. Composted coirpith at 5 t/ha produced the best effect. Significant improvement in yield of sorghum, bajra, cotton, sesamum, soybean, sunflower and senna was registered with the use of various amendments (Muthusankaranarayanan and Alwar Arunachalam, 1998).

Effect of Amendments on Germination and Yield of Crops in Rainfed Redsoil

Crops	Germination %					Crop Yield kg/ha (mean of two seasons)				
	Control	Composted coir pith	FYM	Gypsum	Raw coir pith	Control	Composted coir pith	FYM	Gypsum	Raw coir pith
Sorghum	89.6	96.4	94.6	93.3	94.2	710	879	820	878	665
Bajra	88.0	97.7	93.1	92.4	95.9	688	729	740	750	730
Hirsutum cotton	77.4	89.5	85.4	86.1	87.4	612	699	708	649	620
Arboreum cotton	77.2	90.2	85.9	84.4	86.1	696	753	746	742	726
Sunflower	76.8	87.6	85.0	86.2	87.0	215	260	242	230	235
Sesamum	79.0	86.6	83.2	80.6	84.6	165	180	182	171	200
Senna	64.6	78.0	76.2	74.2	78.6	675	835	814	774	793
Soybean	84.8	96.0	88.2	87.2	90.8	364	437	431	423	445

INTEGRATED FARMING SYSTEM

Integration of allied enterprises along with cropping offers many advantages by way of higher and stable income, more employment, effective recycling of organic wastes and efficient use of resources. Experiments were initiated during 1995 to identify a suitable integrated farming system model for the double cropped wetlands of Tambiraparani Command Area. The farming systems evaluated were cropping alone (Rice - Rice - Blackgram), crop + fish (100 m^2) and crop + fish + poultry (20 layers over fish pond). The results over three years revealed that rice + fish + poultry IFS gave the highest net returns (Rs.31775/ha) followed by crop + fish (Rs.25813/ha) as compared with Rs.21753/ha from cropping alone.

Fish pond sludge was a rich source of nutrients. When poultry shed was located above the fish pond. The nutrient value of fish pond sludge was further increased. Consequently, when fish pond sludge was incorporated prior to planting, the grain yield of rice was significantly improved.

ECONOMICS OF IFS IN WETLANDS (RS/HA)

Source of Income	Crop alone		Crop + fish		Crop + fish + Poultry	
	Gross Income	Net Income	Gross Income	Net Income	Gross Income	Net Income
Crop	32115	21753	33988	23696	37786	27544
Poultry	-	-	-	-	4516	868
Fish	-	-	2575	2117	3875	3363
Total	32115	21753	36563	25813	46177	31775

RICE GRAIN YILD IN IFS

Farming System	Rice Grain Yield (kg/0.40 ha)			
	1996-97		1997-98	
	Kharif	Rabi	Kharif	Rabi
Crop alone	1876	1747	1775	1832
Crop + fish	1970	1835	2062	2043
Crop + fish + Poultry	2217	2029	2269	2202

YIELD MAXIMISATION THROUGH CROPPING SYSTEM APPROACH

RICE BASED CROPPING SYSTEM

The yield of rice is very often reduced in Tambiraparani Command Area due to late release of water/early stoppage of water and exhaustion of soil fertility in typic haplustaff soil. In rice-rice crop sequence, instead of medium duration rice in second (Pishanam) season, short duration rice variety may be cultivated and green manure crops may be included between the two rice crops to improve soil fertility status. Field experiments were conducted for three years (1991 - 93) to evaluate the suitable rice based cropping system. The results revealed that the crop sequence of rice (short duration) in Kar season - green manure - rice (short duration) in Pishanam - summer (blackgram or gingelly) fetched a higher net return of Rs.46373 and 46535 per ha with B:C of 3.71 over other cropping sequence (Nalliah Durairaj, 1990).

MAIZE BASED INTERCROPPING SYSTEM

Grain yield of maize was significantly influenced by different planting systems. The grain yield variation due to different intercropping systems ranged from 4374 to 4933 kg/ha. Among the intercropping systems followed, maize + soybean in paired row system recorded significantly higher grain yield of 4933 kg/ha than the other systems, whereas maize as sole crop produced only 4436 kg/ha of grain yield.

INFLUENCE OF INTERCROPS AND PLANTING SYSTEM IN MAIZE BASED INTERCROPPING SYSTEM

Sl.No.	Treatments	Grain Yield kg/ha	Stover Yield kg/ha	B:C
1.	Maize sole crop	4437	7498	1.77
2.	Maize + cowpea (NR)	4666	7885	2.09
3.	Maize + cowpea (PR)	4805	8126	2.23
4.	Maize + soybean (NR)	4751	8034	2.12
5.	Maize + soybean (PR)	4933	8338	2.26
6.	Maize + redgram (NR)	4374	7400	2.04
7.	Maize + redgram (PR)	4428	7488	1.96
	CD (P = 0.05)	37	39	

NR - normal row; PR - paired row

With regard to growth parameters, yield attributes and yield of intercrops, soybean, cowpea and redgram exhibited reduction in yield under intercropping system but the magnitude of yield reduction was lesser with soybean and cowpea than redgram. Higher B:C of 2.26 was associated with maize + soybean (PR).

SESAMUM BASED INTERCROPPING SYSTEM

The concept of intercropping can be profitably applied to meet out increasing requirement of oilseeds and pulses from a limited land area. Field experiment was conducted during 1992-93 to study the suitability of pearlmillet, blackgram and soybean as intercrops with sesamum. The results on sesamum equivalent yield revealed that sesamum + soy bean at 4:1 row arrangement registered higher sesamum equivalent of 1200 kg/ha as compared to other systems. Likewise higher LER value was associated with the sesamum + soybean 4:1 row arragement. The economics of sesamum intercropping indicated that the net return per rupee invested, was Rs.3.70 with sesamum sole cropwhereas intercropping with soybean in 4:1 ratio increased it to Rs.3.75 (Latha, 1994).

INFLUENCE OF SESAMUM BASED INTERCROPPING SYSTEMS ON SEY, LER AND ECONOMICS

Treatments		SEY kg/ha	LER	Net return per rupee
Sesamum + Pearlmillet	4:1	748	0.63	2.00
Sesamum + Pearlmillet	4:2	568	0.48	1.35
Sesamum + Pearlmillet	6:1	847	0.72	2.00
Sesamum + Pearlmillet	6:2	694	0.59	1.80
Sesamum + Blackgram	4:1	526	0.50	1.00
Sesamum + Blackgram	4:2	360	0.36	0.40
Sesamum + Blackgram	6:1	721	0.66	1.85
Sesamum + Blackgram	6:2	479	0.44	0.90
Sesamum + Soybean	4:1	1200	1.01	3.75
Sesamum + Soybean	4:2	723	0.81	2.70
Sesamum + Soybean	6:1	935	0.78	2.70
Sesamum + Soybean	6:2	689	0.58	1.70
Sesamum sole		1184		3.70

YIELD AND ECONOMICS OF RICE BASED CROPPING SYSTEM

Cropping System	Kar Rice kg/ha		Pishanam Rice kg/ha		Summer Crop kg/ha	Gross Return Rs/ha	Net Return Rs/ha	B:C
	Grain	Straw	Grain	Straw				
R(SD) + R (MD) + BG	4950	5350	5010	5470	510	61170	44420	3.65
R(SD) + R(MD) + GL	4875	5300	4890	5285	425	61313	44463	3.64
R(SD) + R(MD) + SE	4900	5320	4850	5310	-	54945	39445	3.54
R(SD) + R(MD) + SO	4900	5350	4935	5370	615	60340	43340	3.55
R(SD) + R(MD) + BH	4820	5275	4825	5245	1200	56761	39761	3.34
R(SD) + R(MD) + KO	4900	5360	4965	5477	2850	56223	40523	3.58
R(SD) + R(MD) + CO	4900	5350	4925	5347	430	60506	43006	3.46
R(SD) + GM + R(SD) + BG	4975	5420	5225	5695	600	63473	46373	3.71
R(SD) + GM + R(SD) + GL	4920	5350	5100	5570	485	63735	46535	3.71
R(SD) + GM + R(SD) + SE	4875	5325	5070	5515	-	56041	40191	3.54
R(SD) + GM + R(SD) + SO	4900	5360	5085	5550	695	61865	44515	3.57
R(SD) + GM + R(SD) + BH	4850	5310	5050	5510	1270	58378	41028	3.36
R(SD) + GM + R(SD) + KO	4920	5360	5190	5575	2975	57289	41239	3.50
R(SD) + GM + R(SD) + CO	4975	5425	5125	5609	470	62592	44742	3.51
R(SD) + GM + R(SD) + BG	4750	5210	4750	5100	515	58735	42185	3.55
SEd	-	-	105	114	-	1335		
CD (P = 0.05)	-	-	215	234	-	2733		

SD - Short Duration; MD - Medium Duration; GM - Green Manure; BG - Blackgram, GL - Gingelly, SO - Soybean, BH - Bhendi; KO - Kolinji; CO - Cotton; SE - Senna

FUTURE THRUST

Research is a dynamic process. As the existing problems are addressed and solved, new ones arise warranting intervention through further research. Agricultural research is no exception to this rule. A decade of agronomy research at Agricultural College and Research Institute, Killikulam has definitely helped to solve many problems in crop management and to develop many new technologies. Yet, many other issues remain to be resolved and new issues are cropping up continuously. The future research strategy has to have both short and long term focus.

Rice Agronomy has constituted the major research activity in the past years. The issues for future focus in rice crop management are many. The productive potential-wise delineation of rice area will help in identifying suitable management strategies for realising the potential yield with minimum inputs. Early research has hinted at the potential of many crop residues and organic wastes to serve as supplementary or substitute source of rice nutrition. Further studies on exploitation of such unutilised and underutilised organic nutrient sources are warranted for sustaining soil health and rice productivity. In tail end areas of Tambiraparani Command Area where soil constraints limit rice productivity, management strategies for yield maximisation are needed.

Direct seeded rice in wet puddle has been accepted by farmers as a feasible concept. But its adoption is meagre. Constraints in wetseeded rice cultivation have to be identified through farm surveys and research initiated to solve them. In many rice farms today, labour availability and cost have become serious disincentives. A fully mechanised rice farming system with attendant changes in management of rice culture will acceptable to many farmers.

Management requirements for most other irrigated dry crops in the region have not been addressed fully so far. Cotton, once a major crop in Thoothukudi district has lost its primacy and cotton area has considerably declined in the past few years. Efforts are needed to design a new management package to make cotton cultivation more remunerative to herald the revival of cotton in this area. Location specific agronomic research on oilseeds like groundnut, sesamum and sunflower is another field for future research, with emphasis on cost reduction through low cost and nonmonetary in puts. In such crops, institutional research apart, on farm research can help in effective transfer of the developed technologies. Limited water for irrigation is a reality today in irrigated dry crops. New measures to management crops growing under moisture stress are needed to sustain irrigated dryland farms.

The key to the economic well being of a majority of farmers in this region lies in the development of rainfed agriculture. Dryland agriculture in red soil region of the southern districts requires a major research thrust to arrest the tendency to abandon cultivation in these lands. Systematic research on crop substitution and crop management strategies to improve and sustain the productivity of rainfed annual crops and associated cropping systems is very much needed.

A large area of rainfed redsoils remains as wastelands due to many natural, social and economic constraints. Research to reverse the land degradation process and to rehabilitate the degraded lands warrants the active involvements of the agronomists in a multidisciplinary research programme. Conservation of soil and water resources and reestablishment of a vegetative cover in the wastelands call for intensified research efforts. Agronomists have to undertake resource characterisation in the rainfed redsoil wastelands to enable the process of identification of a suitable alternate land use system for these lands. More focus on forage agronomy and agroforestry systems with multipurpose tree species is a felt need in this context.

Integrated farming systems offer many advantages for promoting the well being of marginal and small farmers, in this region. Integrated farming system models in tune with the resource availability conditions have to be evaluated for irrigated drylands and rainfed drylands.

Constraints in resource availability, quality and cost are emerging as major constraints in irrigated agriculture. Agronomic management of these resources may have to be completely new and drastically different from how it is being advocated now. Input substitution through cheaper and efficient sources has to be a continuous exercise. Efficient cropping zones and resource specific cropping systems require long term investigations by agronomists. Water and nutrient budgetting on cropping system basis has been attempted so far only in rice based cropping systems. It has to be extended to other cropping systems in vogue in this region. These can help in economic and efficient use of scarce resources for sustained high productivity of various crops.

Crop weather modelling studies with particular reference to rainfed redsoil tracts can help to quantify crop response to climatic aberrations. Such models can serve as research tools for planning alternative strategies and contingency measures for minimising risks in rainfed agriculture in redsoils.

With many improvements effected in infrastructure facilities and manpower development, agronomy research in the sourthern districts of Tamilnadu can become more focussed and productive in the future.

List of Agronomists of Killikulam

S.No.	Name	Designation	Period		Presently working as
			From	To	
1.	Dr. A. Mohamed Ali	Professor	1985	1993	Dean, AC & RI, Killikulam.
2.	Dr. V. Veerabadran	Professor	1993	till date	Professor & Head, AC & RI, Killikulam.
3.	Dr. J. Krishnarajan	Professor	1984	1987	Professor and Head, Agronomy, Coimbatore.
4.	Dr. J.G. Robinson	Professor	1991	1994	Retired
5.	Dr. M.S. Ramakrishnan	Professor	1987	1992	Retired
6.	Dr. G. Ramadoss	Professor	1994	1995	Professor, Aduthurai.
7.	Dr. A. Alwar Arunachalam	Assoc. Prof. Professor	1988 1995	1995 1997	Professor & Head, Thirupathisaram.
8.	Dr.A. Muthusankaranarayan	Assoc. Prof. Professor	1993 1998	1995 till date	Professor, Killikulam
9.	Thiru A.K. Ranganathan	Assoc. Prof.	1986	1992	Retired
10.	Thiru T.R. Narayanan	Assoc. Prof.	1986	1996	Retired
11.	Dr. S.N.M.Ramachandra Boopathi	Assoc. Prof.	1990	1990	Professor, Madurai.
12.	Dr. K. Velayutham	Assoc. Prof.	1987	1990	Professor, Coimbatore.
13.	Dr. B. Uthayakumar	Assoc. Prof.	1996	till date	Assoc. Prof., Killikulam.
14.	Dr. B.J. Pandian	Assoc. Prof.	1997	"	"
15.	Dr. S.Nalliah Durairaj	Asst. Prof. Assoc. Prof.	1991 1998	1998 till date	"
16.	Dr. K. Wahab	Asst. Prof.	1986	1989	Professor, Annamalai University
17.	Dr. S. Krishnasamy	Asst. Prof.	1990	1992	Assoc. Prof., Madurai.
18.	Dr. N. Asokaraja	Asst. Prof.	1990	1991	Assoc. Prof., Coimbatore
19.	Dr. S. Manoharan	Asst. Prof.	1992	1998	Assoc. Prof., Kovilpatti.
20.	Dr. A. Velayutham	Asst. Prof.	1989	1997	Asst. Prof., Coimbatore.
21.	Dr. R. Balasubramanian	Asst. Prof.	1989	1996	Asst. Prof., Madurai.

22.	Mrs. Myrtle Grace	Asst. Prof.	1989	1990	Asst. Prof., Madurai.
23.	Dr. R. Marimuthu	Asst. Prof.	1995	1996	Asst. Prof., Trichy.
24.	Dr G. Srinivasan	Asst. Prof.	1996	1998	Asst. Prof., Srivilliputhur.
25.	Dr. K. Srinivasan	Asst. Prof.	1994	1996	Asst. Prof., Coimbatore.
26.	Dr. Mark Devasahayam	Asst. Prof.	1994	1996	Asst. Prof., Madurai.
27.	Selvi S. Avudaithai	Asst. Prof.	1997	till date	Asst. Prof., Killikulam
28.	Dr. V.K. Duraisamy	Asst. Prof.	1998	"	"
29.	Thiru R. Panneerselvam	Asst. Prof.	1998	"	"

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