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INTRODUCTION

This report covers the research activities under the All India Coordinated Agronomic Experiments Scheme during the year 1973-74. The focus of the programme of work of the scheme has been mainly on multiple cropping and soil fertility and fertilizer use.

This report is prepared in 3 parts. Part 1 deals with the results of trials conducted at the Model Agronomic Centre, Karamana. Here, the programme was so oriented as to gather information on production potential under optimum resource conditions as well as under conditions of one or more input constraints, farming systems for small holders and efficacy of newer fertilizers and herbicides.

Part 2 of this report embodies the results of simple fertilizer trials conducted on cultivators' fields in Quilon and Trichur districts. In these experiments, emphasis was on the response of high yielding rice varieties to nitrogen, phosphorus, potash and zinc with a view to formulate fertilizer recommendations for the different agroclimatic regions of the State. In Quilon and Trichur districts, trials are actually initiated during the 'mundakan' (rabi) season of 1971-72 and by now, 5 seasons' experimental data have been collected.

Part 3 gives the important conclusions drawn from these studies.

Part I

EXPERIMENTS AT THE MODEL AGRONOMIC CENTRE

EXPERIMENTAL

Altogether eight experiments were conducted at the Model Agronomic Centre, Karamana.

The soil of the experimental farm was a lateritic sandy clay loam containing on an average 0.45% organic carbon, 24.0 kg/ha of available P_2O_5 and 100.0 kg/ha of available K_2O. The pH of the soil was 5.3.

The crop was grown under rainfed conditions, especially in the 'Virippu' (kharif) season. However, irrigations were given whenever rainfall was not sufficient to support plant growth. The agronomic practices stipulated for the test varieties were closely followed in all the trials. Rice crop was transplanted.

The trials included:

i. Production potential under optimum input conditions (trial No. 1 (a));

ii. Maximum production potential under resource constraints (1 (b));

iii. Intensive farming systems for small holders(I (c));

iv. Manurial requirement of a fixed crop rotation (2);

v. Efficiency of potassium schoenite as a source of potassium (3);

vi. Fertilizer requirement of new varieties (4);

vii. Efficiency of rock phosphate on acid soils (10 (b); and

viii. Weed control in transplanted low land rice (12 b)

The experiment nos. (i), (ii), (iii) and (viii) were commenced during the virippu season of 1972-73 and were continued. The experiment no. (iv) was initiated in the virippu season of 1971-72. The rest of the trials were taken up during the current year.

The details pertaining to treatments of the experiments are furnished under ' results and discussion '.

RESULTS AND DISCUSSION

(1). I (a). Production potential experiment

Production potential of a high intensity cropping system and its effect on soil fertility framed the object of this experiment. The treatments comprised of 6 crop rotations. Each rotation had at least 2 crops of rice.

1. Rice-Rice-Rice-Rice (all early duration)
2. Rice-Rice-Rice (all medium duration)
3. Rice-Rice (both long duration)- fallow
4. Rice-Rice (both early duration)- Tapioca
5. Rice-Rice (both early duration)- Colocasia
6. Rice-Rice (both medium duration)-Bhindi

The test varieties of rice were Annapoorna (early), Jaya (medium) and Jagannath (late). The variety of tapioca tried was H 165, an early duration hybrid.

Among the rotations involving rice crops only, 3 crops of Jaya rice as in rotation 2 registered the highest aggregate yield of 11951 kg/ha per annum as against 10,125 kg/ha recorded by Annapoorna raised 4 times in succession (Table-1). The rotation 3, in which 2 crops of Jagannath was raised after a summer fallow, yielded only 8,088 kg/ha thus proving itself to be less profitable. Two crops of Jaya cultivated after a summer crop of Bhindi as in rotation 6, recorded nearly as much yield as that of rotation 2 which involved 4 crops of Annapoorna. This rotation compared well with the rotation involving 3 Jaya crops, the difference being 1,876 kg/ha only in favour of the latter. Obviously, the virippu rice crop derived some residual effect of the manures applied to the previous bhindi crop. Compared to the yield recorded by jaya (4,975 kg/ha)(*) in the corresponding season of 1973-74 was 6,134 kg/ha, the increase being 1,159 kg/ha. In the rotation in which Annapoorna was grown after Tapioca or Colocasia, the yield increase was not as spectacular as this, the increase in yield being 396 kg/ha after tapioca and 596 kg/ha after colocasia. The rotation, rice-rice-tapioca, recorded, however, the highest per hectare production during this year, the contribution of the root crop alone being 39,302 kg/ha. Since grain production is more important than tuber production, rice-rice-bhindi rotation (rotation 6) should receive more attention as it gives the maximum production per day and fetches relatively more profit to the farmer.

(*) as the previous season (1972-73), the yield

Table- 1. Production of crops in high intensity crop rotation, 1973-74

Crop rotation with crop duration (days)			Production (kg/ha)			Total grain yield (kg/ha)	Total prod. of all crops (kg/ha)	No.of idle days	grain yield per day (kg/ha)	Total income (RS)
virippu	mundakan	punja	viri-ppu	munda-kan	pun ja					
1.Annapoorna (73)	Annapoorna (97)	Annapoorna (68) Annapoorna (74)	4237	913	2452 2523	10125	10125	53	32	7493.0
2.Jaya(99)	Jaya (96)	Jaya (102)	5375	3607	2929	11951	11951	68	40	8844.0
3.Jagannath (126)	Jagannath (114)	Fallow	5150	2932	--	8082	8082	125	34	5981.0
4.Annapoorna (73)	Annapoorna (97)	Tapioca (M 165) (147)	4437	1092	39302	5529	44831	48	32	17541.0
5.Annapoorna (73)	Annapoorna (97)	Colocasia local(161)	3941	1201	12197	5142	17339	34	30	10741.0
6.Jaya (99)	Jaya (96)	Bhindi Pusa savani (88)	6134	3941	13953	10085	24028	82	52	19479.0

Annapoorna : early duration rice
Jaya : medium duration rice
Jagannath : long duration rice

Rice @ Re.0074 per kg
Colocasia @ Re. 0.40 per kg
Tapioca @ Re. 0.30 per kg
Bhindi @ Re. 0.50 per kg

(ii). (1 b) Maximum production potential under resource constraints

This trial was initiated in the virippu season of 1972-73 to determine the production potential of a 2 crop (rice-rice) rotation under input constraints. The inputs tested were levels of fertilizers and weed control.

The treatments consisted of 3 doses of N,P and K i.e. 90:45:45; 67.5 : 33.75 : 33.75 and 45: 22.5: 22.5 (kg/ha each) being the 100%, 75% and 50% of the recommended doses of N, P_2O_5 and K_2O for medium duration transplanted rices and 3 methods of weed control i.e. Machete @ 1.0 kg/ha; 2 hand weedings and an unweeded control.

The test variety was Jaya, transplanted at a spacing of 15 cm x 15 cm.

The data recorded during the virippu season only are discussed in this report. The crop failed during the mundakan season.

Grain yield was significantly reduced, when the recommended dose of fertilizers was reduced to 75 and 50% (Table 2). The reduction in yield at 75 and 50% of the recommended doses were 6.9% and 9.9%, respectively. The difference between these levels, however, was not significant.

There was no significant difference between the levels of weed control. The increase in yield registered by the hand weeded and the herbicide treated plots over the unweeded control was 237 and 69 kg per hectare, respectively, Weed growth, in general, was too poor in the experimental plots to cause any significant reduction in yield and, obviously, it did not prove to be a constraint to production at Karamana.

The interactional effects of fertilizer doses and weed control practices were not significant. The results, however, indicate that under limited availability of fertilizers, the dose of nutrients can be reduced with some sacrifice on grain production.

Table. 2. Grain yield as affected by rates of fertilizer application and methods of weed control (virippu, 1973-74)

	Fertilizer applied	Grain yield (kg/ha)
1	100% of the recommended dose (90:45:45 kg/ha)	5706
2	75% of the recommended dose (67.5 : 37.75 : 37.75 kg/ha)	5313
3	50% of the recommended dose (45: 22.5 : 22.5 kg/ha)	5148
	Weed control	
1	Hand weeding twice	5591
2	Machete 1.0 kg a.i/ha	5323
3	Unweeded control	5254
	SE ± (fertilizer rate)	147
	CD (0.05) ,,	301
	SE ± (Weed control)	236

(iii) I (c) Intensive farming systems for small holders

The feasibility of adopting intensive crop production practices in small holdings formed the object of this investigation. An area of 8,000 sq.metres. was divided into 4 dqual parts and the following crop rotations were followed in each plot.

Plot I Banana (variety Nenthran)

Plot II Rice (Jaya)_ Rice (Jaya)- Black gram

Plot III Rice (Annapoorna)- Rice (Annapoorna)- Tapioca (H 165)

Plot IV Rice (Annapoorna)- Rice (Annapoorna) - Colocasia (local)

The manurial and cultural practices recommended for each crop were strictly followed. Banana was planted on raised bunds and tapioca on maunds.

For the calculation of gross and net returns of the cropping scheme, the period from mundakan, 1972-73 to virippu 1973-74 was taken into consideration as it coincided with the duration in which banana was grown.

In the cropping scheme adopted, rice occupied 60% of the total cropped area. Green gram, tapioca, colocasia and banana occupied the remaining area equally. The intensity of cropping was 250 per cent. The cropping pattern provided requisite production of cereals, pulses and cash crops to meet the requirement of the family of a small farmer. Inclusion of banana and colocasia in the cropping scheme, however, proved to be a big drain on the resources, the net returns obtained from these crops being far below the cost of inputs. Yields of these crops were miserably poor probably due to sub-optimal soil conditions. The maximum returns were obtained from Plot II (Jaya-Jaya-black gram) when individual rotations are compared. The net returns from the cropping pattern adopted at Karamana was Rs. 1059/- from a plot of 0.80 hectare.

The results are presented in Table-3.

(iv).2. <u>Manurial requirement of a fixed crop rotation</u>

The direct, residual and cumulative effects of phosphorus, potasium and farm yard manure on the yield of a two crop (rice-rice) rotation was studied in this experiment. The treatments comprised of all the possible combinations of 3 levels of phosphorus (0,30,60 kg P_2O_5 per ha), and 2 levels each of potash (0,30 kg K_2O/ha) and farm yard manure (0,1500 kg/ha). The treatments were applied in 3 phases, viz., manuring every season, manuring in alternate seasons starting from the virippu season and manuring in alternate seasons starting from the mundakan season. All the plots received a common dose of nitrogen at 120 kg/ha at the time of planting. The test variety was IR.8.

The cumulative, direct and residual effects of applied phosphorus were not significant on grain yield during both the seasons. Application of phosphorus, in fact, tended to depress grain production. Similar results were recorded in the previous years also (Table 4).

Table 3. Cropping pattern and output and gross returns from a 0.80 ha holding

	Rotation followed with crop duration (days) virippu ('73-74)	mundakan ('72-73)	summer ('72-73)	Total No.of crop days	Plot area (ha.)	Crop yield (kg) per plot Crop	main product	Straw	Gross return (RS.)	Input cost (RS)	Net return (RS)
I		Banana (one year crop from November to November		360	0.20	Banana	2210	500 (suckers)	2360	3242	-882
II	Jaya (128)	Jaya (108)	Blackgram (86)	322	0.20	Rice Pulses	1812 30	2901	4236	1950	2286
III	Annapoorna (92)	Annapoorna(92)	Tapioca (164)	348	0.20	Rice Tapioca (tuber)	1129 4814	1262 --	3929	3280	649
IV	Annapoorna(92)	Annapoorna(92)	Colocasia(148)	332	0.20	Rice Tuber	1093 568	1320	2651	3645	-994
Total					0.80				13,176	12,117	7059

Wage rates:

Men @ RS. 9.25 per day
Women @ RS.8.45 ,,
Pairs @ RS. 17/- ,,

Price of Produce:

Paddy grain RS.2/- per kg
,, straw RS.0.18 ,,
Banana RS.1/- ,,
,, sukker 0.30 per sucker
Blackgram RS.3/- per kg
Colocasia 0.40 ,,
Tapioca 0.30 ,,

Table 4. Response of rice to applied phosphorus(kg/ha)

Levels of P_2O_5 (kg/ha)	Cumulative effect		direct effect		residual effect	
	Virippu	mundakan	virippu	mundakan	virippu	mundakan
0	5706	2693	5621	2632	5614	2517
30	- 14	-207	- 38	- 86	+ 7	+181
F (0.05)	NS	NS	NS	NS	NS	NS
SE±	210	162	205	157	184	154

NS: Not significant; Sig. Significant

The cumulative effect of potassium (Table 5) was negative and significant during the virippu and mundakan seasons. The decline in yield consequent on the application of K_2O at 30 kg/ha was 362 kg/ha in virippu and 350 kg/ha in mundakan (Table 5). The direct and residual effects were not significant. Lack of response to applied potassium is a common phenomenon in the soils of Karamana.

Table 5. Response of rice to applied potash (kg/ha)

Levels of K_2O (kg/ha)	Cumulative effect		Direct effect		residual effect	
	virippu	mundakan	virippu	mundakan	virippu	mundakan
0	5767	2760	5775	2582	5682	2793
30	5405	-350	5779	+ 52	-149	+331
F (0.05)	Sig.	Sig.	NS	NS	NS	Sig.
SE±	171	132	205	128	150	126
CD(0.05)	349	269				

Farmyard manure recorded significant cumulative and direct effects on grain yield during the virippu season only. (Table 6) The cumulative response in yield was 42.3 kg of grain per quintal of farmyard manure. The direct response was of the order of 30 kg of grain per quintal of the applied manure. There was no significant residual effect on yield during this season. In the mundakan season, response to farmyard manure was of the order of 18.0, -2.0 and 3.6 kg of grain per quintal of farmyard manure at the first, second and third phases of manuring.

The interactional effects- either positive or negative - of fertilizers and manures did not touch the level of statistical significance during both the seasons.

Table 6. Cumulative, direct and residual effect of farmyard manure on grain yield (kg/ha)

Level of F.Y.M (kg/ha	Cumulative effect virippu	Cumulative effect mundakan	Direct effect virippu	Direct effect mundakan	residual effect virippu	residual effect mundakan
0	5360	2487	[illegible]	2623	5505	2591
1500	+638	-196	- 70	- 31	+205	+ 84
F	Sig.	NS	Sig.	NS	NS	NS
SE +	171	132	195	128	150	126
CD (0.05)	318	.	361	.	.	.

(V) 3. Efficiency of potassium schoenites a source of potassium

Potassium schoenite, a by product of salt industry, is considered to be a chemical source of K_2O in constrast to potassium sulphate and potassium chloride. This study was, therefore, taken up to know whether potassium schoenite is as efficient as or superior to potassium chloride or sulphate, which are the common sources of K_2O.

The experiment consisted of 16 treatments including a no fertilizer control (Table 7). Nitrogen and phosphorus were applied at 120 and 60 kg per hectare, respectively in all the plots excepting the control. The variety tried was IR.8. Direct as well as residual effects of the treatments were studied in this trial.

The direct as well as the residual effect of applied potassium -whatever be the source- was not significant (Table 7) on grain yield. Failure of rice crop to respond to potash has been consistently observed at Karamana. Therefore the efficiency of potassium schoenite as a source of K for rice can not be evaluated from the results of this trial.

Table 7. Influence of sources of potassium on the yield of rice

Treatment	Grain yield(kg/ha)	
	direct effect (virippu)	residual effect (mundaka[illegible])
1. Control (unmanured)	4270	219[illegible]
2. N_{120} P_{60} (kg/ha)	4270	343[illegible]
3. Tr. 2 + Pot.schoenite @ 40 kg K_2O/ha	4124	249[illegible]
4. Tr. 2 + Pot.schoenite @ 80 kg K_2O/ha	4239	296[illegible]
5. Tr. 2 + Pot.Schoenite @ 120 kg K_2O/ha	4322	2906
6. Tr. 2 + Pot.Schoenite @ 40 kg K_2O/ha to the first crop	3697	293[illegible]
7. Tr.2 + Pot. schoenite @ 80 kg K_2O/ha to the first crop	3197	263[illegible]
8. Tr.2 + Pot.schoenite @ 120 kg K_2O/ha to the first crop	4239	254[illegible]
9. Tr.2 + Pot.chloride @ 40 kg K_2O/ha to the first crop	3760	273[illegible]
10. Tr.2 + Pot.chloride @ 120 kg/ha to the first crop	4270	287[illegible]
11. Tr.6 + Magnesium sulphate equalising Mg. content in Tr.3 to the first crop	3333	278[illegible]
12. Tr.7 + Mag.sulphate equalising Mg. content in Tr.4 to the first crop	3031	346[illegible]
13. Tr.8 + Mag.sulphate equalising Mg. content in Tr.5 to the first crop	4593	289[illegible]
14. Tr.5 + Zinc sulphate at 50 or 25 kg/ha to the first crop	3697	305[illegible]
15. Tr.8 +Zinc sulphate @ 50 Or 25 kg/ha to the first crop	4145	287[illegible]
16. Tr.13 +Zinc sulphate @ 50 kg or 25 kg to the first crop	4312	285[illegible]
SE +	782	3[illegible]
CD(0.05)	1578	7[illegible]

(vi) 4. Fertilizer requirement of new rice varieties

Response of new rice varieties to nitrogen and phosphorus was studied in this experiment. The treatments included 4 varieties (IR.8, Vijaya, IR.20 and Aswathy), 4 levels of nitrogen (0,60,120 and 180 kg/ha) and 3 levels of phosphorus (0,60 and 120 kg/ha) laid out in a confounded factorial design. A common dose of K_2O at the rate of 60 kg/ha was applied in all the plots.

The trial was conducted during the mundakan season only.

IR.20 and Vijaya, recorded significantly higher yields over IR.8 and Aswathy, the local choice (Table 8). None of these varietis exhibited, however marked interaction with applied nitrogen and phosphorus (Table 8).

The effect due to nitrogen was almost linear, although the levels 180 and 120 kg/ha were on a par. The magnitude of response to nitrogen was only 2.45 kg of grain per kg. of nitrogen when the level was raised from 120 to 180 kg/ha.

Response to applied phosphorus followed a different trend. Although the highest yield was registered at 120 kg P_2O_5/ha, the difference between this level and no phosphate control was negligible, the response being 1.2 kg of grain per kg. of applied phosphorus. The 60 kg P_2O_5/ha level recorded, however, significantly lower yields compared to 0 and 120 kg/ha levels.

Table.8. Response of varieties to nitrogen and phosphorus (mundakan, 1973-74)

Variety	Grain yield (kg/ha)	nitrogen (kg/ha)	Grain yield (kg/ha)	Response over successive levels of N(kg grain per kg of N)	Phosphorus (kg/ha)	Grain yield (kg/ha)
IR.20	3100	0	1760	1760	0	2742
Vijaya	2858	60	2681	15.3	60	2491
IR.8	2536	120	3118	7.3	120	2885
Aswathy	2331	180	3265	2.4	..	..
SE +	140	..	140	..	..	121
CD(0.05)	282	..	282	..	..	244

(vii) 10(b). Efficiency of rock phosphate in acid soils

The relative efficiency of different sources of phosphorus on acid rice soils was studied in this experiment. The phosphate sources were, superphosphate, Udaipur rock phosphate and Peruvian rock phsphates A and B. There were 7 treatments (Table 9) including 2 control plots. The test variety was IR.8.

Neither the sources nor the levels of phosphorus exerted significant influence on yield during the virippu season (Table 9). However, superphosphate applied at the rate of 60 kg P_2O_5 Kg/ha ranked first among the treatments.

In the previous trials also no response was observed to applied P in the soils of Karamana.

During the mundakan season, when the residual effect was studied, all the treatments were on a par in their effect on yield (Table 9) as in the previous season.

Table. 9. Grain yield as affected by sources and levels of applied phosphorus

Treatment	Level of P_2O_5 (Kg/ha)	Grain yield (Kg/ha) virippu (direct effect)	Grain yield (Kg/ha) mundakan (residual effect)
1. Nitrogen only at 120 kg/ha	0	4568	3025
2. Nitrogen @ 120 kg/ha + K_2O @ 60 kg/ha	0	3875	3313
3. Tr.2 + Superphosphate	60	4775	2875
4. Tr.2 + Superphosphate	120	4343	3500
5. Tr.2 + Udaipur rock phosphate (100 mesh)	120	3531	2813
6. Tr.2 + Peruvian rock phosphate (100 mesh)(A)	120	3931	3538
7. Tr.2 + Peruvian rock phosphate (100 mesh)(B)	120	4718	3625
SE +		429	321
CD (0.05)		901	675

(viii). 12 (b) Weed control in transplanted low land rice

The relative efficacy of new herbicides on the control of weeds in low land rice fields was investigated in this trial. The treatments included propanil, 2,4-D and Butachlor (Machete) in 2 different levels, hand weeding and no weeding (Table 10). The variety planted was IR.8. The fertilizer schedule adopted was 120: 60: 60 Kg NPK, respectively, per ha.

During the mundakan season, only the residual effect of herbicides was studied.

The treatment differences on yield were not significant statistically during both the seasons (Table 10). Hand weeding turned out to be the best practice, however, recording the highest yield. In general, weed growth was poor in all the plots and that might be the reason why there was no significant difference between the treatment effects.

Table 10. Grain yield as influenced by the different treatments

	Treatment	Rate of application (kg a.i./ha)	Time of application (DAT)	Grain yield(kg/ha) virippu	Grain yield(kg/ha) mundakan
1	Propanil	1.00	15	4187	2250
2	Propanil	1.50	15	4200	2125
3	2,4-D (Na salt)	0.5	20	4137	2450
4	2,4-D (Na salt)	0.75	20	3750	2398
5	Machete	1.00	8	4218	2437
6	Machete	1.50	8	4250	2100
7	Hand weeding	twice		4568	2412
8	Unweeded control			4200	2375
	CV(%)			7.43	18.76
	CD(0.05)			743	640

DAT = days after transplanting

Part 2

SIMPLE FERTILIZER TRIALS ON CULTIVATORS ' FIELDS

EXPERIMENTAL

As in the previous year the A, B and C types of trials were conducted in Trichur and Quilon districts during the virippu and mundakan seasons of 1973-74. Before the commencement of the virippu season, each district was divided into 3 agriculturally homogeneous zones, leaving the block earmarked for conducting the C type trials. The villages within the blocks and the cultivators' fields within the villages were selected at random. The names of blocks selected in each zone are presented in Table 11 together with the fertility status of the soil of each zone.

Table 11. Blocks selected and mean fertility status of soil

District	Zone	Block	Fertility status N	P	K	Soil pH
Trichur	I	Thalikulam	high	low	high	Acidic
		Mullassery	high	medium	medium	,,
	II	Anthicad	high	high	medium	,,
		Puzhakkal	high	medium	medium	,,
	III	Vellangallore	high	low	high	,,
		Kodakara	high	medium	medium	,,
Quilon	I	Pathanapuram	high	medium	high	,,
		Konni	medium	low	high	,,
	II	Parakode	high	low	medium	,,
		Pakkathacic	high	low	medium	,,
	IV	Chadayamangalam	high	medium	medium	,,
		Chavara	high	low	high	

There were 8 treatments in A and 10 treatments each in B and C types of trials.

The A type trial comprised of 5 levels of nitrogen (0,40,80, 120 and 160 kg/ha), 3 levels each of P_2O_5 and K_2O (0,60 and 90 kg/ha) and a single dose of zinc (zinc sulphate @ 25 kg/ha) in 8 different combinations as detailed below.

1. $N_0\ P_0\ K_0$
2. $N_0\ P_{60}\ K_{60}$
3. $N_{40} P_{60}\ K_{60}$
4. $N_{80} P_{60}\ K_{60}$
5. $N_{120}\ P_{60}\ K_{60}$
6. $N_{160}\ P_{60}\ K_{60}$
7. $N_{120}\ P_{60}\ K_{60} + Zn_{25}$
8. $N_{100}\ P_{90}\ K_{90}$

The treatments in B and C types were the same. The base level of nutrients were 120 kg N, 120 Kg.P_2O_5 and 60 kg K_2O per hectare. There were applied in 10 different combinations as described below:

1.	N_0	P_0	K_0	6. $N_{(b)}$	$P_{(1.5)}$ $K_{(b)}$
2.	$N_{(b)}$	P_0	K_0	7. $N_{(b)}$	$P_{(b)}$ K_0
3.	$N_{(b)}$	P_0	$K_{(b)}$	8. $N_{(b)}$	$P_{(b)}$ $K_{(0.5b)}$
4.	$N_{(b)}$	$P_{(0.5b)}$	$K_{(b)}$	9. $N_{(b)}$	$P_{(b)}$ $K_{(1.5b)}$
5.	$N_{(b)}$	$P_{(b)}$	$K_{(b)}$	10. $N_{(1.5b)}$	$P_{(1.5b)}$ $K_{(1.5b)}$

The suffixes 0.5b, b, and 1.5b denotes half, full and one and a half times respectively of the base levels of nutrients. The base level of P was arrived at based on the P fixing capacity of the soil in the case of C type trials.

The test varieties were IR.8 and Jaya in Trichur and Quilon districts, respectively, which were either transplanted or sown broadcast. The gross plot size was 50 m^2. In all the experiments phosphatic and potassic fertilizers were applied as basal dressing while nitrogen was applied in 2 equal splits at planting and panicle initiation as in Trichur district or in 3 splits at planting, tillering and panicle initiation as in Quilon district.

The crops were raised purely under rainfed condition. The climatic conditions were quite favourable, however, for crop growth during both the seasons. Incidence of brown planthopper in a devastating form in the Talikulam block of Trichur district during the mundakan season adversely affected 3 trials. The data were therefore, rejected.

RESULTS AND DISCUSSION

Response to nitrogen

Response to applied nitrogen was significant during both the seasons in Trichur and Quilon districts, although its magnitude varied from block to block depending upon the local conditions. Application of P_2O_5 and K_2O at 60 kg each per hectare without nitrogen invariably recorded significantly higher yields over the unmanured control in all the blocks except Vellangallore, Mullasseery, Thalikulam (Table 12), Ithickara, Parakode and Mukhathala (Table 13). Addition of nitrogen at 40 kg/ha over this level of P_2O_5 and K_2O did not, however, result in marked yield increases in Vellangallore, Anthicad, Parakode and Mukhathala during the virippu season (Table 12,13) and in Mullasseery during the mundakan season (Table 14). Although successive doses of nitrogen in general resulted in increased grain production in almost all the blocks, the yield differences due to additional increments of N beyond 80 kg/ha did not touch the level of statistical significance. In Anthicad, Vellangallore, Puzhakkal, Mullassery and Konni blocks in the virippu season (Tables 12,13) and Puzhakkal, Vellangallore and Chavara blocks in the mundakan season (Table 14,15). The test variety failed to respond to nitrogen beyond 40 kg/ha in Thalikulam block during both the seasons.

Nitrogen at 160 and 120 kg/ha recorded significantly more yields over the 80 kg/ha level in Kodakara in the virippu season. It, however, failed to effect significant yield increases over the 40 kg level in the mundakan season. The maximum yields were recorded at the 160 kg/ha level in Mullasseery block in both the seasons, and the difference between 120 and 80 kg levels were not significant. The crop responded significantly to N over the 80 kg level in Puzhakkal block in the virippu season, but between 120 and 160 kg N/ha there was no significant difference. Similar results were recorded in Kattupuram, Konni and Parakode blocks in both the seasons and in Mukhathala in the mundakan season. In the Ithikara block of Quilon district, where the A type trial was conducted during the virippu season only, the effects due to nitrogen at 160 and 80 kg/ha were at par and 40 and 120 kg/ha levels produced significantly lower yields over the above referred to levels (Table 13). During the mundakan season, the only block in which significant linear response to applied nitrogen was recorded in Anthicad and but here the yield due to 1 kg N ranged between 3.5 and 3 kg only.

Table 12. Response to nitrogen in the A type experiment, Virippu 1973-74 (grain yield kg/ha)

District	Zone	Block	No.of trials	unmanured control (0-0-0)	0-60-60 (kg/ha)	Response to nitrogen over 0-60-60 (kg/ha)				Response to 160 kg /ha over 90 kg lack of P_2O_5 and K_2O/ha	SE + -	CD (0.05)
						40	80	120	160			
Trichur	I	Thalikulam	7	2601	2535	704	873	738	507	+ 598	215	434
		Mullassery	8	3391	2710	308	940	1121	1817	- 237	246	494
			15	3022	3160	654	908	931	1162	+ 215	147	290
	2	Anthicad	8	3865	4033	142	221	267	350	+ 361	75	151
		Puzhakal	8	3390	3875	435	970	1398	1391	+ 456	180	362
			16	2621	3953	287	595	832	871	+ 408	95	188
	3	Vellangallor	6	2903	2706	283	663	832	737	- 96	163	332
		Kodakara	8	3912	4427	530	657	1117	1473	+ 110	123	248
			14	3485	3687	425	660	995	1105	22	67	131

Table 13. Response to nitrogen in the A type experiment, virippu 1973-74 (grain yield kg/ha)

District	Zone	Block	No.of trials	Unmanured control	0-60-60 (kg/ha)	Response to nitrogen over 0-60-60				Response to N @ 160 kg/ha over 90 kg each of P_2O_5 and K_2O	SE ±	CD (0.05)
						40	80	120	160			
Quilon	1	Pathanapuram	8	2085	2568	318	490	763	932	28	120	242
		Konni	6	2581	2873	493	1128	1326	1227	179	137	278
			14	2296	2694	390	777	1004	1059	92	91	180
	2	Parakode	8	3093	3377	568	1175	1817	1975	88	367	738
		Mukhathala	4	2836	2712	533	757	1621	595	812	301	625
			12	3016	3155	556	1034	1279	1285	450		
	3	Ithickara	4	2969	3005	534	720	458	913	535	140	291
			4	2969	3005	534	720	458	913	535	140	291

Table 14. Response to nitrogen in the A type experiment, mundakan 1973-74 (grain yield, kg/ha)

District	Zone	Block	No. of trials	unmanured (0-0-0)	0-60-60 (kg/ha)	Response to nitrogen over 0-60-60 (kg/ha) 40	80	120	160	Response to N @ 160 kg/ha over 90 kg each of P_2O_5 and K_2O	SE ±	CD (0.05)
[illegible]	1	Talikulam	[illegible]	2894	[illegible]	511	626	723	978	64	146	296
		Mullassery	8	3002	3124	50	196	418	986	238	192	386
			14	2948	2931	272	561	573	982	161		
	2	Anthikad	8	3540	3600	140	260	360	480	220	38	76
		Puzhackal	8	2600	2980	60	580	580	840	-140	180	362
			16	3070	3290	100	420	470	660	40		
	3	Vellangallore	9	1700	1680	320	420	580	660	140	138	276
		Kodakara	8	2720	3020	260	420	620	840	140	408	821
			17	2210	2350	290	420	600	750	140		

Table 15. Response to nitrogen in the A type experiment, mundakan 1973-74 (grain yield, kg/ha)

District	Zone	Block	No.of trials	un-manured control (0-0-0)	0-60-60 (kg/ha)	Response to nitrogen over 0-60-60 kg/ha				Response to N @ 160 kg/ha over 90 kg each of P_2O_5 and K_2O	SE ±	CD (0.05)
						40	80	120	160			
Quilon	1	Pathanapuram	6	3020	3700	280	680	1420	1220	340	180	366
		Konni	9	2600	2960	720	1320	1720	1460	80	174	348
			15	2810	3330	500	1000	1570	1340	210		
	2	Parakode	7	3560	2800	620	1300	1980	2100	140	36	72
		Mukhathala	8	2840	3220	380	720	1300	1060	280	110	222
			15	2700	3010	500	1010	1640	1580	210		
	4	Chavara	8	1720	2040	200	460	420	120	120	104	210

Increasing the dose of phosphorus (P_2O_5) and potash (K_2O) from 60 kg to 90 kg each per hectare enhanced the magnitude of response to 160 kg N/ha in Thalikulam, Anthicad, Vellangallure, Puzhackal, Mukhathala and Ithickara blocks during the viripPu season and in Anthickad and Parakode blocks in the mundakan season. In the other blocks no marked variation was observed in the reaction of the test varieties to 160 kg N/ha due to additional increments of phosphorus and potash.

Response to Phosphorus

During the mundakan season, no marked response to applied phosphorus was observed in Thalikulam, Anthicad, Puzhakkal and Vellangallore blocks in Trichur district (Table 16,18) and in Pathanapuram and Ithickara blocks in Quilon district (Table 17,19). The Mullasseery, P_2O_5 applied at one and a half times the base level (180 kg/ha) produced significantly higher yield over the other 2 doses, the rate of response per unit of P_2O_5 being 4.7 kg of grain. The lower two doses were on a par in their effect on yield. Although response to P_2O_5 was linear in Kodakara, the differences between half the base level (60 kg) and the base level (120 kg) and that of the one and a half of the base level and the base level did not touch the level of statistical significance. In Mukhathala and Parakode blocks of Quilon district the three levels of P_2O_5 significantly increased the grain yield although between themselves there was no marked difference. The base level of P_2O_5 effected significant yield increases over the no phsphate control in Konni block. The differences between it and the 60 and 180 kg levels, however, were not significant statistically.

Phosphate application at 1½ the base level effected significant yield increases in Thalikulam, Anthicad and Vellangallore blocks in the Trichur district (Table 17) and in all the blocks except Chavara in the Quilon district (Table 19) during the mundakan season. In Mullasseery, Puzhakkal, Kodakara and Chavara, the differences between ½ the base level and no phsphate control had no significant difference. Except in Vellangallore, Puzhakkal and Pathanapuram the effects due to the three doses- ½, 1, 1½ the base level- were on a par. In Vellangallore and Pathanapuram, response to P was linear and significant. The highest yield was recorded at the 180 kg P_2O_5 level in Puzhakkal and it was significant statistically compared to the other levels.

In Parakode, Chavara and Mukhathala blocks of Quilon district, although the response to phosphate was significant, the differences between the base level and 1½ times the base level were not significant.

Table 18. Response of rice to phosphorus and potash virippu 1973-74 grain yield (kg/ha) (B type experiment)

District	Zone	Block	No.of trials	unmanured control	120-0-60	Response to phosphorus over 120-0-60			Response to potash over 120-120-0			120-60-60 (kg/ha)	120-60-60 (kg/ha)	SE ±	CD (0.05)
						60	120	180	30	60	90				
Quilon	1	Konni	6	2518	3752	527	729	681	270	503	862	892	1107	340	685
		Pathanapuram	5	2097	2799	162	422	795	118	123	298	582	593	843	NS
			11	2322	3275	344	575	738	194	313	580	737	850		
	2	Parakode	8	3159	3598	1126	1179	1467	447	945	1134	1936	2118	79	157
		Mukhathala	4	2544	2951	872	1224	1082	330	790	941	1632	1287	268	591
			12	2651	3225	1200	1351	1274	388	867	1037	1784	1702		
	4	Ithikkara	5	3265	3992	422	- 12	-156	- 7	209	554	677	467	..	NS

Table 17. Response of rice to phosphorus and potash, mundakan, 1973-74 (grain yield (kg/ha) (B type experiments)

District	Zone	block	No.of trials	0-0-0 (kg/ha)	120-0-60 (kg/ha)	phosphorus (kg/ha)			Potash (kg/ha)			120-60-60 (kg/ha)	120-90-90 (kg/ha)	SE ±	CD (0.05)
						60	120	180	30	60	90				
Quilon	1	Pathanapuram	6	3620	4080	640	980	1600	80	260	220	1240	1140	134	270
		Konni	9	2580	3600	820	1020	840	180	480	660	1440	1100	144	288
			15	3100	3950	730	1000	1220	130	370	440	1340	1120		
	2	Perakode	7	2580	3920	740	1020	1080	260	660	860	1480	1560	70	140
		Mukhathala	8	2840	3620	1220	1480	1100	160	660	520	1920	1400	84	168
			15	2710	3770	980	1250	1240	210	660	690	1700	1480		
	4	Chavara	3	1720	2420	80	260	320	200	320	500	500	260	100	200

Table 18. Response of rice to phosphorus and potash, virippu, 1973-74 (grain yield (kg/ha)
(B type experiment)

District	Zone	Block	No.of trials.	un-manured control	120-0-60 (kg/ha)	Phosphorus (kg/ha)			potash (kg/ha)			120-60-60 (kg/ha)	120-90-90 (kg/ha)	SE ±	CD (0.05)
						60	120	180	30	60	90				
Palghat	1	Thalikulam	7	2606	3571	47	187	-90	52	546	332	608	387	206	413
		Mullassery	8	3716	4837	141	343	851	93	76	537	569	1063	174	348
			15	3161	4204	94	267	380	72	311	434	588	725		
	2	Anthicad	8	4187	4332	172	389	443	123	-59	106	433	881	224	448
		Puzhackal	8	3884	5595	9	67	-71	-66	-56	-86	249	101	49	98
			16	4035	4964	90	228	186	28	-57	10	341	491		
	3	Vellangalloor	7	3123	3399	28	528	102	12	295	165	-117	-241	NS	NS
		Kodakara	8	4365	5125	124	449	758	250	-182	309	943	1576	194	388
			15	3744	4412	76	489	430	131	56	237	413	667		

Table 19. Response of rice to phosphorus and potash, mundakan, 1973-74 (grain yield (kg/ha)
(S type experiment)

District	Zone	block	No. of trials	Unmanured control	120-0-60 (kg/ha)	phosphorus (kg/ha) 60	120	180	potash (kg/ha) 30	60	90	120-60-60 (kg/ha)	120-90-90 (kg/ha)	SE	CD (0.05)
Trichur	1	Chalikulam	6	3080	3640	180	260	220	20	300	400	100	-40	49	98
		Mullassery	8	3220	3600	220	440	540	240	280	1000	600	1140	201	400
				3650	3620	200	350	380	130	290	700	350	550		
	2	Anthicad	8	3500	3640	100	160	220	20	120	80	240	260	42	84
		Puzhackal	8	3000	3680	160	200	300	340	240	440	180	980	125	250
				3250	3660	130	180	260	180	180	260	210	270		
	3	Vellangallore	8	1680	1420	300	160	580	260	-380	300	180	640	145	290
		Kodakara	8	2920	3760	80	180	320	60	-180	-	260	820	167	334
				2300	2590	190	170	450	160	-280	150	220	730		

Table 20. Response of rice to zinc, virippu and mundakan, 1973-74

District	Zone	block	No.of trials.	120-60-60 (kg/ha)		response to zn over 120-60		Sig.or not		CD (0.05)	
				viri-ppu	munda-kan	viri-ppu	munda-kan	viri-ppu	munda-kan	viri-ppu	munda kan
Trichur	1	Thalikulam	7	3273	3466	158	236	NS	NS	434	296
		Mullassery	8	4834	3542	408	630	NS	Sig.	494	386
			15			2483					
	2	Annicad	-	1310	3560	308	160	Sig.	Sig.	151	76
		Pushpagiri		5273	3560	403	.	Sig.	NS.	362	363
			15								
	3	Vellangallore	6	3538	2260	493	-60	NS	NS	Sig.	276
		Kodakara	8	5544	3640	47	120	NS	NS	248	821
			14								
Quilon	1	Pathanapuram	8	3331	5120	- 4	60	NS	NS	242	366
		Kondi	6	4199	4680	-138	60	NS	NS	278	348
			14				60				
	2	Parakode	8	5194	4780	59	40	NS	Sig.	738	72
		Mukhathala	4	4333	4520	-207	60	NS	NS	625	222
			12				50				
	4	Ithickara	4	4463	-	46	-	NS	-	291	-
		Chavara	8	-	2460	-	100	-	NS	-	210

Response to Potash

Potash application resulted significant yield increases in Thalikulam and Mullassery blocks in Trichur district (Table 16) and Konni, Parakode and Mukhathala blocks in Quilon district during the virippu season (Table 17). In the other blocks the response to K was not significant. In the Thalikulam block significantly higher yield was produced by the base level of K_2O (60 kg/ha) over the other levels which were on par. In Mullassery, application of K_2O at 1½ times the base level significantly out yielded the other levels. The trend of the results was almost similar in Konni, Parakode and Mukhathala blocks of Quilon district where the maximum yields were recorded at 90 kg. K_2O/ha. While the difference between 1½ times the base level (90 kg) and the base level of K_2O was significant in Konni and Parakode, it was not significant in Mukhathala.

During the mundakan season, the test variety IR 8 exhibited significant yield response to 1½ the base level (90kg) in Thalikulam, Mullassery and Pazhayannur blocks in Trichur district (Table 18) and in Parakode block in Quilon district (Table 19). In Konni, Chavara and Mukhathala blocks the effects due to the base level and 1½ the base level were on par. In Anthicad, the maximum yields were produced at the base level of K_2O, and there was no significant difference between the other levels of K_2O. The effect due to K_2O was not significant in Vellangallore, Kodakara and Pathanapuram blocks in the mundakan season.

Response to zinc

Application of zinc at [illegible] kg/ha over 120 kg N, 60 kg P_2O_5 and [illegible] kg K_2O per hectare exerted significant yield increases over no zinc in Anthicad block of Trichur district during both the seasons, the mean response being [illegible] kg/ha in virippu and [illegible] kg/ha in mundakan. While the [illegible] responded to zinc during the virippu season in [illegible] Pazhayannur [illegible] first crop season, it failed to [illegible] in the second crop season. The magnitude of response [illegible] touched the level of statistical significance in Mullassery, Thalikulam, Anthicad and Parakode blocks in the mundakan season, although response was moderate to nil in the previous season. In some of the blocks in Quilon district zinc had no marked influence on yield. Similar results were recorded in the [illegible] block of Trichur district. In Parakode the test variety exhibited a mean response of 40 kg/ha in the mundakan season and it was significant statistically.

The results are summarised in Table 20.

Table 21. Response of rice to nitrogen, phosphorus and potash as influenced by fertility classes, Virippu, 1973-74 (C type experiment- grain yield, kg/ha)

District	Fertility class	No.of trials	No manure control	120-0-0 (kg/ha)	phosphorus (kg/ha) 60	120	180	potash (kg/ha) 30	60	90	120-60-60 (kg/ha)	120-90-90 (kg/ha)	SE + -	CD (0.05)
[illegible]	LL	5	[illegible]	4180	66	102	78	217	136	193	256	391	190	385
	LM	5	[illegible]	3867	89	262	84	411	290	333	367	301	168	339
	ML	5	[illegible]	4052	8	109	162	117	132	132	199	202	167	336
	MM	5	[illegible]	4177	117	-81	-210	64	50	215	116	326	202	408
Quilon	LL	9	2889	2981	172	401	657	58	-84	459	520	879	97	193
	LM	9	3286	3382	284	563	752	68	16	430	674	912	83	164

Soil test values and crop response (c type trials)

Nitrogen by itself produced significant yield increases over the unmanured control in all the 4 fertility classes in the Ollukkara block of Trichur district during the virippu season (Table 21). In the mundakan season, however, effect due to applied nitrogen was confined to ML and MM soil fertility classes only (Table 22). The magnitude of response to nitrogen was relatively higher in these groups of soils compared to those of LL and LM classes. Application of phosphorus had little effect on yield during both the seasons. Response to potash was significant in the LM class of soil only. In all the classes of soil fertility, however, in combination with nitrogen, phosphorus and potash tended to increase grain production although their interactional effects were not significant. In general, response to fertilizers was rather poor at Ollukkara, irrespective of the soil fertility classes.

The results recorded during the virippu season in the Kottarakkara block of Quilon district where there were only 2 fertility classes in each season- LL and LM in virippu and LM and MM in mundakan- showed a different trend (Tables 21, 22). Here, response to nitrogen was practically nil in the absence of phosphorus and potash. Response to phosphorus and potash, on the other hand, was significantly high during the seasons.

In all the fertility classes, the treatment receiving N, P_2O_5 and K_2O at 120, 120 and 90 kg per hectare respectively, produced the maximum yields indicating that a combinations of all the 3 nutrients are quite essential for the soils of Kottarakkara. The results also showed that phosphorus and potash are the limiting factors in crop production in the soils of this block.

Table 11. Response of rice to nitrogen, phosphorus and potash as influenced by fertility class, Mundakan, 1975-7? (? type experiment; grain yield, kg/ha)

District	Ferti-lity class	No. of trials	[illegible] control	120-?-? (kg/ha)	phosphorus (kg/ha) 60	120	150	potash (kg/ha) 30	60	90	120-60-60 (kg/ha)	120-90-90 (kg/ha)	SE ±	CD (0.05)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-258	[illegible]	[illegible]	-15	[illegible]	24	239	338	409	810
	[illegible]	5	[illegible]	[illegible]	-21	-200	155	[illegible]	32	[illegible]	174	284	223	450
	[illegible]	[illegible]	[illegible]	[illegible]	-13	[illegible]	[illegible]	[illegible]	189	306	.01	195	132	264
	MM	5	[illegible]	[illegible]	14	-21	[illegible]	-116	-130	[illegible]	94	108	161	329
Quilon	LM	9	3638	3778	215	511	741	184	-103	522	662	949	136	269
	MM	9	3249	3426	293	631	890	268	-155	755	804	1227	161	322

Part 3

SUMMARY AND CONCLUSION

Experiments at the Model Agronomic Centre, Karamana were oriented to gather information on production potential under adequate as well as limited production inputs and to study the long term effects of different agronomic practices on cropping systems. The following important conclusions are drawn from the results of trials conducted during 1973-74.

* The suitable cropping system for maximum production of grain annually is to raise 3 crops of Jaya in succession during the 3 cropping seasons in an year.

* A rotation including a cash crop gives nearly 2 times the gross returns as against the one without a cash crop.

* Under the existing conditions in the southern Kerala, 2 medium duration rice (virippu and mundakan) followed by a bhindi crop (vegetable) is the best cropping pattern.

* Under input constraint like fertilizer shortage, the recommended levels of nutrients for medium duration rice (90:45:45 kg/ha, N, P and K) can be reduced to 75% without much sacrifice on yield.

* Response to applied phosphorus and potash is almost absent in the lateritic sandy clay loam soils of Karamana.

* Application of farm yard manure increases crop yields in the virippu season. It does not, however, leave any residual effect in the soil.

Response of high yielding rice varieties to nitrogen, phosphorus, potash and zinc was studied in the experiments conducted on cultivators' fields in Quilon and Trichur districts. The following are the conclusions drawn:

* There is good response to applied nitrogen in all the blocks except Thalikulam in the Trichur district.

* Addition of nitrogen beyond 80 kg/ha, although brings about increased yields, does not seem to be a sound practice, judged from the results gathered from the majority of the blocks.

* High response to nitrogen (beyond 80 kg/ha) is obtained in Mullasseery, Puzhakkal, Pathanapuram, Konni and Parakode blocks in both the seasons.

* The range of response to phosphate, on an average, is moderate to good. The magnitude of response is more pronounced in the mundakan season than in the virippu season.

* Potash application results in significant yield increases in all the blocks except Vellangallore, Kodakara and Pathanapuram.

* In the Ollukkara block of Trichur district, response to nitrogen is high even without the addition of phosphate and potash; while in the Kottarakkara block of Quilon district, response to nitrogen is poor when it is applied alone.

* Irrespective of the soil fertility status, there is response to applied phosphorus and potash in the Kottarakkara block, while it is not observed in the Ollukkara block of Trichur district.

* Response to zinc is erratic and inconsistent. The only block in which response to zinc observed is Anthicad in Trichur district.