

Studies In Ceylon Paddies

1. Investigations on varieties grown in the Hambantota District —

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INTRODUCTION

THE varieties of paddy grown in the Hambantota District take three to four months from sowing to harvest. The same varieties are sown in the two seasons, *maha* and *yala*. *Maha* sowings are done in November-December, and *yala* sowings in May-June. This paper presents the results of investigations on paddies which take eleven to thirteen weeks from sowing to flowering, viz., *Rathkarayal*, *Sinnanayan*, and *Suduheenati*. Pure-line selections of *Rathkarayal* and *Sinnanayan* were made by Mr. G. V. Wickremasekera, Paddy Officer, in 1938: these were 3753 and 3777 in *Rathkarayal*; 2208 and 398 in *Sinnanayan*. The *Suduheenati* selections were ICPY-15 and Hf 9, and were made by Lord in the Central Province.

DESCRIPTION OF VARIETIES UNDER TEST

Descriptions of Ceylon Paddies are available only of a few recommended pure-lines. These descriptions are of qualitative characters, mainly pigmentation. Grain size determinations of some pure-lines were made by Lord in 1929.

Anthocyanin pigment.—Differences, though not pronounced, are found between varieties, and even between strains of the same variety, in the intensity and distribution of anthocyanin pigment. *Rathkarayal* and *Sinnanayan* have anthocyanin in the leaf sheath, stigma and apiculus; the *Suduheenati* selections, ICPY-15 and Hf 9, lack anthocyanin pigment. In grain colour, *Suduheenati* Hf 9 is pale straw; the others, viz., *Suduheenati* ICPY-15, *Rathkarayal* and *Sinnanayan* have dark brown furrows and lighter ridges. Like most varieties of Ceylon Paddy, *Rathkarayal*, *Sinnanayan* and *Suduheenati* have a red pericarp.

Grain size.—Grain size determinations of the six selections, *Rathkarayal* 3753 and 3777, *Suduheenati* Hf 9 and ICPY-15, and *Sinnanayan* 2208 and 398, were made. The length, breadth and thickness of two hundred grains of each selection were first measured. These same grains were then carefully husked and the length, breadth and thickness of the two hundred husked grains (rice) were recorded. The means and standard errors of length, breadth and thickness of unhusked grain are given in Table I, and of husked grain in Table II. With a standard error of 0.025 mm. and less, a difference between means greater than 0.07 mm. is significant; with a standard error of 0.01 mm. and less, the significant difference between means is 0.03 mm. Applying these critical differences to the differences between mean grain dimensions, it is possible to distinguish between varieties, and even between strains of the same variety.

Table I—Dimensions of Paddy (Unhusked Grain)

Variety	Length				Breadth				Thickness			
	Mean (mm.)	Range		Standard Error of the Mean	Mean (mm.)	Range		Standard Error of the Mean	Mean (mm.)	Range		Standard Error of the Mean
		Lowest	Highest			Lowest	Highest			Lowest	Highest	
Sinnanayan 2208	7.76	6.8	8.4	0.0165	3.41	3.1	3.9	0.0098	2.29	1.9	2.8	0.0088
Sinnanayan 398	8.13	7.2	9.0	0.0219	3.30	2.7	3.7	0.0117	2.26	1.6	2.6	0.0096
Rathkarayal 3753	7.99	7.0	9.0	0.0263	3.14	2.8	3.5	0.0089	2.23	2.0	2.5	0.0068
Rathkarayal 3777	8.18	7.1	8.8	0.0190	3.22	2.7	3.6	0.0098	2.24	1.8	2.5	0.0068
Suduheenati ICPY 15	8.43	7.1	9.5	0.0248	3.22	2.9	3.7	0.0103	2.16	1.8	2.5	0.0076
Suduheenati Hf 9	8.00	7.2	8.9	0.0213	3.34	2.9	3.6	0.0106	2.27	2.0	2.5	0.0077

Table II—Dimensions of Rice (Unhusked Grain)

Variety	Length						Breadth						Thickness					
	Mean (mm.)	Range		Standard Error of the Mean	Mean (mm.)	Range		Standard Error of the Mean	Mean (mm.)	Range		Standard Error of the Mean						
		Lowest	Highest			Lowest	Highest			Lowest	Highest							
Sinnanayan 2208	5.48	5.1	5.9	0.0181	2.94	2.2	3.2	0.0092	2.06	1.7	2.3	0.0073						
Sinnanayan 398	5.64	4.9	6.6	0.0179	2.74	2.1	3.1	0.0137	2.05	1.5	2.4	0.0099						
Rathkarayal 3753	5.72	5.0	7.4	0.0209	2.70	2.1	3.0	0.0122	2.03	1.7	2.3	0.0089						
Rathkarayal 3777	5.81	4.9	7.0	0.0155	2.80	2.4	3.1	0.0101	2.04	1.8	2.3	0.0057						
Suduheenati ICPY 15	5.94	5.1	7.0	0.0146	2.68	1.8	3.2	0.0124	1.95	1.5	2.2	0.0075						
Suduheenati Hf 9	5.60	5.0	8.2	0.0185	2.91	2.4	3.1	0.0108	2.07	1.7	2.3	0.0078						

Flowering.—The interval between sowing and flowering for each of the varieties is indicated in Table III. All varieties took less time to flower in *maha* than in *yala*, and this may be a photoperiodic response to the shorter day length in *maha*. The number of days from sowing to flowering has been consistently less in *maha* than in *yala*, for all varieties. The difference in the age of each variety in *maha* and *yala* is indicated in Table IV. This difference was more in some varieties than in others, but in all varieties the difference between *yala* and *maha* age was significant.

Table III—Age of Varieties from Sowing to Flowering expressed in Days

	Rathkarayal			Suduheenati			Sinnanayan		
	3753	3777	Local	Hf 9	ICPY 15	2208	398	Local	
Ambalantota—									
Yala, 1945	.. 90	.. 86	.. 86	.. 86	.. 91	.. 86	.. 86	.. 86	
Yala, 1946	.. 91	.. 92	.. 91	.. 91	.. 95	.. 92	.. 91	.. 91	
Yala, 1947	.. 83	.. 83	.. 89	.. 89	.. 91	.. 84	.. 88	.. 85	
Tissamaharama—									
Yala, 1945	.. 84	.. 84	.. 84	.. 84	.. 88	.. 84	.. 84	.. 84	
Yala, 1946	.. 91	.. 84	.. 84	.. 91	.. 91	.. 84	.. 91	.. 91	
Yala, 1947	.. 87	.. 92	.. 82	.. 85	.. 87	.. 82	.. 87	.. 82	
MEAN (YALA)	.. 88	.. 85	.. 86	.. 88	.. 90	.. 85	.. 88	.. 86	
Ambalantota—									
Maha, 1945-46	.. 80	.. 80	.. 80	.. 80	.. 80	.. 80	.. 86	.. 80	
Maha, 1946-47	.. 80	.. 77	.. 74	.. 77	.. 79	.. 74	.. 87	.. 79	
Maha, 1947-48	.. 79	.. 68	.. 70	.. 71	.. 72	.. 71	.. 79	.. 71	
Tissamaharama—									
Maha, 1945-46	.. 80	.. 78	.. 80	.. 78	.. 79	.. 79	.. 82	.. 79	
Maha, 1946-47	.. 79	.. 77	.. 77	.. 77	.. 77	.. 77	.. 81	.. 77	
Maha, 1947-48	.. 76	.. 69	.. 69	.. 72	.. 69	.. 72	.. 76	.. 69	
MEAN (MAHA)	.. 79	.. 75	.. 75	.. 76	.. 76	.. 75	.. 82	.. 75	

Table IV—Age Difference in Yala and Maha expressed in Days

Varieties	Mean Age		Difference in mean age between Yala and Maha	Standard Error of the difference in mean ages	Significant difference (5% Point)
	Yala	Maha			
Rathkarayal 3753	.. 88	.. 79	.. 9	.. 1.58	.. 3.50
Rathkarayal 3777	.. 85	.. 75	.. 10	.. 2.52	.. 5.59
Rathkarayal local	.. 86	.. 75	.. 11	.. 2.40	.. 5.32
Suduheenati Hf 9	.. 88	.. 76	.. 12	.. 1.92	.. 4.26
Suduheenati ICPY 15	.. 90	.. 76	.. 14	.. 2.16	.. 4.79
Sinnanayan 2208	.. 85	.. 75	.. 10	.. 2.09	.. 4.63
Sinnanayan 398	.. 88	.. 82	.. 6	.. 1.78	.. 3.95
Sinnanayan local	.. 86	.. 75	.. 11	.. 2.46	.. 5.46

DESIGN OF FIELD EXPERIMENTS

The six selections already mentioned and the unselected *Rathkarayal* and *Sinnanayan* from cultivator's fields were compared in variety trials set down at the Ambalantota and Tissamaharama Paddy Stations. The trials commenced in the *yala* season of 1945 and continued over the *maha* and *yala* seasons of three years, viz., 1945, 1946 and 1947.

The design of the experiment was a randomized block replicated four times at each station. The eight strains were represented by eight plots, one for each, arranged in a block which measured 47 feet by 112 feet. The individual plots were 47 feet by 14 feet; a border of one foot around each plot was discarded at harvest; yields were recorded of a 45 feet by 12 feet plot, which in extent was 1/80 acre.

All varieties were sown and not transplanted. No fertilizers were applied. Intercultivation and weeding were not done. The plots were kept almost weed free by regulation of irrigation water.

RESULTS AND DISCUSSION

The thirty-two plots at each station made 384 plots in all at the two stations, in the two seasons of three years. The total variation between the 384 plots was analysed into components due to varieties, stations, seasons, years, and the first, second and third-order interactions of these main effects. The variation between the 48 blocks included the variation due to stations, seasons, years, and their interactions. In computing the block sum of squares, the sums of squares due to stations, seasons, years, and their interactions were deducted from the total sum of squares between blocks. The mean squares for varieties, stations, seasons, years, and all interactions, except varieties x stations x years and varieties x seasons x years, were significant at the 1 per cent. point. The standard error of a single plot was 2.73 and the coefficient of variability 8.6 per cent. Significant differences within main effects and interactions were determined at the 5 per cent. point of probability.

Table V—Analysis of Variance of Yield in Pounds

	Degrees of Freedom	Sum of Squares	Mean Square	Variance Ratio	5 Per Cent. Point	1 Per Cent. Point
Stations	.. 1	.. 5,593.71	.. 5,593.71	.. 751.84	.. 3.89	.. 6.76
Seasons	.. 1	.. 189.84	.. 189.84	.. 25.51	.. 3.89	.. 6.76
Years	.. 2	.. 1,580.55	.. 790.27	.. 106.21	.. 3.04	.. 4.71
Stations x Seasons	.. 1	.. 3,175.15	.. 3,175.15	.. 426.76	.. 3.89	.. 6.76
Stations x Years	.. 2	.. 425.07	.. 212.53	.. 28.56	.. 3.04	.. 4.71
Seasons x Years	.. 2	.. 6,844.44	.. 3,422.22	.. 459.97	.. 3.04	.. 4.71
Stations x Seasons x Years	.. 2	.. 5,527.65	.. 2,763.82	.. 371.48	.. 3.04	.. 4.71
Varieties	.. 7	.. 700.35	.. 100.05	.. 13.44	.. 2.05	.. 2.73
Varieties x Stations	.. 7	.. 141.29	.. 20.18	.. 2.71	.. 2.05	.. 2.73
Varieties x Seasons	.. 7	.. 243.93	.. 34.84	.. 4.68	.. 2.05	.. 2.73
Varieties x Years	.. 14	.. 276.30	.. 19.73	.. 2.65	.. 1.74	.. 2.17
Varieties x Stations x Seasons	.. 7	.. 139.34	.. 19.90	.. 2.67	.. 2.05	.. 2.73
Varieties x Stations x Years	.. 14	.. 156.42	.. 11.17	.. 1.50	.. 1.74	.. 2.17
Varieties x Seasons x Years	.. 14	.. 161.18	.. 11.51	.. 1.54	.. 1.74	.. 2.17
Varieties x Stations x Seasons x Years	.. 14	.. 242.33	.. 17.30	.. 2.32	.. 1.74	.. 2.17
Blocks	.. 36	.. 1,531.72	.. 42.54	.. 5.71		
Error	.. 252	.. 1,876.78	.. 7.44			
Total	.. 383	28,806.05				

Table VI—Variety Yields (Totals of both stations)

<i>Varieties</i>	<i>Total yield of 48 plots, each of 1/80 acre (pounds)</i>	<i>Yield per acre in pounds</i>	<i>Yield per acre in bushels (calculated at an average bushel weight of 48 pounds)</i>
Rathkarayal 3753	1556.2	2593.6	54.0
Rathkarayal 3777	1475.8	2459.6	51.2
Rathkarayal local	1406.6	2344.3	48.8
Suduheenati Hf 9	1473.6	2456.0	51.1
Suduheenati ICPY 15	1636.2	2727.0	56.8
Sinnanayan 2208	1526.1	2543.5	53.0
Sinnanayan 398	1533.3	2555.5	53.2
Sinnanayan local	1560.4	2600.6	54.1

Significant between the totals of 48 plots = 53.9 pounds

Table VII—Interaction of Varieties x Seasons and Varieties x Stations

(Yields are totals of 24 plots, expressed in pounds)

<i>Varieties</i>	<i>Seasons</i>		<i>Stations</i>	
	<i>Maha</i>	<i>Yala</i>	<i>Tissamaharama</i>	<i>Ambalantota</i>
Rathkarayal 3753	817.1	739.1	677.6	878.6
Rathkarayal 3777	733.0	742.8	661.3	814.5
Rathkarayal local	703.9	702.7	614.5	729.1
Suduheenati Hf 9	754.3	719.3	665.3	808.3
Suduheenati ICPY 15	826.0	810.2	697.4	938.8
Sinnanayan 2208	758.7	767.4	676.7	849.4
Sinnanayan 398	814.4	718.9	665.7	867.6
Sinnanayan local	811.7	748.7	692.8	867.6

Significant difference between the totals of 24 plots = 37.41 pounds

Table VIII—Interaction of Varieties x Stations x Seasons

(Yields are totals of 12 plots expressed in pounds)

<i>Varieties</i>	<i>Ambalantota</i>		<i>Tissamaharama</i>	
	<i>Maha</i>	<i>Yala</i>	<i>Maha</i>	<i>Yala</i>
Rathkarayal 3753	487.9	390.7	329.2	348.4
Rathkarayal 3777	450.5	364.0	282.5	378.8
Rathkarayal local	431.1	361.0	272.8	341.7
Suduheenati Hf 9	449.7	358.6	304.6	360.7
Suduheenati ICPY 15	495.0	443.8	331.0	366.4
Sinnanayan 2208	466.0	383.4	292.7	384.0
Sinnanayan 398	491.1	376.5	323.3	342.4
Sinnanayan local	480.7	386.9	331.0	361.8

Significant difference between the totals of 12 plots = 26.45 pounds

Varieties.—In the comparison of total yields of varieties over all stations, seasons and years, *Suduheenati* ICPY-15 was significantly superior to all other varieties (Table VI). The comparison of variety yields in each season and at each station (Table VII), indicates *Suduheenati* ICPY-15 as the highest yielder, but significant superiority over all other varieties was obtained only in the *yala* season, and at Ambalantota. The interaction of varieties into stations into seasons is presented in Table VIII: *Suduheenati* ICPY-15 was significantly better than all other varieties in *yala* at Ambalantota; in *maha*, at Ambalantota, *Suduheenati* ICPY-15 was still the highest yielder, but did not differ significantly from *Rathkarayal* 3753, *Sinnanayan* 398 and *Sinnanayan* local. At Tissamaharama, in *maha*, *Suduheenati* ICPY-15 was equal in yield to *Sinnanayan* local, and these two were the highest yielders; they were not significantly better than *Rathkarayal* 3753 and *Sinnanayan* 398. In *yala*, at Tissamaharama, *Sinnanayan* 2208 was the highest yielder, but was not significantly different from *Sinnanayan* local, *Suduheenati* ICPY-15, *Suduheenati* Hf 9 and *Rathkarayal* 3777.

A comparison of selections against unselected local material (Table VIII) indicates that the *Sinnanayan* selections were not significantly superior to *Sinnanayan* local in any season or station. *Sinnanayan* 398 yielded higher than 2208 in *maha*, and 2208 more than 398 in *yala*. These differences were significant at Tissamaharama. The two *Sinnanayan* selections show differences in habit; 2208 grows tall and has erect tillers; 398 is not tall and has a wide tillering angle. 2208 lodges, particularly in *maha*; when it does not lodge, as in *yala* at Tissamaharama, it yields significantly more than 398. Similar differences in respect of habit and lodging were observed between *Rathkarayal* 3753 and 3777. *Rathkarayal* 3777 grows taller than 3753 and lodges badly, but when it does not lodge, as in *yala* at Tissamaharama, it yields significantly more than 3753. In the *maha* season at Tissamaharama 3753 is significantly better. At Ambalantota, 3753 is significantly better both in *maha* and *yala*. *Suduheenati* ICPY-15 always yielded higher than *Suduheenati* Hf 9; this was significantly so, except in the *yala* season at Tissamaharama.

The only non-significant interactions were varieties into stations into years, and varieties into seasons into years. The interpretation would be that the three years had no differential effect on the two significant first-order interactions, varieties into stations and varieties into seasons. The effects, already discussed, of stations and seasons on varieties are therefore taken to be similar in all years.

Stations and Seasons.—The difference in yields between stations and between seasons is highly significant: the yield at Ambalantota was higher than that at Tissamaharama; the yield in the *maha* season was higher than in the *yala* season (Table IX). These significant differences between the main effects of stations and seasons should be interpreted in relation to the significant interaction of stations into seasons: at Ambalantota, the *maha* season was significantly better than the *yala* season; at Tissamaharama, the *yala* season was significantly better than the *maha* season.

Table IX—Interaction of Stations x Seasons

(Yields for each station x season are totals of 96 plots in pounds; Yield totals for each station and for each season are of 192 plots)

Stations	Seasons		
	Maha	Yala	Total
Tissamaharama	.. 2467.1	.. 2884.2	.. 5351.3
Ambalantota	.. 3752.0	.. 3064.9	.. 6816.9
	<u>6219.1</u>	<u>5949.1</u>	<u>12168.2</u>

Significant difference between totals of 96 plots = 74.82 pounds

Significant difference between totals of 192 plots = 105.80 pounds

Table X—Maha and Yala Acre-Yields at Ambalantota and Tissamaharama
(Calculated from Table IX)

Station	Season	Yield per Acre	
		Pounds	Bushels
Ambalantota	Maha	.. 3126.6	.. 65.1
	Yala	.. 2554.0	.. 53.2
Tissamaharama	Maha	.. 2055.9	.. 42.8
	Yala	.. 2403.5	.. 50.0

The differences in soil at the two stations provide a possible explanation for the observed differences in yield. The Tissamaharama soil is a grey-brown loam, somewhat on the light side, with a pH. of 7.23. Its salt content is low, viz., 0.045 per cent. Its base exchange capacity and power of regeneration are lower than that of Ambalantota. It is poor in both available potash and phosphoric acid. The Ambalantota soil is a heavy brown loam of pH 7.00, slightly saline, but becoming more markedly saline (nearly 0.28 per cent. salt) in dry weather. During the *yala* season, the increasing concentrations of salts may have a slightly depressant effect on yield. The available potash content of the soil is low, but it is moderately rich in phosphoric acid.

Table XI gives the monthly rainfall at the two stations, Ambalantota and Tissamaharama. It will be seen that the rainfall in *yala* was much less than in *maha*. The low rainfall in *yala*, while increasing soil salinity at Ambalantota and depressing yields, provided more favourable conditions during sowing, growth, and flowering. This would explain the higher yield in *yala* over *maha* at Tissamaharama. At Ambalantota, however, it would appear that yields depended more on the degree of soil salinity than on other factors. Soil fertility would account for the higher yields of Ambalantota over Tissamaharama in both *maha* and *yala*.

Table XI—Rainfall in inches at Ambalantota and Tissamaharama

	Ambalantota				Tissamaharama			
	1945	1946	1947	1948	1945	1946	1947	1948
January	0.29..	0.29..	2.26..	2.26..	0.63..	1.50..	4.12..	6.13
February	1.02..	0.41..	0.20..	0.30..	1.62..	1.10..	0.29..	nil
March..	5.88..	3.90..	3.14..	0.78..	7.02..	4.48..	7.27..	1.02
April ..	5.48..	4.67..	2.68..	3.80..	4.06..	5.45..	4.47..	2.81
May ..	0.97..	0.81..	8.98..	1.40..	0.74..	nil ..	4.72..	1.20
June ..	5.19..	1.46..	7.68..	2.44..	1.43..	1.41..	4.12..	1.26
July ..	1.42..	0.67..	0.31..	0.65..	1.57..	nil ..	0.15..	0.42
August	0.69..	1.25..	4.51..	0.67..	nil ..	nil ..	1.63..	1.44
September	0.78..	1.50..	0.85..	2.47..	nil ..	0.23..	0.45..	0.43
October	5.13..	12.16..	6.11..	9.28..	6.13..	8.82..	7.30..	4.59
November	13.80..	10.26..	6.05..	11.09..	10.09..	10.99..	12.58..	6.46
December	0.67..	7.29..	4.58..	8.49..	5.34..	3.73..	3.93..	3.96
Total ..	41.32	44.67	47.45	44.19	39.63	37.71	51.03	29.72

Years.—The significant difference between the yields of any two of the three years at each of the stations indicates the expected variation in yield from year to year. (Table XII.) Variation in environmental factors, such as rainfall, and the incidence of pests and diseases can account for these differences. No attempt is however made in this paper to relate yield differences to differences in the environmental factors of the three years.

Table XII—Interactions of Stations x Years

(Yields for each station x year are totals of 64 plots in pounds; yields for each year are totals of 128 plots)

	Years		
	1945-46	1946-47	1947-48
Tissamaharama ..	1831.3	1590.9	1929.1
Ambalantota ..	2470.0	2105.8	2241.1
	4301.3	3696.7	4170.2

Significant difference between totals of 64 plots = 61.09 pounds

Significant differences between totals of 128 plots = 86.40 pounds

SUMMARY

1. Grain size determinations have been used for distinguishing varieties and strains of varieties. Differences in grain size between varieties and strains of varieties were significant.

2. The earlier flowering of short-aged paddies in *maha* than in *yala* is possibly a photoperiodic response to a shorter day length in the *maha* season.

3. Variety tests at Ambalantota and Tissamaharama over the *maha* and *yala* seasons of three years indicate *Suduheenati* ICPY-15 as the best of the 3½ months paddies cultivated in the Hambantota District.

4. The yields at Ambalantota are higher than at Tissamaharama, the difference being attributed to higher soil fertility at Ambalantota.

5. At Tissamaharama, higher yields are obtained in *yala* than in *maha*, but at Ambalantota the yields are higher in *maha*. The *yala* season with its lower rainfall provides conditions more favourable for growth and production, but on slightly saline soil at Ambalantota, increasing concentrations of salts in dry weather (*yala*) may have a depressant effect on yield.

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