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The Temperature Optima for Rice Culture

BY

Y. B. MORACHAN[1], K. VENUGOPAL[2] and SP. PALANIAPPAN[3]

ABSTRACT

The average per / ha yields of rice in different rice growing regions in India were correlated with the temperature factor (Relative temperature disparity) of the respective regions. The Relative temperature disparity (RTD) factor during the period of grain setting and ripening gave positive correlation with the yield levels. The higher or lower yield potential of rice in a particular region appears to be decided largely by the ' RTD ' factor of the respective cropping zone.

INTRODUCTION

Over 70 per cent of the world's rice is grown in humid tropical regions of the world. Though rice is the typical crop of humid tropics, its yields are the highest at temperate climates. Angladette (1966) reported that the highest yields of rice were obtained in a typical Mediterranean climate and not in the tropical environment in which it is most widely grown. Analysis of data on average yield of rice in the rice growing regions from equator to 40° latitudes on either side of the globe revealed that the yield of rice grown from equator to higher latitudes increases by one to five tons given/ha (Uexkull, 1967)

The same author has found the temperature factor "Relative temperature disparity" to correlate well with the yield levels of rice observed in different regions of Japan. An attempt is made in this paper to discuss such temperature relations with the rice yield from the data available pertaining to Tamil Nadu and other rice growing States in India.

MATERIALS AND METHODS

The relative temperature disparity factor 'RTD' has been worked out as indicated by Uexkull (1967).

$$RTD = \frac{\text{Average temperature disparity} \times 100}{\text{Average maximum temperature}}$$

$$= \frac{\text{M. M. Max. temp} - \text{M. M. Mini. temp} \times 100}{\text{M. M. Max. temp.}}$$

M. M. Max. temp = Mean monthly maximum temperature.

M. M. Mini. temp = Mean monthly minimum temperature.

1. Professor and, Head 2. Instructor and 3. Associate Professor. Department of Agronomy Tamil Nadu Agricultural University, Coimbatore 641003.

TABLE 1. The estimated Relative temperature disparity factor [RTD] for different districts in Tamil Nadu

Name of the district	January	February	March	April	May	June	July	August	September	October	November	December
Chingleput	38	41	33	25	31	28	26	26	26	28	27	35
South Arcot	25	27	26	21	27	27	28	26	24	22	21	25
North Arcot	37	40	38	35	31	27	26	29	27	28	27	38
Salem	41	44	40	34	32	31	32	30	30	31	32	36
Coimbatore	40	37	40	36	32	31	29	29	31	29	27	34
Tiruchirapalli	29	24	36	31	31	28	30	30	31	27	29	39
Thanjavur	25	21	22	18	22	27	25	23	26	22	21	21
Madurai	33	34	34	32	31	28	30	28	29	25	26	26
Ramanathapuram	14	17	22	18	15	16	19	19	19	16	17	14
Nilgiris	63	57	52	45	37	34	31	31	40	38	36	52

For different regions in Japan, Uexkull (1967) obtained RTD values which were running between 20 to 40. The respective RTD values for different districts of Tamil Nadu are presented in Table 1. The average per hectare rice yields for different districts of Tamil Nadu for the period from 1959–60 to 1968–69 are presented in Table 2 and 3.

The temperature data, RTD values and the average per ha yield of rice (1st crop) from different rice growing states of India are presented in Table. 5 Correlations were made between average per ha rice yields and the RTD values of the respective regions.

RESULTS AND DISCUSSION

The yield and RTD value rrom Tamil Nadu revealed positive correlation (Table 4). The first crop (*Kuruvai*) yields and RTD values of September gave significant positive correlation. Similarly the correlation between RTD of September and the first crop rice yields from different

TABLE 2. Average rice yields of 1st crop in different districts of Tamil Nadu (kg/ha)

Name of the District	1959 - 60	60 - 61	61 - 62	62 - 63	63 - 64	64 - 65	65 - 66	66 - 67	67 - 68	68 - 69	Per hectare yield average of 10 years
Chingleput	1101	1248	1067	1426	1343	1274	1213	1183	1235	807	1190
South Arcot	1440	1691	1487	1420	1450	1527	1402	1515	1679	1743	1535
North Arcot	1440	1626	1404	1478	1448	1602	1471	1267	1287	1137	1416
Salem	1770	1723	1803	1666	1834	1824	1728	1763	1725	1577	1744
Coimbatore	1994	1894	1727	2000	1723	1823	2069	1790	2014	2658	1969
Tiruchirapal	1220	1289	1287	1301	1325	1262	1379	1466	1417	1583	1353
Thanjavur	1571	1700	1520	1540	1490	1736	1542	1472	1574	1852	1600
Madurai	1703	1889	1621	1890	1883	1874	1601	1594	1456	1517	1703
Ramanathapuram	851	789	780	1024	980	822	939	1068	1050	671	897
Tirunelveli	1669	1735	1738	1755	964	1520	1121	1194	1901	1834	1543
Nilgiris	1666	1518	1289	1341	997	928	610	995	907	1440	1169
Kanyakumari	1547 1797	1691	1884	1889	2112	1945	2019	1747	2013	2225	1907

Source : Annual reports on crop cutting experiments — Tamil Nadu

states in India gave significant positive correlation (Table 5). In Japan the RTD values of August was considered for correlation, since, during that month, the grain-setting and ripening of rice occur (Vexkull, 1967)

Though both August and September temperature - data were considered for correlation in the present study, the RTD values of September alone gave significant positive correlation. This may probably be due to the fact that in India, the grain-setting and ripening of rice (1st crop) invariably occurs in the month of September.

TABLE 3. Average rice yields of 2nd crop in different districts of Tamil Nadu (kg/ha)

Name of the District	1959–60	60–61	61–62	62–63	63–64	64–65	65–66	66–67	67–68	68–69	Per hectare yield average of 10 years.
Chingleput	1430	1115	1263	989	966	1395	1416	1080	1315	1362	1233
South Arcot	1743	1457	1394	1487	1309	1729	1458	1555	1960	1733	1582
North Arcot	1534	1343	1262	1338	1408	1499	1183	1431	925	1466	1389
Salem	1904	1770	2109	2010	1625	1837	2104	1926	1759	2225	1926
Coimbatore	1500	1763	1786	2185	1513	1833	2048	2039	1936	1538	1814
Tiruchirapalli	1417	1971	1733	1889	1979	2225	1474	1897	1575	2013	1817
Thanjavur	1128	1440	1700	1400	1420	1688	1265	1298	973	1505	1382
Madurai	1504	1492	1573	1900	1648	1670	1525	1430	1654	1253	1565
Ramanathapuram	1524	1518	1624	1579	...	1646	1448	1498	671	...	1437
Tirunelveli	2022	1696	1987	1934	1530	1309	1512	1594	1504	1541	1663
Kanyakumari	1956	1591	2031	2088	2194	1624	1760	1629	1576	1808	1826
State Average	1605	1559	1678	1708	1559	1677	1563	1579	1440	1644	1572

Source : Annual reports on crop cutting experiments - Tamil Nadu

The physiological basis for such relation can be explained as below.

The higher RTD value is indicative of a higher mean maximum temperature and relatively low mean minimum temperature. The maximum temperature is accompained with ample sun light which aids in effective photosynthesis. The minimum temperature during night hours favours translocation of the photosynthate to the sink (grains) and also reduces photo-respiration thereby avoiding unnecessary loss of photosynthate. Thus the relative temperature disparity factor 'RTD' dominates as one of the chief climatic factors, influencing the rice yield.

TABLE 4. The 'RTD' values and average per ha yields of rice in different districts of Tamil Nadu

Name of the District	RTD Values		1st crop yield (kg/ha)	RTD values		2nd crop yield (kg/ha)
	August	September		January	February	
Chingleput	25	26	1190	36	35	1233
South Arcot	26	24	1535	25	27	1582
North Arcot	29	27	1416	37	40	1338
Salem	30	30	1744	42	44	1926
Coimbatore	29	31	1969	40	37	1814
Tiruchirapalli	30	31	1352	29	24	1817
Thanjavur	22	26	1599	25	21	1381
Madurai	28	29	1702	33	34	1564
Ramanathapuram	19	19	897	14	17	1150

Correlation : [at P = 0.05%] RTD × Average yield

1st crop — August to : r = 0.6200 NS

September : r = 0.7414 *

2nd crop — January to: r = 0.54792 NS

February : r = 0.4248 NS

The RTD values of Salem, Coimbatore and Tiruchirapalli districts of Tamil Nadu (Table 1) were high throughout the year compared to other districts. The average yields are also observed to be higher. Similarly the lower RTD values from Thanjavur and Ramanathapuram coincided with lesser yields. The National demonstration results (1972—73) revealed that the rice yields of Cuddalore (South Arcot district) is lower than Madurai and Tiruchirapalli region. Here again the RTD values of South Arcot were found lower than the other two districts. The acreage on summer cropping of rice revealed that Ramanathapuram and Thanjavur go without summer cropping of rice. This may be due to the quite unfavourable values of RTD in

TABLE 5. Temperature, RTD and average rice yield data for different States in India

Name of different States	Mean monthly temperature (°C)				RTD Values		Average per hectare yield of rice in kg/ha (1st crop)
	August		September		August	September	
	Maximum	Minimum	Maximum	Minimum			
West Bengal	31.5	25.8	31.9	25.7	16	19	1274
Orissa	31.1	25.7	31.6	25.5	16	22	1002
Bihar	31.9	26.0	32.0	25.5	19	22	951
Uttar Pradesh	32.3	25.8	32.9	24.7	19	24	748
Punjab	34.5	26.0	34.7	23.7	24	31	1533
Himachal Pradesh	30.6	21.4	29.9	19.3	32	36	1128
Jammu-Kashmir	25.1	12.6	24.7	8.7	48	64	1944
Madhya Pradesh	29.2	23.2	30.2	22.7	21	23	755
Bombay [Konkan]	29.0	24.8	29.2	24.2	14	17	1083
Mysore [South]	28.4	19.8	29.7	19.5	28	36	1805
Kerala	28.4	23.5	29.0	23.7	18	17	1453
Tamil Nadu	33.9	24.6	33.4	24.3	26	27	1732
Rajasthan	31.7	24.4	32.8	23.3	25	30	799
Gujarat	31.1	25.0	32.2	23.9	20	25	863
Assam	31.7	25.6	31.1	24.4	19	23	982
Andhra Pradesh [Coastal]	32.8	26.1	32.2	25.6	21	22	1004

Correlation : [at P = 0.05%] RTD × Average yield

August to - $r = 0.1329$ NS

September - $r = 0.5489^{*}$

these districts in the month of April. Whereas for the same month, the RTD values for Coimbatore, Salem, Tiruchirapalli districts are higher, Thus the higher yields are possible in these districts with summer cropping of rice. Data on monthly trials with IR 8 conducted at Coimbatore confirmed the above view.

In the year 1969–70, summer cultivation of rice (variety 'Karuna') was ventured in Kollidam Block of Thanjavur district as part of seed multiplication programme. The observed yields ranged between 1500 — 1800 kg/ha whereas for the same variety the yield ranged in the preceding *kuruvai* season between 2500–3500 kg/ha. This disparity between *kuruvai* and summer crop yields could be explained with the RTD factor. The RTD of that region in September was 26 and that of April was 18. Though, the summer cropping was launched with utmost enthusiasm, care, offical supervision and credit supply, the observed yields were much lower than expected. Here, the low RTD value of 18 would have been the primary factor in limiting rice yield in summer season.

A perusal of rice yield data from different States in India (Table 5) reveals that the yields of rice from West Bengal, Bihar, Bombay, Madhya Pradesh and Assam are low ranging between 851–1274 kg/ha. Also the RTD values for these States in the month of September were found low, ranging between 17 to 22. Conversely the RTD values of Jammu-Kashmir, Mysore and Tamil Nadu are higher and the observed yield levels were also higher. However, Rajasthan and Himachal Pradesh show high RTD values but are with lower yield levels. This may be due to other limiting factors as poor soil type and lack of assured moisture supply.

An ideal climatic environment for rice culture has been reported from Peru of South America (Sanchez *et al*,, 1973). At Peru, for IR 8, the average yield is reported to be 10 tons/ha. Here planting and harvest of IR 8 is between October and June and the duration of the crop prolongs to 180 days due to long day (13–14 hours) conditions. The mean maximum temperature rises gradually from 24°C to 30°C from October to January and thereafter decreases towards June. The mean minimum temperature also follows a similar trend with maximum and minimum values ranging between 18° and 21°C. The RTD values are higher throughout. The rising temperature from planting to flowering and gradual lowering of temperature towards ripening is helpful for greater photosynthesis and efficient translocation of photosynthate to grains (sinks). Hence the yield potential in that region is

higher. Such favourable conditions prevail at higher latitudes and hence the observed rice yields from Japan and Australia are always higher than the chief rice growing countries of South East Asia lying close to the equator.

REFERENCES

ANGLADETTE, A. 1966. Le Riz, Maisonneuve & Larose, Paris, 930 pp illustr. as quoted by Arnon, 1972. *Crop production in dry regions volume II* p. *188* Leonard Hill, London, 1972

ANONYMOUS 1971. *Estimates of area and production of principal crops in India 1970–71.* Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India.

SANCHEZ, P. A., G. E. RAMIREZ, and M. V. DE CALDERON, 1973. Rice response to nitrogen under high solar radiation and intermittent flooding in Peru. *Agron. J.* 65.

VEXKULL, H. R. V. 1965. Problems in development of Modern Tropical Agriculture, Proceedings - Japanese potassium symposium, 1965.