

THE FACTOR WHICH STIMULATES TO DEVELOP
THE RICE INTO FLOWERING UNDER
TROPICAL CONDITIONS

Basil Scripchinsky,

Voroshilovsk, Caucasus, U. S. S. R.

[This article is published as received with only a few minor amendments so that both the style and the argument of the writer may remain intact. Although the composition is unorthodox the meaning is sufficiently clear.—Ed., *The T. A.*].

THE theory of the stage development of plants, created by Lyssenko, gives the possibility to explain and control the processes of flowering by a lot of plants. It is known that for many plants the transition from the vegetative growth to the reproduction depends on two stages of development: on the stage of vernalization and on the photo-stage. The author of this paper has studied these stages of rice during three years on the Experiment Rice Station at Krasnodar (U. S. S. R.). In consequence of this work it was established that the rice has nearly no stage of vernalization (29). This conclusion was confirmed through a series of experiments, which were made by other investigators (2, 3, 5, 12, 13, 14, 23).

On the other hand it grew evident that the photo-stage has an immense significance for the rice. This conclusion is also confirmed by a series of experiments which were made by some other investigators who have studied the photoperiodism of the rice (4, 6, 7, 17, 18, 22, 27, 28, 30).

During this work the author paid attention to the following fact. In some parts of the tropics (India, Ceylon) experiments were conducted at different dates of sowing which gave astonishing results. (See Table I.)

TABLE I.

Number of Days from the Date of Sowing till the Heading (or Flowering) of the Rice which was sown at different Times (Ceylon-Peradeniya ; India-Coimbatore).

The Time of Sowing	Peradeniya, Ceylon			Coimbatore-India	
	Lord and De Silva (19), 1928-29	Haigh (15) 1933-35		Ramiah (24) 1925-26	Ramiah (24) 1927-28
	Mawi	Mawi B-11	Heenati I-CPY-15	p.l. No. 24	p.l. No 24.
January ..	302	344	83	104	130
February ..	220	312	95	224	231
March ..	175	300	99	—	—
April ..	165	256	132	—	—
May ..	120	232	125	—	—
June ..	100	190	95	138	—
July ..	90	173	90	118	113
August ..	142	159	94	98	98
September ..	125	141	88	90	85
October ..	135	197	102	94	88
November ..	142	276	88	91	116
December ..	302	343	90	95	98

This table shows that the vegetative period of all kinds of rice changed with the variation of dates of sowing. The behaviour of the different kinds is unlike and in some cases gives astonishing difference.

Nevertheless none of the authors who made these experiments gave any explanation of the causes of this phenomenon. It seemed that it was impossible to find in the environment the causes of this strange behaviour of some kinds of rice because the climatic conditions change very little during the whole year in South India (Coimbatore) and especially in Ceylon (Peradeniya). In an anonymous author's paper (1), which gives an account of Lyssenko's theory, these experiments were discussed. This author writes: "Since length of day and temperature are said to be factors controlling changes in development, it does not appear why such changes should take place as a result of a change of sowing date in so uniform an environment".

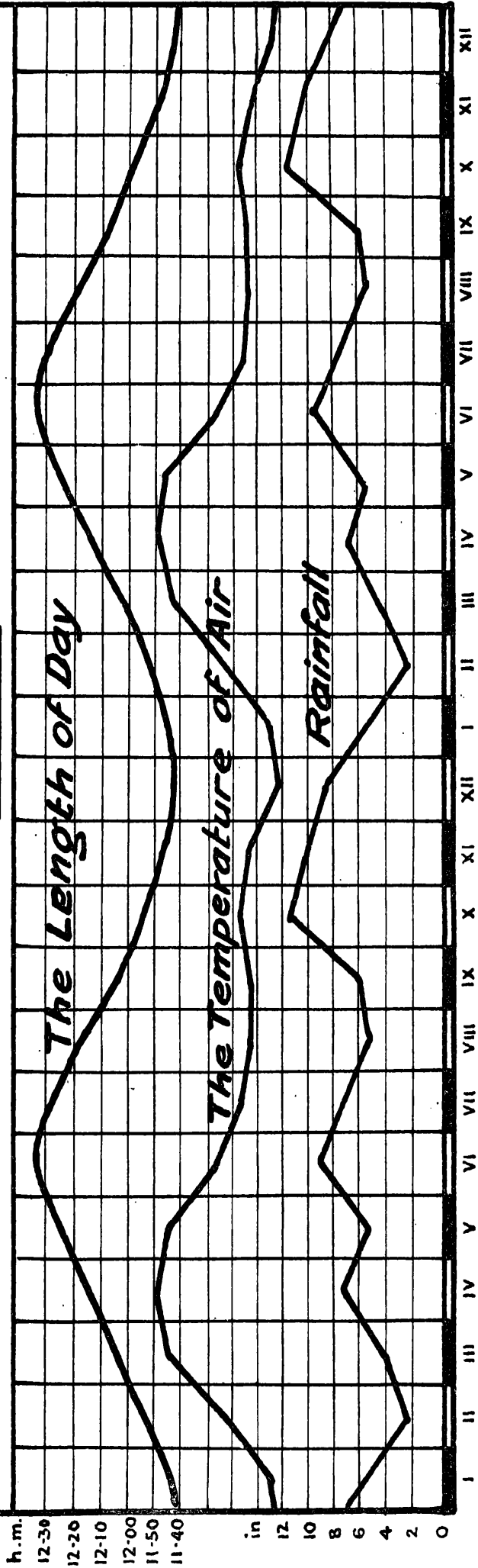
Further, Garner and Allard have already surmised in their first communication (8) that in the region of the equator the natural change in the day's length is so little variable that it does not make a photoperiodic effect on the plants. In consequence of such opinion the study of the photoperiodism was insufficient in the tropical regions. But the previously

The effect of the length of day on the interval between the sowing and plowing of Ceylon paddies.

**LORD AND DE SILVA
MAWI**

**HAIGH
MAWI-B11**

**HAIGH
HEENATI-I-CPI-15**



mentioned experiments clearly demonstrated that *in the tropical regions the natural day's length change stipulates also a delay or an acceleration of heading and flowering of rice.*

For the confirmation of this thesis we shall examine the behaviour of the rice which was sown at different dates in Peradeniya. We connected the vegetative periods of these sowings of rice with the natural length of day and the principal elements of the weather. The natural length of day was calculated for Peradeniya by means of tables of day's length. The temperature of the air and the amount of rainfall taken from meteorological reports which had been published monthly in *The Tropical Agriculturist* (20).

These tables give not only monthly values of air temperatures and the amount of rainfall for 1929, but show the difference with the average. We have calculated the average of the temperature and of the rainfall according to this difference. All the dates were taken on Kandy Meteorological Station (See Table II.).

TABLE II.
Meteorological Data for Kandy.

Month	Temperature of Air			Mean humidity for 1929	Rainfall		
	Mean daily shade for 1929	Difference from Average	Average		Amount in inches for 1929	Difference from Average	Average
January ..	75.0	+ 0.5	74.5	70	0.49	- 4.82	5.31
February ..	76.4	+ 0.3	76.1	66	0.42	- 1.86	2.28
March ..	78.1	- 0.3	78.4	72	4.78	+ 0.71	4.07
April ..	77.9	- 1.1	79.0	80	11.77	+ 5.01	6.76
May ..	78.9	+ 0.2	78.7	78	2.44	- 3.31	5.75
June ..	76.7	+ 0.1	76.6	79	11.89	+ 2.54	9.35
July ..	76.2	+ 0.6	75.6	79	7.25	- 0.30	7.55
August ..	76.5	+ 1.2	75.3	76	1.66	- 4.07	5.73
September ..	77.0	+ 1.7	75.3	78	6.52	+ 0.52	6.00
October ..	76.4	+ 0.5	75.9	77	2.67	- 8.99	11.66
November ..	76.0	+ 0.6	75.4	80	12.51	+ 2.04	10.47
December ..	75.6	+ 1.5	74.1	80	9.07	+ 0.16	8.91

The comparison of the vegetative periods of rice with environments are shown in fig. I.

This figure shows that the behaviour of these kinds on the whole is unlike. But the kinds of rice "ma-wi" behaved approximately equally in Haigh's experiment as well as in Lord and De Silva's. The heading corresponding to most of the dates of sowing took place in Lord and De Silva's experiments from the end of August till the end of October and in Haigh's experiment from December till January. If we shall examine the

change of natural day's length so we shall observe that in Lord's experiments the heading began only after the shortening of the long summer days. In Haigh's experiments the heading began only when the shortest winter days came.

The kind of rice "heenati I-CPY-15" behaved completely differently. In this case all dates of sowing had nearly an equal length of the vegetative period.

This phenomenon might be explained in the following way:—The "ma-wi" kinds of rice are generally sown in "maha" season (in August). Therefore their growth before heading takes place as a rule during August-December with the condition that *the length of day is shortening uninterrupted*. The kind of rice "heenati I-CPY-15" is generally sown in "yala" season (in March) and therefore its growth before heading takes place as a rule during March-June with the condition that *the length of day is lengthening uninterrupted*.

Consequently the rices of "maha" season are adapting themselves to the shortening length of day and the rices of "yala" season to the lengthening days. This circumstance fully explains the behaviour of these kinds of rice sown at different dates.

As is shown in fig. I. there is no connection between the dates of heading and the temperatures of air as well as the amount of rainfall.

It is very interesting to make a comparison of these experiments with the experiment which had been done by Garner and Allard with soybean in a greenhouse (10). Here is an indisputable analogy between the behaviour of the rice variety "ma-wi" and the Biloxi soybean (short day type). On the other hand the "heenati" rice behaved like the Mandarin soybean (indifferent type).

A still more bright example gives Rhind's experiment (25) with sesamum which had been made at Mandalay, Burma (lat. 22°N). Here we can notice a full analogy in the behaviour of "ma-wi" kinds of rice and the "late" kinds of sesamum (Burmese "hngyi"), which proved to be the typical short day plant. The yala's kinds of rice behaved analogically to "early" kinds of sesamum (Burmese "hnanyin"), which do not react on the length of day. It is characteristic that the "early" kinds of sesamum in Burma are sown in April and harvested in August and September. The "late" kinds are sown in September and harvested in December and January.

Therefore, it is necessary to state that the least variation of the day's length influences photoperiodically on some *native* plants in the tropical regions. To verify this conclusion the kind of rice "ma-wi B-11" must be sown in Ceylon in December

or in January and after the germination it must be cultivated with artificial shortened days (11h. 40m. or less). By these conditions its heading will take place in April or in May, while the same rice grown in natural conditions will be heading in November or in December. Apparently the "heenati I-CPY-15" will not react on the artificially shortened days.

On the ground of these experiments we have the right to make the following conclusion :—

In the tropical region of South India and of Ceylon there are two groups of rice kinds. To the first group belong such kinds which demand for their photo-stage short (or uninterrupted shortening) days (the kinds of the "maha" season). To the second group belong such kinds which pass through the photo-stage by every kind of variation of the natural day's length.

Moreover, the material of this article gives the right to make still a whole row of general conclusions and suppositions.

1. The opinion must be refuted that the natural change in day's length does not cause the photoperiodic reaction of *the native plants* in the tropical regions, which are in the neighbourhood of the equator. It is obvious that the native plants, which have grown during many hundreds of years in such conditions, adapted themselves to the small variations in day's length and possess a big sensibility. Therefore they react on a little variation on the tropical's day's length not less than the plants of temperate climate do on the large variation on the day's length. On the ground of this conclusion it shall be made a reconsideration of the old view which concerns the periodicity of the development of the plants in the tropical regions. It is possible that Volkens' (31), Klebs' (16) and Molish's (21) facts about the periodicity of life processes in the tropics (for instance fall of the leaves, &c.) will obtain an entirely different significance, if the photoperiodic reaction will be taken into account.

2. These conclusions have confirmed the point of view which had been surmised by Garner and Allard in 1920 and was evolved in 1923 and in 1930 (8, 9, 10), that the plants have a so-called "critical length of day for flowering". These experiments show that at least for some plants this point can be fixed very exactly.

3. These conclusions refute once more the old theory which had been expressed by Reomur in 1735 and is revived now by Selaninov (25) in U. S. S. R. that the arithmetical sum of degrees of heat can be the index for the length of the vegetative period of plants. But in reality the sum of the so-called "active temperatures" for one date of sowing will be three times more than for another date.

Moreover all our data raise doubts of the correctness of Gustchin's conclusion that "the flowering of the rice does not come in natural conditions before the moment, when the temperature will reach its culmination point and after this will go down" (11). Fig. I. shows that the fall of the temperature from its culmination point, at least in the tropics, has no importance for the heading of the rice.

4. Finally, the quoted data raise the question: What is the cause of the passing of the rice through its photostage—either the day's length which crosses the critical point or the process itself of the uninterrupted shortening day's length. The examination of this problem in the condition of Ceylon is very interesting because it is possible that it will discover some new important regularities in the processes of the plant's development.

ACKNOWLEDGEMENTS

The author desires to express his grateful thanks to the chief of the section of rice in the Institute of Plant Industry of U. S. S. R., D. S. Ivanov, for his kind interest in this work and his amiable help.

LITERATURE CITED

1. Anonymous.—Vernalization and Phasic Development of Plants (Review).
2. Avakian, A. A.—The Vernalization of Rice (in Russian). *Jarovizatsia*, N. 1 (4), 47–52, 1936.
3. British Guiana Dept. of Agriculture.—Personal communication to the Imperial Bureau of Plant Genetics. Vernalization and Phasic Development of Plants, 1935, p. 142.
4. Chien-Liang Pan.—Length of Exposure to Light in Relation to Plant Growth in Rice. *Jour. of Amer. Soc. of Agron.* Vol. 28, No. 1, 58–63, 1935.
5. Codd, L. E. W.—Vernalization—A Recent Development in Agricultural Research and Its Application to Rice. (i.) *The Agric. Jour. of British Guiana*. Vol. 5, No. 3, 212–213, 1934. (ii.) *The Tropical Agriculturist*. Vol. LXXXIV., No. 1, 36–37, 1935.
6. Dennett, J. M.—Further Pot Experiments with Padi. *The Malayan Agric. Journal*. Vol. XXIV., No. 7, 309–331, 1936.
7. Fuke, Y.—On the Short Day and Illumination Treatment in Rice, Referring Specially to the Time and Duration of Treatment. *Jour. Imp. Agr. Exp. Sta.* (Tokyo), I., No. 4, 263–286, 1931.
8. Garner, W. W. and Allard, H. A.—Effect of the Relative Length of Day and Night and other Factors of the Environment on Growth and Reproduction in Plants. *Jour. Agr. Res.* Vol. XVIII., No. 11, 553–606, 1920.
9. Garner, W. W. and Allard, H. A.—Further studies in Photoperiodism, the Response of the Plant to Relative Length of Day and Night. *Jour. Agric. Res.* Vol. XXIII., No. 11, 871–920, 1923.
10. Garner, W. W. and Allard, H. A.—Photoperiodic Responses of Soybean in Relation to Temperature and Other Environmental Factors. *Jour. Agr. Res.* Vol. XLI., No. 10, 719–735, 1930.
11. Gustchin, G. G.—The Rice (in Russian). Moscow, pp. 831, 1938.
12. Haigh, J. C.—Vernalization. *The Tropical Agrict.* Vol. LXXXII., No. 4, 214–216, 1934.

13. Haigh, J. C.—Vernalization. *The Trop. Agrict.* Vol. LXXXIII., No. 6, 329–338, 1934.
14. Haigh, J. C.—Personal Communication to the Imperial Bureau of Plant Genetics. Vernalization and Phasic Development of Plants, pp. 135–136, 1935.
15. Haigh, J. C.—A Note on the Effect of Sowing date on the Age of Paddy. *The Tropic. Agrict.* Vol. LXXXVI., No. 5, 284–288, 1936.
16. Klebs, G.—Ueber die Periodischen Erscheinungen Tropischer Pflanzen. *Jahrbüch fur. Wiss. Bot.* LVI., 1915.
17. Kondo M., Okamura T., Isshiki Sh. und Kasahara Y.—Untersuchungen über "Photoperiodismus" der Reispflanzen (Erste Mittelung). *Berichte d. Ōhara Inst.* Bd. V., Ht. 2, 242–280, 1932.
18. Kondo M., Okamura T., Isshiki. Sh. und Kasahara Y.—Untersuchungen über "Photoperiodismus" der Reispflanzen (Zweite Mittelung) *Ber. d. Ōhara Inst.* Bd. VI., Ht. 307–330, 1934.
19. Lord, L. and De Silva, J. S. T.—Paddy Notes (IV.), A Note on the Effect of Sowing Date on the Age on Maha Paddy. *The Trop. Agrict.* Vol. LXXVI., No. 6, 332–333, 1931.
20. Meteorological Reports.—*The Tropic. Agrict.* Vol. LXXII., No. 1–6 (1929), Vol. LXXIII., No. 1–6 (1929).
21. Molisch, H.—Pflanzenphysiologie als Theorie der Gartnerey Wien.
22. Noguiti, J.—On the Control of Flowering Time of Paddy Rice Plants by the Action of Light. *Jour. Agric. Soc. Japan*, N 299, 487–500, 1925. *Abst. Jap. Jour. of Botany*, Vol. IV., 1930.
23. Ossewaarde, I. J. G.—Jarowisatie van rijst. *Landbouwkundig Tijdscher Wageningen*, 46, N 571, 156–161, 1935.
Absts.—(1) *Plant Breed Abstr.* Vol. V., No. 4, Abs. N 1026. (2) *Riz et Riziculture.* Vol. 10, f. 1, 1936, &c.
24. Ramiah, K.—Inheritance of Flowering Duration in Rice (*Oryza sativa* L.). *The Indian Jour. of Agric. Sci.* Vol. III., Pt. III., 377–410, 1933.
25. Rhind, J. A. S.—A Note on Photo-Periodism in Sesamum. *The Indian Jour. Agric. Sci.* Vol. V., Pt. VI., 729–736, 1935.
26. Selaninoff.—On the Agricultural Estimation of Climate (in Russian). *Bull. Agric. Meteorology.* Vol. XX., 165–177, 1928.
27. Siroku Hara.—On the Influence of the Duration of Illumination upon the shortening Time and Growth of Paddy Rice (in Japanese). *Ann. Agr. Exp. Sta. Tokgen (Corea)* 5, 223–249, 1930. *Absts.—Jap. Jour. of Bot.* Vol. V., No. 3, 1931.
28. Scvorzoff.—The Photoperiodism of Rice (in Russian). *Trudy Azerbaidjan. Otdel. Transcaucas. Filialtion Academy of Sciences of U. S. S. R.*, V. 3, 79–88, 1934.
29. Scripchinsky, B. B.—Vernalization of Rice (in Press).
30. Terao H. and Katayama T.—On the Premature Heading of Rice. *Jour. of the Imp. Agr. Exp. Sta. (Tokyo)*. Vol. I., No. 1, 25–40, 1929.
31. Volkens, G.—Laubfall und Lauberneuerung in den Tropen, Berlin, 1912.