Mem. Fac. Agr. Kagoshima Univ., 17, 53–68, 1981

Variations of Growth-Period of Italian Millet Strains, *Setaria italica* Beauv. and their Responses to Day-Length and Temperature

III. Changes of Growth-Period due to Temperature under the Different Day-Lengths

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Received for Publication September 10, 1980

Introduction

From the standpoints of photo-sensitivity, thermo-sensitivity and basic vegetative growth, many workers[7,8,9,10] up to date have made investigations into the changing of the growth-period of crop varieties under the various environmental conditions, especially in detail into that of rice plant, main summer crop in this country.

In spite of their efforts, concerning the effects of the interactions between the day-length and the temperature upon the changing of growth-period of crop plant, many vague points have been yet left to be solved.

In the previous paper[6], the authors reported that the variations of the growth-period of Italian millet strains, gathered from different districts, both native and foreign, and their responses to day-length and temperature, were closely related to their gathering districts.

In this paper, especially, the relationships between the photo-responses and the thermo-ones in the typical strains of Italian millet, selected out of the materials used in the previous experiment, were investigated in detail under the natural and controlled day-length conditions and the various temperatures gained by the different seeding dates.

Materials and Methods

Twenty strains, which were gathered from different districts, both native and foreign, and showing various changes of the growth-period due to different seeding dates, respectively, were used as shown in Table 1.

In order to cultivate these strains under different temperature conditions, they were seeded in pots six times, at two-month-intervals through one year, as follows, May 31, July 30, September 28 and November 27, 1971, January 26 and March 26, 1972. The pots used for seeding, 13 cm in both depth and diameter, were filled up with the same amount of soil admixed with ammonium sulfate 0.125 g, potassium chloride 0.125 g and super-phosphate of lime 0.125 g per pot, respectively. After germination, the plants were thinned in, about 5 cm distant apart each other, and five plants of the same strain were cultivated in one pot.

During the experimental period, the seeded pots were laid in the greenhouse which was heated in winter to prevent the plant growth from being stopped on account of lower temperature.

Table 1. Materials used and the summarized data of their growth-periods, total leaf-numbers, critical day-length and critical temperature

Strain no.	Collection no.	Districts	Latitude	Growth-period in days Max.	Growth-period in days Min.	Growth-period in days Dif.	Leaf-number* Max.	Leaf-number* Min.	Leaf-number* Dif.	Critical day-length (h.min)	Critical temperature (°C) 9 h	Critical temperature (°C) 14 h	Critical temperature (°C) 19 h
1	F. no. 5	Sweden	60–55	107	33	74	7.8	8.8	−1.0	13.56	21.5	22.4	23.6
2	〃 no. 35	Russia	60–45	107	34	73	7.5	9.2	−1.7	13.56	21.4	22.4	23.5
3	〃 no. 37	Germany	55–47	114	37	75	8.6	10.0	−1.4	13.54	21.7	22.7	24.3
4	〃 no. 36	Switzerland	48–46	133	36	97	12.5	10.0	2.5	13.54	22.2	22.9	27.0
5	Genpei awa	Japan Nagano	37–35	195	35	160	17.0	8.0	9.0	13.54	21.7	22.6	31.7
6	Kintoki no. 2	〃 〃	〃	188	37	151	21.0	8.8	12.2	13.50	21.9	20.4	30.6
7	Nara no. 270	〃 Nara	35–34	242	43	199	27.5	8.6	18.9	—	21.8	24.3	31.1
8	Nagasaki no. 279	〃 Nagasaki	34–33	271	55	216	23.8	11.2	12.6	13.23	22.3	25.1	30.8
9	Kumamoto no. 363	〃 Kumamoto	33–32	244	39	205	20.0	9.0	11.0	13.10	21.8	24.9	30.3
10	〃 no. 338	〃 〃	〃	219	40	179	18.0	8.6	9.4	13.18	22.0	24.7	30.9
11	Aso no. 1 (Red)	〃 〃	〃	220	41	179	21.4	9.0	12.4	13.49	22.0	24.2	28.8
12	〃 〃 (White)	〃 〃	〃	236	41	195	20.0	9.8	10.2	13.49	19.3	22.6	28.4
13	Kumamoto no. 394	〃 〃	〃	206	44	162	18.6	9.6	9.0	13.11	21.8	26.3	28.8
14	Kagoshima no. 76	〃 Kagoshima	32–31	241	37	204	17.6	8.6	9.0	13.12	21.8	25.0	30.5
15	〃 no. 102	〃 〃	〃	226	38	188	15.2	8.2	7.0	13.02	21.6	29.0	31.5
16	〃 no. 172	〃 〃	〃	251	42	209	20.3	9.0	11.3	13.39	20.7	22.4	30.6
17	〃 no. 49	〃 〃	〃	238	47	191	27.5	9.4	18.1	12.52	19.7	29.5	31.8
18	〃 no. 54	〃 〃	〃	260	49	211	21.6	12.2	9.4	13.27	21.0	23.7	30.8
19	Taiwan no. 12	Formosa	21–25	297	59	238	30.0	12.2	17.8	—	23.1	24.9	31.0
20	F. no. 52	Africa	10–20	204	57	147	16.5	12.0	4.5	—	22.0	23.5	27.9

* Leaf-numbers of main stems when the strains showed the maximum or minimum values of the growth-periods

Though the attention was paid not to make the minimum temperature in the greenhouse in winter fall less than 15°C, it sometimes fell to 13°C for a short time at early morning before the sunrise. The temperature in the greenhouse showed the seasonal changes according to the changes of the temperature outside of the door, as shown in Fig. 1.

The above mentioned fertilizers were admixed as the additional ones in the same amount per pot at twenty-five-day-intervals.

The plants of the respective strains seeded on the same seeding date, were cultivated under four different day-length conditions, consisting of the natural, 9, 14 and 19 hours day-lengths, from their germination to the heading. The day-lengths mentioned above were decided after due considerations of the maximum or minimum day-length of the districts from which the strains used in this experiment were gathered. Artificial day-lengths were controlled by the following method. Namely, an incandescent electric lamp, 100 W, 1.8 m in height, was automatically switched on or off in the dark room set up in the greenhouse by means of the method of covering the frames with black cloths.

As shown in Fig. 2, the plants treated with 9 hours day-length were laid under the sunlight from 7 o'clock to 16 o'clock, then they were laid in the dark room up to 7 o'clock in the next day. The plants treated with 14 or 19 hours day-length were laid under the sunlight from 7 o'clock to 17 o'clock, then they were exposed to an incandescent electric light switched on in the dark room, up to 21 o'clock or 2 o'clock in the next day, respectively. The plants cultivated under natural day-length were laid in the greenhouse through their whole growth periods. The changes of the natural day-length, from the sunrise to the sunset, in this district during the experimental period, are shown in Fig. 1.

The growth period in days, namely, the number of days from the seeding to the heading, and the number of leaves of main stems, were recorded.

The whole data were illustrated by the average value of five plants of the respective strains.

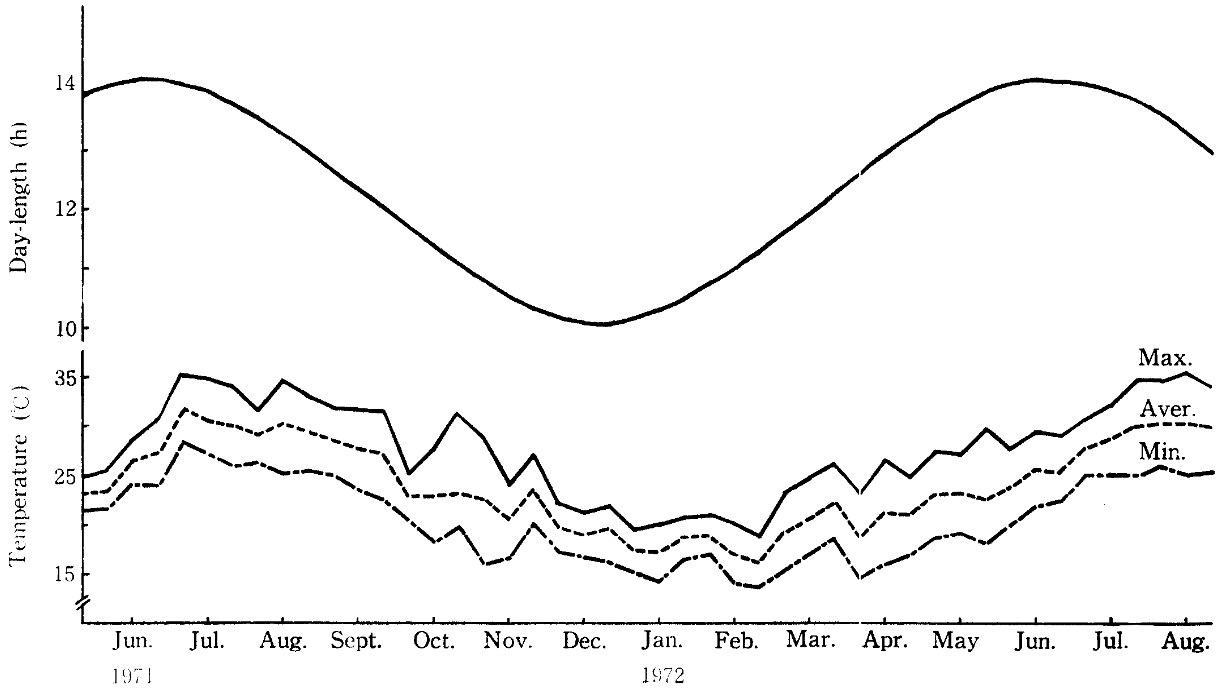

Fig. 1. Changes of natural day-length and the temperature in the greenhouse during experimental period.

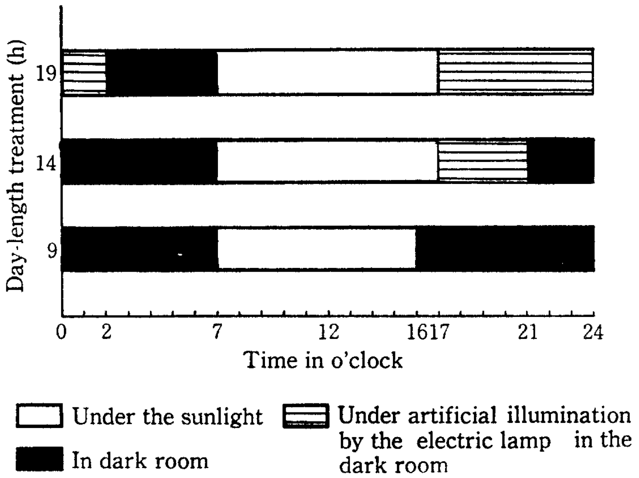

Fig. 2. Diagramatic illustration of day-length treatment.

Results

1. Relationship between the growth periods and the seeding dates

The relationship between the growth periods counted in days and the seeding dates in several strains cultivated under different day-lengths are shown in Fig. 3. As shown in Fig. 3, provided that they were cultivated under 9 hours day-length, these strains showed the shortest growth-periods when they were seeded in May (only one strain, no. 9) or July (all the other strains), showing the longest ones when they were seeded in November.

In case of being cultivated under 19 hours day-length, they also showed the shortest growth period when they were seeded in May (19 strains except no. 1) or July (only one strain no. 1), show-

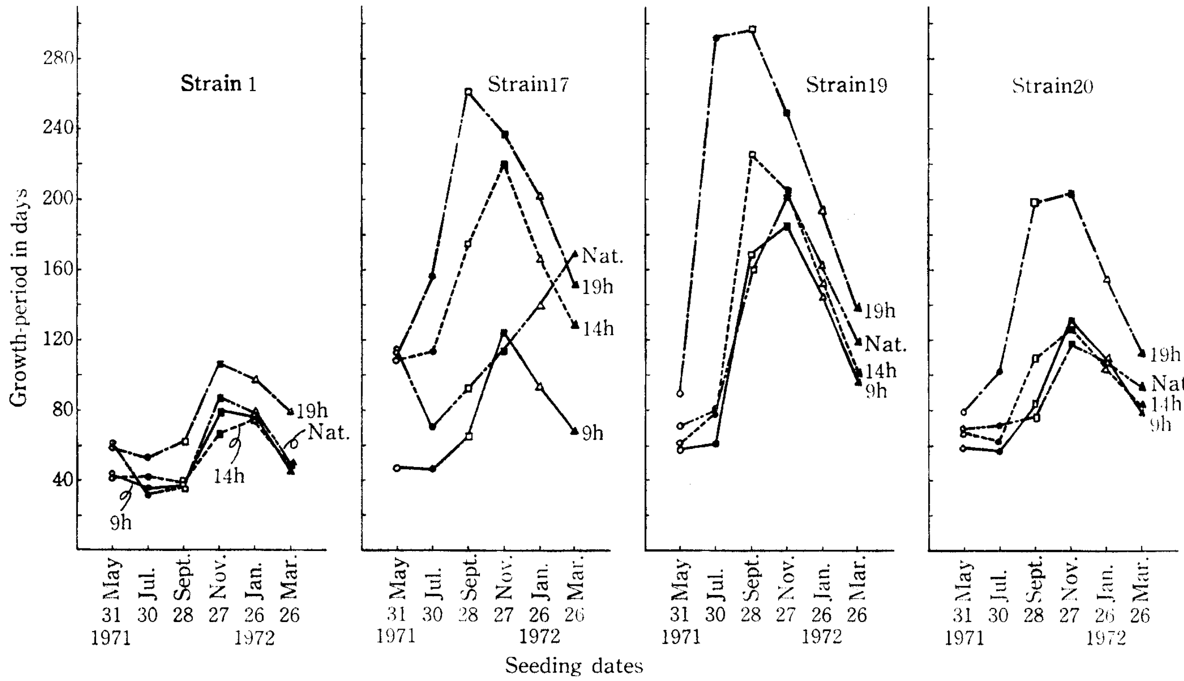

Fig. 3. Relationship between the growth-period in days and the seeding dates in several strains which were cultivated under different day-lengths.
Note: Nat.; Natural day-length

ing the longest growth-periods when they were seeded in September or November.

In case of being cultivated under 14 hours day-length, the relationships between the growth-periods and the seeding dates in the respective strains approached to those in case of being cultivated under 9 hours or 19 hours.

In case of being cultivated under natural day-length, these relationships in the respective strains became complex.

Irrespective of the seeding dates, the growth-periods of the respective strains with the same seeding date became extremely longer in case of being cultivated under 19 hours day-length than under 9 hours one.

As mentioned above, the growth-periods of the respective strains were largely affected in various degrees due to seeding dates; in other words, due to the temperature during the growth-periods, and due to the day-lengths, respectively.

In order to clear the summarized relationships between the variations of the growth-period and those of the total leaf-numbers of main stems as an index of developmental growth, the maximum and minimum values of the growth-period of the respective strains through the whole experimental plots, consisting of four day-length conditions and six seeding dates, and the difference between them, the leaf-numbers of main stems in the respective strains when they showed the maximum or minimum values of the growth-period, and the difference between them, are shown in Table 1. As shown in Table 1, four strains from Europe, strain 1, 2, 3 and 4, and two strains from Japan, strain 11 and 12, showed the shortest growth-period when they were seeded in July and cultivated under the natural day-length condition. Also, one strain from Formosa, strain 19, showed the shortest growth-period when it was seeded in May and cultivated under 9 hours day-length. The other thirteen strains showed the shortest growth-periods when they were seeded in July and cultivated under 9 hours day-length. On the other hand, the strains showed the longest growth-period when they were seeded in September or November and cultivated under the 19 hours day-length condition. The differences between the longest growth-periods and the shortest ones in the respective strains were very large and ranged from 73 days to 238 days.

Whereas, the differences between the leaf-numbers of main stems in the respective strains when they showed the longest growth-period, and those of main stems when they showed the shortest one, ranged from -1 to 18.1 and changed greatly with the variation of strains. Namely, for example, strain 1, 2 and 3 decreased by one or two leaf-numbers when they increased about 73–75 days-growth-period. Moreover, though both strain 7 and 14 showed almost the same differences between the longest growth-period and the shortest one, 199 and 204 days, respectively, the former showed about twice difference of the leaf-numbers, 18.9, as compared with that of the latter, 9.0.

From these results, it is clear that the relationships between the changing of growth-period and that of leaf-numbers under different day-lengths and temperatures changed greatly with the variation of strains.

Before the analysis of the effect of temperature on the growth of the respective strains, the critical day-lengths of the respective strains were decided by means of the method similar to the previous paper[6]. As shown in Fig. 4, the largest values of the ratios of the changing of growth-period counted in days between the two successive seeding dates to the changing of natural day-length counted in minutes (30 days before the heading) in the respective strains between the two, were almost shown between the seeding in May and that in July, as shown in strain 1 and 17 in Fig. 4. But in a few strains, for example, in strain 19, the largest value was shown between the seeding in July and that in September. This value was excluded, because it was estimated to be

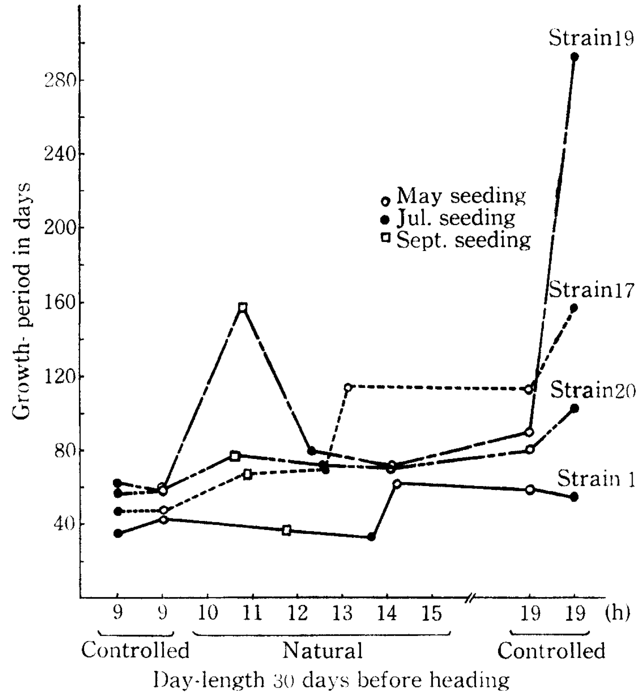

Fig. 4. Relationship between the growth period in days and the day-length 30 days before heading in several strains.

the one resulted from the delaying of the heading due to lower temperature, based on the comparison with the two growth-period of the plants of this strain when they were seeded in May and July, both of which being cultivated under 19 hours day-length condition. In the result, the critical day-lengths of the respective strains were decided by the average values of natural day-lengths 30 days before heading of the respective strains seeded in May and those seeded in July, when the strains were cultivated under natural day-length. The critical day-lengths in the respective strains are shown in Table 1. In strain 7, 19 and 20, their decision was impossible because the ratios were extremely small.

2. Relationship between the growth period and the average temperature during the growth-period

The relationships between growth period in days and the average temperature during the period in the respective strains are shown in Fig. 5. As shown in Fig. 5, it is clear that under any day-length conditions, the growth-periods in days of the respective strains were shortened as the temperature during the period was raised. Moreover, the shortening degrees of the growth-periods varied with the day-length conditions and they became extremely larger when the strains were cultivated under longer day-lengths than shorter ones, though the shortening degrees varied with the variations in the respective strains. For example, strain 1, 2, 3 and 4, from Europe, compared with the other strains showed relatively smaller shortening degrees of the growth-period due to the rising of the temperature during the period under any day-length conditions.

When the strains were cultivated under 9 hours day-length, many strains showed somewhat radical changing of the growth-period at the ranges from 20°C to 22°C, but in case of being cultivated under 14 and 19 hours day-lengths, these radical changings were not so clear.

Concerning the relative positions of the three relationship-lines between the growth-period and

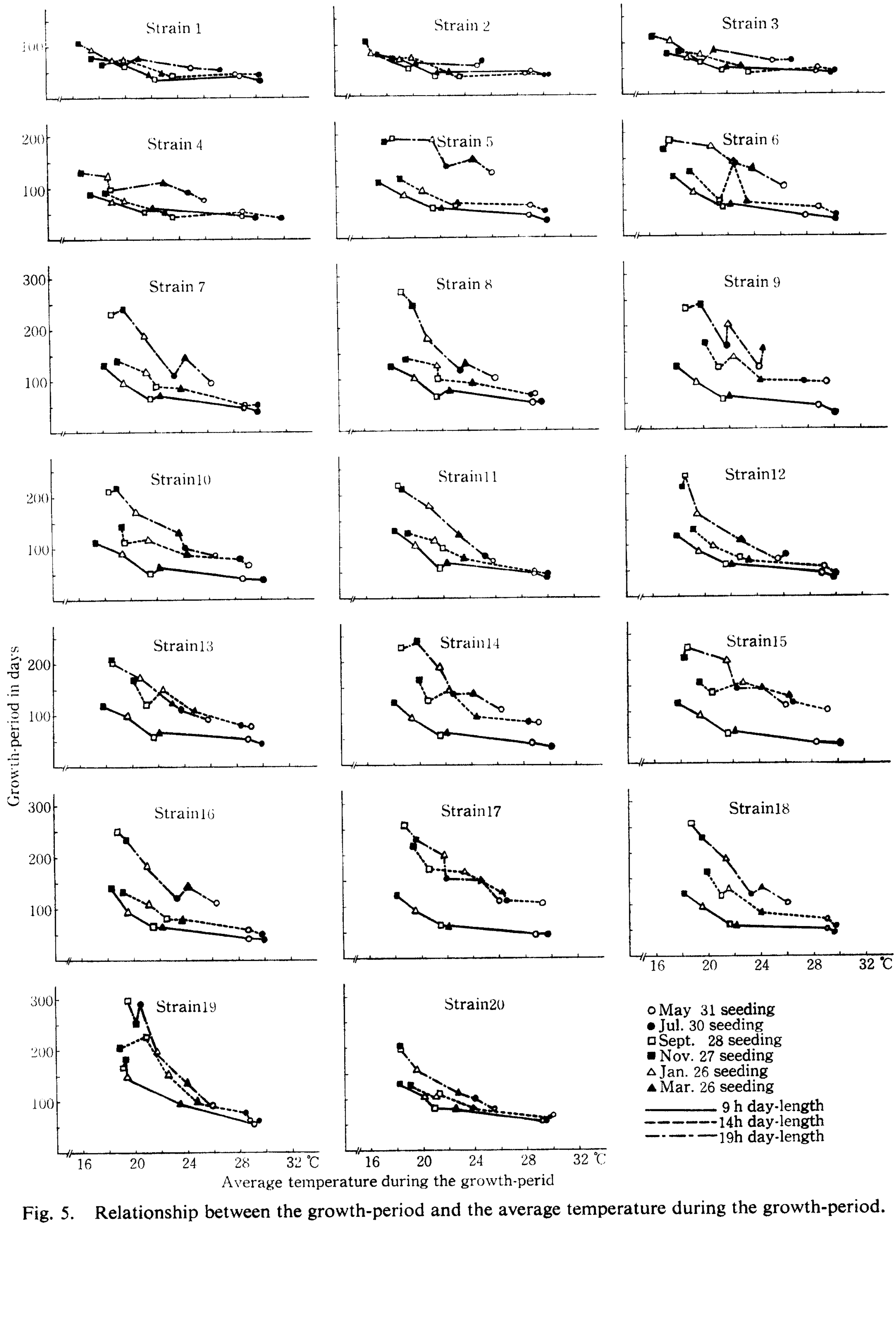

Fig. 5. Relationship between the growth-period and the average temperature during the growth-period.

the temperature, 9, 14 and 19 hours day-length-lines, in the respective strains, there were four cases. Namely, 14 hours day-length-lines approached to 9 hours day-length-lines (strain 4, 5, 6, 11, 12 and 20); 14 hours day-length-lines approached to the 19 hours day-length-lines (strain 13, 14, 15, 17 and 19); 14 hours day-length-lines were laid between the 9 hours day-length-lines and the 19 hours ones (strain 7, 8, 9, 10, 16 and 18); three lines were overlapped each other (strain 1, 2 and 3).

These four case were intimately related to the critical day-length of the respective strains. Namely, the 14 hours day-length-lines in the respective strains approached to the 9 hours day-length-lines, when the strains had longer critical day-length, and the lines approached to 19 hours day-length-lines in case of the strain having shorter critical day-length, and also the lines lay between the 9 hours day-length-lines and the 19 hours ones in case of the strains having the intermediate day-length.

It seems that the artificial 14 hours day-length had an effect of the short day-length or the long day-length on the respective strains, according to the length of their critical day-length.

3. Relationships between the total leaf-numbers of main stems and the average temperature during the growth-periods

As the total leaf-numbers of main stems are generally considered to be an index of the developmental growth, the effect of the temperature on the changing of the leaf-numbers was analyzed. The relationships between the total leaf-number of main stems and the average temperature during the growth-periods in the respective strains are shown in Fig. 6.

In case of being cultivated under 9 hours day-length, the leaf-numbers of the respective strains became smaller in comparison with those under the other day-length, not varying largely with the changing of the temperature.

In case of being cultivated under 19 hours day-length, the leaf-numbers of the respective strains became larger than those under any other day-length conditions. There were two cases concerning the changing of the leaf-numbers in the strains, due to the rising of the temperature during the growth-period. Some strains showed a little changing of leaf-numbers due to the rising of the temperature (strain 1, 2, 3, 4, 5, 9, 10, 13, 14 and 15). The other strains showed the decreasing tendency of the leaf-numbers as the temperature rose. But, the leaf-numbers of a few strains of this group did not show such a tendency as this in case of the seeding in September or November (strain 6, 7 and 16).

In case of being cultivated under 14 hours day-length, the leaf-numbers of the respective strains became intermediate between the 9 hours day-length and 14 hours one, and the changing of the leaf-numbers due to the temperature, differed with the variations of the strains, showing the intermediate tendencies between the two.

According to the results of the Fig. 5 and 6, it is clear that there are two cases concerning the relationship between the changing of the growth-period and that of the leaf-number. Namely, in case of being cultivated under long day-length conditions, some strains decreased their leaf-numbers according to the shortening of their growth-period due to the rising of the temperature (strain 8, 11, 12, 17, 18 and 19), and the other strains hardly decreased their leaf-numbers in spite of the shortening of their growth-period due to the rising of the temperature (strain 1, 2, 3, 4, 5, 9, 14 and 15).

These results seem to show that particular upperlimit of the leaf-number of the respective strains may be controlled by the day-length, and the leaf-numbers of some strains may be variable according to the temperature, and those of other strains were unvariable due to the temperature.

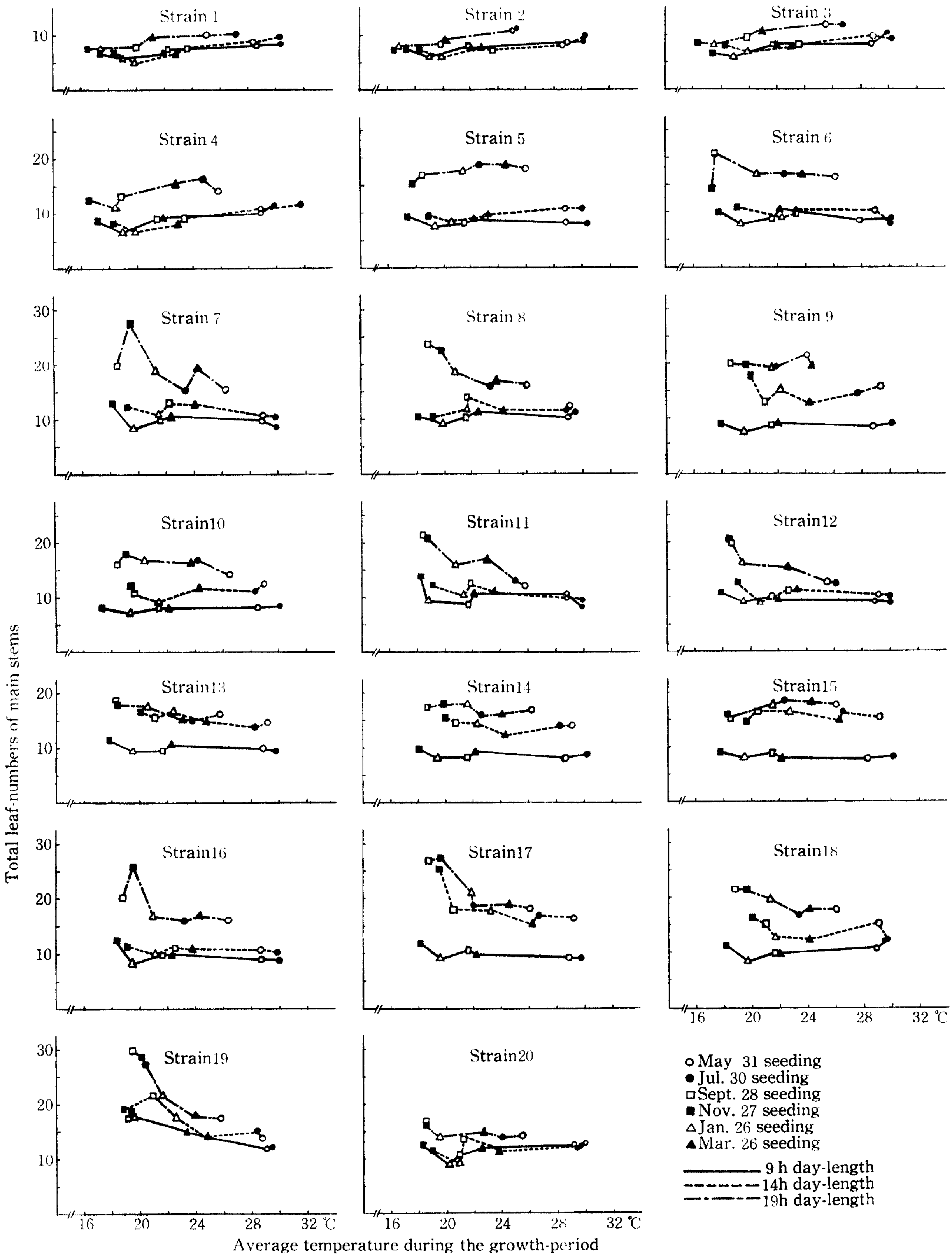

Fig. 6. Relationship between the total leaf-numbers of main stems and the average temperature during the growth-period.

4. Relationship between the growth-period and the average temperature during the young panicle formation stage

As shown in Fig. 1, the plants seeded in May or July, were cultivated under higher temperature conditions during their early growth-periods, and also cultivated under lower ones during their late growth-period, especially, in case of being extremely elongated their growth-period due to the long day-length conditions. On the other hand, the plants seeded in November, January and March, were cultivated under lower temperature conditions during their early growth-period and cultivated under higher ones during their late growth-periods. So, it was judged to be essential that the effects of the average temperature during the young panicle formation stages, in stead of those during the total growth-periods, on the changing of the growth-periods, should be analyzed.

The relationships between the growth period in days and the average temperature during the young panicle formation stages are shown in Fig. 7. As shown in Fig. 7, in case of being cultivated under the 9 hours day-length condition, the relationships between the growth-period and the temperature during the young panicle formation stages in some strains resembled the ones between the growth-period and the temperature during the total growth-periods (strain 1, 2, 3, 4, 5, 6, 10, 12 and 14). But the former relationship (in Fig. 7) in other strains became rather irregular, in comparison with the latter ones (in Fig. 5), owing to the irregular spots of the seeding in September (strain 7, 8, 9, 11, 13, 15, 16, 17, 18 and 20). On the other hand, the former relationship (in Fig. 7) in strain 19 became more regular than the latter one (in Fig. 5).

In case of being cultivated under 19 hours day-length, the relationships between the growth-period and the temperature during young panicle formation stage in some strains became irregular, owing to the irregular spots of the seeding in May or July (strain 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18 and 20). On the other hand, the relationship-lines between the growth-period and the temperature during the young panicle formation stages in strain 12 and 19, showed especially clear tendencies. These relationship-lines show that the growth-period in these strains were radically shortened when the temperature during their young panicle formation stages rose up to a particularly high temperature. Namely, from these relationship-lines, it can be estimated that the panicle initiation of these strains might be induced due to the duration of the particularly high temperature. So, again, if the spots of the seeding in May or July in the strains (strain 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18 and 20) which showed irregular relationships-lines in Fig. 7, are left out of consideration, the other spots of these strains depict relatively regular tendency-curves similar to the ones observed in strain 12 or 19. Namely, it might be estimated that in case of the seeding in May or July, the plants of these strains which showed irregular tendency-curves, might perhaps have induced the young panicle formation due to the higher temperature during earlier periods than 35 days to 15 days before heading, and the temperature of the latter period (35 days to 15 days before heading), became lower according to the changing of the temperature as shown in Fig. 1. Basing on this estimation, it can be judged that, similar to the case of strain 12 and 19, these strains induced the young panicle formation due to the duration of the particular high temperature, and that the degrees of the shortening of the growth-period due to the induction became radical in the particular temperature ranges.

In case of being cultivated under 14 hours day-length condition, above mentioned estimation could be applied, basing on the same reason as it was applied in case of being cultivated under 19 hours day-length.

Now, from the relationship-lines in the respective strains in Fig. 7, in which irregular spots were left out of consideration, it can be estimated that, in case of being cultivated under any day-

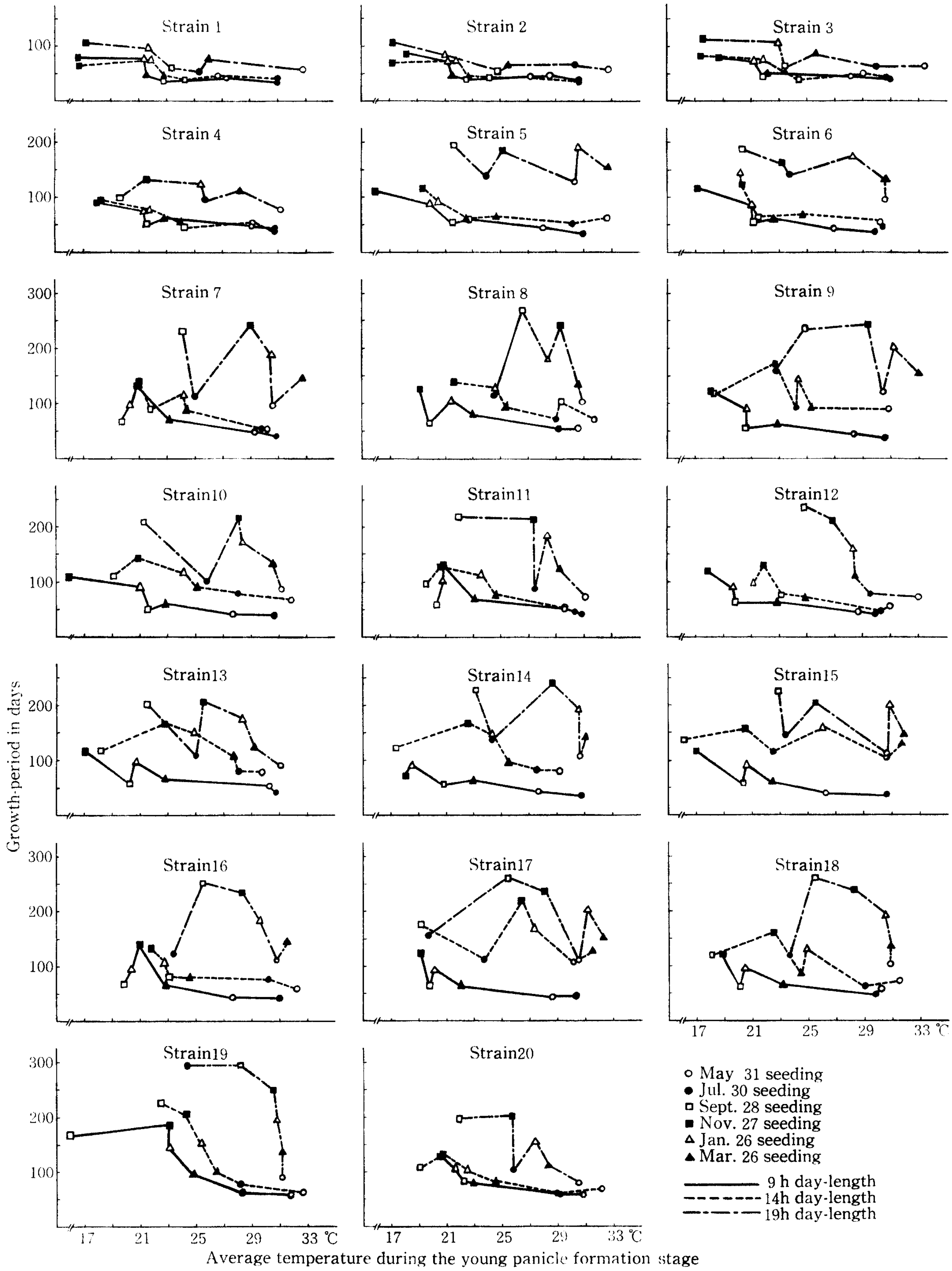

Fig. 7. Relationship between the growth-period in days and the average temperature during the young panicle formation stage (35 days to 15 days before heading).

length conditions, most strains accelerated young panicle formation, due to higher temperature during the period about 35 days to 15 days before heading or somewhat earlier than the former, and it was resulted in the shortening of the growth-period, and they had the particular temperature ranges where the shortening degrees of their growth-periods changed radically.

The average value of the upper temperature and the lower one of the ranges showing the most radical changing of the growth-periods are shown in Table 1, as the critical temperature under respective day-length condition. In this case, for example, the critical temperatures of strain 9 in Fig. 7 in case of being cultivated under 9, 14 and 19 hours day-length condition were calculated by the averaging of the temperature during the panicle formation stages in the seeding in January and those ones in March, respectively, and the following were left out of consideration: the spot of September seeding under 9 hours day-length, the ones of July and September seeding under 14 hours day-length, and the ones of May and July seeding under 19 hours day-length. As shown in Table 1, critical temperature in the respective strains changed with the variety of the day-length under which they were cultivated.

Generally, the critical temperatures in the respective strains were lower in case of being cultivated under short day-length, and became higher in those under long day-length.

5. Relationships between the total leaf-numbers of main stems and the average temperature during the young panicle formation stages

The effect of the average temperature during the young panicle formation stages on the total leaf-numbers of main stems in the respective strains, were analyzed.

Relationships between the total leaf-numbers of the main stems and the average temperature during the young panicle formation stages in the respective strains when they were cultivated under 9, 14 and 19 hours day-length, are shown in Fig. 8. As shown in Fig. 8, in case of being cultivated under 9 hours day-length condition, the almost all strains showed smaller leaf-numbers than those under any other day-length conditions, and the leaf-numbers did not largely vary according to the changing of the temperature during the young panicle formation stages. This tendency was the same as in case of the relationships between the leaf-numbers and the temperature during the total growth-periods.

In case of being cultivated under 19 hours day-length, the strains showed larger leaf-numbers than those under any other day-length conditions, and the strains respectively showed different responses of the changing of the leaf-numbers due to the rising of the temperature during the panicle formation stages. Namely, several strains showed a little changing of the leaf-numbers (strain 1, 2, 3, 9, 10, 13, 14, 15 and 20), and the others showed large changing of the leaf-numbers (strain 4, 5, 6, 7, 8, 11, 12, 16, 17, 18 and 19).

Among the strains showed large changing of the leaf-numbers in case of being cultivated under 19 hours day-length conditions, strain 12 and 19, showed very simple relationship-curves between the leaf-numbers and the temperature during panicle formation stages. Namely, the leaf-numbers in these strains were radically reduced as the temperature during the panicle formation stages rose up. The changing of the leaf-numbers in strain 19 was very radical. These relationship-curves in strain 12 and 19 suggest that these strains have particular temperature ranges during the panicle formation stages in which they show the radical decreasing of the leaf-numbers due to the rising of the temperature.

In the other strains cultivated under 19 hours day-length conditions which showed large changing of leaf-numbers due to the changing of the temperature during the young panicle formation

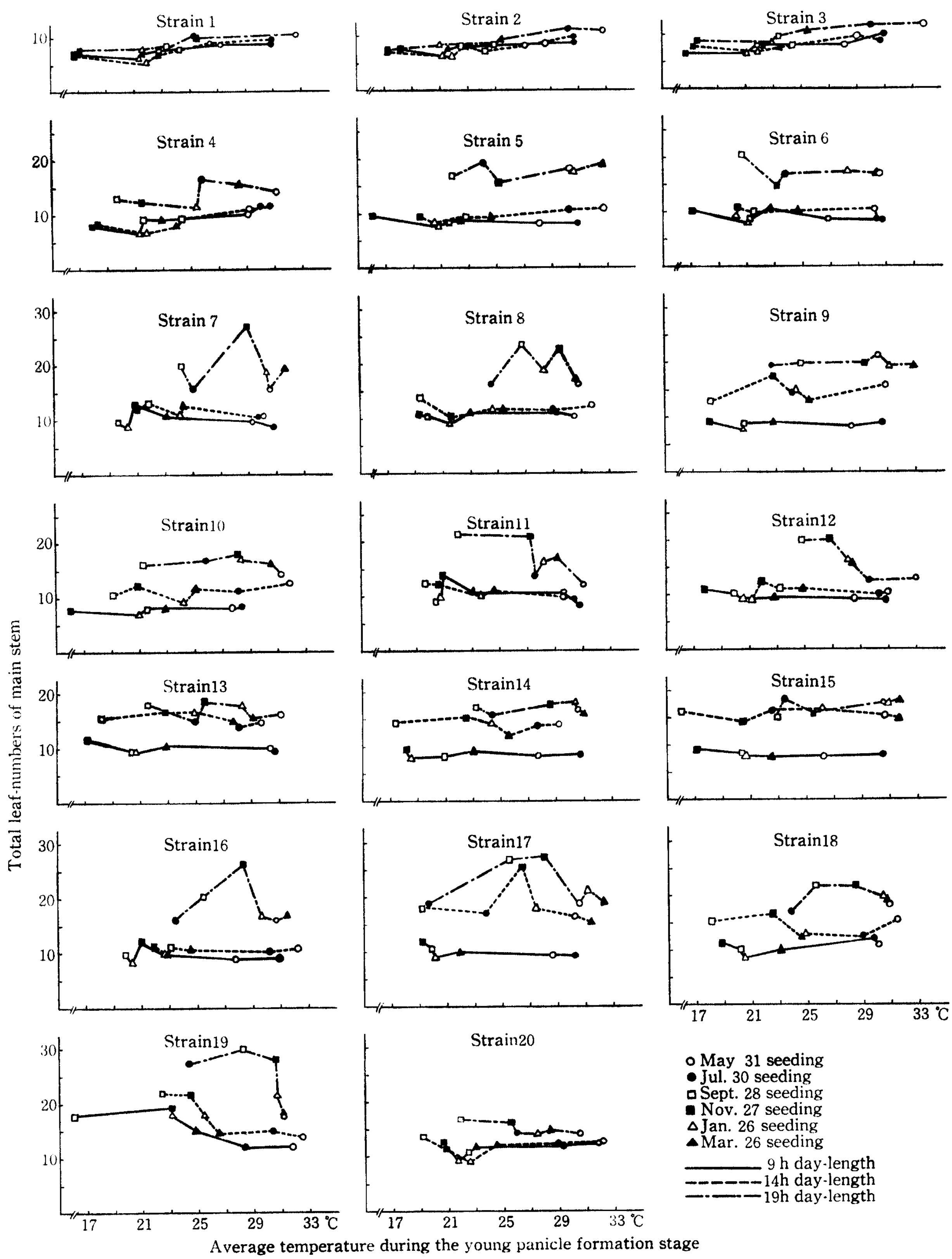

Fig. 8. Relationship between the total leaf-numbers of main stems and the average temperature during the young panicle formation stages (35 days to 15 days before heading).

stage, their relationship-lines between the leaf-numbers and the temperature during the panicle formation stages, showed more irregular tendencies than those between the leaf-number and the temperature during the total growth-periods. But, for these strains which showed irregular relationship-lines under 19 hours day-length conditions, and also the strains which showed same irregular relationship-lines as the former under 14 hours day-length conditions, the same standpoint as in case of the relationship-lines between the growth-period and the temperature during the panicle formation stage could be applied. For example, in case of being under 19 hours day-length conditions in Fig. 8, if the spots of the seeding in July and September in strain 7, the one of the seeding in July in strain 8, the ones of the seeding in July and September in strain 16, and the ones of the seeding in July in strain 17 and 18, were left out of consideration, the other spots in the respective strains depict regular relationship-lines similar to those observed in strain 12 or 19. Namely, it can be estimated that some strains decreased the leaf-numbers as the temperature during the young panicle formation stages or somewhat earlier one than the former rose and showed radical changing of the leaf-numbers at the particular temperature ranges for them. The most typical relationship-lines between the leaf-numbers and the temperature during the young panicle formation stages are shown in strain 19 in Fig. 8.

Discussion

Wada[10] reported that there was a high relationship between the photo- and thermo-sensitivities of rice plant varieties and their geographical distribution. The varieties distributed in southwestern Japan showed high photo-sensitivity and low thermo-sensitivity, while the varieties in the northern districts showed low photo-sensitivity and high thermo-sensitivity. Oka[8] reported the geographical variations of photo-sensitivity and critical day-length in rice varieties both native and foreign. Kuriyama[7] noted that the photo-periodic response in rice plant was expressed by the combination of two factors, the critical day-length of the optimum region and the degree of retardation of heading caused by superoptimum photoperiod. Asakuma[1] noted that the number of days from seeding to heading of the late rice varieties was controlled by higher temperature in summer but affected little by natural day-length when they were sown in later season in southwestern Japan. On the other hand, Hosoi[2–4] reported that thermo-sensitivity in rice plant proved to have no direct influence on the heading response under natural day-length in eastnorthern Japan, though he recognized that there was a interaction between the photo-response and the thermo-one in this crop. Kobayashi[5] reported that the lower limit of the favourable temperature of the flowering (heading) time in rice plant was considered to be lying between 17.5 to 18.6°C for all varieties, and the effect of the temperature to heading was large at panicle formation stage.

From the above mentioned investigations, it has been clear that as the factors causing the changing of the growth-periods of crop plant, there are the critical day-length of the optimum region and the degree of retardation of heading caused by superoptimum photo-period, as the photo-factor, and lower limit of the favourable temperature of heading time and the degree of retardation of heading caused by unfavourable temperature, as the thermo-factor. But, the interaction of these four factors consisting of two photo- and thermo-factors, respectively, have not been so clear.

From the results in this experiment, the interactions between the photo-factors and the thermo-ones analyzed clearly. Under definite day-length conditions, Italian millet strains have the critical temperature ranges during young panicle formation stages in which their growth-periods change radically due to the rising of the temperature and the critical temperatures vary with day-length under which they are cultivated. The shortening-degrees of the growth-periods due to the rising of the temperature are especially larger under longer day-length than under shorter one. Even in the strains not showing the critical day-length, the effects of the day-length to the changing of the growth-period were very large as shown in strain 19 in Fig. 8.

There are two cases in which the strains change the growth-period. In one case of them, strains do not vary the leaf-numbers according to the changing of growth-period, and in the other case they vary the leaf-numbers according to the changing of growth-period. These results seem to show that under a definite day-length condition, some strains of Italian millet need definite leaf-numbers for the induction of panicle formation, but the others do not need definite leaf-numbers for the induction when the temperature conditions are satisfactory.

Summary

Twenty strains of Italian millet, gathered from different districts both native and foreign, were cultivated under the different temperatures, and the natural, 9, 14 and 19 hours day-length. From the relationship-lines between the growth-period and the temperature during the young panicle formation stages, and those between the leaf-numbers and the temperature during the young panicle formation stages, it is clear that these strains have critical temperature at which the growth-period vary radically. This critical temperature in respective strains rose as the day-length became longer. Some strains decreased the leaf-numbers as their growth-periods became shorter, while the others showed no conspicuous changing of the leaf-numbers due to the shortening of their growth-periods.

Acknowledgements

The authors are grateful to the members of our laboratory for their cooperation in many ways.

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