Botany. — *"Rapid Flowering of Darwin-tulips."* I. By Prof. A. H. BLAAUW. (Laboratory for Plantphysiol. research. Communic. N⁰. 21, Wageningen.)

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§ 1. *Introductory.*

Our experiments on "the results of the temperature-treatment in summer for the Darwin-Tulips" have only been made on the red variety Pride of Haarlem. From those experiments follow various indications for culture, also for early flowering. On exposure to 44 different combinations of temperature in summer from lifting to planting (1922), it was already a striking fact for the botanist to discover that an exposure of 11 weeks to so low a temperature as 9°, gives the earliest bloom the next spring (1923). (See N⁰. 17, Tab. 2 and fig. 2.)

Meanwhile exposures to other combinations occurred, described in N⁰. 19; the question was a.o. whether more rapid flowering might be obtained in another way than by a permanent exposure to 9° in summer. Not that this could be of economical interest for field-cultures, but it might give an indication with respect to earliest bloom. Moreover on permanent exposure to 9° those flowers, though early, were rather frequently irregular or crooked, on account of transitional forms between the upper foliage-leaf and the first tepal. If we compare the number of temperature-combinations tried in 1924, among which 21 which had not yet been applied in 1922, we see in table 14, last column, that the tulips exposed to 9° for 11 weeks in summer, and those exposed to 20° for 3 weeks + 9° for 8 w. flower earliest and simultaneously in spring ; that just as before, those of 11 w. 9° flowered very irregularly, but those exposed first to 20° for 3 w. and then to 9° were quite uniform.

So that was the most suitable summer-treatment for Darwin-tulips, that were to be forced. And this is reasonable. For in 20° (and 17°) the flower-formation progresses most rapidly and the flowers show less irregularities than in 9°.

Let us now further consider this summer-treatment : 3 w. 20° and next 9°. After those 3 weeks 20° the flower had averagely reached stage III in 1924, i.e. the outward tepals are all visible as individual organs ; the bulbs in 9° are still merely leaf-forming. (See N⁰. 19, Tab. 22.) If we had exposed to 20° for 5 w. and then to 9°, the flower-formation was quite finished on transition from 20° to 9°. (See also Tab. 22.) But already by that time the successive number of flowering in the field has become 4 instead of 1. Accordingly it is not at all necessary, nay undesirable, to wait for a celerrimal flowering (most rapid flowering) till all floral parts have been formed in 20°. Besides it is worth notice (see tab. 15 in N⁰ 19) that the joint number of floral parts, if we transfer after 3 w. or 5 w. from 20° C. to 9°, amounts resp. to 16.10 and 16.55, i.e. shows no difference (0.45) worth mentioning, whereas the flower is in stage III after 3 w. 20° in 1924, quite finished after 5 w. On regarding the mean errors of Tab. 16 and the fact (s. Tab. 15), that the chief difference between 3 w. and 5 w. 20° is still found in the tepals already for the greater part formed (0.35 in the tepals and 0.45 for the joint number), whereas more floral parts might be expected "earlier in 9°", the noticeable fact is observed, that when the flower is well-started in 20°, transition to 9° may take place. It is striking that 3 w. 20°, besides a rapid finishing of the foliage-leaves has such results, that the number of floral parts is brought to 16—16.5 instead of ± 21, when flower-formation is started and continued both in 9°. Even this increased number often produces transitional forms of the organs, frequently attended with the flower growing crookedly on the stalk.

So starting in 20° and an early transition to 9°, has been the base for the experiments on early-flowering, described in this first part. (For the sake of application this was already communicated in Laboratory-communication N⁰. 19, p. 7; = p. 1073 of these Proceedings, Vol. **34**, 1925).

We shall see in this paper, that for succesful experimenting we are indeed compelled to mind the stage, in which the flower is, before the temperature is changed, and that it does not suffice to fix a certain date, as in the successive years this varies according to the climate to which the plant has been exposed in the field in the previous months.

What can be given in this first part on Early flowering of Darwin tulips is by no means complete. Though the results were an uncommonly early flowering for the Pride of Haarlem — yet I did not intend publishing until further modified experiments were made this year. But this division in at least two parts seemed better to me after all: 1⁰. the result as far as it could be ascertained hitherto, is sooner known to everybody who wants to apply or to experiment in this sphere; 2⁰. a description of the experiments of 2 or 3 years at a stretch would grow too long-winded for the readers; 3⁰. if for shortness' sake at the end of the experiments we give only the results of the exposures which ultimately lead to earliest flowering, we lose the whole connection with the preliminary experiments which indicated the direction how we could gradually attain that celerrimal flowering. Besides the proof-material is lacking which treatments are wholly unfavorable, which fairly favorable, e.g. in producing a somewhat later flowering. Besides various results of no value for practical purposes, may be of botanic-scientific importance. In such results economical interest is concentrated to those treatments having a celerrimal or optimal effect, but scientifically it is of at least as much importance to know the extreme treatments, the limits, either high or low temperatures, at which the flower-formation becomes impossible or shows abnormalities.

§ 2. *The beginning of the experiments and the influence of one and the same temperature.*

We received the lifted bulbs (from VAN TUBERGEN of Haarlem) already early in 1925, but the internal condition round the growing-point accorded fairly well with what we found in the bulbs of Pride of Haarlem a few weeks later in previous years. I.e. the temperature-exposures were started in 1922 on July 20, number of new foliage-leaflets in formation 2 or 3 — in 1924 on July 15 number of foliage-leaflets in formation 1 or 2, i.e. about 1 less — in 1925 already 2 foliage-leaflets had been formed on July 3. *From this it appears that the more or less advanced interior state of the bulb must be ascertained and we cannot rely on the date.* In 1925 namely the state of the growing-point on July 3 was intermediate between July 15, 1924 and July 20, 1922, whilst in those years the main bulbs were sent to us as soon as possible after lifting and had not been kept in a high temperature at the grower's.

The bulbs were kept in 20° from July 3—July 31, i.e. 4 weeks, then put in 9° for a long time. Besides on July 31 10 bulbs were fixed in alcohol 96 % and examined *later.*

It appeared *later on,* that in that transition from a short time 20° to a long time 9° the length of the outer young foliage-leaf in the bulb (which is to appear from the bulb later with the other leaflets as "nose" (tip)), was as a rule 3.0 to 3.5 mms. long. For the rest the flower was already in stage VI to VII. This appeared later on, and on comparison with other years (see above) we could safely (according to the field-cultures) have put the bulbs in 9° a little earlier, i.e. when stage III has been attained (outer whorl of tepals split off as 3 *individual* organs). This will be taken into account in the new series of experiments of this year. Doing so is also of practical importance; but if this sure method is thought to take up too much time or to be too difficult, the transition from 20° to 9° may fairly safely take place 3 or 4 weeks after lifting.

These bulbs were planted for early flowering on Sept. 7, 1925, in groups of 8 in boxes measuring 25 × 40 cms. and 21 cms. deep. (This year we are going to use groups of 6 in much smaller boxes). On Sept. 7, so on planting, the length of the outer leaflet, i.e. of the "nose", varied from 17—20 mms. in 9 bulbs. It seems to me, as far as we know at present, certainly not advisable to plant later. But fixing the date of *transferring* the bulbs from 20° to 9° (see above) requires much greater precision. For by that time they are in the midst of the rapidly progressing flower-forming period; — if the planting occurs at the beginning of September a week earlier or later *may* have its influence, but the organs of foliage-leaves and flowers are simply more or less long ; by planting somewhat earlier or later the chance of producing an injurious effect is by no means so great and the temperature remains the same (9°). Yet it is important for studies on earliest flowering to consider if that flowering may be accelerated by *planting* more or fewer weeks after the *transmission* from 20° to 9°.

The Darwin tulips thus treated were all planted on Sept. 7, 1925, viz. groups of 8 in 16 boxes. Besides the division in the actual experiments was started by that time. For the theoretical study of most rapid stretching the 1st was placed in 17°, the 2nd in 12°, the 3rd in 9° and the 4th in 5° C. — moreover 6 boxes were placed in 9° and 6 in 5° C. These 'stores' in 9° and 5°, served for experiments to be further described, in which after a shorter or longer period, i.e. with a shorter or longer "nose" length (= the outer leaf growing from the bulb), the boxes were transferred to higher temperatures (see § 3). We shall first describe how the stalks with leaves mainly behave, if they remain from the planting on Sept. 7 in 5°—9°—12° à 13° and 17°. From this it may be concluded whether *change* of *temperature* is *necessary* to attain the earliest flowering and cannot be substituted by continuous application of one certain average temperature.

The first shooting of the roots.

After about 4 weeks i.e. at the beginning of Oct. we noticed that the bulbs in 5°, 9° and 12° lifted up the soil, i.e. it appeared that the shooting roots did not go down well, but lifted up the bulb and some cms. of soil on top of it. This had to be redressed directly; all the bulbs were carefully replanted in looser sandy soil and the rest of the empty hard *outer brown scale* was removed. This namely greatly impedes the downward growth of the roots. For early flowering it is advisable as, I think, some growers also do — to carefully remove that outer scale *on planting*. Besides we could now observe the effect of the temperature on the shooting of the roots after 4 weeks. In 17° not a single root had shooted ; in 12° all the bulbs had roots the longest of which were already 4—7 cms. ; in 9° the shooting of the roots is most advanced, the longest is already 6—10 cms. ; in 5° the longest roots are 4—5 cms.

Accordingly 9° already shows a "celerrimum" in the shooting of the roots (most rapid ; we might call it an optimum, but who knows whether this is really most favorable, whereas we do know it is most rapid, so a celerrimum).

Besides 12° and 5° are also well-advanced, 12° slightly more so than 5°, while 17° is lagging behind. We shall revert to this subject, so remarkable with a view to the revision of the current botanical conceptions of optima, in connection with the other organs.

Only when the foliage-leaves ("the noses") had grown 9 cms .or more from the bulb, they were put in the light in constant hothouses. *In the bulb itself* we find by that time 4 cms. of the stalk with leaves. As throughout 5°

remained far behind other temperatures, they were not continued in 5° in the light, because this experiment would have been too expensive, but they were transferred to 13° (light).

The results of continuous 5°—9°—13°—17° from Sept. 7 follows in the table subjoined.

Length from the tip of the bulb to the apex of the leaf in mms.

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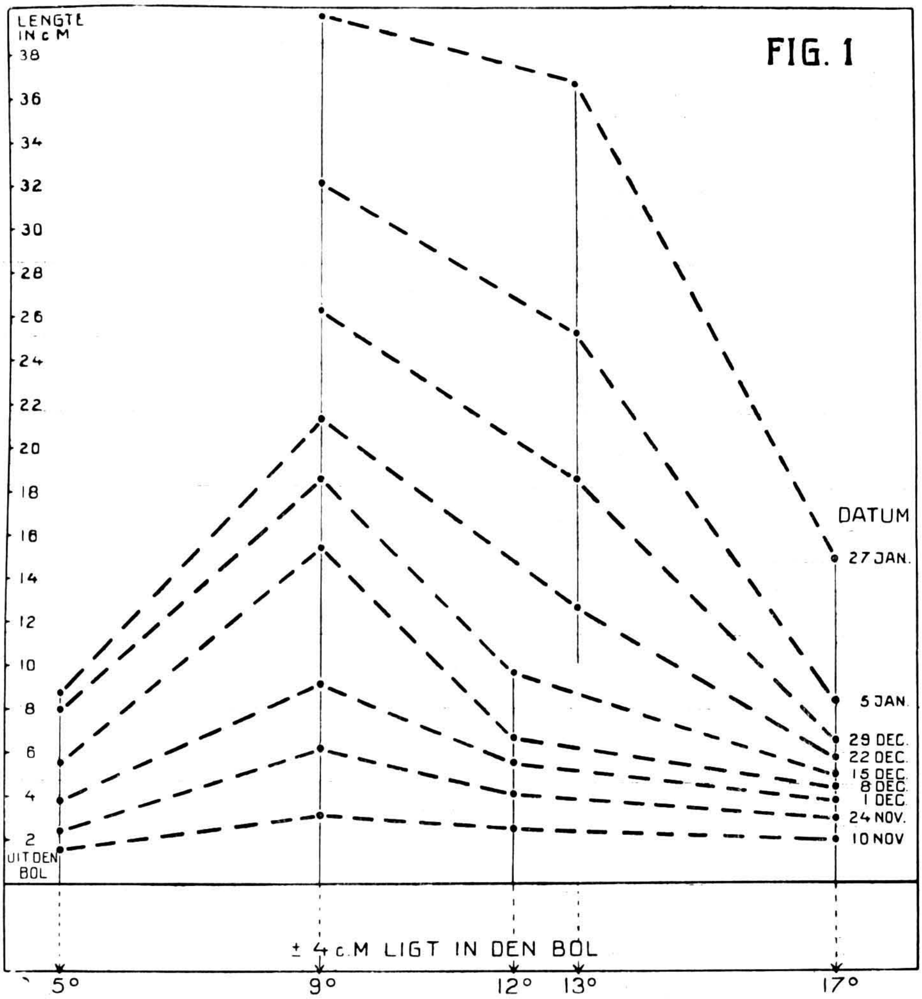
	5°	9°	12°/13°	17°
Nov. 10 '25	16.7 mms.	30.3 mms.	25.5 mms.	20.9 mms.
Nov. 24	26.5	60.5	41.1	30.8
Dec. 1	38.6	91.6	54	38.4
Dec. 8	53.7	157.0 L	68.6	44.5
Dec. 15	81.1	188	100.3 L	50.6
Dec. 22	90.5 L.13° ↓	216	130	59
Dec. 29	152	266	189	66.5
Jan. 5 '26	276	327	257	85 — L Jan. 12
Jan. 27	411	403 (310)	373 (444)	149
Febr. 9	428	435 (340)	386 (531) *	190
March 10		444 (358)		210 (450) *

The data of Tab. I up to and including Jan. 27 are also graphically represented in Fig. I. The temperatures are plotted on the abscis. Those of 12° C. have got to 13° C. on transmission to light for technical reasons. The temperatures give the degrees of heat of the soil in the boxes, as long as the largest growing part is still found there. When leaves and stalk have grown some way and the boxes are moved into the light, the temperature among the plants above ground is constantly kept at 9°, 13°, 17°, because by that time (at least with the tulip) the most important part of the stretching takes place in the air. On the day that the boxes are put in light, an *L* is placed in the table behind the linear measure. On the ordinate (Fig. 1) the linear measure is placed to the left ; to the extreme right the date of observation. In the table the figure between brackets from Jan. 27 denotes the distance from the tip of the bulb to the lower side of the flower, i.e. the length of the stalk to which is added ± 40 mms. inside the bulb. The period of full bloom has been indicated in the table with an *. In small print the length of the plants outside the bulb has been given, after transmission from 5° to 13°.

Lengte in cM. = Length in cms. Datum = Date.



Uit den bol = out of the bulb. cm. ligt in den bol = cms. are in the bulb.
For explanation the text should be consulted.

From table and figure the following conclusions may be drawn. (The figures always represent an average of 8 bulbs.)

1°. The stretching of the main-axis with leaves, e.g. from Nov. 10 to Dec. 22 yields exactly the same picture as we have observed in the shooting of the roots: *in 9° most rapidly*, in 12° distinctly less rapid than in 9°, in 5° less rapid than in 12°, *in 17° slowest*.

2⁰. Those in 12° and later (in light) in 13°, were the first to flower of these groups (Febr. 9); those in 5°, were continued in light in 13° (small printed figures in the table) and flowered some days later than those constantly kept in 12°—13° C. Those of continuously 17° flowered as late as March 10. But in the temperature, which causes "most rapid" progress for months together, i.e. 9°, the flowers remain in bud, green, even up to ± March 15; while both light and moisture of soil and air are perfectly identical to those in 13°.

3⁰. Accordingly none of these temperatures, *continuously* applied, is conductive to *early* flowering. And 9° is the only suitable temperature for months at a stretch. When the Darwin tulip has reached stages III to V (the progress is very quick then) in 20°, i.e. about 3 or 4 weeks after lifting, the bulbs remain from Aug. 1 to e.g. some days in Nov. in 9° to promote celerrimal stretching (and have meanwhile also been planted into boxes ± Sept. 1).

4⁰. Starting with 20° followed by one temperature, e.g. 9° for months together will not do for a celerrimum, but we must find out at what time of growth we had better transfer from a low temperature to another. This is also known to the growers, but we must try to approximate and fix this point of time in the growth as exactly as possible.

This will be discussed in the next §.

But it should be borne in mind that this is a first part and a new series of experiments follows made in 1926.

§ 3. *By what change of temperature may the earliest flowering be attained?*

Simultaneously with the experiments described above in constant 5°—9°—13°—17° some (6) boxes (planted on Sept.) were left in 9° and 6 transferred form 9° to 5°.

From these two boxes were taken from 5° and two from 9° and one of each placed into 17° and into 20°, when the length of the "nose", i.e. the distance from the tip of the bulb to the apex of the leaf (in which measure extention of stalk and leaf are mingled) amounted to *averagely 3 cms.* Next again 4 boxes were transferred, one from 5° and one from 9°, respectively to 17° and 20° when this measure amounted to ± *6 cms.* On reaching a length of 9 cms. (or longer) all were put in the light and besides those from 20° somewhat cooler, viz. in 17°. Those still kept in the dark in 5° and 9°, protruding ± 9 cms. from the bulb, were directly moved into 17° light and by way of control one box from 5° and 9° to 23°. They remained there for a short time till the flower-bud became visible, when they were also transferred to 17°.

In order to get a survey of this set of experiments, this is repeated in the following schematic representation:

After lifting all 20° for 4 weeks, next all 9°, on Sept. 7 planted into boxes (each containing 8 bulbs). One box was constantly kept in 5°, one in 12°—13°, one in 17°, as has been described in the preceding §. Moreover on Sept. 7 6 boxes were planted in 5° and 6 in 9°.

These were treated as follows:

Mode of treatment. Length of the plant out of the bulb.

	Upwards of 3 cms.	Upwards of 6 cms.	> 9 cms. light.	Flower-bud visible.
9°	→ 17° ——	——	——	——→
9°	→ 20° ——	——	→ 17° ——	——→
9°	——	→ 17° ——	——	——→
9°	——	→ 20° ——	→ 17° ——	——→
9°	——	——	→ 17° ——	——→
9°	——	——	→ 23° ——	→ 17° ——→
5°	→ 17° ——	——	——	——→
5°	→ 20° ——	——	→ 17° ——	——→
5°	——	→ 17° ——	——	——→
5°	——	→ 20° ——	→ 17° ——	——→
5°	——	——	→ 17° ——	——→
5°	——	——	→ 23° ——	→ 17° ——→

The results of these experiments are summarised below from figures 2—6, giving a graphical representation of them, also from § 2, from Nov. 10.

For comparison with figs. 3—6 fig. 2 repeats the results of constant 5° (in light 13°, then dotted line), constant 9°, 13° and 17°. The figures are found in Tab. I, so they are not repeated here, the graphical representation is connected with figs. 3—6, consequently differing from Fig. 1. Here the data of observation are placed along the basal line at proportional distances of time and the length of the part grown from the bulb erected vertically upon it, indicated by a dot. The temperature has been given at the line of growth, and on transferring to another temperature, the new temperature has been recorded behind that date, behind that dot. A transfer to light is indicated by a cross-stroke with an *L* above it. The date on which the group concerned was in full flowers, has been indicated by a rosette with a central dot.

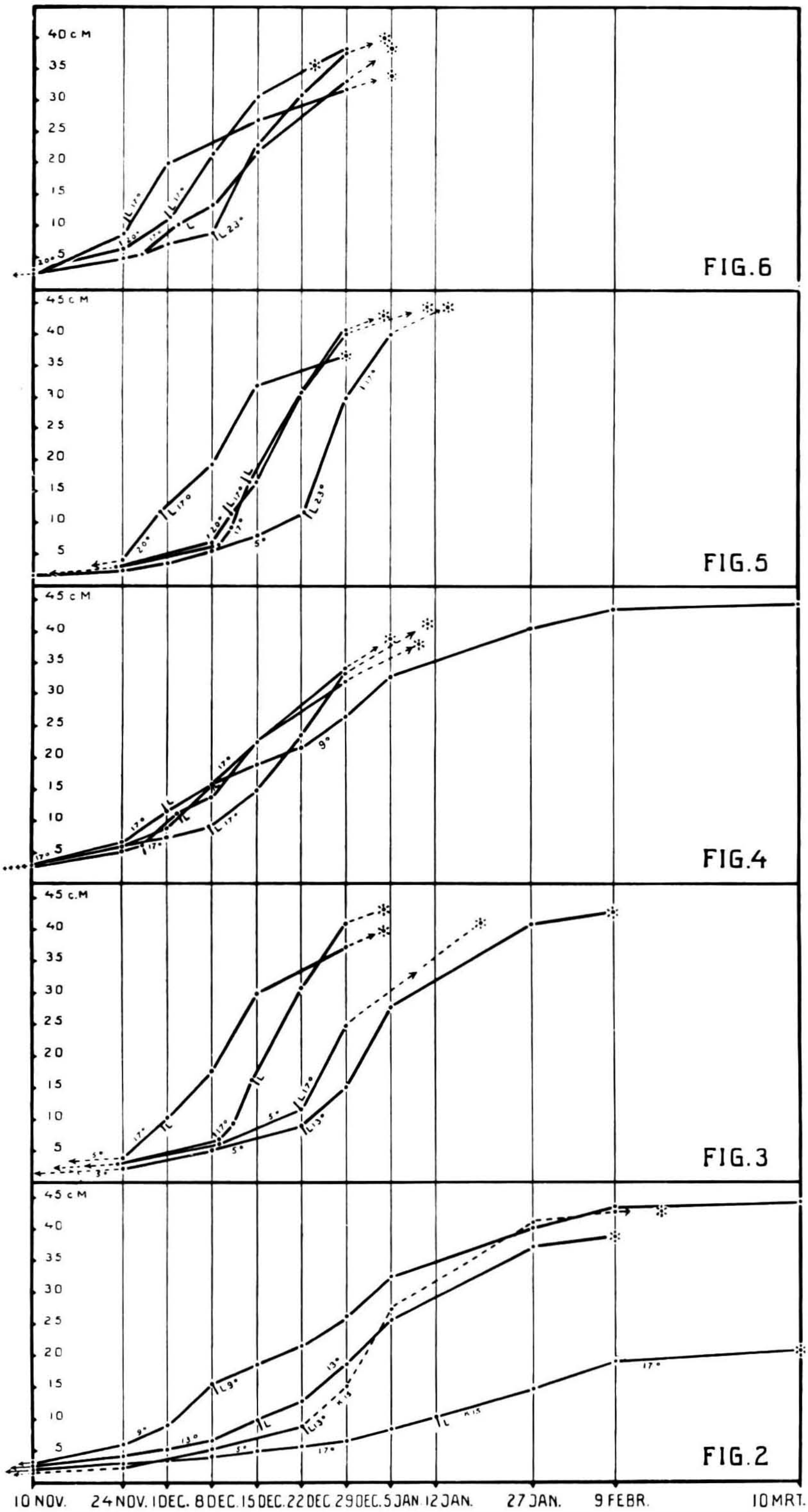


FIG.6
FIG.5
FIG.4
FIG.3
FIG.2
10 NOV.
24 NOV.
1 DEC.
8 DEC.
15 DEC.
22 DEC.
29 DEC.
5 JAN.
12 JAN.
27 JAN.
9 FEBR.
10 MRT.

Fig. 3 gives four lines of growth, viz. it first repeats a curve of fig 2, concerning some 8 tulips stored in 5° and transferred to light in 13° on Dec. 22 (length from the bulb 90.5). Besides three curves, when from 5° (since Sept. 7) the bulbs are transferred to 17° C. at a "nose"-length of upwards of 3 cms. — upwards of 6 cms. — and upwards of 9 cms.

1⁰. On conveying from 5° to 17° we directly notice a considerable acceleration of growth. An increasing acceleration of growth and earlier flowering compared to 5° and afterwards 13°.

2⁰. The strongest acceleration of growth we find on transferring from 5°, upwards of 6 cms. to 17°. Then this group equals in growth and bloom the one put in 17° already at 3 a 4 cms. The full flowering occurs on the same days (Jan. 4). The third group transferred to 17° does not flower until Jan. 19.

3⁰. Whereas we saw in Tab. I and Fig. 1, that on Dec. 8, 15 and 22 a constant exposure to 17° was unfavorable compared to 5°, we see the striking fact, that when the bulbs have *first* been exposed to a *lower* temperature (here 5°) and *next* 17°, a much more vigorous growth and earlier bloom is attained than when the low temperature is still continued. *Accordingly about that time the celerrimum of growth and flowering is shifted from a lower to a much higher temperature.*

We shall not add any separate tables of figures from which all lines of growth have been composed. Every one can read and measure these lengths and data from the figures.

Fig. 4 repeats "constant 9°", even on March 10 still closed as green flower-buds. The difference with 17° is not so striking now as in fig. 2, also because "constant 9°" were first rather vigorous growers, but yet it is evident that earlier or later transmission to 17° after some time causes more rapid growth than 9°, while in previous months 9° most of all others excelled 17° far in rate of growth (see fig. 1). Here too the celerrimal temperature of 9° is moved upwards at a certain point of time, i.e. with a certain length of the plant. All three groups transferred from 9° to 17° attain full bloom from Jan. 5—12; the earliest (Januari 5) those which were moved to 17° at upwards of 6 cms.

Now let us compare fig. 5 with fig. 3. In fig. 5 we do not transfer to 17° but to 20° from 5°, at an average length of upwards of 3 cms. and 6 cms, besides 8 tulips with a length of nearly 12 cms. were transferred from 5° to 23° C. The curve of fig. 3, where we transferred from 5° to 17° at a length of upwards of 6 cms., was repeated, as giving the quickest result in those experiments of fig. 3.

What may be concluded from this ? 1⁰. That the first transmission from 5° to 20° (and a short time after in light to 17°) gave the most rapid flowering (Dec. 29); 2⁰. that when at a "nose"-length upwards of 6 cms. the bulbs were put in 20° for some days, the progress of growth is fairly identical to the growth of the bulbs directly put in 17°; — the flowering of the group 15° — 6 cms. 17° was a week earlier (Jan. 4) than of 5° — at 6 cms. 20° (for 3 days, next light 17°). We must not attach too much value to this difference, because 5° — 6 cms. — 17° was not put in light until a length of upwards of 16 cms. had been reached and 5° — 6 cms. — 20° already at a length of 11.5 cms. We are now investigating whether light or dark in these days plays an important part; this will be discussed in the 2nd part on early Flowering. 3⁰. transferring from 5° to 23° when a length of 12 cms. was attained gave us a hint. For though this group was kept a long time (up to Dec. 22) in 5°, before that length had been attained, 23° (in light) gives a considerable acceleration of growth; only when the bud shows from the leaves, they are transferred to 17° and are in full flowers on Jan. 14. The stretching however is so forcedly rapid, that the insertion-spot of the upper leaves along the stalk often grows together with the stalk and causes the upper leaves or outer tepals to be torn. This method is not recommended, though it proves, how accelerating an influence a high temperature can have in *that later period*. It might be expressed in this way, that here for a short period of time the celerrimum (most rapid) is found in a higher temperature than the optimum (most favorable).

Finally Fig. 6 gives the most important result. On transferring after that initially celerrimal temperature of 9° to 20° at ± 3 cms. or upwards of 6 cms., it appears that "transferring to 20° at 6 cms." gives *the earliest flowering* of all experiments hitherto made, viz. on Dec. 24. Indeed those transferred to 20°already at 3 cms. first exceed a good deal in growth, but they are overtaken by those moved to 20° a fortnight later (± 6.8 cms.), as to growth in length and early flowering. And though they remain *in 20° but one week* before being removed to 17° in light, they do flower 10—12 days earlier, than the group directly put in 17° at 6 cms.

A photo of the first red Darwin-tulips flowering at Christmas, is shown in fig. 7 (Plate).

In various ways the experiments are continued on this base. That base consists in this, that the Tulips, 3 or 4 weeks after lifting, preferably controlled, viz. till at least the outer tepals have been formed, are kept in 20° next in 9°, after 4½ to 6 weeks planted in boxes in 9°, and only then, when the plant has grown from the bulb ± 6 cms., are transferred to a higher temperature (preferably 20°).

The above is however repeated and varied to discover whether e.g. that temperature should be more or less raised or lowered; whether at 6 cms. an exposure to dark up to ± 10 cms. (as we did now) is really better than directly to light at 6 cms. etc. These subjects will be treated in the 2nd part on Early Flowering of Darwin-tulips and later likewise in a paper on Early Flowering of Early Tulips.

Fig. 7. Pride of Haarlem, flowering on Christmas in Holland; — $3^1/_2$ week in 20° — afterwards 9° until 6 cm. above the bulb (Nov. 24th) — then 20° at first dark and in light 17° (see the text).

Fig. 8. Flowering in the first week of January, with example of a withering Flowerstalk (the right one).

§ 4. *Conclusion first part.*

So it is possible to get the Darwin-tulips Pride of Haarlem flowering at Christmas without abnormally early lifting or particular technical means. In the above it has been sufficiently described (summarily), how from 65 temperature-combinations between lifting and planting one most rapid and favorable mode was chosen (9° was most rapid, but not best) and how this summer-treatment served as a base for treating in 16 various modes after the planting in boxes to the flowering. That of those 16 there was one exceptional group flowering at Christmas and some other groups flowering 5—10 days later.

In the second part this celerrimal flowering will be repeated and different slight variations will be made to investigate whether the results are corroborated and may possibly be somewhat accelerated or improved.

Now we have still to point out a reverse in our experiments. Two "mistakes" appeared in the various groups, so that only half the number of the plants got to full bloom. Firstly in part of them the extension lags behind the others at a certain point of time and the flower-bud with the top-part of the stalk gets a withered strawlike appearance. This is not due to forcing, it occurred in the lower temperatures as well as in the higher. Nor can it be possibly owing to a dry atmosphere, for it occured in a degree at least equally strong in very moist air in small glass boxes (e.g. thermostats of 13°). Secondly we also observed in our experiments the phenomena of the tipping flowerstalks. Just as the withered flower-buds, it occurred in low temperatures as frequently as with the tulips transferred to a high temperature, also in very moist rooms.

Fig. 8 (Plate) represents a group on Jan.13 (transferred from 9° at 9 cms. length to 17°). It shows the Tulip to the extreme right in full bloom completely broken. The different hue of the rest of the Tulips is but seeming, as two are in the shade, others in sunlight. We also notice a short stalk with "straw-like" flower-bud between the leaves. The tipping occurred in our experiments, when the flowers were still in bud, but as well when the flower was in full bloom or even when it was beginning to fade. The spot where the stalk snapped lay as a rule 8—12 cms. below the flower. For further description of this phenomenon VAN SLOGTEREN's papers and further investigation should be consulted; and further STEVENS a. PLIMKETT "Tulip Blossom Blight" Bull. N°. 265, Agr. Exper. Station, Univ. of Illinois.

Certainly it is not due to forcing in higher temperature, and therefore we mention, that it did not occur in the box flowering at Christmas. This did yield however four flower-buds that remained strawy. But as already stated this likewise occurred in constant 13°, etc. For the rest we shall not go into these phenomena any further; we shall only record in the second part whether this year in somewhat altered treatments the two phenomena re-appear in an equally strong degree.

Besides we wish to mention here that a box, come to bloom with some broken flowers and a few withered buds was emptied. It appeared that the soil was sufficient and moderately moist and the root-system looked equally healthy in all of them.

Besides on the description of the experiments and the way in which we attained this flowering so early for Darwin-tulips, I mainly emphasized those parts essential for practical purposes. Meanwhile in the data of this and of previous papers there are found many things interesting from a scientific-physiological viewpoint and requiring profounder investigation. All this may be found in the preceding ; but I wish to emphasize some cardinal points, because they make us ask about the inner causes of these phenomena.

1^0. We know now that the formation of the last leaflets and of the floral parts progresses most rapidly in 20° C. (also fairly rapidly in 17°), in the first 3 or 4 weeks after lifting. This concerns the organs formation; that celerrimum is comparatively low, considering the "optimal" temperatures found for other processes, as respiration and assimilation. But in our researches we have to deal with *the plant as a whole.*

2^0. Even more astonishing it is to the botanist used to those high "optima" of simpler physiologic-chemical processes, that the plant, studied *as a whole,* shows us — when the first floral parts have been formed — a very low celerrimum of 9°. That which according to the standing phrase is called the optimum, is shifted rapidly downwards, when the first floral parts have been formed and is found at ± 9° C. And this for months at a stretch. A higher temperature, as 13°, gives a slower development, 17° still slower. In that 9° C. the flower is finished, the stalk, the young foliage-leaflets, the floral parts increase in size most rapidly in that temperature. What is the cause of this, that the celerrimum falls so strongly and continues so for months together ? Because from the process of *organ-formation* we proceed to the process of organ-*enlargement?* But even then a celerrimum ("optimum") of 9° is particularly low.

3^0. After ± 3 months, when the length of the plant (the part still inside the bulb, plus length of the leaves growing from the bulb) is 8—10 cms. — the optimum of growth is shifted to a higher temperature and we are obliged to transfer to ± 20° for a celerrimal stretching and flowering. This fact is almost more surprising. Whereas for so many months, for what we might call the "little stretching" the celerrimum is found in ± 9°, at a certain length, which requires rather great precision, the celerrimum is moved rapidly upwards to ± 20°. Where it will be exactly found, we shall further investigate in the second part. But to what is it due, that the "little stretching" with a celerrimum of 9° for months together passes into the "great stretching" progressing most rapidly at ± 20° ? If in Aug. the bulbs had been left and planted in 20° or 17°, everything would have progressed very slowly and the flowering would have occurred in March. If after 20° they had remained in 9°, the result had even been worse (see above "constant 9°"). It is exactly 9° for months together followed by ± 20°, which yields flowers as early as the end of Dec.

Such instances of exposure to cold then finally to heat with a view to early flowering are familiar to practice. To determine these temperatures and periods more exactly is the first task of these researches. But here botanical science is put before questions with which it has been too rarely occupied and which teach us, that *from a botanical point of view we have first of all to mind the behaviour of the plant as a whole,* before entering upon the deeper and more detailed processes of finding an explanation for that behavior. With this botany and application will both be served.

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