Botany. — "*The Results of the Temperature during flower-formation for the whole Hyacinth*". (Second Part). Laboratory for plant-physiological Research, N°. 11, Wageningen, Holland). By A. H. BLAAUW.

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§ 10. *Had the different temperature-treatments a noticeable influence on the growing-point formed during that period?*

In connection with the results discussed in the first part (Verh. Kon. Akad. v. Wet. 2nd section. Part XXIII N°. 4; §§ 1—9), there were many questions to be answered. They have partly been solved in the cultural year 1923—1924 and will be briefly communicated in this paper.

The results of 44 different temperature-treatments were described in part I. Where-ever a flower-cluster was formed under a certain treatment (whether this cluster became a failure or not) the new growing-point was also formed. This new growing-point which is to form a flower-cluster a year later and to flower next April twelvemonth, originated and grew during the first weeks that is under very different temperature-conditions.

Now the question is, whether those different temperatures have a noticeable influence on this new bud and the flowering plant arising from it.

For this purpose the circa 20 bulbs of each of the 44 experiments were treated *all in the same way* during the summer of 1923, i.e. from the beginning of July to Sept. 1 in 25° to 26°, from Sept. 1 to planting-time in 17°, which is the optimal treatment for flower-formation as hitherto *approximated.*

But the material was, as communicated before, far from uniform after the 44 treatments. I refer to the weight of the bulbs, which at the end of the experiments previously described (July 1923) had become as shown in table 21. This should be taken into consideration when judging the results. (See table 21 next page).

Secondly we should bear in mind that in some extreme treatments there was not formed any flower-cluster at all and the same growing-point was retained. In that case no new growing-point has been formed in that temperature; only the existing growing-point which was to form a flower-cluster next year, has experienced that temperature. This is quite an other matter than the formation of a new growing-point in a certain temperature, because on retention of the same growing-point in consequence of extreme temperatures, processes of growth and division are fairly brought to a standstill.

TABLE 21. Average weights of the bulbs at the beginning of July 1923 in grams per bulb, after having been *variously* treated in the *summer* of *1922* and before being *uniformly* treated in the *summer* of *1923*.

Temp.	3 w.	5 w.	8 w.	12 w.
1½°	18.0	15.7	11.2	8.5
5°	17.7	17.2	11.9	8.9
9°	19.4	17.3	15.8	8.9
13°	23.3	20.5	18.5	14.9
17°	22.9	21.5	19.1	22.9
20°	23.0	24.7	25.0	22.9
23°	25.8	27.2	30.4	28.9
25½°	30.4	27.6	31.6	29.2
28°	28.8	30.2	29.0	29.5
31°	26.6	29.7	30.8	20.9
35°	31.1	40.6	38.2	23.4

Table 15 part I already shows that (judged per 10 bulbs in January) in 1½°, 5°, 35° during a 12 weeks' treatment the same growing-point was nearly always retained (in 9 or 10 of the 10 bulbs). Consequently after 8 or 5 or 3 weeks' treatment there usually has not been formed a flower-cluster in those temperatures and the same growing-point has been retained. The flower-cluster and new growing-points found, *after* 8, 5 or 3 weeks' treatment in 1½°, 5°, 35° still generally occurring, *are formed under the influence of the further treatment in* 17°. Let us subject fig. 2 part I to a closer examination. It shows us that only in temperatures from 13° up to and inclusive of 31° all or the greater part of the growing-points form a cluster, so a new growing-point; in 1½°—5°—9° and 35° only less than half the number or an exceptional few. (If stage III is reached (first indication of the first 1 or 2 flower-primordia) the young growing-point at the base is *always* present. We must allow for the fact, that with those bulbs which were treated a year before in $1^1/_2$°, 5°, 9°, and 35° *as a rule the new growing-point was not formed in those temperatures*, but that either the old growing-point was retained, (usually in $1^1/_2$°, 5° and 35°, after 12 weeks' treatment) or a new growing-point was formed later on in lower temperatures (in the rooms in 17° or even after planting in the garden in October). As chief result it may be mentioned, that in the material of these bulbs *grown later* under equal circumstances, not any particular deviation occurred in the flower-clusters (or other organs). Of course there appeared in the heavier more compact clusters occasional deviating flowers as may always be found under normal treatment on large clusters. The influence of temperatures from 13° to 31° during bud-formation led to no sort of deviation in the flower-clusters, which arose from these growing-points the next year. No more in the few specimens which this new growing-point will have formed in 35° or 9°. This however proves by no means, that it would be impossible to effect constant lasting *bud*-variations by brief exposures to strong heat or to increase the chance of causing them. This chance however does not seem great to me.

The flowering of this field of Hyacinths, with uniform treatment during the last year, but after so dissimilar a treatment in the preceding summer, was quite uniform. The size of the clusters diverged greatly, but was normally dependent upon the size of the planted bulbs. A table of the most diverging groups will suffice.

TABLE 22.

I. Treatment summer 1922	II. Weight July 1922 per bulb	III. Weight July 1923 per bulb	IV. Treatment summer 1923	V. Numbers of flowers April 1924 per bulb	VI. Number of leaves p. 10 bulbs in 1924	VII. Weight July 1924 per bulb
35° 5 weeks	11.8 grs.	40.6 grs.		29.2	56	54.0 grs.
35° 8 „	11.7 „	38.2 „	25½°	23.4	54	51.2 „
25½° 8 „	11.4 „	31.6 „	8 weeks	18.3	49	40.0 „
9° 12 „	11.5 „	8.9 „	17°	4.8	40	22.0 „
5° 12 „	11.5 „	8.9 „	4½ weeks	3.8	39	19.8 „
1½° 12 „	11.5 „	8.5 „		0	33	19.3 „

From this it appears: 1°. When in 1922 no cluster was formed (9°—5°—1$^1/_2$° 12 weeks), this did not benefit the leaf-formation. The number of leaves, assimilating the next year was normally small with regard to the circumferences of the bulbs, which also remained small (see column VI). 2°. The number of leaves on the cluster was the greater according as the bulbs were heavier in the beginning of the cultural year (columns III and VI); so that also at the end the same order of succession in bulb-weight was maintained (column VII), while those bulbs which had lagged behind, vigorously made up for lost time. 3°. The number of flowers (col. V) was likewise in accordance with the weight of the bulbs (col. III). The bulbs which after a previous treatment in 1$^1/_2$° for 12 weeks had been reduced from 11.5 to 8.5 grs did not flower, of those from 5° (reduced to 8.9. grs) 8 of the 18 plants flowered with very poor clusters (average 3$^3/_4$ flowers). This is quite as might be expected of a similar bulb-weight (or bulb-circumference). We are here on the limit of flowering-ability, to which subject I shall revert in a next paper. Those which had previously been in 9° produced 16 clusters on 21 plants, with an average of 4$^3/_4$ flowers. While the average bulb-weight in *both* these groups (see table 21) was 8.9 grams, it appears that the previous treatment in 5° is still a little more unfavourable in its after-effect than 9°. 4°. It is of more importance that the bulbs treated a preceding year in 35° for 5 or 8 weeks had normally full clusters according to their circumferences, larger clusters therefore than those which received an optimal flower-treatment the year before. It should be borne in mind, as described in part I, that the leaf-optimum, i. e. the optimum for circumferential bulb-increase, lies much higher than for flower-formation, viz. in a temperature very unfavourable to flower-formation. Practically in the first years when the clusters are of no consequence, a high temperature might be applied and only later on ± 26° might be used with a view to flower-formation. But it had not yet been ascertained whether bulbs one year treated in 35° and giving no or bad clusters and beautiful foliage, could yield optimal clusters in 26° the next year. This now appears to be the case. After a treatment in 35° for 8 weeks in 1922 there appeared 3 clusters on 30 plants in April 1923; after optimal flower-treatment in the summer of 1923 all of these bulbs produced clusters with an average of 23 flowers in 1924 (in their 4th year, circumference 12 to 13 cms). See further table 22.

On the optimal foliage-treatment various experiments are being made, but it is certain, *that after optimal foliage-treatment optimal flower-treatment may be successfully started the next year.*

§ 11. *A control of the optimal temperature found for one year older bulbs.*

The experiments discussed in part I were made on young newly flowering bulbs, for reasons mentioned there. The optimal temperature found for the plant in general and particularly for the flower-cluster was now checked for a year older bulbs (circumference 120 to 130 mms at the beginning of July 1923). So these bulbs have been judged in the course of their fourth year. As to their size trade would class them as miniatures. But while the bulbs of the previous experiments were only just capable of flowering, these bulbs have passed that limit. For this control-experiment I preferred *one* year older bulbs, because the variation in number of flowers on the cluster is not yet so great, because not so many abnormal flowers occur as in the more compact clusters and lastly because the bulbs of this variety in their fourth year increase in size more uniformly than in older years.

Bulbs were chosen of a circumference (beginning of July) from 120 to 130 mms. In this experiment only the temperature-optimum was checked, not the period during which the temperature influenced. Thus 30 bulbs were kept in 17°—20°—23°—$25^1/_2{}^\circ$—28° and (25 specimens) in 31° for 8 weeks and next $4^1/_2$ weeks in 17°. This was to serve as a control for the *flower-optimum* hitherto approximated ($25^1/_2{}^\circ$ 8 weeks + $4^1/_2$ weeks 17°). On the *foliage-optimum* further details will be given in a later paper.

After the treatment on planting (4 Oct. 1923) the average weight of these six groups (17° to 31°) was 27.3—27.9—27.0—27.8—28.0 and 28.6 grams resp. I shall presently revert to this, but I mention here, that since the summer of 1924 we do not only make an accurate selection of the bulbs according to their circumference, but we also divide the various groups of each series of experiments into equal weights. Consequently the difference between the groups to be compared becomes still smaller, the comparison more accurate.

The *root-whorl* (beginning of Oct.) was least visible after treatment in 17°, a little more in 20°, a little farther in 23°, better in $25^1/_2{}^\circ$, in 28° and 31° most advanced, fairly uniform, very good, almost alarmingly long for planting (beginning of October).

As to *showing above ground* (this refers to leaf-length) those from $25^1/_2{}^\circ$—28°—31° were most advanced and fairly equal, those from 23°—20° and 17° were advanced in a lessening degree.

As to *coming into bloom* $25^1/_2{}^\circ$ is farthest, 28° about equally far, next 23° and 31° much less advanced, 20° behind 31°, but more vigorous, 17° less far and less favourable than 20°.

TABLE 23. *Number of clusters* (numerator) with respect to the number of plants (denominator), and the *number of flowers* on the succeeded clusters, both of these bulbs in their fourth year and of a year younger bulbs.

	17°	20°	23°	$25\frac{1}{2}$°	28°	31°
Succeeded clusters (bulbs 12—13 cms)	30/30	30/30	30/30	29/30	30/30	25/25
Idem on bulbs of 8—9 cms	12/30	24/30	28/30	30/30	27/30	27/30
Average numbers of flowers per cluster on bulbs of 12—13 cms.	**13.50** $m \pm 0.48$	**14.47** $m \pm 0.43$	**14.93** $m \pm 0.49$	**16.24** $m \pm 0.38$	**15.30** $m \pm 0.35$	**11.12** $m \pm 0.32$
Idem on bulbs of 8—9 cms	**6.07** ± 0.23	**5.57** ± 0.14	**6.0** ± 0.18	**5.57** ± 0.18	**5.68** ± 0.25	**3.15** ± 0.28

From this it appears that as contrasted with the younger bulbs, these older ones without an exception produce a flower-cluster after treatment in 17° to 31°. With the younger ones only 12 of the 30 bulbs yielded a flower-cluster after a treatment in 17°. This proves that bulbs from 8 to 9 cms are so much closer to the limit of flowering-ability, that it requires a so much more delicate treatment to make them all produce flowers than larger bulbs.

As far as the cluster succeeds with the smaller bulbs, the number of flowers per cluster is fairly equal after the various temperatures, as is already discussed in part I; only in 31° a smaller number was found, which, considering the slight mean error (m), is certainly not due to chance.

With the greater bulbs a slight rise is found from 17° to $25\frac{1}{2}$°. Though the difference between 2 succeeding temperatures is slight, so that the mean error might explain the difference, the fact that this rise gradually progresses till $25\frac{1}{2}$° and next decreases first slowly, in 31° however faster, shows that these differences are certainly not due to chance.

The strong decrease in 31° (5 flowers per cluster or ca $\frac{1}{3}$ of the number after treatment in $25\frac{1}{2}$°) is corroborated on the older bulbs, while likewise in this case $25\frac{1}{2}$° is most favourable with regard to the number of flowers. It cannot be attributed to an unfavourable influence of this temperature, that one cluster is lacking on 30 plants; with the *younger* bulbs all bulbs happened to bear a cluster after that treatment.

Lastly it should be mentioned that after treatment in 31° a great many abnormal flowers occurred in the clusters, in spite of the fact, that the clusters were rather poor in flowers. These abnormalities caused by abnormal circumstances will be discussed later on in connection with the material collected in these years.

The experiments discussed in this § are only meant as a check on the optimal temperature for flowering in a year older bulbs. The result is a corroboration that a *treatment in* 25°—26° (for 8 weeks) is most *favorable.*

The experiment did not aim at leaf-surface and circumferential increase of the bulb, which will be discussed later on. In that discussion however the data of this experiment may be of use to us; hence I will communicate something about them here.

TABLE 24. Number of assimilating leaves shooted in April 1924 after a treatment in 17°—31° July to Aug. 1923.

	17°	20°	23°	25½°	28°	31°
Number of leaves:	10 × 3 16 × 4 4 × 5	4 × 3 12 × 4 14 × 5	17 × 5 13 × 6	4 × 5 24 × 6 2 × 7	3 × 5 26 × 6 1 × 7	1 × 5 26 × 6 3 × 7
Average p. 10 bulbs	38.0	43.3	54.3	**59.3**	**59.3**	**60.7**
m =	± 1.2	± 1.3	± 0.9	± 0.8	± 0.65	± 0.65

It is again corroborated on these bulbs, that *high temperatures are needed for a subsequent shooting of all young leaflets ready in the beginning of July*: After 25½°, 28°, 31° the average 6 leaflets formed all get to assimilation later on; already after 23° not all of them unfold, after 20° and 17° a great number of them is arrested. Observe the very slight mean error and compare these data with the result given in part I § 3 A Tab. 2. In those younger bulbs of 8 to 9 cms circumference in July there succeeded:

25 31 35 [1]) 40 39 41 leaves resp.

of the ca 40 leaves formed per 10 bulbs after that same treatment.

[1]) 45 instead of 35 in part I is due to a printer's error.

TABLE 25. The *average leaf-length* in mms. (longest leaf, average of 30 bulbs, inclusive of the ca. 80 mms. below the surface of the soil) amounted in the beginning of June to:

17°	20°	23°	$25^{1}/_{2}$°	28°	31°
343	356	370	373	388	402

We notice a slight rise according as the temperature was higher. In the younger bulbs we found the foliage-length about equal from 23° to 31° and only much increased in 35°. The favorable effect of a very high temperature on the leaf surface is corroborated here at any rate. In connection with this I add the increase in weight.

TABLE 26. Increase in weight per bulb with initial weight (July 1923) and final weight (July 1924) after a treatment in July and Aug. 1923 in:

17°	20°	23°	$25^{1}/_{2}$°	28°	31°
34.1 44.7 } 10.6	34.9 45.0 } 10.1	33.8 48.0 } 14.2	34.8 48.6 } 13.8	35.0 50.5 } 15.5	35.5 59.7 } **24.2**

On the whole this increase in weight is not great in comparison with the younger bulbs, *but a strong increase of the assimilation-effect is already attained by 31° and consequently corroborated for high temperatures.* Later on this will be discussed in detail, because the relation between bulb-circumference, bulb-weight and annual "normal" increase in weight and circumference require a separate treatment. The cause of the rather slight increase in the moderate temperatures may also be due to the fact that in the very late spring of 1924 flowering and assimilation commenced in the experimental grounds *more than* 3 *weeks later* than in 1923; whereas the assimilation after the sunny months of May and June 1924 was finished earlier than after the wetter early-summer of 1923.

§ 12. *May the approximated optimum be perceptibly improved by exposure to a temperature still higher than* $25^{1}/_{2}$° *soon after lifting?*

In the following §§ the question is discussed whether the approximated optimal treatment for the flowering plant might be improved. This subject will be continued in a subsequent paper. After lifting

8 weeks in $25^{1}/_{2}$°, then till planting-time $4^{1}/_{2}$ weeks in 17° is the optimal combination hitherto approximated.

May the effect be improved by exposure to a higher temperature than $25^{1}/_{2}$° in the beginning after lifting for a shorter of longer period? As the effect of 28° and $25^{1}/_{2}$° was not very different, I preferred to use 31° as a higher initial temperature, seeing that otherwise no difference worth mentioning might be expected.

While the control-group remained in $15^{1}/_{2}$° for 8 weeks, 5 other groups were put in 31° the 1^{st}, the 2^{nd}, the 3^{rd}, the $1^{st} + 2^{nd}$ and the $2^{nd} + 3^{rd}$ week resp. and for the rest kept in $25^{1}/_{2}$° after 8 weeks in 17°. Each group also the control-group contained 40 bulbs of 80 to 90 mms circumference. Moreover each group was divided into two in order to find out whether a difference worth mentioning was obtained, when *the planting took place after only* $2^{1}/_{2}$ *weeks in* 17° *or* in the beginning of October *after* $4^{1}/_{2}$ *weeks' stay in* 17°.

So the experiments discussed in this § refer to two different questions. The groups planted after $2^{1}/_{2}$ weeks 17° and after $4^{1}/_{2}$ weeks 17° resp. will be indicated "earlier" and "later".

The *root-whorl* on Oct. 4 is not perceptibly different in the groups 'later'.

On *showing above ground* (leaf-length) March 24, 1924 (very late spring after long winter) $1^{st} + 2^{nd}$ week 31° and $2^{nd} + 3^{rd}$ week 31° are more advanced both in the earlier and in the later groups, however but little farther than the control-group; — on the other hand 1^{st}, 2^{nd}, 3^{rd} week 31°, both earlier and later planted, are somewhat behind the control-group.

$1^{st} + 2^{nd}$ week 31° or $2^{nd} + 3^{rd}$ week 31° have a slight advantage over the control-group as concerns the foliage-length when showing above ground. Planted "earlier" however does not mean showing above ground "earlier"; "later" on the contrary means a greater uniformity.

Also *as to flowering* with those planted later the $1^{st} + 2^{nd}$ and $2^{nd} + 3^{rd}$ week 31° are somewhat more advanced than the control-group (with those planted earlier the groups are equal as to rate of flowering). — (It should be borne in mind that in a long winter slight differences in the flowering-period are easily effaced).

Soon after lifting the leaf-formation ceases and the growing-point is raised and is about to form flowers. So the treatment described here might easily influence the number of flowers.

The average number of flowers per cluster amounts to ca 6, and corresponds with the findings on equally large bulbs the previous

TABLE 27. Number of flowers per cluster, as an average of ca. 20 plants. As planting a fortnight earlier or later can have no influence on the number of flowers, those results may be taken together.

Control earlier	6.20	$m = \pm 0.28$
Control later	6.10	$m = \pm 0.22$
1st week 31° earlier	5.90	± 0.33
1st week 31° later	6.16	± 0.31
2nd week 31° earlier	6.76	± 0.34
2nd week 31° later	6.05	± 0.20
3rd week 31° earlier	6.80	± 0.29
3rd week 31° later	5.80	± 0.29
1st + 2nd week 31° earlier	5.95	± 0.26
1st + 2nd week 31° later	5.95	± 0.20
2nd + 3rd week 31° earlier	5.94	$+ 0.20$
2nd + 3rd week 31° later	5.60	± 0.24

year with the same treatment (see table 19 part I) or may be a little more favorable.

Between the various experiments no difference is to be ascertained with certainty: 2^{nd} week 31° "earlier" (6.76) seems, considering the mean error, somewhat higher, but those planted later (6.05) are "normal"; likewise 3^{rd} week 31° earlier (6.80) is rather high, but those planted later (5.80) are again fairly low. As planting on Sept. 17 or Oct. 2 cannot affect the number of flowers of a cluster each two groups may be taken together.

The conclusion must be *that the number of flowers is not altered worth mentioning by the treatment described;* perhaps it decreases slightly in the $2^{nd} + 3^{rd}$ week 31°.

As in 31° the flower-formation is much inhibited the first 3 weeks also therefore the $1^{st} + 2^{nd}$ week (see fig. 2 part. I), it is a remarkable fact, that in spite of this about the same number of flowers is attained, and this very group $1^{st} + 2^{nd}$ week 31° (likewise $2^{nd} + 3^{rd}$ week 31°) is flowering yet a little earlier in spring.

The differences however are so slight, *that with respect to optimal flowering the optimum already found may be maintained; with respect* *to celerrimal flowering a small advantage in time might be gained by beginning the* 1st *and* 2nd *week (not longer) with e.g.* 28° *to* 30° *C.* in stead of 25° to 26° C. We shall revert to this in a later paper on early-flowering; it may be of some interest for early-flowering and I will not omit pointing out that as to the first couple of weeks we arrive at the same temperature with which practice starts in preparing for early-flowering. As I already demonstrated before e.g. l'Innocence does not require lifting earlier than at the normal point of time provided a *suitable* treatment *follows.*

The number of leaves shooted normally in all experiments, as might be expected on exposure to 25$^1/_2$° and 31°. Neither did the increase in weight yield special phenomena. It amounted to *ca* 16 *grams per bulb from July* 1923 *to July* 1924 in most groups. This corroborates our supposition with respect to the other bulbs at the end of § 11, for the bulbs of these experiments can be directly compared as to age and size with the experiments from part I, where *the increase in weight from July* 1922 *to July* 1923 *amounted to ca* 20 *grams per bulb after optimal flowering-treatment.* (See table 8). Meantime these experiments have not been directed at optimal increase in weight; as has already been demonstrated a greater increase in weight can be attained by an other treatment.

§ 13. *Is it desirable that the transition from a higher* (25$^1/_2$°) *to a lower temperature* (17°) *should take place before or after* 8 *weeks?*

Hitherto as an optimal treatment for flowering 8 weeks 25° to 26°, next 17° till planting-time was found. In these experiments however (part I) long intervals of time were taken, and 3 weeks, 5 w., 8 w. and 12$^1/_2$ w. in 25$^1/_2$° (for the rest 17° or planting at once after 12$^1/_2$ weeks) were compared. 8 weeks proved most successful for the plant as a whole and particularly for the flower-cluster. The difference between 5 w. and 8 w. was not very great, between 8 and 12 weeks easily perceptible and showing itself in an injurious effect of a prolonged stay in a high temperature. Now it might be desirable to make that high temperature last a little shorter or longer than 8 weeks before transmitting the bulbs to 17°.

For this purpose 20 bulbs of 80 to 20 mms were kept 6, 7, 8 and 9$^1/_2$ week resp. in 25° to 26° C. and next transferred to 17° C. Can a difference or advantage worth mentioning be gained upon 8 weeks 25$^1/_2$°?

In the *root-whorl* no difference is visible in the beginning of Oct., or may be 6 and 7 weeks a little more advanced.

On *showing above ground all four groups are equal*; 8 and 9 weeks a little more uniform and vigorous.

As to *coming into bloom* 6 weeks is most advanced, 7 and 8 weeks equal, especially 9 weeks perceptibly later.

This corroborates the celerrimum of flowering (table 18 part I), where 5 weeks 25½° were obviously earlier as to flowering than 8 weeks 25½°.

I have availed myself of this experience in my experiments with respect to early-flowering (celerrimal flowering) when already after 5 weeks the high temperature is abandoned. On the correct temperature thereafter experiments are being made.

TABEL 28. Number of flowers, number of leaves, increase in weight after 6, 7, 8 and 9 weeks 25½°.

25½°	Number of flowers per cluster	Assimilating leaves per 10 plants	Increase in weight per bulb in grams (July '23 – July '24)
6 weeks	6.50 ± 0.23	35 ± 1.3	11.5
7 weeks	5.95 ± 0.22	38 ± 0.9	10.35
8 weeks	7.26 ± 0.37	38 ± 0.9	13.75
9 weeks	6.50 ± 0.27	37 ± 0.1	12.8

The number of shooting leaves appears, considering the slight mean error, to slightly decrease in 6 weeks (this surely was the case in 5 weeks 25½° the year before). With this group the increase in weight is slight, obviously less than with the experimental plants discussed in § 12 which were equally large and grown in the same frame with equal groundwater-level. It appears how cautious we must be in comparing the increase in weight of various experimental series and how necessary it is to place the groups to be compared of one experimental series as close together as possible. Comparison of the 4 groups one with another (table 28) shows that the increase in weight in the 8 weeks' experiment is the most favourable at any rate.

As to the number of flowers per cluster, 6, 7 and 9 weeks yield the normal average of a little over 6 flowers per cluster, considering the mean error. Only 8 weeks (7.26) shows a slightly higher average which can hardly be attributed to chance. On the whole the number of flowers in this series is slightly higher than with the equally large and equally old bulbs of table 27 and so the result of 8 weeks is somewhat more favorable than with the control-specimens of table 27 which were treated in the same way. The question is whether any value may be attached to this, but it is certain that it appears from this more detailed experiment, that with respect to optimal treatment for flower-clusters 8 weeks $25^1/_2$° remains to be recommended, only after that a cooler temperature.

Separating into 6, 7, 8, 9 weeks was of so great an interest, because it was the way to answer the question, how long a high temperature is permitted and necessary with regard to the flower-cluster. On regarding the formation even in the small clusters after 8 weeks, we notice that in the basal flowers the formation of the various organs is nearly always ready (see fig. 2 part I), and the basal couple of flowers was always used as a criterion for the stage of development.

The top-flowers also on these poor clusters are not so far advanced after 8 weeks, and so the question rose, whether it would be a perceptible advantage to the number of flowers, if about that time the high temperature was continued longer or shorter than 8 weeks. This appears not to be the case. It is of great importance to know when that cooler temperature had better begin. We started exposure to the high temperature on July 5th to 7th, directly after lifting and so got to "8 weeks", or ca Sept. 1. But the bulbs may be lifted later, when the beginning of the summer is wet, or they may be lifted earlier and treated differently with a view to early-flowering; moreover with early-flowering varieties as l'Innocence the cluster-formation probably will be sooner finished. The expression "Sept. 1" or even "after 8 weeks" does not suffice. More objectively, less blindly or at random, it should be mentioned in what condition the top-flowers were at the period which appeared to be most favourable for a transition from hot to cooler temperature. A more detailed discussion of this point will be given in the next paper. From observations made by Mr. WOLLRING in our laboratory I can communicate that with this treatment in the greater part of the top-flowers at the most favourable time of transmission to 17° the primordia of the outer whorl of stamens have been formed, so that the top-flower was in stage VII (see part I § 6 A). When the top-flower has advanced no farther than this in the formation of the flower-parts, a transition to a lower temperature may be effected without risk, so that the flower still fully develops and unfolds.

A longer stay in that high temperature yields no advantage, e. g. it does not give rise to the formation of more flowers by the vegetation-point.

When we aim at *early-flowering* (celerrimal flowering) the high temperature may be discontinued earlier when a suitable treatment till the flowering-period follows. To the question in what stage the top-flowers should be for early-flowering before we pass on to a lower temperature, we shall revert in a later article.

§ 14. *Is a transition from the higher temperature* (23°, 25½° *or* 28°) *after* 8 *weeks to a temperature lower than* 17°, *e. g.* 13°, 9° *or* 5° *desirable?*

In the experiments discussed in part I the bulbs were transferred to ca 17° C. from 11 different temperatures after 4 different periods. This temperature was originally chosen somewhat at random. After the experiences obtained it appeared, e. g. when the bulb was treated in 20° for 8 weeks that a transition to 17° was better than a continued exposure to 20° for the remaining 4½ weeks. From this it followed, that with a view to the after-treatment there was little occasion to expect the approximation of the optimal treatment above 17°. It being not possible and desirable to make and judge more time- and temperature-combinations simultaneously, experiments were made in a second year to investigate the possibility of improving the initial approximated optimum by passing from the high temperature not only to 17°, but also to 13°, 9°, and 5°. Though 25° to 26° had appeared to be best for the treatment for 8 weeks in the higher temperature and an after-treatment in 17°, yet it seemed advisable to me to expose to 23° and 28° by the side of 25½°, because it might be possible, that the combination e.g. of 28° with e.g. 13° or 9° might yield a better result than of 25½° with 17° or lower.

Thus 12 experiments each with 30 bulbs measuring 80 to 90 mms (at the end of their second year) were made, the material of which was exposed to 23°, 25¹/₂°, and 28° for 8 weeks and next 17°, 13°, 9° and 5° till the beginning of October. Then 10 specimens were fixed and the remaining 20 planted in concrete frames with a 60 cms ground-water-level in common mould of our ground, for the rest manured and mixed with lime in the same way as trade prepares a good Hyacinths plot.

The *root-whorl* is farthest advanced and in both cases about equal after 25¹/₂°—17° and after 28°—17° in October. Next from 17° to

5° the progress of the root-whorl is perceived to diminish. At the end of the temperature-treatment, 10 specimens were at once fixed in order to ascertain the *direct effect* of the 12 treatments.

TABLE 29. **Length of the 1st, 2nd and 3rd foliage-leaf and height of the cluster on Oct. 5th 1924.**

		Length 1 Sept.	5°	9°	13°	17°
1st Leaf	23°	6.0	13.0 (± 0.15)	16.9 (± 0.23)	19.3 (± 0.19)	18.1 (± 0.43)
	25½°	5.9	11.7	17.1	19.5	19.5
	28°	5.4	9.8	17.3	19.1	19.5
2nd Leaf	23°	—	11.1	15.1	17.2	16.2
	25½°	—	9.8	15.4	17.2	16.9
	28°	—	8.6	15.8	17.0	18.2
3rd Leaf	23°	—	9.5	12.9	15.0	14.5
	25½°	—	7.3	13.6	15.5	15.1
	28°	—	7.2	13.8	15.2	15.4
Cluster	23°	2.5	5.9 (± 0.54)	9.9 (± 0.38)	11.6 (± 0.46)	12.1 (± 0.42)
	25½°	2.6	4.6	9.7	11.9	12.3
	28°	1.9	4.2	9.0	12.1	12.5

The lengths of the second and third leaves were also measured in order to have a better control on the effect of the young leaflets in the slight number of 10 specimens. Only in the case of 23° 1st leaf and flower-cluster the mean error was computed and added, in order to get an impression of the amount of the mean error in these experiments. On the whole it may be observed, that this is slight for so small a number of observations (10), that the variation in length of these young organs is not great. The length of the 1st leaf and of the cluster on Sept. 1, i.e. at the period of transition from 23°—25½° and 28° to a cooler temperature has been added as far as it was known.

From this table it may be concluded:

1. *An after-treatment in* 9° *and* 5° *yields a distinctly slighter length of leaflets and flower-cluster than* 13° *and* 17°.

2. *As to* 5° *it is striking that the inhibition is less according as the preliminary treatment was less warm.* As already on Sept. 1, 23° is

more advanced in length than 28°, it might be concluded, that in that low temperature 28° had no opportunity of overtaking 23°, as has been the case with 13° and 17°. But 25½° and 23° were practically equal on Sept. 1 and yet in 5° after preliminary treatment with 23° the length of the organs always surpasses their length in 25½°.

3. Between 13° and 17° there is no clear difference as far as the young leaves are concerned. On the whole it seems that after 23° a cooler after-treatment with 13° is to be preferred to 17°, and that the organs after 25½° and 28° and next 13° and 17° are longest in the 12 experiments, but that there is not much difference between these four kinds. Considering however that on Sept. 1, the organs in 28°, both leaflets and cluster lag a little behind in length with 25½° and 23°, we arrive at the conclusion, that 28° and next 13°, but especially 17° is most effectual. Here again it is proved, how important preliminary treatment in high temperature is, so that the organs, initially lagging behind in length in embryonic state make up for lost time most satisfactorily. It may be all but safely accepted that in those higher temperatures the number of embryonic cells is greater and the extension does not progress so fast as in the less high temperatures (20°, 23°), so that later on there are more cells available for extension. I state this only as a supposition. In a later paper its correctness will be probed.

4. Judging from the cluster-length 17° is a little more advanced than 13°. Considering the mean error (above 0.40) no value must be attached to this in one group, but as it is repeated perfectly regularly three times (after 23°, 25½°, 28°), we may attach value to it in my opinion.

TABLE 30. Order of succession of coming into bloom, the quickest being indicated 1. — etc. On April 19, 1924.

	5°	9°	13°	17°
23°	3	3	2 to 3	2 to 3
25½°	4	3	1	1
28°	5	4	2	1 to 2

25½°—13° *and* 25½°—17° *are celerrimal as to coming into bloom,* next 28°; the after-treatment in 9° and 5° causes distinct delay. It strikes us again that the *after-treatment of* 5° *retards the less, according as the warm initial temperature was lower.*

TABLE 31. Number of assimilating leaves per 10 plants

	5°	9°	13°	17°
23°	37	36	37	37
25 ½°	38	39	41	39
28°	40	39	40	40

It appears that especially the warm initial temperature is decisive, with respect to the growing out of all young leaflets, which are already there at the beginning of July; upon these the cool after-treatment has no perceptible influence, so that after the treatment with 5° the leaves extend as well as after 17°. Though 23° is not so very unfavourable, yet it is corroborated again, that already by that temperature some leaflets are arrested in growth. To make them all unfold it appears again that at least 25° is needed.

In connection with this we want to draw the attention to the increase in weight. We started with 12 groups, the average initial weight of which varied in the various groups from 12.1 to 12.8 grams per bulb in July 1923.

TABLE 32. Increase in weight per bulb from July 1923 to July 1924.

	5°	9°	13°	17°
23°	12.3	14.0	11.6	13.9
25½°	12.8	14.6	21.8	18.7
28°	14.5	15.9	18.9	19.2

We know already that slight differences of weight cannot be attached much value to; but it is evident that in all cases 23° lags behind higher temperatures, that after 25½° and 28° an after-treatment with 13° or 17° gives the greatest increase in weight. Conspicuously higher among these four is 25½°—13°; whether this is of real value, I could not conclude from this one figure. I wish to point out that after treatment in 25½° and 28°—13° and 17°

increases of weight are found, corresponding very well with those which were ascertained the year before (see table 8 part 1), which are relatively high in comparison with the experiments of §§ 11, 12 and 13 made in the same year.

Let us now consider the flower-clusters which were of more moment in these experiments than the increase in weight.

TABLE 33. Number of *succeeded clusters* on 30 plants.

	5°	9°	13°	17°
23°	22	23	28	29
25½°	15	25	29	30
28°	14	26	28	29

It is obvious that after-treatment with 9° or 5° is injurious, but this criterion corroborates anew, that the disadvantage of 5° is the smaller according as the preliminary treatment was a little less warm (23°).

Between 13° and 17° there is no certain difference; at any rate 25½°—17° and 13° are among the optimal treatments.

TABLE 34. Number of flowers per succeeded cluster. The number from which the average is taken, we find in the above table 33.

	5°	9°	13°	17°
23°	7.27 ± 0.29	7.09 ± 0.29	7.43 ± 0.34	6.65 ± 0.26
25½°	7.47 ± 0.30	6.25 ± 0.27	6.54 ± 0 23	6.41 ± 0.29
28°	6.00 ± 0.37	5.85 ± 0.26	5.82 ± 0.24	5.72 ± 0.23

It is very probable, that there where many clusters don 't develop in consequence of a less satisfactory treatment (5°), the strongest clusters with more flowers are most likely retained. Therefore I think it better to leave these numbers of flowers out of account. If we regard the remaining columns, especially 13° and 17°, it appears that with respect to the number of flowers exposure to 23°

seems to be more favourable and to 28° certainly is a little more unfavourable than $25^1/_2$°. As on Sept. 1, when the cooler after-treatment begins, the number of flowers has already been fixed and consequently 23°—13° and 17° may be added up, it is obvious, that the advantage of 23° to $25^1/_2$° with respect to number of flowers, if existing, is very slight. As for the rest for celerrimal flowering and especially for increase in weight $25^1/_2$°—17° and 13° are certainly to be preferred, my opinion is that for an *optimal combination of optima* it is safest to abide by $25^1/_2$° (practically $24^1/_2$° to $26^1/_2$°) 8 weeks and $4^1/_2$ weeks in 17° or a little lower (practically 14° to 17°). On the influence of the temperatures on the extension of the organs after ca. Sept. 1, detailed experiments are being made by Miss LUYTEN and Miss VERSLUYS. It is desirable to await these results. Nor shall I give a summary of the results described in these §§, because after some time I shall be able to communicate other experiments which will enable us to form a final conclusion for the variety Queen of the Blues on the following 3 points: 1. celerrimal flowering (early-flowering), 2. optimal flowering or optimal field-culture, in which flowering and increase in weight are combined as well as possible, and 3. optimal increase in weight, in which the flowering is left out of account.