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The Effect of Daylength and Temperature on the Production of Tubular Florets (Quills) by INDIANAPOLIS CHRYSANTHEMUMS

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CONTENTS

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THE EFFECT OF DAYLENGTH and TEMPERATURE ON THE PRODUCTION OF TUBULAR FLORETS (QUILLS) BY INDIANAPOLIS CHRYSANTHEMUMS.

ROBERT O. MILLER and D. C. KIPLINGER

The chrysanthemum is one of the most important cut flowers in the florist industry because of its excellent keeping quality and wide range of color and form. Since development of large scale production of spray-type flowers in Florida, Northern operators have found that it is more profitable to produce the large-flowered cultivars which have to date proven unprofitable to produce in the south. Among the larger flowered cultivars in demand, those of the Indianapolis series rank high. During the fall and spring, especially, these cultivars are extensively produced.

The Indianapolis cultivars are seldom used during December, January, and February, however, because they generally produce flower heads[1] with a large number of tubular florets or "quills" which give the flower a ragged, uneven appearance, Figure 1. Florets may be wholly or partially quilled or even ligulate as shown in Figure 2. Counting the number of the various kinds of florets of well-formed flowers has indicated that 10-20 tubular, 30-40 half-tubular and 200-250 ligulate florets, in the proper locations, result in a desirable flower. In addition to the fact that a large number of quills are present, flowers formed during mid-winter are usually flat rather than deep. Such flattened flowers are not desirable since additional depth gives the appearance of greater flower size.

This is a preliminary report of an investigation conducted to determine what environmental factors affect the production of flattened, quilled flowers of different cultivars of the Indianapolis series. Since the quilling phenomenon is most often encountered during mid-winter

[1]The "flower" of **Chrysanthemum morifolium** is an inflorescence consisting of closely packed florets situated on a capitulum. Throughout this discussion, however, the term flower will designate the whole inflorescence and the term floret will refer to the individual flower.

when the photoperiod is quite short and temperatures are low, these two factors were investigated.

Review of Literature

Post and Lacey (1951) suggested the use of interrupted short days (providing 12 short days followed by 10 long days followed by short days to flower; 10-12 formula) to improve the size of large-flowered chrysanthemums by increasing the number of florets initiated. They presented data showing that the number of florets was increased by applying the interrupted short day treatment thus preventing "open centers". Their results indicated that the diameter of the flower was not increased greatly by interrupted lighting.

Duffett (1956) reported that the use of the interrupted short day treatment markedly increased the number of florets in flowers of several clones of the Indianapolis series and produced flowers with greater depth than those produced under abrupt short day treatment. Further, Duffett (1956) investigated the use of "after lighting" (using short periods of artificial light each night during the flower development period) to improve the size and form of Indianapolis cultivars. His data indicated that flower diameter was increased and the number of quills

Fig. 1.—The illustration shows a well developed flower (left) and an undesirable quilled one on right

decreased by after lighting, however, the heads were flattened and generally undesirable when 15 minutes of light of 10 foot-candles intensity was used.

1957-58 Experiment

Methods and Materials

Rooted cuttings of *Chrysanthemum morifolium* Indianapolis Yellow were planted in a 60° fahrenheit minimum night temperature greenhouse December 30, 1957. The plants were spaced 5×6 inches and were grown to a single stem. There were 64 plants in each of the following treatments which were not replicated: (1) abrupt short days, (2) interrupted short days (10-12 formula), and (3) after lighting for a period of 1, 5, 10, or 15 minutes each night at midnight for two weeks, four weeks, or until flowering.

Short days were started January 16, 1958, for all plants except those receiving interrupted short days. Cathey and Borthwick (1957) reported that 2 to 6 rows of flower primordia were present on the capitulum of Indianapolis Yellow after 14 short days, thus after lighting was begun 10 days after the start of short days. Interrupted lighting

Fig.2.—Florets may be wholly and partially quilled or even ligulate as shown here

was started January 4 giving 10 short days, followed by 12 long days, then short days to flower.

The plants in the different plots were suitably shielded to prevent unwanted illumination, and all plants were completely covered with black cloth at 4:30 p.m. and uncovered at 8:00 a.m. each day with light being applied under the cloth. All plants were fertilized in the same way based on soil tests. Watering was done in the accepted commercial manner. At harvest (the date of flowering), total weight of stem, flower diameter, total number of florets, and the number of florets tubular for more than one-half their length for 10 plants from the inner rows of each treatment were recorded. The data were not statistically analyzed.

Results

Length of the after lighting period each night had a greater effect on flowering date than the duration of the after lighting treatment. Plants grown for 2 weeks, 4 weeks, or until flowering and receiving 1 minute of light flowered April 1, 1958. Those receiving 5 minutes of light flowered April 7; those receiving light for 10 minutes flowered April 16; and those receiving 15 minutes of light flowered April 18. Plants in the interrupted short day treatment flowered April 4 while those receiving abrupt short days flowered April 17. At the time of maturity, there was little difference in height and weight except for plants subjected to the 15-minute light treatment which were approximately two inches taller and slightly heavier than other plants.

Table 1 contains data on the flowers produced. Flowers of plants receiving interrupted short days were larger in diameter than those receiving abrupt short days. There were no consistent trends indicating an important effect of either light interval each night or duration of the light treatment on flower diameter or depth. All flowers produced were rather shallow. No consistent trends indicating an effect of light treatment on the number of florets per flower were evident. Plants receiving interrupted short day treatment produced an average of 337 florets per flower as compared to 274 for abrupt short day plants. This compares with an average of 267 florets for plants in all after lighting treatments.

The percentage of tubular florets in each flower was appreciably decreased below that of flowers produced under abrupt short days by the use of interrupted lighting. There was an indication that continuous lighting for the duration of the crop resulted in a decrease in the percentage of tubular florets (except light for 5 minutes each night). In both cases, however, there was still an excessive number of tubular florets produced and further, flower shape was not markedly improved.

Table 1.—Average diameter, depth, florets, and the percent tubular florets of flowers of Indianapolis Yellow chrysanthemums. Wooster, Ohio, 1958.

Light treatment	Flower diameter (inches)			Flower depth (inches)			Florets per flower			Percent tubular florets		
	Weeks			Weeks			Weeks			Weeks		
	2	4	Cont.	2	4	Cont.	2	4	Cont.	2	4	Cont.
1 minute	4.0	4.2	4.0	1.8	1.8	1.8	273	267	261	40.5	45.8	32.5
5 minutes	4.2	3.9	4.5	2.0	1.9	2.2	268	254	272	44.8	47.1	51.4
10 minutes	4.0	4.1	4.0	2.0	2.3	1.8	277	272	217	58.6	67.0	31.6
15 minutes	4.5	4.6	5.0	2.0	1.9	2.0	272	253	311	59.4	32.2	36.2
Interrupted SD		4.8			2.0			337			29.4	
Abrupt SD		4.3			1.9			274			40.6	

1958-59 Experiment

Methods and Materials

Rooted cuttings of *Chrysanthemum morifolium* Indianapolis White and Improved Indianapolis White, a cultivar introduced by Yoder Bros., Inc., Barberton, Ohio, because it produces flowers of good form under mid-winter conditions, were planted in two raised benches in a 62° F minimum night temperature greenhouse October 3, 1958. The plants were spaced 4×5 inches (on the assumption that reduced light intensity possibly would help induce severe quilling) and arranged in 12 plots with 60 plants of each cultivar per plot.

The following procedures were applied to 3 replications of each treatment in a randomized complete block design: (1) abrupt short days, (2) interrupted short days. (3) an 11-hour day, and (4) a 13-hour day.

Short days were started November 25 for all plants except those receiving interrupted short days. The interrupted short day treatment was started November 15 giving 10 short days, followed by 12 long days, followed by short days to flowering.

It was originally planned to start short days on all plots except the interrupted short day group on November 15; however, some plants apparently did not receive enough light because crown (flower) buds were evident on some plants on that date. An additional 10 days of artificial light was given and the crown buds were by-passed by vegetative shoots so that flowering occurred on terminal buds.

The plants in the various plots were shielded to prevent unwanted illumination from adjoining treatments, but they were not completely covered with black cloth each night and thus received natural light or natural light plus artificial illumination. Fertilization was according to soil test and watering was done in the accepted commercial manner.

At harvest, (the date of flowering), total weight of stem and weight of the flower were obtained. In addition, flower size, flower depth, and quilling were rated and the number of tubular florets, half-tubular florets, ligulate florets (see Figure 2) and florets too small to classify were recorded for 10 plants from each cultivar in each plot.

Results

Plants were harvested January 23 and 24, 1959. Flower buds initiated on the plants held at 13 hour daylengths but they failed to develop. Among the plants remaining there were no important differences in the total stem weight as a result of cultivar or treatment, Table 2.

Table 2.—Average effect of abrupt short days, 11-hour days, and interrupted short days (10-12 formula) on various characteristics of two Indianapolis chrysanthemum cultivars. Wooster, Ohio, 1959

Daylength treatment	Stem weight, grams	Flower weight, grams	Size rating[1]	Depth rating[2]	Quilling[3]
		Treatment Averaged Over Cultivar			
Abrupt SD	59.1	14.6	3.2	3.2	2.1
11-hour	61.9	16.9	2.5	3.1	1.9
Interrupted SD	60.5	19.9	2.6	2.5	2.0
LSD 01	NS	4.12	NS	NS	NS
		Cultivar Averaged Over Treatment			
VARIETY					
Indianapolis White	62.7	18.1	2.7	3.4	2.6
Improved Indianapolis White	58.3	16.1	2.9	2.5	1.5
F 01	NS	NS	NS	S	S

[1]Size was rated from 1 to 4 with 1 being the largest flower.
[2]Depth was rated from 1 to 4 with 1 being the deepest flower.
[3]Quilling was rated from 1 to 4 with 1 being the most desirable.

Flowers of both cultivars in the interrupted short day treatment were heavier than those under abrupt short days; however, flowers produced at the 11-hour daylength were not appreciably heavier than in the abrupt short day treatment. The various daylength treatments did not affect the size of flowers of either cultivar to any extent. Improved Indianapolis White plants produced deeper flowers than did those of Indianapolis White. Depth of the flower was not affected significantly by daylength treatment.

Quilling was more severe in Indianapolis White than in Improved Indianapolis White. No difference in quilling resulted from daylength treatment in either cultivar.

It is evident from Table 3 that interrupted short day treatment increased the number of florets produced by both cultivars. Differences in the number of small florets indicated differences in maturity at the time of harvest. For this reason, and because of the various numbers of the total florets due to treatment, the percentage of tubular, half-tubular, and ligulate florets, based on the total number minus the small florets, have been determined and are presented in Table 3. Since there were no significant interactions between cultivars and treatment, treatment

Table 3.—Effect of abrupt short days, 11-hour days, and interrupted short days (10-12 formula) on the percentage of florets of various types produced by two Indianapolis chrysanthemum cultivars. Wooster, Ohio, 1959.

Daylength treatment	Total florets	Total minus small florets	Percentage of florets that were		
			Tubular	Half-tubular	Ligulate
		Indianapolis White			
Abrupt SD	292.8	216.1	34.3	44.4	21.3
11-Hour	306.9	224.5	29.4	57.3	13.3
Interrupted SD	337.6	282.6	25.0	55.1	19.9
		Improved Indianapolis White			
Abrupt SD	290.0	187.4	5.3	21.3	73.4
11-Hour	231.7	202.7	6.8	29.9	63.3
Interrupted SD	382.4	278.6	4.4	26.2	69.4

and cultivar averages are presented. Of the total florets produced by Indianapolis White, there was a higher percentage of tubular and half-tubular florets but a lower percentage of ligulate florets than produced by Improved Indianapolis White. Data in Table 3 indicate, however, no important consistent differences in the percentages of the various types of florets because of daylength treatment.

1959-60 Experiment

Methods and Materials

Rooted cuttings of *Chrysanthemum morifolium* Indianapolis White were planted, one cutting per 4-inch pot, November 19, 1959. All plants were grown under long days at 62° F minimum night temperatures until short day treatment began. Seven groups of 24 plants each, to be exposed to abrupt short day treatment, were grown under long days until December 24 when the various treatments listed below were applied:

ABRUPT SHORT DAYS

	Treatment Description	Code
1.	50° F constant temperature	(A50C)
2.	62° F constant temperature	(A62C)
3.	67° F constant temperature	(A67C)
4.	62° F for 21 days, 50° F until color visible, 62° F until flowering	(A50CV)
5.	62° F for 21 days, 67° F until color visible, 62° F until flowering	(A67CV)

6. 62° F for 21 days, 50° F until flowering (A50F)
7. 62° F for 21 days, 67° F until flowering (A67F)

On December 12, 11 groups of 24 plants each were distributed among the interrupted short day treatments listed below:

INTERRUPTED SHORT DAYS

	Treatment Description	Code
8.	50° F constant temperature	(I 50C)
9.	62° F constant temperature	(I 62C)
10.	67° F constant temperature	(I 67C)
11.	62° F during 9 SD and 12 LD, 50° F until color visible, 62° F until flowering	(I 50CV)
12.	62° F during 9 SD and 12 LD, 67° F until color visible, 62° F until flowering	(I 67CV)
13.	62° F during 9 SD and 12 LD, 50° F until flowering	(I 50F)
14.	62° F during 9 SD and 12 LD, 67° F until flowering	(I 67F)
15.	62° F for 9 SD, 50° F for 12 LD, 62° F until flowering	(I 50-12)
16.	62° F for 9 SD, 67° F for 12 LD, 62° F until flowering	(I 67-12)
17.	50° F for 9 SD and 12 LD, 62° F until flowering	(I 50 9-12)
18.	67° F for 9 SD and 12 LD, 62° F until flowering	(I 67 9-12)

Hereafter, all references to treatments will be by the code appearing to the right of the treatment description.

The plants were watered and fertilized simultaneously with a dilute fertilizer solution. Insects were controlled with a soil application of demeton which was inadvertently applied at a higher than recommended rate that caused foliage burn of plants in some treatments. Plants severely injured were discarded. Temperatures stated were minimum night temperatures in thermostatically controlled greenhouses. Day temperatures ranged 5 to 10° F higher depending on light intensity.

At harvest, (the date of flowering), height, weight, flower diameter, and flower depth were recorded. In addition, flowers were rated from 1 to 5 on the amount of quilling with 1 being most desirable. Flower shape was rated from 1 to 4 with 1 being most desirable. An additional index of the shape of the flower was obtained by calculating a diameter to depth ratio for each flower.

Results

Except for plants growing in the I50C and I50F treatments, those receiving interrupted short day treatment flowered significantly later than these receiving abrupt short days, Table 4. Interrupted short day treatment caused a delay of 3 to 9 days depending on temperature treatment. It is doubtful if differences in flowering date within daylength treatment (except at 50° F) were of practical significance.

Table 4.—Effect of abrupt and interrupted short day treatment and various temperature treatments on stem and flower characteristics of Indianapolis White chrysanthemums. Wooster, Ohio, 1960.

Number	Treatment	Harvest date	Height, inches	Stem weight, grams	Flower diameter, inches	Flower depth, inches	Flower form[1]	Dia. to depth ratio	Quilling[2]
				Abrupt Short Days					
1	A50C	Mar. 13	21.0	58.7	4.9	2.2	4.0	2.2	5.0
2	A62C	Feb. 23	20.9	66.9	5.0	3.5	2.0	1.5	3.2
3	A67C	Feb. 21	20.8	68.6	4.2	4.0	1.0	1.1	2.2
4	A50CV	Feb. 28	21.1	59.2	4.8	2.7	3.6	1.9	5.0
5	A67CV	Feb. 22	20.0	64.2	4.8	3.5	1.5	1.4	2.2
6	A50F	Mar. 4	20.9	57.9	4.9	2.3	4.0	2.2	5.0
7	A67F	Feb. 21	20.5	62.6	4.5	3.5	1.3	1.3	2.0
				Interrupted Short Days					
8	I 50C	Mar. 13	22.4	72.6	5.2	2.8	3.6	1.9	5.0
9	I 62C	Feb. 28	21.2	78.0	5.4	4.1	1.7	1.4	3.6
10	I 67C	Feb. 28	20.9	71.9	4.8	3.8	1.2	1.3	2.0
11	I 50CV	Mar. 2	21.4	66.7	5.3	3.3	3.3	1.7	5.0
12	I 67CV	Mar. 2	21.3	82.1	5.3	4.0	1.2	1.4	2.5
13	I 50F	Mar. 3	21.1	68.3	5.8	3.0	3.8	2.0	5.0
14	I 67F	Mar. 1	21.4	76.1	4.9	3.8	1.2	1.3	5.0
15	I 50 12	Feb. 28	20.1	71.8	5.3	3.4	2.6	1.6	3.9
16	I 67 12	Mar. 1	20.5	83.7	5.4	3.9	1.8	1.4	3.6
17	I 50 9-12	Mar. 1	20.3	73.9	4.8	3.5	1.8	1.4	2.6
18	I 67 9-12	Feb. 28	21.5	76.1	5.4	4.0	1.6	1.4	2.8
	LSD 01	2.27		7.19	.23	.33	47	.17	.52
	LSD 05		1.07						

[1]Flower form rated from 1 to 4 with 1 being the most desirable.
[2]Quilling was rated from 1 to 5 with 1 being the most desirable.

Plants receiving interrupted short day treatment were slightly taller than those exposed to abrupt short days; however, the difference was significant only in the case of the I50C and I67CV treatments. Differences in height were of no practical importance.

In all comparisons within comparable temperature treatments, plants receiving interrupted short days were significantly heavier than those treated with abrupt short days with the exception of plants in treatment I67C, Table 4. Within either abrupt or interrupted short day treatment, weight increased as temperature increased except for plants in treatment I67C.

The data presented in Table 4 shows that flower diameter was increased significantly in all temperature exposures by interrupted short day treatment. Exposure to 50° F or 62° F temperatures resulted in flowers of larger diameter than produced at 67° F if plants were exposed continuously or after 21 short days until maturity. No significant differences resulted from temperature treatment after 21 short days until color was visible (I50CV). Plants exposed to 50° F for 21 short days (I50 9-12) produced significantly smaller flowers.

Within comparable temperature treatments, Table 4, depth of flower was increased by interrupted short day treatment except when plants were exposed to 67° F continuously or after 21 short days until finishing (I67C or I67F). Increasing temperature increased flower depth in all combinations of daylength and temperature treatments except that flowers in the I67C treatment were not deeper than those in the I62C group

Within comparable temperature treatments interrupted short day treatment did not improve flower form as judged by rating each flower, Table 4. Figure 4a shows the average effect of continuous temperatures (C) on flower form. Flower form improved as temperature increased except when 67° F was given during 21 days of the interrupted short day treatment (I67 9-12).

Figure 3 shows the effect of interrupted and abrupt short day treatment at 62° F and 67° F on flower form.

In general, flower form as indicated by the ratio of flower diameter to flower depth followed much the same pattern as form measured by rating except plants grown for any time at 50° F with abrupt short days produced flowers which were significantly flatter than comparable plants exposed to interrupted short days. Daylength treatment did not affect flowers produced at other temperatures except that those grown at 67° F continuously under abrupt short days were significantly deeper than those receiving interrupted short day treatment.

Figures 4b and 4c show that in both abrupt and interrupted short day treatments, exposures to 67° F until color was visible (CV) was not as effective in decreasing the diameter-depth ratio as was continuous exposure or exposure after 21 short days until finishing (C or F). Temperature treatment for 12 or 21 days of the interrupted short day treatment had little effect, although, unexplainably, flatter flowers were produced by plants which received 50° F temperatures during the 12 long days of the interrupted lighting schedule.

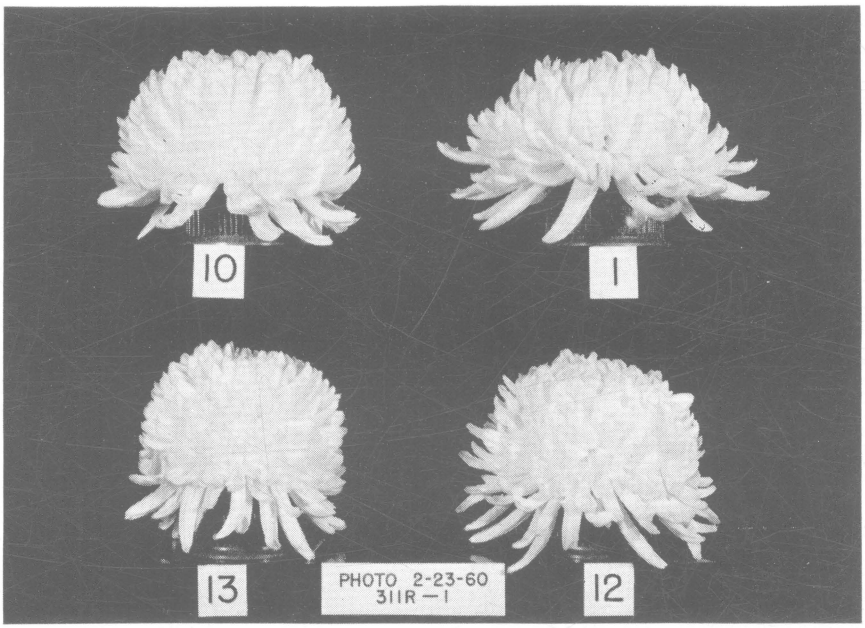

Fig. 3.—Effect of interrupted and abrupt short day treatment at 62 F and 67 F on the form of Indianapolis White chrysanthemum flowers.
Upper left—interrupted short day, 67° F
Upper right—interrupted short day, 62° F
Lower left—abrupt short day, 67° F
Lower right—abrupt short day, 62° F

Interrupted daylength treatment did not influence quilling significantly, Table 4. The amount of quilling decreased as temperature increased in all cases where temperature treatment was given during the first 21 days after the start of short days (67-12, 50-12, 67 9-12, and 50 9-12). The average effect of continuous temperatures (C) is shown in Figure 4d. There were no significant differences in quilling as a result of length or exposure to various temperatures except those exposed during the first 21 days.

Discussion and Conclusions

Work by Duffett (1956) showed that supplemental illumination for 15 minutes each night at an intensity near 10 foot-candles from the time buds were visible until flowering (after lighting) produced flattened flowers of larger diameter but caused some decrease in quilling. In the present experiments no important decrease in quilling or increase in flower diameter resulted from any combination of light interval or duration treatment. Although continuous lighting for the duration of

the crop caused a slight decrease in the percentage of tubular florets produced, enough quills remained to reduce severely the quality of the flower. It must be concluded that after lighting is of no practical benefit in improving the form or in decreasing quilling.

In 1958-59, an attempt was made to provide daylengths only slightly shorter than the critical (13½ hours, Post, 1948) necessary for flower

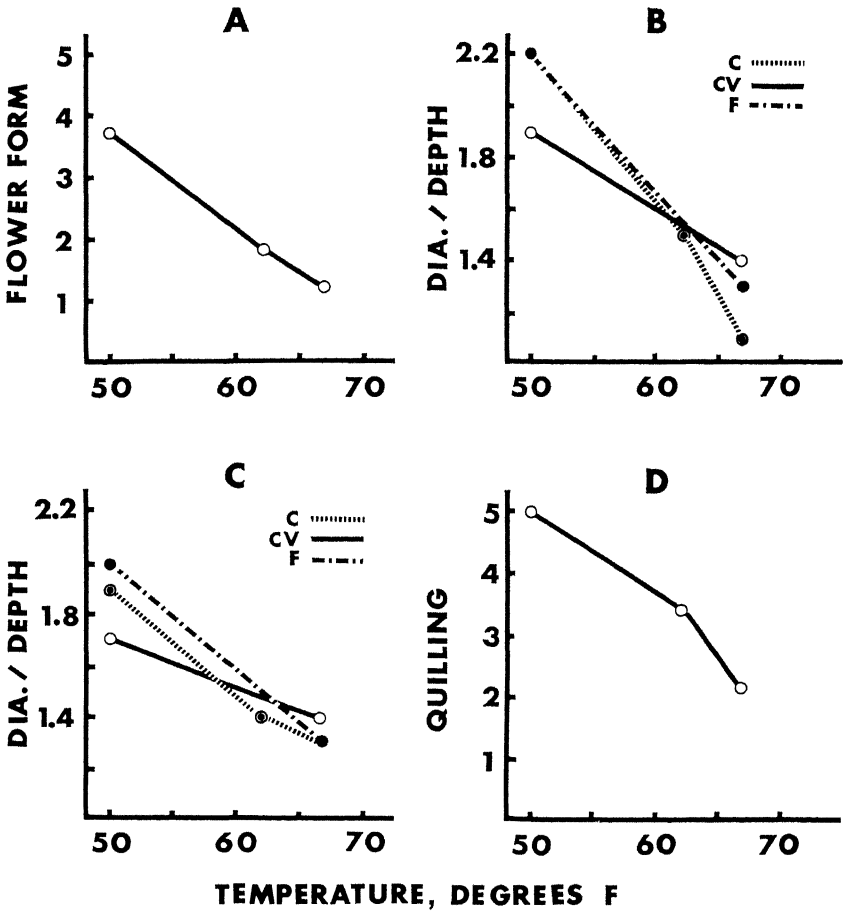

Fig. 4.—A. Relationship between flower form and temperature. The lower flower rating indicates more desirable form. Flowers were rated from one to four. B. Relationship between the diameter/depth ratio of the flower and temperature for plants receiving abrupt short days and exposed continuously (C), after 21 short days until color was visible (CV), or after 21 short days until flowering (F). Lower diameter/depth ratios indicate more desirable form. C. Relationship between the diameter/depth ratio of the flower and temperature for plants receiving interrupted short days and exposed continuously (C), after 21 short days until color was visible (CV), or after 21 short days until flowering (F). Lower diameter/depth ratios indicate more desirable form. D. Relationship between amount of quilling and temperature. The lower ratings indicate more desirable form. Flowers were rated from one to five.

development with the thought that more r a p i d flower development under abrupt short days might induce quilling. Plants grown at 13 hour daylengths, however, failed to develop flowers indicating that for Indianapolis White and Improved Indianapolis White, shorter daylengths than 13 hours are necessary for development. Eleven-hour days did not affect diameter, depth, or quilling, when compared to abrupt short day treatment.

Interrupted (9-12 or 10-12 formula) short day treatment has been recommended (Post and Lacey, 1951 and Duffett, 1956) to increase the number of florets per inflorescence and improve flower form. In these experiments, more florets were produced by this procedure; 23 percent more than abrupt short day plants of Indianapolis Yellow in 1957-58 and 15 and 32 percent more for Indianapolis White and Improved Indianapolis White, respectively, in 1958-59. It is significant, however, that no consistent effect on flower diameter, flower depth, or more importantly, quilling, resulted from interrupted short day treatment over a three year period. It must be concluded that this procedure does not consistently improve the form or reduce quilling of those Indianapolis cultivars tested. Observations to this effect have been made under commercial conditions (Anonymous, 1960).

It can be concluded from the results of experiments in 1959-60 that temperature is the most important factor governing flower form and quilling in Indianapolis cultivars. Although flower diameter was decreased by continuous exposure to 67° F (I or A67C) or exposure after 21 short days (I or A67F), flower depth was increased markedly by any exposure to 67° F as opposed to 62° F. More importantly, temperatures of 50° F had very deleterious effects on form, showing that low temperatures aggravate the condition.

In addition to improving form, exposure to 67° F greatly reduced the amount of "quilling" when compared to plants held at 62° F or, especially, 50° F.

Length of exposure to temperature was important in modifying form and quilling. Under abrupt short days, form, as measured by rating, or by the diameter to depth ratio, was improved more by exposures to high temperature continuously (A67C) than exposure after 21 short days finishing (A67F) which, in turn, was more effective than exposure after 21 short days until color was visible (A67CV). Under interrupted daylength, little difference was noted between plants in the I 67C and I 67F treatments. A similar relationship existed under abrupt short days at 50°—longer exposure to 50° F resulted in flatter flowers.

The length of exposure did not significantly affect the amount of quilling except for those plants exposed during the first 21 days.

It is of particular interest to note the effect of cultivar on flower form and quilling. In 1958-59, Improved Indianapolis White was used in comparison with Indianapolis White. According to originator's description, Improved Indianapolis White is slightly smaller and develops a more rounded form during the winter than Indianapolis White. Data presented bear out this description. In addition, Improved Indianapolis White produced significantly fewer quills.

Specific recommendations concerning temperatures necessary to produce ideally formed flowers free of quills cannot yet be made. It is significant to note, however, that Figures 4a and 4d indicate that the higher the temperature, up to 67° F, the more desirable the form and the fewer the quills. It is also apparent from Figure 4b and 4c that temperatures during the period from visible color (CV) to flowering (F) may exert some effect on flower form.

It is generally conceded that high finishing temperatures have a deleterious effect on color intensity (except white) and quality. Whether or not exposure to temperatures sufficiently high to eliminate flat, quilled flowers can be accomplished, yet still allow the production of flowers of good quality, remains to be seen.

Maintaining minimum temperatures as high as is consistent with acceptable quality and using improved selections of the Indianapolis cultivars as they become available, at the present time,appear to be the most practical methods of producing well formed flowers free of quills.

Summary

In a study to determine what environmental factors affect the production of flattened, "quilled" flowers of Indianapolis chrysanthemum cultivars, the following conclusions were reached:

1. "After lighting", the procedure of subjecting the plants to short intervals of artificial light nightly after short days begin, was not effective in improving form or reducing "quilling".
2. Eleven-hour daylengths as opposed to natural daylengths prevalent during mid-winter are not effective in improving form or reducing quilling.
3. Interrupted short day treatment was not consistent in improving

form or reducing quilling even though 15 to 32 percent more florets were formed per flower under such treatment. Use of interrupted lighting on Indianapolis cultivars for winter flowering is not recommended.

4. Air temperatures of 67° F resulted in more desirable flowers and nearly eliminated quilling as compared to growing temperatures of 62° F.

5. Length of exposure to temperatures of 67° F affected both flower form and quilling. The critical period was between three weeks after short days were started and flowering. Further research is necessary to more exactly determine this critical period.

6. Selection of improved cultivars is an important consideration in producing flowers of good form free of quills.

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