GREENHOUSE CULTURE OF THE SHASTA DAISY WITH EMPHASIS ON ITS SOIL FERTILITY AND PHOTOPERIODIC REQUIREMENTS

by

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TABLE OF CONTENTS

INTRODUCTION

The shasta daisy, Chrysanthemum maximum (Raymond) is an herbaceous perennial of the family Compositae. Large acreages are used in California for commercial flower production and the shasta daisy with its many clones is one of the commonly grown species. Daisy flower production in California occurs in the late spring and its flowers are welcomed by the florist trade since shasta daisy flowers command premium market prices.

This study was undertaken to determine shasta daisy response when grown as a greenhouse cut-flower crop for a major portion of a year. Particular emphasis was placed upon its soil fertility and photoperiodic requirements.

REVIEW OF LITERATURE

Luther Burbank (9, 21) is credited with the development of the shasta daisy. He began with a selection of the wild ox-eye daisy, Chrysanthemum leucanthemum (Linn.) from New England. He introduced the shasta daisy in 1901 after 17 years of breeding and selection using three other chrysanthemum species as pollen parents: C. maximum (Raymond) from England, C. lacustre (Brot.) from Germany, and C. nipponicum (Hort.) from Japan. Numerous clones have been introduced since the development of the shasta daisy.

The shasta daisy was originally classified botanically as Chrysanthemum leucanthemum hybridum, however, Bailey (1, 2) in "Hortus Second" and "The Standard Cyclopedia of Horticulture"

classified it as Chrysanthemum maximum (Raymond). This binomial has been adopted by Kelsey and Dayton (11). The shasta daisy, as described by Bailey (1, 2) is:

> A short-lived perennial often treated as a biennial, erect, simple or only sparingly branched, 1-2 feet tall; leaves are long and narrow, serrate-dentate with the lower leaves petioled, wedge shaped at the base or long oblanceolate; the upper leaves becoming few are lanceolate but not usually very prominently pointed, the teeth not very large or striking; flower heads are terminal, 1-headed and large, 2-4 inches across with many white rays.

Plant divisions taken in the spring appear to be one of the better methods of propagating the shasta daisy (15). Divisions taken in the fall do not have enough time to become established. Hartmann and Kester (5) report that for herbaceous perennials like the shasta daisy, large numbers of rooted offshoots are produced from the crown. They suggest that each shoot can be broken from the crown and used as propagation material, with the older portions of the crown being discarded.

Whitson and Williams (22) recommend planting field grown daisies in full sunlight, spaced three feet between rows and one and one-half feet within rows. Hawthorn and Pollard (6) suggest spacing daisies 40 inches between rows and 12 inches within rows. Cultural practices as reported by Houghton (8) include planting daisies in a heavy, well-drained, slightly acid soil having sufficient humus material. It was noted that sufficient soil moisture should be maintained since daisies wilt rapidly when the soil becomes dry. Adequate soil moisture was reported to be especially important after initiation of flower buds.

Yemm and Willis (24) report that Chrysanthemum maximum

leaves are amphistomatous. The stomata open shortly after sunrise reaching a maximum aperture between 8 to 10 A.M., after which a gradual closure occurs. Diurnal action of the stomata appeared related to the carbohydrate content of the epidermis and the rate of water intake with stomatal closure taking place when the water deficit exceeds five per cent of the water content of a fully turgid leaf.

Small amounts of nitrogen fertilizer applied after the development of flower buds was found beneficial, although, excessive amounts produced weak flower stems (8). Application of fertilizer late in the growing season was not recommended since field grown daisies apparently need a period for hardening before the onset of winter. Post (19) recommends growing daisies at a medium fertility level.

Kirkegaard (12) and Whitson and Williams (22) report that the shasta daisy produces large numbers of flowers from June to September and is an especially good cut-flower owing to its long, stiff stems and lasting flower quality. Butler (4) found varietal differences in the time of flowering, some varieties begin flowering later in the season. Houghton (8) suggests that lateral shoots along the stem and all but one of the terminal flower buds be removed to permit maximum development of the terminal flower.

Laurie and Poesch (16) reported that two year old clumps of field grown shasta daisies, placed in the greenhouse in midwinter, responded to supplementary illumination from 6 to

10 P.M. by earlier flower production. Kofranek (14) reported that earlier flower production is realized when daisies in the field are illuminated for four hours during the middle of the night. Daisies subjected to 2-7 foot-candles of irradiance produced the earliest flowers while plants subjected to 1-2 foot-candles of irradiance produced a greater number of flowers per plant both in number and on any one cutting date. Each intensity of irradiation, however, resulted in considerably earlier flower production than the normal daylength. Kofranek (13) recommends that field grown daisies in California be illuminated from January 25 to May 5.

MATERIALS AND METHODS

Numerous clones of Chrysanthemum maximum have been developed since the original introduction in 1901. Clones Esther Reed and C. P. Kilham were selected because of the flower head each variety possesses and their acceptance by the florist industry. Clone Esther Reed has a double flower while clone C. P. Kilham has a large, single flower (Plate I).

A preliminary greenhouse study was conducted to gain insight into the cultural requirements of the shasta daisy since recommendations are not available concerning greenhouse culture. Rooted divisions of clone Esther Reed were planted in a raised greenhouse bench while clone C. P. Kilham divisions were planted in pots. A steam sterilized soil mixture consisting of two

parts silty loam soil and one part horticultural peat moss was used as the growing medium. Results of this study indicated that the soil mixture and a medium fertility level supported favorable plant growth.

Plant divisions were obtained on June 12, 1959, from benched clone Esther Reed plants. Flower shoots and stems were cut back 1-2 inches above the soil prior to potting the divisions into six inch clay pots containing a steam sterilized soil mixture of the same proportions as used in the preliminary study. Clone C. P. Kilham plants were not divided since they were in clay pots, however, flower shoots and stems were cut back 1-2 inches above the soil.

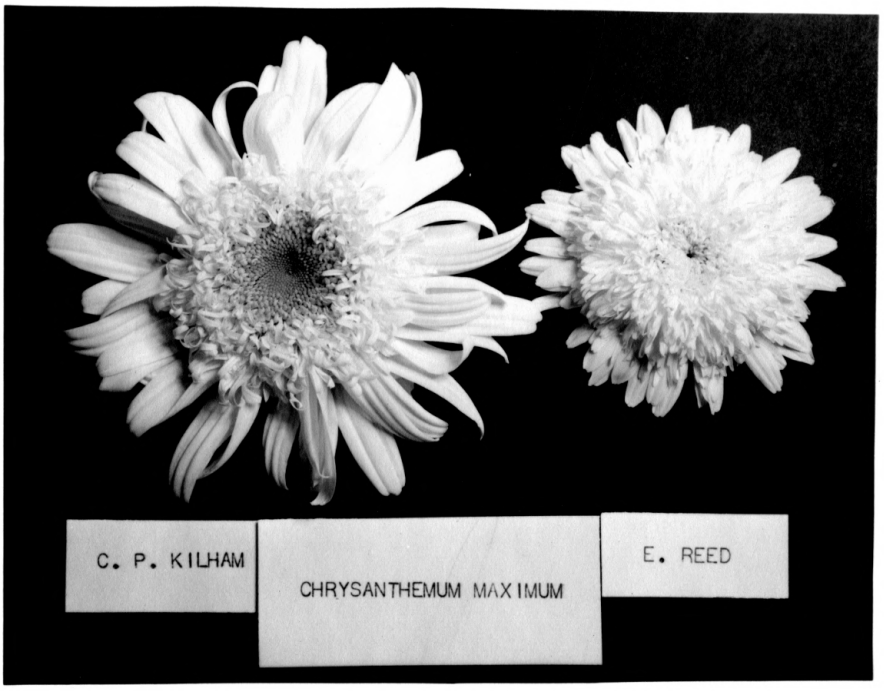
The main investigation using the potted divisions was inaugurated on July 6, 1959. Two, raised, V-bottom, concrete benches were used, one for a fertility experiment, and the other for a photoperiod experiment. Each bench was 36 feet 9 inches long, three feet wide, and eight inches deep. Two inches of coarse sand and a half-tile water conductor were placed in the bottom of each bench. The growing medium consisted of two parts silty loam soil and one part horticultural peat moss. The benches and soil mixture were steam sterilized before the addition of 20% superphosphate fertilizer at the rate of five pounds per 100 square feet of bench area. Each bench was located on the south side of an east-west greenhouse in order for the daisies to receive greater solar irradiation during the winter months. Shasta daisies are reported to require maximum sunlight (10), (22) and it is believed that the south location

EXPLANATION OF PLATE I

Left: *Chrysanthemum maximum* clone C.P. Kilham flower head.

Right: Chrysanthemum maximum clone Esther Reed flower head.

PLATE I



would help circumvent minimum solar irradiation during this period.

The fertility bench was divided into five sections to facilitate maintenance of different fertility levels presented in Table 1. The nitrogen and potassium levels given in Table 1 represent combinations of high (50-75 ppm), medium (25-30 ppm), and low (5-10 ppm) nitrogen fertilizer levels with high (30-35 ppm), medium (20 ppm), and low (10 ppm) potassium fertilizer levels. Phosphorus fertilizer levels were the same in all treatments.

Table 1. Proposed nitrogen, phosphorus, and potassium fertilizer levels in the fertility treatments.

Treatments	N-P-K levels expressed in parts per million*		
	Nitrogen	Phosphorus	Potassium
F-1 (east plot)	25-30	5	10
F-2	25-30	5	30-35
F-3	25-30	5	20
F-4	5-10	5	20
F-5 (west plot)	50-75	5	20

* N- nitrate nitrogen (NO_3)
P- phosphorus pentoxide (P_2O_5)
K- potassium oxide (K_2O)

Wooden partitions covered with film plastic were used to separate the fertility treatments. The proposed fertility level in the photoperiod bench was the same as the F-3 treatment in Table 1.

The photoperiod bench was divided into four sections, each representing different daylength extension durations (Table 2).

Table 2. Duration of daylength extensions in the photoperiod treatments.

Treatment	Daylength extension duration*
9 P.M. treatment (east plot)	sunset to 9 P.M. each evening
8 P.M. treatment	sunset to 8 P.M. each evening
7 P.M. treatment	sunset to 7 P.M. each evening
10 P.M. treatment (west plot)	sunset to 10 P.M. each evening

* One hundred watt frosted, glass, tungsten, incandescent lamps provided artificial illumination with time clocks controlling the duration of illumination in the different treatments.

Since the duration of the daylength extensions varied, barriers were constructed to prevent artificial irradiation from entering another photoperiod treatment. Lath-wood frames were permanently placed between treatments. Each evening before the treatments were lighted, cardboard sheets, 3½ by 3½ feet, were attached to the lath frames. The sheets were removed each night after the completion of the 10 P.M. daylength extension. Location of the treatments in both benches was determined randomly.

Artificial illumination in both studies was supplied by one hundred watt tungsten bulbs suspended 2½ feet above the plants. Three bulbs without reflectors were used in each fertility treatment while three bulbs with 12 inch reflectors were used in each photoperiod treatment. Maximum and minimum irradiance in foot-candles from the tungsten bulbs in the fertility and photoperiod treatments are presented in Table 3. A General Electric light meter, model 8DW4D-Y16, was employed for the determinations.

Table 3. Maximum and minimum irradiance in foot-candles from the tungsten bulbs in the fertility and photoperiod treatments.*

Fertility treatments		Photoperiod treatments	
Maximum	Minimum	Maximum	Minimum
55-65fc.	5-12fc.	77-100fc.	10-30fc.

* Maximum irradiance measurements were taken at soil level directly beneath a tungsten lamp while minimum irradiance measurements were taken in the corners of the treatment. Frosted, glass, tungsten, incandescent lamps were used.

Artificial illumination measurements showed one foot-candle or less of irradiation was entering completed photoperiod treatments from noncompleted photoperiod treatments. Black sateen cloth barriers were placed along the two sides of the 7 P.M. treatment beginning October 18, 1959, in an attempt to determine if one foot-candle of irradiance had an effect on the photoperiodic response of the plants. The cloth barriers were placed in position before lighting the treatment each evening and were removed after the completion of the 10 P.M. treatment. The cloth barriers were used for the remainder of the study.

Soil samples were taken from the different treatments and analyzed regularly to determine the fertility level. Samples were tested for nitrate nitrogen (NO_3), phosphorus pentoxide (P_2O_5), and potassium oxide (K_2O) in parts per million, relative acidity, and total soluble salt content. The revised Spurway-Lawton method of soil testing (20) was used for the NO_3, P_2O_5, and K_2O determinations. A Beckman Zeromatic pH meter was used for the relative acidity determinations and a Bouyoucos bridge, model C, was employed for the total soluble salt determinations. Average monthly fertility levels main-

tained in each fertility treatment and photoperiod bench are presented in Table 4.

Thermographs, placed in both greenhouses, provided a 24 hour record of air temperatures at which the daisies were grown. Since night temperatures are reported to have a greater effect upon growth than day temperatures (17), the mean monthly night temperatures maintained in the fertility and photoperiod greenhouses are given in Table 5.

Table 5. Mean monthly night temperatures in degrees fahrenheit maintained in the fertility and photoperiod experiment greenhouses.

Month	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Fertility G.H.	70.7	74.9	62.2	60.6	59.0	57.7	56.6	56.1	60.3	64.3
Photoperiod G.H.	71.6	75.5	62.5	59.8	57.4	56.3	54.1	54.7	59.0	63.1

A fertility treatment had ten plants of each clone represented by three consecutive three plant rows plus a tenth plant located in the center row of each treatment. The location of the consecutive rows and the plants in the center row was determined randomly. A photoperiod treatment had twelve plants of each clone represented by four consecutive three plant rows, the location of which was determined randomly. Plants in all treatments were spaced one foot by one foot.

On July 6, 1959, potted clones Esther Reed and C.P. Kilham daisies were planted in the respective treatments. The daisies in all treatments were subjected to a nine hour photoperiod to prevent initiation of flower buds during the summer days. Black, sateen cloth, placed over the entire bench from 5 P.M. to 8 A.M.

Table 4. Average monthly fertility levels maintained in the fertility treatments and photoperiod bench.

Experiment	Treatment	Level	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Fertility Study	F-1*	NO_3**	8.	19.	25.	30.	45.	25.	15.	22.
		P_2O_5**	4.	4.	3.	4.	5.	4.	5.	5.
		K_2O	2.	4.	7.	10.	15.	10.	5.	5.
		pH	6.5	6.1	5.9	6.0	6.1	6.1	6.1	6.0
		tss***	2850.	2025.	1540.	1780.	1540.	1580.	1830.	2100.
	f-2	NO_3	7.	21.	23.	35.	35.	25.	18.	25.
		P_2O_5	3.	3.	4.	4.	5.	4.	5.	5.
		K_2O	2.	4.	4.	18.	30.	25.	25.	38.
		pH	5.8	5.9	5.8	5.9	6.1	6.1	6.1	6.1
		tss	1740.	2200.	1350.	1715.	1560.	1530.	1740.	1950.
	F-3	NO_3	9.	19.	25.	35.	35.	50.	25.	30.
		P_2O_5	3.	4.	4.	5.	5.	4.	5.	5.
		K_2O	3.	5.	6.	15.	22.	25.	20.	20.
		pH	6.6	5.9	5.7	5.9	6.2	6.1	6.0	6.1
		tss	2540.	2250.	1400.	1500.	1350.	1230.	1640.	1250.
	F-4	NO_3	14.	12.	17.	15.	13.	5.	8.	10.
		P_2O_5	3.	3.	4.	4.	5.	4.	5.	5.
		K_2O	2.	5.	6.	15.	20.	20.	25.	22.
		pH	6.2	6.0	5.4	6.0	6.2	6.1	6.1	6.0
		tss	2215.	2375.	1150.	1630.	1400.	1930.	1840.	2140.
	F-5	NO_3	11.	22.	19.	63.	95.	40.	45.	55.
		P_2O_5	3.	3.	4.	4.	5.	4.	4.	5.
		K_2O	2.	5.	10.	15.	20.	25.	20.	20.
		pH	6.0	5.6	5.4	5.9	5.9	5.9	6.1	6.0
		tss	2185.	1870.	1700.	1610.	1200.	1440.	1770.	1660.
Photoperiod Study	Entire Bench	NO_3	10.	18.	25.	30.	45.	25.	15.	25.
		P_2O_5	4.	4.	4.	4.	5.	4.	5.	5.
		K_2O	10.	3.	8.	10.	22.	25.	20.	25.
		pH	6.4	6.5	6.2	6.4	6.3	6.4	6.6	6.6
		tss	2350.	2550.	1620.	1925.	1480.	1580.	2000.	1760.

* See Table 1 for the F-1 to F-5 code.
** NO_3, P_2O_5, and K_2O are expressed in parts per million.
*** tss -- total soluble salt content in ohms.

each night, provided the shortday photoperiod. This photoperiod was maintained until September 1, 1959, when the daisies in the fertility treatments were subjected to a long-day photoperiod to promote flower development. Plants in the fertility treatments received artificial illumination each evening from sunset to 10 P.M., until the study was terminated May 7, 1960. Plants in the photoperiod treatments received artificial illumination from sunset to 7, 8, 9, and 10 P.M. each evening (Table 2), until the study was terminated in May with the exception of the 7 P.M. treatment. Artificial illumination in this treatment was discontinued on April 12, 1960, since the natural daylength extended to 7 P.M. The length of day from sunrise (CST) to 7 P.M., including the addition of artificial illumination when necessary, is presented in Table 6 for Manhattan, Kansas. Addition of 1, 2, or 3 hours to the figures given in Table 6 will provide the photoperiod to which the plants were exposed in the 8, 9, and 10 P.M. daylength extension treatments.

During the process of planting clone C. P. Kilham into the different treatments, root-knot nematode swellings were observed on some of the root systems. Since divisions of clone C. P. Kilham were not available from commercial sources, planting was continued. Clone Esther Reed was free of nematodes at time of planting. On September 1, 1959, both benches were treated with 67.8% Nemagon EC-2 (1, 2-dibromo-3-chloropropane) at the rate of four gallons per acre (1 cubic centimeter per 2.8 square feet of bench area) using a syphonex proportion apparatus.

Individual plant records were taken weekly on flower height,

Table 6. Length of day from sunrise (CST) at Manhattan, Kansas to 7 P.M. expressed in hours and minutes.* (39 12' NL, 96 35' WL.)

Day	Sep.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	hr.	min.	hr.	min.	hr.	min.	hr.	min.	hr.	min.	hr.	min.	hr.	min.	hr.	min.
1	13	6	12	38	12	6	11	34	11	14	11	27	12	1	12	49
2		5		37		5		33		14		28		3		51
3		4		36		4		32		14		29		4		52
4		3		35		2		31		14		30		6		54
5		2		34		1		30		14		31		7		55
6		1		33	12	00		29		14		32		8		56
7	13	00		32	11	59		28		14		33		10		58
8	12	59		31		58		27		14		34		11	12	59
9		58		31		58		26		14		35		13	13	1
10		58		30		57		25		14		36		14		3
11		57		29		56		24		14		37		15		4
12		56		28		55		23		15		38		17	13	6**
13		55		27		54		23		15		39		18		
14		54		26		53		22		16		41		20		
15		54		25		51		22		16		42		21		
16		53		24		50		21		16		43		23		
17		52		23		48		21		17		44		25		
18		51		22		47		20		17		45		27		
19		50		21		46		20		18		46		28		
20		49		19		45		19		18		48		30		
21		48		18		44		19		19		50		32		
22		47		17		43		18		19		51		34		
23		46		16		42		18		20		53		35		
24		45		15		41		17		20		54		37		
25		44		14		40		17		21		55		38		
26		43		13		39		16		22		57		40		
27		42		12		38		15		23		58		42		
28		41		12		37		15		23	12	00		43		
29		40		10		36		14		24	12	01		44		
30	12	39		9	11	35		14		25		--		46		
31		--	12	7		--	11	14	11	26		--	12	48		

* Add 1, 2, or 3 hours to the above figures to obtain the photoperiod for the 8, 9, and 10 P.M. daylength extension treatments.

** Sunset on April 12, 1960, was at 7 P.M.

fresh weight, diameter and number of flowers produced. Flower height was obtained by measuring from the base of the stem to the top of the flower head and flower diameter by measuring between the tips of the outside ray florets. Height and diameter measurements were recorded in centimeters. The flower stem, head, and foliage were used to determine flower fresh weight recorded in grams.

Visual and written observations were made on plant growth habit during the study and photographs were taken of pertinent plant response.

Analyses of variance were conducted on flower height, fresh weight, diameter, and number. Least significant differences were determined wherever the "F" test showed significance.

RESULTS

Fertility Experiment - Clone Esther Reed

Flower quality evaluated by flower height, fresh weight, and diameter and flower quantity are summarized in Table 7. Mean flower production varied from 17.82 to 32.83 flowers per plant. A medium nitrogen level in combination with medium or low potassium levels produced plants yielding the greatest number of flowers. Plants in the low nitrogen, high nitrogen, and high potassium treatments produced the least number of flowers (Table 7).

Daisies in the high nitrogen treatment had significantly greater mean flower fresh weight and height (Table 7). The least mean flower fresh weight occurred in treatments having medium or low nitrogen levels in combination with medium potassium levels. Differences between fertility mean flowers diameters were non significant (Table 7).

Mean monthly flower production (Table 8) shows a general trend of increasing flower yield from October to April with the exception of March when flower production decreased. Mean monthly flower height, fresh weight and diameter (Table 9) show a similar trend, however, flower height and diameter decreased in April. This decrease is believed related to high flower production in April (Table 8).

Significant differences in flower measurements were found between plants within treatments. Analyses of variance on mean flower height, fresh weight, diameter, and number are presented in Tables 10 to 13.

Photoperiod Experiment - Clone Esther Reed

A progressive increase in mean flower yield as the duration of the daylength extensions became longer is seen in Table 7. Mean flower production ranged from 8.67 to 24.91 flowers per plant. Plants lighted until 10 P.M. had significantly greater flower production than either the 7 or 8 P.M. treatments, however, differences between the 9 and 10 P.M. treatments were nonsignificant (Table 7).

Daisies in the 7 P.M. treatment produced no flowers from December 12 to April 23 while flower production in the 8 P.M. treatment averaged 1.26 flowers per plant from December 5 to April 23. Flower production records (Table 8) show that daisies lighted until 7 and 8 P.M. produced 80 per cent or more of their flowers during April and the first week of May. The most uniform monthly flower production occurred in the treatment lighted until 10 P.M. (Table 8).

Flowers produced in the 9 and 10 P.M. treatments were cut on or before April 23, 1960, however, daisies in the 7 and 8 P.M. treatments had not completed flowering when the study was terminated on May 7. Wilcoxon-Mann-Whitney test (18) (23) was conducted to determine if either the 7 or 8 P.M. treatments had significantly greater number of flower stems remaining; results were non significant (Table 14).

The two longer daylength extensions had significantly greater mean flower height than the two shorter daylength extensions (Table 7). Greatest mean flower height occurred in the treatment lighted until 9 P.M. Mean flower fresh weight of plants in the 7, 8, and 9 P.M. treatments was significantly greater than the mean flower weight of plants in the 10 P.M. treatment (Table 7).

Mean monthly flower measurements presented in Table 9 show that plants in the 9 and 10 P.M. treatments had consistently greater mean flower height than plants in the 7 and 8 P.M. treatments. The three shorter daylength extensions produced plants having greater mean monthly flower fresh weight than

plants lighted until 10 P.M. (Table 9).

Analyses of variance on mean flower height, fresh weight, diameter, and number for the photoperiod experiment are given in Tables 15 to 18.

Plants in the fertility experiment receiving medium levels of nitrogen and potassium fertilizer were compared with plants lighted until 10 P.M. since plants in both treatments were grown under similar conditions. Differences in mean flower fresh weight, diameter and number were non significant while a highly significant difference was found between mean flower height measurements (Table 19). Monthly flower height data in Table 9 show that plants in the 10 P.M. treatment had consistently greater flower height, excluding November, than did the medium fertility treatment. Analyses of variance on mean flower height, fresh weight, diameter, and number are presented in Tables 20 to 23.

Fertility Experiment - Clone C.P. Kilham

Flower production was low until April when plants in all treatments produced flowers in quantity (Table 24). Mean flower height, fresh weight, and diameter measurements are presented in Table 25. Mean flower height ranged from 60.00 to 67.82 centimeters while mean flower fresh weight ranged from 54.94 to 71.84 grams. Flower diameter means varied from 10.91 to 12.09 centimeters. Sizable differences in monthly flower measurements are shown in Table 26. Development of flower stems either from a

rhizome or as a lateral branch is thought to have caused these differences. Evaluation of differences between fertility treatment levels was not practical since there was limited number of plants within treatments.

Photoperiod Experiment - Clone C.P. Kilham

Plants in the longer daylength extensions flowered earlier than plants receiving fewer hours of artificial illumination (Table 24). The 10 P.M. treatment produced the earliest flowers. Plants in the 7 and 8 P.M. treatments produced no flowers during the study, although, flower stems were present on all plants in both treatments when the study was terminated on May 7, 1960. Flower stems in the 7 P.M. treatment had a mean height of 21 centimeters compared with 46 centimeters in the 8 P.M. treatment. Table 25 summarizes flower height, fresh weight, and diameter means while mean monthly flower measurements are presented in Table 26. Statistical evaluation of the data presented in these tables was not practical owing to the small number of plants in each treatment.

Table 7. Effect of fertilizer level and daylength duration on height, fresh weight, diameter, and number of flowers produced by Chrysanthemum maximum clone Esther Reed.

Experiment	Mean Height cm./flw	Fresh Weight gms./flw	Diameter cm./flw	Flower Number per plant
Fertility Experiment				
25-30 ppm NO_3 10 ppm K_2O	42.91	15.82	7.39	32.70
25-30 ppm NO_3 30-35 ppm K_2O	41.57	15.88	7.37	20.67
25-30 ppm NO_3 20 ppm K_2O	40.36	14.08	7.25	32.83
5-10 ppm NO_3 20 ppm K_2O	40.08	14.02	7.28	19.11
50-75 ppm NO_3 20 ppm K_2O	44.05	17.39	7.31	17.82
LSD (5%)	1.35	2.04	NS	11.05
LSD (1%)	1.77	2.69	NS	15.55
Photoperiod Experiment				
Sunset to 7 P.M.	35.09	26.11	7.10	8.67
Sunset to 8 P.M.	36.90	18.83	6.98	17.00
Sunset to 9 P.M.	44.74	24.98	7.68	21.25
Sunset to 10 P.M.	42.81	14.98	7.26	24.91
LSD (5%)	1.70	2.83	.18	7.20
LSD (1%)	2.23	3.73	.23	9.65

Table 8. *Chrysanthemum maximum* clone Esther Reed mean monthly flower production per plant in the fertility and photoperiod experiments.

Experiment	Mean Flower Production Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May*	Total
Fertility Experiment									
25-30 ppm NO_3 10 ppm K_2O	.50	1.60	3.20	2.80	5.90	3.00	15.70	---	32.70
25-30 ppm NO_3 30-35 ppm K_2O	1.56	1.44	.89	1.22	1.56	3.11	10.89	---	20.67
25-30 ppm NO_3 20 ppm K_2O	.83	1.17	4.17	3.17	5.00	2.83	15.67	---	32.83
5-10 ppm NO_3 20 ppm K_2O	.44	.44	1.11	2.44	3.44	1.44	9.78	---	19.11
50-75 ppm NO_3 20 ppm K_2O	1.45	.55	2.36	1.36	2.18	1.55	8.36	---	17.82
Photoperiod Experiment									
Sunset to 7 P.M.	.44	.89	.33**	---	---	---	4.11	2.89	8.67
Sunset to 8 P.M.	.25	.63	.13***	.25	.63	.38	10.88	3.88	17.00
Sunset to 9 P.M.	.50	1.00	1.25	1.83	1.92	2.58	12.17	---	21.25
Sunset to 10 P.M.	1.09	.91	2.18	4.82	5.18	2.36	8.36	---	24.91

* May column figures represent the final flower cut on May 7.
** No flowers produced from December 12 to April 23.
*** From December 5 until April 23, plants in the 8 P.M. treatment averaged 1.26 flowers per plant.

Table 9. Summary of flower quality as measured by flower height, fresh weight, and diameter of *Chrysanthemum maximum* clone Esther Reed. Figures expressed as monthly means.

Experiment		Means	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Fertility Experiment										
25-30 ppm NO_3 10 ppm K_2O		Ht.*	30.20	30.19	36.53	41.03	44.71	43.07	45.54	-----
		Wt.*	6.24	6.53	10.03	10.33	14.41	16.64	19.60	-----
		Diam.*	6.20	6.81	7.36	6.93	7.44	7.82	7.47	-----
25-30 ppm NO_3 30-35 ppm K_2O		Ht.	30.86	28.08	37.00	40.09	47.71	48.14	42.67	-----
		Wt.	6.83	6.84	7.89	8.63	13.97	18.03	19.50	-----
		Diam.	6.57	6.69	6.94	6.91	7.39	8.00	7.48	
25-30 ppm NO_3 20 ppm K_2O		Ht.	28.60	32.71	38.56	39.16	40.87	44.47	41.36	-----
		Wt.	5.06	6.77	9.39	8.80	12.61	16.03	17.54	-----
		Diam.	6.10	7.07	7.28	6.95	7.37	7.76	7.24	-----
5-10 ppm NO_3 20 ppm K_2O		Ht.	27.00	29.00	34.60	38.59	41.77	42.77	41.18	-----
		Wt.	5.50	5.50	8.87	8.70	12.49	15.32	17.06	-----
		Diam.	6.50	6.75	7.00	6.88	7.37	7.61	7.38	-----
50-75 ppm NO_3 20 ppm K_2O		Ht.	34.12	31.50	42.00	45.06	45.46	51.64	45.23	-----
		Wt.	8.92	6.87	10.21	8.54	11.94	18.51	24.23	-----
		Diam.	6.84	6.58	7.17	6.33	7.17	8.03	7.54	-----
Photoperiod Experiment										
Sunset to 7 P.M.		Ht.	30.50	28.25	27.00	-----	-----	-----	33.24	41.46
		Wt.	11.45	10.14	12.43	-----	-----	-----	27.24	33.25
		Diam.	6.50	6.69	7.50	-----	-----	-----	7.01	7.40
Sunset to 8 P.M.		Ht.	23.50	27.00	35.00	28.00	32.20	27.33	37.39	40.29
		Wt.	6.50	8.50	18.20	17.35	25.00	23.23	21.65	12.06
		Diam.	6.25	6.60	8.00	8.25	8.10	8.00	7.05	6.50
Sunset to 9 P.M.		Ht.	32.33	34.17	37.27	40.73	39.78	41.74	48.90	-----
		Wt.	10.10	9.38	12.33	15.80	17.59	24.66	30.79	-----
		Diam.	6.83	6.63	7.40	7.54	7.61	8.14	7.76	-----
Sunset to 10 P.M.		Ht.	35.33	30.20	41.29	40.69	42.68	46.15	45.90	-----
		Wt.	7.80	5.85	11.50	9.49	11.09	17.24	22.75	-----
		Diam.	6.87	6.45	7.66	7.02	6.92	7.71	7.51	-----

* Height - in centimeters
Weight - in grams
Diameter - in centimeters

Table 10. Analysis of variance of flower height in the fertility experiment. Shasta daisy clone Esther Reed.

Sources of variation	D.F.	M.S.	F.	Significance
Treatments	4	572.82	13.61	***
Plants	44	359.92	8.55	***
Remainder	1029	42.09		
Total	1077			

Table 11. Analysis of variance of flower fresh weight in the fertility experiment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	4	382.0403	3.94	**
Plants	44	173.0794	1.78	***
Remainder	1029	97.0495		
Total	1077			

Table 12. Analysis of variance of flower diameter in the fertility experiment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	4	.8447	1.81	NS
Plants	44	1.1081	2.37	***
Remainder	1029	.4679		
Total	1077			

Table 13. Analysis of variance of flower number in the fertility experiment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	4	490.11	4.28	**
Error	40	114.49		
Total	44			

Table 14. Wilcoxon-Mann-Whitney test of significance between remaining flower stems of shasta daisy clone Esther Reed in the 7 and 8 P.M. daylength extensions.

Flower Stems 5-8 P.M.	Rank	Flower Stems 5-7 P.M.	Rank	Significance
1	11.5	1	11.5	
6	5.5	11	1.0	
8	3.0	10	2.0	
1	11.5	1	11.5	
2	9.0	3	7.5	
18		7	4.0	
		3	7.5	
		6	5.5	NS
		42		

Table 15. Analysis of variance of flower height in the photoperiod experiment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	3	3074.89	82.81	***
Plants	39	680.87	18.34	***
Remainder	700	37.13		
Total	742			

Table 16. Analysis of variance of flower fresh weight in the photoperiod experiment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	3	5420.0801	52.35	***
Plants	39	762.1874	7.36	***
Remainder	700	103.5389		
Total	742			

Table 17. Analysis of variance of flower diameter in the photoperiod experiment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	3	17.8097	45.02	***
Plants	39	3.1394	7.94	***
Remainder	700	.3956		
Total	742			

Table 18. Analysis of variance of flower number in the photoperiod experiment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	3	476.87	8.95	***
Error	36	53.31		
Total	39			

Table 19. Comparative mean flower height, fresh weight, diameter, and number in the medium fertility treatment and the 10 P.M. photoperiod treatment. Shasta daisy clone Esther Reed.

Treatment	Height cm./flw	Weight gms./flw	Diameter cm./flw	Flower Number per plant
25-30 ppm NO_3 20 ppm K_2O	40.36	14.08	7.25	32.83
Sunset to 10 P.M.	42.81	14.98	7.26	24.91
LSD (5%)	1.03	NS	NS	NS
LSD (1%)	1.36	NS	NS	NS

Table 20. Analysis of variance of flower height between the medium fertility treatment and the 10 P.M. photoperiod treatment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	1	690.65	21.84	***
Plants	16	264.58	8.36	***
Remainder	453	31.63		
Total	470			

Table 21. Analysis of variance of flower fresh weight between the medium fertility treatment and the 10 P.M. photoperiod treatment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	1	92.5703	.90	NS
Plants	16	184.0974	1.79	*
Remainder	453	102.6075		
Total	470			

Table 22. Analysis of variance of flower diameter between the medium fertility treatment and the 10 P.M. photoperiod treatment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	1	.0202	.05	NS
Plants	16	.5148	1.25	NS
Remainder	453	.4130		
Total	470			

Table 23. Analysis of variance of flower number between the medium fertility treatment and the 10 P.M. photoperiod treatment. Shasta daisy clone Esther Reed.

Sources of Variation	D.F.	M.S.	F.	Significance
Treatments	1	243.79	1.54	NS
Error	15	158.52		
Total	16			

Table 24. *Chrysanthemum maximum* clone C.P. Kilham mean monthly flower production per plant in the fertility and photoperiod studies.

Experiment	Mean Flower Production								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May*	Total
Fertility Experiment									
25-30 ppm NO_3 10 ppm K_2O	---	---	1.00	---	---	---	14.00	2.00	17.00
25-30 ppm NO_3 30-35 ppm K_2O	---	---	---	---	.40	---	8.40	1.00	9.80
25-30 ppm NO_3 20 ppm K_2O	---	---	---	---	1.00	---	15.00	---	16.00
5-10 ppm NO_3 20 ppm K_2O	---	---	---	---	---	---	7.50	1.50	9.00
50-75 ppm KO_3 20 ppm K_2O	---	---	---	---	.50	---	12.50	.50	13.50
Photoperiod Experiment									
Sunset to 7 P.M.	---	---	---	---	---	---	---	---	---
Sunset to 8 P.M.	---	---	---	---	---	---	---	---	---
Sunset to 9 P.M.	---	---	---	---	---	---	5.00	2.50	7.50
Sunset to 10 P.M.	---	---	---	---	---	2.00	17.00	---	19.00

* May column figures represent the final flower cut on May 7.

Table 25. Effect of fertilizer level and daylength duration on height, fresh weight, diameter, and number of flowers produced by shasta daisy clone C.P. Kilham.

Experiment	Height cm./flw	Fresh Weight gms./flw	Diameter cm./flw	Flower number per plant
Fertility Experiment				
25-30 ppm NO_3 10 ppm K_2O	67.82	71.84	12.09	17.00
25-30 ppm NO_3 30-35 ppm K_2O	65.43	60.91	11.38	9.80
25-30 ppm NO_3 20 ppm K_2O	63.94	54.94	10.91	16.00
5-10 ppm NO_3 20 ppm K_2O	60.00	58.98	11.22	9.00
50-75 ppm KO_3 20 ppm K_2O	63.07	55.93	11.35	13.50
Photoperiod Experiment				
Sunset to 7 P.M.	-----	-----	-----	-----
Sunset to 8 P.M.	-----	-----	-----	-----
Sunset to 9 P.M.	76.33	104.23	11.23	7.50
Sunset to 10 P.M.	59.56	46.42	11.71	19.00

Table 26. Summary of flower quality as measured by flower height, fresh weight, and diameter of Chrysanthemum maximum clone C.P. Kilham. Figures expressed as monthly means.

Experiment		Mean Figures.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May**
Fertility Experiment										
25-30 ppm NO_3 10 ppm K_2O		Ht.*	---	---	44.00	---	---	---	71.07	57.00
		Wt.*	---	---	15.50	---	---	---	81.48	32.45
		Diam.*	---	---	12.00	---	---	---	12.29	10.75
25-30 ppm NO_3 30-35 ppm K_2O		Ht.	---	---	-----	---	61.00	---	67.88	46.60
		Wt.	---	---	-----	---	37.25	---	66.97	19.50
		Diam.	---	---	-----	---	13.75	---	11.38	10.30
25-30 ppm NO_3 20 ppm K_2O		Ht.	---	---	-----	---	60.00	---	64.20	-----
		Wt.	---	---	-----	---	41.10	---	55.87	-----
		Diam.	---	---	-----	---	13.50	---	10.73	-----
5-10 ppm NO_3 20 ppm K_2O		Ht.	---	---	-----	---	-----	---	59.73	61.33
		Wt.	---	---	-----	---	-----	---	60.19	52.90
		Diam.	---	---	-----	---	-----	---	11.30	10.83
50-75 ppm NO_3 20 ppm K_2O		Ht.	---	---	-----	---	72.00	---	63.32	48.00
		Wt.	---	---	-----	---	46.30	---	57.43	28.20
		Diam.	---	---	-----	---	13.00	---	11.38	9.00
Photoperiod Experiment										
Sunset to 7 P.M.		Ht.	---	---	-----	---	-----	---	-----	-----
		Wt.	---	---	-----	---	-----	---	-----	-----
		Diam.	---	---	-----	---	-----	---	-----	-----
Sunset to 8 P.M.		Ht.	---	---	-----	---	-----	---	-----	-----
		Wt.	---	---	-----	---	-----	---	-----	-----
		Diam.	---	---	-----	---	-----	---	-----	-----
Sunset to 9 P.M.		Ht.	---	---	-----	---	-----	---	76.90	75.20
		Wt.	---	---	-----	---	-----	---	122.43	67.84
		Diam.	---	---	-----	---	-----	---	11.15	11.40
Sunset to 10 P.M.		Ht.	---	---	-----	---	-----	58.00	59.76	-----
		Wt.	---	---	-----	---	-----	32.85	48.01	-----
		Diam.	---	---	-----	---	-----	13.50	11.50	-----

* Height - in centimeters.
weight - in grams.
Diameter - in centimeters.

** The final flower-cut was on May 7.

DISCUSSION

Fertility Experiment - Clone Esther Reed

Results of the fertility study indicated that the shasta daisy grows satisfactorily over a wide range of commonly recommended greenhouse cut-flower fertility levels. Nutrient deficiency or excess symptoms were not apparent on plants in any treatment.

The monthly fertility levels maintained in the treatments presented in Table 4 show that fertilizer levels were low relative to the proposed levels until December. However, from December until the study was terminated, treatment fertilizer levels were in general agreement with the proposed levels. The trend of increasing flower production and measurements from October to April recorded in Tables 8 and 9 is believed to be the result of plant development rather than increased fertility levels. Plants in all treatments, regardless of fertility level, responded in this manner. The increased natural day-length after the winter solstice undoubtedly played a role in this trend. Post (19) reported that the increased amount of light from late winter onward often benefits greennouse crops. Daisies illustrated in Plate II show the degree of plant development between August and February.

Comparison of mean flower production and measurements between treatments indicated that fertilizer levels influenced flower production and quality. Greater flower production

EXPLANATION OF PLATE II

Fig. 1: **Daisies one month after planting.**

Fig. 2: **Daisies seven months after planting illustrating the extent of plant development.**

PLATE II

Fig. 1

Fig. 2

(Table 7) occurred when plants were subjected to a medium nitrogen level in combination with medium or low potassium levels while the least number of flowers was produced by plants in the high nitrogen, low nitrogen, and high potassium treatments (Table 7).

The daisy appeared particularly sensitive to the nitrogen fertilizer level. Plants in the high nitrogen treatment had the greatest mean flower height and fresh weight while plants in the low nitrogen treatment had the least mean flower height and fresh weight (Table 7). Mean flower data in Table 9 shows that flower yeild in all treatments was greatest during the month of April. The least flower production during this month occurred in the high and low nitrogen treatments illustrating the sensitivity of the daisy to nitrogen fertilizer.

The effect of potassium fertilizer on daisy development is not as distinct as that of nitrogen fertilizer. Data presented in Table 7 suggest that high levels of potassium may reduce flower production while medium or low levels tend to encourage flower yield when in combination with medium nitrogen fertilizer levels. Apparently a balance exists between nitrogen and potassium which, if altered, will affect plant response. A more intensified study concerning such a balance may be warranted.

A distinction between Chrysanthemum morifolium, the common greenhouse chrysanthemum, and Chrysanthemum maximum, the shasta daisy, should be made in regard to fertilizer needs. C. morifolium requires high fertilizer levels for optimum

response (17). This study suggested that high levels of fertilizer may have an adverse effect on shasta daisy flower production.

Photoperiod Experiment - Clone Esther Reed

Results of the photoperiod study showed a progressive increase in mean flower production as the duration of the daylength extensions became longer (Table 7). Differences in flower production between treatments were small during October and November, however, flower production from December to April was considerably greater in the 9 and 10 P.M. treatments than in the 7 and 8 P.M. daylength extensions (Table 8). Daisies in the 7 P.M. treatment produced no flowers from December 12 to April 23 while plants in the 8 P.M. treatment produced 1.26 flowers per plant from December 5 to April 23 (Table 8). The limited flower production by plants in the 8 P.M. treatment from December to April suggests that one foot-candle of irradiance that was recorded entering from non-completed photoperiod treatments may have influenced flower production.

On several occasions in all daylength treatments, the dates flower buds first became visible and later flowered were recorded. The approximate interval between budding and flowering was 30 days. This suggests that the effect of the length of the photoperiod with respect to the reproductive phase of development is on initiation of flower buds. The development of flower buds, once initiated, apparently is not affected by the length

of photoperiod.

The growth habit of the shasta daisy in the different daylength treatments varied considerably indicating that the relative length of day and night influenced morphological development. Plant growth habit as observed on February 19 in the 7, 8, 9, and 10 P.M. treatments is presented in Plate III. Plants in the 7 P.M. treatment, Figure 1, were in a leaf-rosette stage of development. This response is typical of long-day plants grown on a regime of a short light period followed by a long dark period (3). Plants in the 8 and 9 P.M. treatments, Figures 2 and 3 respectively, produced flower stems which developed horizontally before bending upward. Apparently, the daylength was not of sufficient length to permit direct, vertical development. Daisies in the 10 P.M. treatment as seen in Figure 4 were upright illustrating a greater degree of elongation. Flower stems in the 10 P.M. treatment expressed little horizontal development.

The relative height and degree of stem curvature of flowers produced in the 8, 9, and 10 P.M. treatments on February 20 are presented in Plate IV. Comparison of the flower stems from the 8, 9, and 10 P.M. treatments suggest that the daylength influenced both flower height and stem curvature. Representative basal leaves produced by clones Esther Reed and C.P. Kilham in the 7, 8, 9, and 10 P.M. treatments are exhibited in Plate V. The progressive increase in length as the daylength extensions became longer indicates that the daylength also influenced leaf development.

EXPLANATION OF PLATE III

Fig. 1: Plants lighted until 7 P.M.; Clone Esther Reed plant is on the left, clone C.P. Kilham on the right.

Fig. 2: Clone Esther Reed lighted until 8 P.M.

Fig. 3: Clone Esther Reed lighted until 9 P.M.

Fig. 4: Clone Esther Reed lighted until 10 P.M.

PLATE III

Fig. 3

Fig. 4

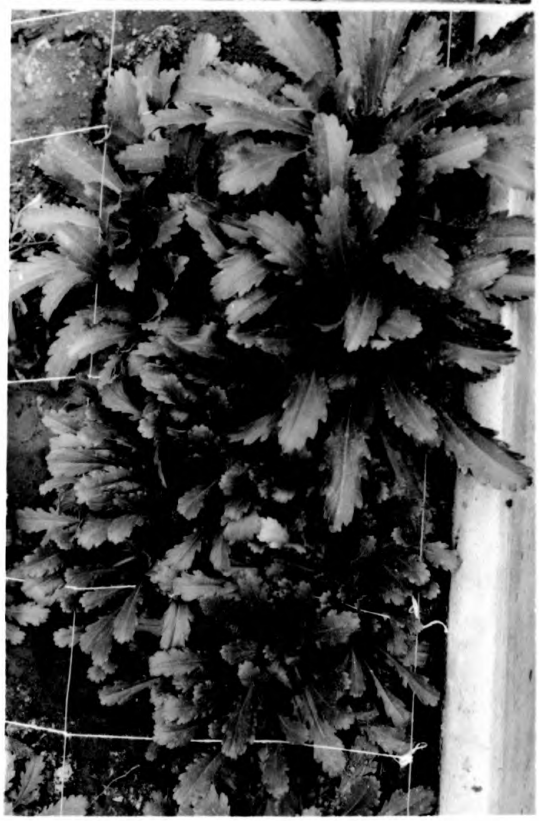


Fig. 1

Fig. 2

Apical dominance was evident on the flowers produced in the 9 and 10 P.M. treatments until the first week in March when axillary buds were observed in most leaf axils. The formation of axillary buds by plants in the 7 and 8 P.M. daylength extensions was not observed until the last week in March. Flower stems cut from plants on March 12 in the 8, 9, and 10 P.M. treatments are presented in Plate VI. Figure 1 shows apical dominance of the flower stem from the 8 P.M. treatment while Figures 2 and 3 illustrate the loss of apical dominance by flower stems in the 9 and 10 P.M. treatments. The whorled arrangement of leaves about the stem from the 8 P.M. treatment suggests that the daylengths prior to and during March were not conducive for elongation. Comparison of mean monthly flower height data in Table 9 from January to April also suggest a lack of stem elongation in the 8 P.M. treatment relative to the mean flower height in the longer daylength extensions.

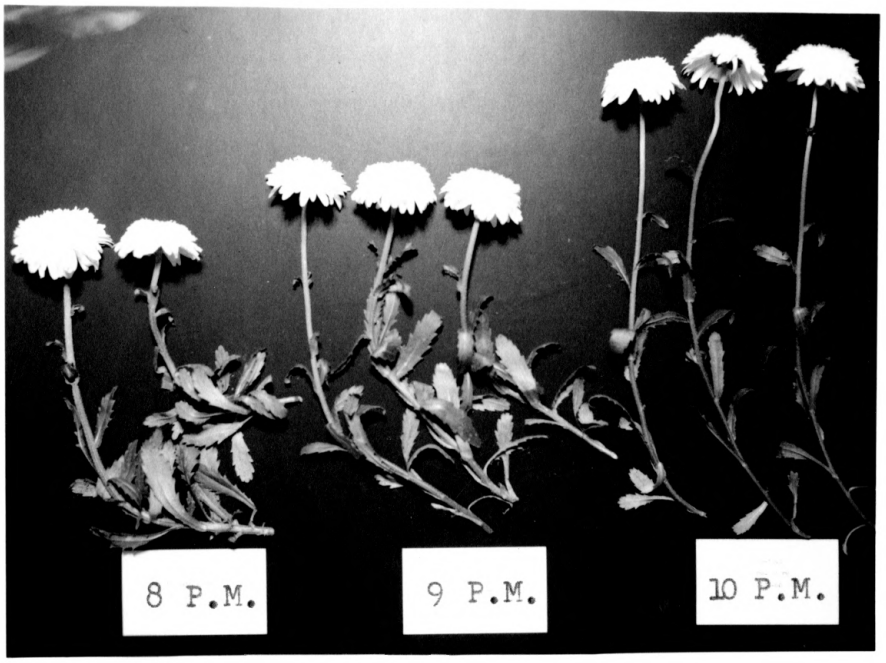
Axillary buds, allowed to remain on the flower stem, developed into lateral flowers (Plate VII). This resulted in delayed maturity of the terminal bud and a decrease in flower quality. Disbudding was practiced in this study with the exception of the flower stem presented in Plate VII.

Parallel to the advent of axillary bud formation was the development of large numbers of flower stems. The flowers produced during April and the first week in May (Table 8), approximately one month subsequent to the axillary bud formation, represent the product of the surge in flower stem development. Mean monthly flower height and fresh weight measure-

EXPLANATION OF PLATE IV

Left to right: Clone Esther Reed flowers produced from the 8, 9, and 10 P.M. treatments illustrating the effect of daylength on flower height and stem curvature.

PLATE IV



EXPLANATION OF PLATE V

Top: From left to right, clone C.P. Kilham leaves from plants lighted until 7, 8, 9, and 10 P.M.

Bottom: From left to right, clone Esther Reed leaves from plants lighted until 7, 8, 9, and 10 P.M. Scale in the bottom right is in centimeters.

PLATE V

EXPLANATION OF PLATE VI

Fig. 1: Clone Esther Reed flower stem from treatment lighted until 8 P.M. illustrating apical dominance.

Fig. 2 and 3: Clone Esther Reed flower stems from treatments lighted until 9 and 10 P.M. illustrating axillary bud development.

Fig. 1

Fig. 2

Fig. 3

EXPLANATION OF PLATE VII

Fig. 1 and 2: Clone Esther Reed flower stem picturing the degree of lateral branch development when axillary buds are not removed.

PLATE VII

Fig. 2

Fig. 1

ments during April and May presented in Table 9 reflect the good quality of flowers produced.

Plant response after the flush of flower production in April and the first week in May by plants in all daylength extensions is presented in Plate VIII. Figure 1 illustrates the over-all condition of plants in a representative treatment. The close-up of a typical plant from the treatment, Figure 2, reveals that flower and axillary buds had formed on stems 1 to 3 inches in length. The mean flower height, fresh weight, and diameter of all flowers produced by the plant pictured in Plate VIII, Figure 2, were: 27 centimeters, 7.7 grams, and 6.5 centimeters respectively. These mean flower measurements suggest a reduction in flower quality which indicates that shasta daisy flower production after the Spring peak may not be practicable.

Fertility and Photoperiod Experiments - Clone C.P. Kilham

Root-knot nematodes, indicated as swellings on some of the root systems at time of planting, reduced the number of clone C.P. Kilham plants. Statistical evaluation of plant differences was not believed feasible owing to the reduced plant number.

Flower production was low in treatments of both studies until April when plants in the 9 and 10 P.M. photoperiod treatments and fertility treatments produced flowers in quantity (Table 24). Shoot elongation en masse was observed in February on plants lighted until 9 and 10 P.M. with flower bud primordia

EXPLANATION OF PLATE VIII

Fig. 1: Clone Esther Reed daisies two weeks after the Spring flush of flower production.

Fig. 2: Close-up of a representative plant illustrating the formation of terminal and axillary buds on flower stems 1 to 3 inches long.

PLATE VIII

Fig. 1.

Fig. 1.

becoming visible the last week in February. Considerable stem elongation occurred after the development of flower buds as evidenced by mean flower height data presented in Table 26. The flower stems observed in February produced flowers the last two weeks in April and the first week in May (Table 24). This suggests that 50-60 days are necessary for flower development. Apparently, clone C.P. Kilham requires a longer photoperiod for flower bud initiation than does Esther Reed as suggested by the lack of flower production during the mid winter (Table 24).

Plants in the 7 and 8 P.M. daylength extensions produced no flowers during the study, however, flower stems were present when the study was terminated on May 7. Mean stem height of plants in the 7 P.M. treatment was 21 centimeters as compared with 46 centimeters in the 8 P.M. treatment. These data indicate a progressive increase in flower development as the duration of the daylength extensions became longer.

Proliferation of stem tissue at soil level by clone C.P. Kilham plants was a commonly observed phenomenon. This proliferation is illustrated in Plate IX. Plant vigor did not appear to be affected by this disorder, although, the number of flower stems produced may have been reduced. Proliferated tissue was removed whenever it appeared.

SUMMARY

A medium nitrogen level in combination with medium or low potassium levels produced daisies yielding significantly greater

EXPLANATION OF PLATE IX

Proliferation of stem tissue at soil level on clone C.P. Kilham indicative of a bacterium.

PLATE IX

number of flowers. Least flower production occurred in the high nitrogen, low nitrogen, and high potassium treatments.

Daisies in the high nitrogen treatment produced flowers having the greatest mean flower height and fresh weight while daisies in the low nitrogen treatment produced flowers having the least mean flower height and fresh weight. This suggests that shasta daisies are particularly sensitive to nitrogen fertilizer levels.

High levels of potassium fertilizer appeared to suppress flower production while medium or low potassium levels in combination with medium nitrogen levels encouraged flower production. Further investigation relating to a balance between nitrogen and potassium fertilizers may be warranted.

Nutrient deficiency or excess symptoms were not apparent on plants in the fertility treatments. This indicates that the shasta daisy grows satisfactorily over a wide range of commonly recommended greenhouse cut-flower fertility levels.

Clone Esther Reed showed a progressive increase in mean flower production as the duration of the daylength extensions became longer. Daisies lighted until 9 and 10 P.M. had significantly greater flower production than daisies in the 7 and 8 P.M. treatments.

Eighty per cent of the flowers produced by plants in the 7 and 8 P.M. treatments were cut in April and the first week in May. The most uniform flower production occurred in the treatment lighted until 10 P.M.

Mean flower height was significantly greater in the 9 and

10 P.M. treatments as compared with flowers produced in the 7 and 8 P.M. treatments.

Mean flower fresh weight was greater in the three shorter daylength extensions as compared with the fresh weight of flowers produced in the 10 P.M. treatment.

Plants in all treatments produced flowers in quantity in April. This is believed related to the increased natural daylength.

The growth habit of clone Esther Reed varied considerably in the different daylength extensions. Axillary bud formation, leaf development, and flower stem height and curvature appeared to be influenced by the relative length of day and night.

Flower production by clone C.P. Kilham was low in all daylength and fertility treatments until April when plants in the 9 and 10 P.M. photoperiods, including the fertility treatment, produced flowers in quantity.

Plants in the 7 and 8 P.M. treatments produced no flowers during the study, however, flower stems had developed when the study was terminated.

Evaluation of clone C.P. Kilham plant differences was not practiced owing to a reduction in plant number by root-knot nematodes.

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GREENHOUSE CULTURE OF THE SHASTA DAISY WITH EMPHASIS ON ITS SOIL FERTILITY AND PHOTOPERIODIC REQUIREMENTS

by

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Chrysanthemum maximum clones Esther Reed and C.P. Kilham were planted into raised greenhouse benches containing a soil mixture of two parts silty loam soil and one part horticulture peat moss. Rooted divisions were planted on July 6, 1959, and the study was terminated on May 7, 1960.

Two benches were employed, one for a fertility study and the other for a photoperiod study. The fertility bench was partitioned to facilitate maintenance of five fertility plots representing combinations of high, medium, and low nitrogen fertilizer levels with high, medium, and low potassium fertilizer levels. Phosphorus fertilizer levels were the same in all treatments. All fertilizer plots received artificial illumination from sunset to 10 P.M..

The photoperiod bench was divided into four sections, each representing a different photoperiod produced by extending the daylength from sunset to 7, 8, 9, and 10 P.M. each evening. One hundred watt tungsten lamps were used.

Results of the fertility study indicated that the shasta daisy grows satisfactorily over a wide range of commonly recommended greenhouse cut-flower fertility levels. Nutrient deficiency or excess symptoms were not apparent in any treatment. A medium nitrogen level in combination with medium or low potassium levels appeared best for flower production.

Daisies in the high nitrogen plot produced flowers having the greatest mean flower height and fresh weight while daisies in the low nitrogen plot produced flowers having the least mean flower height and fresh weight. This indicated that the shasta

daisy is particularly sensitive to the nitrogen fertilizer level.

High potassium levels appeared to suppress flower production while medium or low potassium levels in combination with medium nitrogen levels seemed to encourage flower production. Further investigation concerning the balance between nitrogen and potassium fertilizer levels may be warranted.

Clone Esther Reed showed a progressive increase in mean flower production as the duration of the daylength extensions increased. Daisies in the 9 and 10 P.M. photoperiods had significantly greater flower production than did the plants in the 7 and 8 P.M. treatments. Eighty per cent of the flowers produced in the 7 and 8 P.M. treatments were cut in April or the first week in May. The most uniform production occurred in the treatment lighted until 10 P.M.

Mean flower height was significantly greater in the 9 and 10 P.M. photoperiods as compared with mean flower height in the 7 and 8 P.M. photoperiods.

Flowers produced in the three shorter daylength extensions had significantly greater mean fresh weight than flowers produced in the 10 P.M. treatment.

Plants in all treatments produced flowers in quantity in April which was believed related to the increased natural daylength.

The growth habit of Clone Esther Reed varied considerably in the different daylength extensions. Axillary bud formation,

leaf development, flower stem curvature, and elongation appeared to be influenced by the relative length of day and night.

Flower production by clone C.P. Kilham was low in all day-length and fertility treatments until April when plants in the 9 and 10 P.M. photoperiods, including the fertility treatments, produced flowers in quantity. Kilham plants in the 7 and 8 P.M. produced no flowers during the study, however, flower stems had developed when the study was terminated.

Evaluation of clone C.P. Kilham plant differences was not practiced owing to a reduction in plant number by root-knot nematodes.