facteurs qui favorisent les contaminations de l'asperge par *Rhizoctonia violacea*. Compt. Rendi Hebd. Séances Acad. Agr. France 51(5):314–317.

Nelson, P.E., T.A. Toussoun, and W.F.O. Marasas. 1983. *Fusarium* species: An illustrated manual for identification. Pennsylvania State Univ. Press, University Park.

Putnam, A.R. and M.L. Lacy. 1977. Asparagus management with no-tillage. Michigan State Univ. Agr. Expt. Sta. Res. Rpt. 339.

Takatori, F. and F. Souther. 1978. Asparagus workshop proceedings. Dept. of Plant Sciences, Univ. of California, Riverside.

Van Bakel, J.M.M. and J.J.A. Kerstens. 1970. Root rot in asparagus caused by *Fusarium oxysporum* f. sp. *asparagi*. Netherlands J. Plant Pathol. 76:320–325.

HORTSCIENCE 24(2):368–370. 1989.

Nature and Inheritance of Compact Plant Habit in *Cuphea leptopoda* Hemsley

Anson E. Thompson

U.S. Water Conservation Laboratory, Agricultural Research Service, U.S. Department of Agriculture, 4331 E. Broadway, Phoenix, AZ 85040

Additional index words. indeterminate flowering, shortened internode, new crops

Abstract. **Plants with a compact growth habit have been identified in populations of *Cuphea leptopoda* Hemsley. The primary morphological effect has been shown to be conditioned by a single recessive gene, designated *si* for shortened internodes. Short internodes on compact plants result in reduced length of the main stem, reduced number and length of both primary and secondary branches, and reduced flowering resulting from a decrease in number of flowers per node on the main stem and branches. The compact growth habit and more concentrated flowering of the shortened-internode plants may have horticultural and agronomic value in new interspecific hybrids being developed.**

Several cuphea species are used on a limited scale in landscape plantings as tender annuals and perennials in the southern part of the United States (Thompson, 1984). Some of our recently synthesized interspecific hybrids are being evaluated as new bedding and pot plants because of their attractive flowers and plant growth characteristics (Ray et al., 1988; Thompson, 1986; Thompson et al., 1987). In addition, cuphea species are being domesticated and developed to serve as a new industrial oilseed crop for the production of lauric and other medium-chain fatty acids (Hirsinger and Knowles, 1984; Thompson, 1984, 1985; Thompson and Kleiman, 1988). Major constraints to successful commercialization of cuphea for either horticultural or agronomic purposes are indeterminate growth and flowering, excessive seed shattering, seed dormancy, and viscid glandular hairs on flowers, stems, and leaves. Various breeding, genetic, and cultural methods are being employed to remove these constraints. We are using interspecific hybridization to develop enhanced germplasm and new cultivars (Ray et al., 1988; Thompson, 1984).

During the ongoing germplasm evaluation, plants with a compact growth habit were observed within populations of three accessions of *Cuphea leptopoda* Hemsley [A0029 (Graham 602), A0065 (Graham 713), and A0072 (Graham 720)] (Fig. 1). These accessions have chromosome numbers of N = 10 and produce predominately capric acid (C10:0) in the seed oil (Hirsinger and Knowles, 1984; Ray et al., 1988; Thompson and Kleiman, 1988). *C. leptopoda* plants usually exhibit a high level of seed dormancy, are normally highly cross-pollinated by insects, and set few seeds in the greenhouse. The objective of this study was to characterize the nature of the growth and flowering habit of the compact plants in comparison with normal plants, and to possibly determine the mode of inheritance.

Seeds from accession number A0072 were germinated on moistened filter paper in petri dishes on 13 Mar. 1985, transplanted into seed flats in a greenhouse on 18 Mar., and moved into pots with volume of 400 cm^3 on 5 Apr. 1985. On 17 May 1985, 65 days after planting, 17 of the 38 plants obtained were classified as having the compact growth habit. We measured node number, internode length, total height of the main stem, and recorded the number and length of primary and secondary branches and the node from which they arose. Flower numbers on main stem nodes and on primary and secondary branches were counted and recorded. Means, standard errors, and coefficients of variation were calculated for each measurement within each

Received for publication 25 Jan. 1988. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Table 1. Comparison of internode length and total plant height of normal and compact (shortened internode) *Cuphea leptopoda* plants 65 days after planting.

	Internode length (mm)		
Internode number	Normal (n = 21)	Compact (n = 17)	Difference (N − C)
0[z]	20.5	13.5	7.0
1	8.6	7.1	1.5
2	15.0	9.1	5.9
3	23.8	14.4	9.4
4	37.6	23.5	14.1
5	44.3	29.7	14.6
6	45.5	28.8	16.7
7	37.6	26.5	11.1
8	27.9	19.4	8.5
9	21.7	13.8	7.9
10	17.6	9.1	8.5
11	14.0	8.2	5.8
12	11.2	6.8	4.4
13	7.9	4.1	3.8
14	5.0	2.4	2.6
15	2.1	0.9	1.2
16	1.2	0.0	1.2
Internode length ($\bar{x}$)	21.3	13.6	7.7
SE	0.7	0.3	0.9
CV (%)	15.2	9.1	---
t (df = 36)	---	---	7.98**
Total plant height ($\bar{x}$)	341.5	217.3	124.2
SE	11.0	8.7	14.6
CV (%)	14.8	16.5	---
t (df = 36)	---	---	8.53**

[z]Internode number 0 indicates the stem from the soil line to the cotyledonary node.

**Differences between means of two unequal sized groups (21 normal vs. 7 compact plants) are significantly different from zero at the 1% level.

Table 2. Characterization of branching and flowering habit of normal and compact (shortened internode) *Cuphea leptopoda* plants 65 days after planting.

	Normal (n = 21)		Compact (n = 17)		Difference (N − C)	
	Number	Length (mm)	Number	Length (mm)	Number	Length (mm)
Branches/plant						
Primary	8.4	833	7.2	519	1.2	314
Secondary	3.5	76	0.2	6	3.3	70
Total	11.9	909	7.4	525	4.5	384
SE	0.73	73.3	0.45	56.4	1.16	108.8
CV (%)	28.0	37.2	24.8	44.4	---	---
t (df = 36)	---	---	---	---	3.88**	3.49**
Flowers/plant						
Main stem	20.0		16.1		3.9	
Branches	26.3		17.5		8.8	
Total	46.3		33.6		12.7	
SE	3.80		3.25		5.14	
CV (%)	37.6		39.9		---	
t (df = 36)	---		---		2.47**	

**Differences between means of two unequal sized groups (21 normal vs. 17 compact plants) are significantly different from zero at the 1% level.

group (21 normal vs. 17 compact plants). The significance of the differences between the means of the two unequally sized groups was measured by a t test calculated from the mean differences and the standard errors of the mean differences derived from the pooled variances.

Plant height of compact plants was ≈120 mm shorter than normal plants (Table 1). The mean number of nodes on the main stems of compact plants was reduced slightly (13.6 ± 0.6 vs. 12.5 ± 0.7), but the difference was not significant. Reduction in height of compact plants was due primarily to the significant shortening of internode lengths throughout the main stem. The largest differences, >10 mm between the normal and compact plant types, were observed between the fourth and seventh internodes above the cotyledons. The large difference at these internodes is a good characteristic for differentiating between compact and normal plants in segregating populations. In most instances, the compact plants' internode lengths in the fourth to seventh internode region do not exceed 30 mm. With normal plants at least one of the internodes in this region is 40 mm or longer.

Fig. 1. Compact plant (**left**) conditioned by the single recessive gene, shortened internode (*si*), and normal plant (**right**) of *Cuphea leptopoda* (A0072) at 75 days after seeding.

The compact or shortened internode character also affected the branching habit of the plant (Table 2). Compact plants had significantly fewer and shorter primary and secondary branches than comparable normal plants. *C. leptopoda* normally produces a pair of branches at the first node above the cotyledonary node on the main stem. On occasion, short branches will form at the cotyledonary node. At the cotyledonary and first nodes, the compact plants tend to produce fewer branches, but they produce more branches at the second and third nodes. After the fourth node, branch production decreases rapidly on the compact plants in comparison to normals.

On average, compact plants produced 12.7 fewer flowers than normals (Table 2). The reduction in flower number was observed on both the main stem and branches. About two-thirds of the reduction in flower number occurred on the branches even though the number of flowering branches was essentially the same on both types of plants (4.1 ± 0.4 and 4.2 ± 0.4 for normal and compact, respectively). Compact plants had fewer main stem flowering nodes per plant (10.7 ± 0.4 vs. 9.2 ± 0.5), but this difference was not statistically significant. In summary, the reduced flowering of compact plants in comparison to normals results from a combination of fewer flowers per node on the main stem and the significant reduction in length of the primary and secondary branches.

Two weeks after measurement, no seed set was observed on any of the plants. Many of the stigmas were exerted beyond the corolla tube. Hand self-pollinations on all plants were begun to produce seeds for advanced generations and to determine the possible mode

Table 3. Numbers of normal and compact (shortened internode) plants in three progenies of self pollinated heterozygous normal *Cuphea leptopoda* plants with X^2 tests and probabilities for goodness of fit to single gene 3:1 ratio.

Pedigree number	No. plants Normal	Compact	X^2	P
72-2	31	11	0.010	0.90
72-15	23	7	0.344	0.50
72-25	12	4	0.000	1.00
Sum			0.354	0.90
Total	66	22	0.000	1.00

of inheritance. A total of 257 seeds were obtained from nine compact plants and 496 seeds from 14 normal plants. Seed numbers per plant ranged from four to 54 and one to 88 on compact and normal plants, respectively. To minimize the effects of seed dormancy, the seeds were held at room temperature ($\approx$22C) for about 20 months before planting in seed flats in a greenhouse on 3 Apr. 1987. Germination was very low, with only 7.4% and 25.4% for compact and normal, respectively.

All but two of the 19 progeny plants from compact parents were classified as compact. These two probably arose from chance outcrossing. Eleven of the 14 originally classified normal plants produced progenies of only one to eight plants. Three of the normals had plant populations ranging from 16 to 42, and were segregating for compact plant habit (Table 3). The X^2 test for the three plant populations and the pooled results support the hypothesis that the compact plant growth characteristic is conditioned by a single recessive gene. Since the primary effect of the gene is to shorten the internode length, it is proposed that the recessive gene be designated by the symbol *si* for shortened internode.

The compact plant and flowering habit may have value as pot and bedding plants, as well as for agronomic purposes. Although not determinate flowering, the shortened-internode plant does produce a compact plant with concentrated flowering, which should reduce the need for growth retardants in pot culture. This character also may be of value for once-over harvest for oilseed production. However, the apparent reduction in branching and flowering may have a negative effect on seed yield, offsetting a possible positive effect on yield concentration.

We are using both normal and shortened internode *C. leptopoda* plants in our interspecific hybridization program. As yet we have not been able to evaluate the effect of the *si* gene within the genetic background of another species. However, we are optimistic that this gene may have value in certain interspecific combinations.

Literature Cited

Hirsinger, F. and P.F. Knowles. 1984. Morphological and agronomic descriptions of selected *Cuphea* germplasm. Econ. Bot. 38:439–451.

Ray, D.T., A.E. Thompson, and A.C. Gathman. 1988. Interspecific hybridization in *Cuphea*. HortScience 23:751–753.

Thompson, A.E. 1984. *Cuphea*—a potential new crop. HortScience 19:352–354.

Thompson, A.E. 1985. New native crops for the arid Southwest. Econ. Bot. 39:436–453.

Thompson, A.E. 1986. Germplasm evaluation of *Cuphea*, a potentially new ornamental crop. HortScience 21:884. (Abstr.)

Thompson, A.E., D.T. Ray, and M.S. Roh. 1987. Evaluation of *Cuphea procumbens* x *C. llavea* hybrids as new floral and bedding plants. HortScience 22:1142–1143. (Abstr.)

Thompson, A.E. and R. Kleiman. 1988. Effect of seed maturity on seed oil, fatty acid and crude protein content of eight *Cuphea* species. J. Amer. Oil Chem. Soc. 65:139–146.

HORTSCIENCE 24(2):370–372. 1989.

Interspecific Hybrids Between Two *Chrysanthemum* Species

J. de Jong and W. Rademaker
Institute for Horticultural Plant Breeding (IVT), P.O. Box 16, 6700 AA Wageningen, Netherlands

Additional index words. chrysanthemum, flowers, seed set, chromosomes, ploidy, interspecific crosses

Abstract. ***Dendranthema pacificum*** **Nakai (*Chrysanthemum pacificum* Nakai; 2n = 10x = 90 chromosomes), a species native to Japan, was crossed to *Dendranthema grandiflora* Tzvelev (*C. morifolium* Ramat.; 2n = 6x = 54), the florist chrysanthemum, to develop a type with numerous small flowerheads. The first-generation hybrid was fertile, but the flowerheads were too small. In the first backcross to *D. grandiflora*, the desired type was obtained. The backcross (2n = 7x = 63) was very fertile, despite the odd number of genomes. *D. pacificum* may also be used as a source of resistance to the serpentine leaf miner (*Liriomyza trifolii*).**

In common with other compositae, the inflorescence of *Dendranthema* contains tubular disk florets in the center and an outer ring of ray florets with large ligules. "Double" types have mainly ray florets. *Dendranthema grandiflora* production is increasing (from 182 million stems in 1970 to 910 million in 1987) in the Netherlands. To keep the demand lively, the industry continually introduces new flower types and colors. The two most recent novelties have bicolored ligules and green heads. So far, all variants were found in *D. grandiflora*, itself an old species hybrid. To secure future genetic diversity in *D. grandiflora*, crosses were made with various species of Asiatic origin. The results of the cross with *D. pacificum* are reported here.

D. pacificum is found along the eastern coast of Japan (8). The plants have thick leaves with white pubescence on the undersurface of the leaf and along the leaf margins. An attractive feature is its ability to produce several heads per leaf axil, unlike *D. grandiflora*, in which a leaf axil produces only one head. The heads of *D. pacificum* are small and carry disk florets only. The aim of the project was to introduce this branched flowering characteristic into *D. grandiflora*. We also wanted heads that were small and carried ligules in all available colors.

We received an early flowering *D. pacificum* selection from J. Kawata (see ref. 4). Crosses were made with 14 *D. grandiflora* cultivars that included both cut flower and pot plant types. We chose to use *D. pacificum* as the pollen plant so that hybrids of this cross can readily be distinguished from selfings, if present. The hybrids were intermediate in many characters. The heads were very small and frequently carried 10 to 20 short, reflexed ligules. The ligules were white, yellow, or pink, depending on the *D. grandiflora* parent used. The variation found in these first-generation (F_1) interspecific hybrids allowed for selection on plant architecture, size, and shape of ligules; e.g., by removal of types with reflexed ligules, which, in Holland, are associated with overmaturity.

To increase the size of the heads, backcrosses to *D. grandiflora* were made. In this first backcross generation (BC_1), commercially acceptable plants with many attractive small heads were selected. The breeding sequence and the size of the heads that were characteristic for each generation are illustrated in Fig. 1. Besides this first backcross, we also tested crosses between F_1 hybrids, but these only yielded types much like the

Received for publication 11 Apr. 1988. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.