Table 1. Seed germination of crosses of selected inbred and noninbred strawberry selections.[z]

Cross	Type of progeny	Mean germination (%)	Germination index
4509 x 4519	$S_1 \times S_2$	79.2a[y]	17.7a
4509 x 4515	$S_1 \times S_1$	74.0ab	14.7b
4515 x 4426	$S_1 \times N$	70.0b	14.4bc
4509 x self	S_2	66.2bc	12.7bc
4355 x 4426[x]	N x N	66.2bc	12.4c
4426 x self	S_1	59.6cd	12.4c
4520 x 4519	$S_2 \times S_2$	58.2cd	12.6c
4520 x 4426	$S_2 \times N$	55.6d	11.1cd
4520 x self	S_3	53.6d	10.0d

[z]50 seeds germinated per plot with 8 replications. Correlation coefficient between germination % and germination index was +0.9.

[y]Mean separation in columns by Duncan's multiple range test, 5% level.

[x]Control, cross between 2 vigorous noninbred clones.

Table 2. Mean vigor of strawberry seedlings from crosses of inbreds and noninbreds expressed as mean dry or fresh weights of plant parts.[z]

Cross	Type of progeny	Shoot dry wt (mg)	Shoot fresh wt (mg)	Root dry wt (mg)
4355 x 4426[x]	N x N	88a[y]	533a	14ab
4520 x 4426	$S_2 \times N$	86a	522a	11abc
4520 x 4519	$S_2 \times S_2$	82ab	503ab	13abc
4515 x 4426	$S_1 \times N$	78ab	484ab	14a
4509 x 4519	$S_1 \times S_2$	75ab	478ab	12abc
4426 x self	S_1	71b	380c	10cd
4509 x 4515	$S_1 \times S_1$	70b	445b	11bc
4520 x self	S_3	49c	263d	6e
4509 x self	S_2	47c	299d	8de

[z]Tops of 720 plants and roots of 360 plants were weighed to estimate vigor.

[y]Mean separation in columns by Duncan's multiple range test, 5% level.

[x]Control or check cross between 2 vigorous noninbred clones.

4509) or low (Md-US 4520) germination percentage. In this study the germination index was highly and positively correlated with total germination. This correlation may reflect the more rapid germination of viable seeds following stratification.

Selfed progenies from inbred and noninbred parents showed less early shoot growth or root growth than did the control cross (Table 2). Selfing for 2 or 3 generations (Md-US 4509 or 4520) depressed early seedling growth compared to that of cross-pollinated progenies or to selfing or a vigorous clone for 1 generation. Most inbred x inbred and inbred x noninbred crosses recovered vigor equivalent to that of the control, indicating that vigor was largely restored by hybridization or outcrossing, even between full sibs. However, note that the control progeny showed the most vigor, even though the other crosses did not differ significantly. The better early growth of outcrossed seedlings compared to that of crosses among inbreds was often visible in young seedlings in the greenhouse. The shoot growth of cross 4509 x 4515 ($S_1 \times S_1$) was apparently poorer than that of the control, but root growth was apparently equal.

Correlation coefficients among shoot fresh and dry weight and root dry weight were all highly significant. Correlation coefficients were: shoot dry weight with shoot fresh weight, r = .73; shoot dry weight with root dry weight, r = .72; shoot fresh weight with root dry weight, r = .74. However, the germination index was not correlated with any of the plant weight measures. This result indicated that any one of the growth criteria except the germination index could be used as a measure of strawberry seedling vigor.

Literature Cited

1. Aalders, L. E. and D. L. Craig. 1974. Analysis of fruit yield and related factors in a diallel of seven inbred strawberry clones. *Can. J. Genet. Cytol.* 16:381-387.
2. Anstey, T. H. and A. N. Wilcox. 1950. The breeding value of selected inbred clones of strawberries with respect to their vitamin C content. *Sci. Agr.* 30:367-374.
3. Brooks, R. M. and H. P. Olmo. 1972. Register of new fruit and nut varieties, 2nd ed. Univ. of Calif. Press, Berkeley.
4. Darrow, G. M. 1952. Albritton Strawberry and Angola and Ivanhoe blueberries. *Fruit Var. & Hort. Dig.* 7:19-20.
5. Jones, D. F. and W. R. Singleton. 1940. The improvement of naturally cross-pollinated plants by selection in self-fertilized lines. *Bul. Conn. Agr. Expt. Sta.* 435:325-347.
6. Melville, A. H., A. D. Draper, and G. J. Galletta. 1980. Transmission of red stele resistance by inbred strawberry selections. *J. Amer. Soc. Hort. Sci.* 105:608-610.
7. Morrow, E. B. and G. M. Darrow. 1952. Effects of limited inbreeding in strawberries. *Proc. Amer. Soc. Hort. Sci.* 59: 269-276.
8. Ng, Timothy J and E. C. Tigchelaar. 1973. Inheritance of low temperature seed sprouting in tomato. *J. Amer. Soc. Hort. Sci.* 98:314-316.
9. Scott, D. H. 1962. Breeding and improvement of the strawberry in the United States of America, a review. *Hort. Res.* 2: 35-55.

HortScience 15(6):750–751. 1980.

Low Temperature and Flowering of Primocane-fruiting Red Raspberries[1]

Miltiadis D. Vasilakakis, Brent H. McCown, and Malcolm N. Dana[2]

Department of Horticulture, University of Wisconsin, Madison, WI 53706

Additional index words. Rubus idaeus, flower induction

Abstract. **Low temperature was not a requirement for flowering in 'Heritage', a primocane-fruiting red raspberry, as non-cold treated primocanes flowered at about 80 nodes. The amount of growth before flowering was inversely related to the amount of growth before cold exposure. Cold exposure (7°C) for 25 days at the 10-12 or 14-16 nodes stages of growth was followed by flowering at 32 and 28 nodes, respectively. Winter cold exposure until mid-December at the stage of adventitious buds on the root resulted in flowering at 41 nodes. Cold treatment did not influence the number of nodes that developed inflorescences on any one primocane.**

In primocane-fruiting red raspberry cultivars flowering occurs in the apical region of the primocane during summer. All buds are potentially flower buds (2) but all do not become flower buds in the first year. Buds below the fall-fruiting region become flower buds on the floricane during late fall and winter. Flower induction in mature canes of 'Heritage' is temperature independent (1), but flower bud differentiation is influenced by low temperature. Williams and Hudson (3) showed that flowering could be induced on elongated canes of 'Lloyd George' a primocane-fruiting cultivar by a cold treatment of 2.5-4.5°C for periods up to 6 weeks. In contrast flowering could not be induced by

[1]Received for publication August 23, 1978. Research supported by the College of Agricultural and Life Sciences. Hatch project 2171. This research was conducted in partial fulfillment of the requirement for the Ph.D. degree by the senior author.

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

[2]Research Assistant, Associate Professor and Professor, respectively.

low temperature on canes with fewer than 12 nodes. The present study was designed to establish the effects of low temperatures on flowering of 'Heritage' primocanes.

'Heritage' plants from root cuttings were grown in 20 cm clay pots in a greenhouse with 22-24°C and 16 hr daylength. Selected plants were exposed to low temperature regimes at stages of growth as follows: 1) no temperature below 22° from time of adventitious shoot bud initiation on the root to flowering, 2) exposure in the field until December 5 of initiated shoot buds on roots (such buds contain 4-5 nodes), 3) primocanes at 10-12 nodes of growth exposed to 25 days of 7° and 16 hr photoperiod in a controlled temperature chamber, and 4) primocanes at 14-16 nodes of growth treated as 3 above. The primocanes in the controlled temperature chambers were lighted with a combination of fluorescent and incandescent lights.

Plants grown from adventitious buds without cold treatment flowered terminally and basipetally at 80 nodes of growth. Plants from adventitious buds exposed to low temperature until mid-December flowered at 41 nodes of growth. Primocanes cold treated (7°C) for 25 days at the 10-12 or 14-16 node stage of development flowered at 32 or 28 nodes, respectively. No relationship was found between the number of flowering nodes per primocane and the time of low temperature exposure as all plants produced 12 ± 2 flowering nodes.

'Heritage' primocanes flowered in the absence of any temperatures below 22°C during the life of the cane. Exposure of developing primocanes to temperatures at 7° shortened the vegetative growth phase of the primocanes. The extent of vegetative growth after low temperature exposure was inversely related to the extent of vegetative growth before the low temperature treatment. Low temperatures were not obligatory for floral initiation but influenced the time or growth stage at which floral initiation occurred.

Low temperature, plant age, time of flowering and the termination of the primocane vegetative extension are interrelated. The control of plant development exercised by low temperature may result from a direct influence on floral induction that, in turn, stops vegetative extension (3), stage of plant development being the limiting factor for response. Alternatively, the primocane may have an endogenously controlled seasonal cycle in which flowering is the final phase. Low temperature exposure, at any stage of plant development, shortens the seasonal cycle and earlier flowering results. Because vegetative growth for several nodes follows cold exposure before inflorescences appear we hypothesize that floral induction is not a direct response to cold but rather follows after the impact upon the endogenously controlled cycle. This cycle may be analogous to the juvenility/phase change cycle readily observed in woody plants.

The extent of vegetative growth is determined by low winter temperatures in the field. Encouragement of growth in spring and early summer should advance the fall harvesting season.

Literature Cited

1. Vasilakakis, M. D., B. E. Struckmeyer, and M. N. Dana. 1979. Temperature and development of red raspberry flower buds. *J. Amer. Soc. Hort. Sci.* 104:61-62.
2. Waldo, G. J. 1934. Fruit bud formation in brambles. *Proc. Amer. Soc. Hort. Sci.* 20:263-267.
3. Williams, J. H. and J. T. Hudson. 1956. Effect of environment upon growth and development of raspberry canes. *Nature* 177:789-799.

HortScience 15(6):751–752. 1980.

Cellular Variation in Chromosome Number Induced by *p*-Fluorophenylalanine in Grape Seedlings[1]

M. Omura and T. Akihama

Fruit Tree Research Station, Ministry of Agriculture, Forestry and Fisheries, Yatabe, Ibaraki, Japan 305

Additional index words. Vitis vinifera, haploidy

Abstract. ***p*-Fluorophenylalanine reduced germination and growth of diploid seedlings of grape (*Vitis vinifera* L. cv. Neo Muscat) and induced variation in chromosome numbers from haploidy to tetraploidy including aneuploidy in root cells.**

p-Fluorophenylalanine (PFP) is reported (a) to alter amino acid metabolism (6); (b) to inhibit growth of roots (5) and callus (1); and (c) to induce haploids (2, 3, 4). The original objective of the present study was to induce haploidy grape seedlings.

Seeds of 'Neo Muscat' grape (2n = 38), which were fully stratified in a refrigerator, were germinated at 25°C in vermiculite beds which were moistened with a 160, 80, 40, 20, 10, or 0 ppm PFP solution for the first 10 days and thereafter with tap water. The germination test was replicated 6 times with 10 seeds each time.

Seed germination was observed for 50 days after sowing and shoot and root length was measured. Chromosome numbers were counted in root tip cells according to the following procedures: pretreatment in distilled water at 2°C for 24 hr, fixation with acetic-alcohol (1:3), dissociation in 1N HCl at 60°C for 30 sec, and staining with aceto-orcein. In each tip, more than 10 mitotic figures were observed.

Although PFP did not decrease total germination, it significantly reduced survival 50 days after sowing (Table 1). Though shoot growth was not appreciably affected, root growth was significantly inhibited by PFP. Some root tips became brown after treatment with a high concentration of PFP solution and this reaction appeared to be correlated with the reduction of survival. In these root tips, there were some abnormal mitotic figures in which

[1]Received for publication April 30, 1980. Contribution A-110, Fruit Tree Research Station.

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

Table 1. Seed germination, growth, and mitotic abnormalities of grape seedlings treated with PFP at beginning of germination.

PFP concn (ppm)	Seed germination (%)		Avg length, 50 days (cm)		Mitotic abnormalities		
	Total	Survival[z]	Shoot	Root	Total[y] plants examined	No. abnormal plants	No. abnormal cells
0	63	60	31	155	26	0	0
10	73	60	35	164	27	4	4
20	57	48	34	182	22	4	8
40	67	45*	30	112*	21	2	2
80	57	32**	25	83*	10	2	6
160	63	18**	23	12**	5	1	2

[z]Seedlings surviving 50 days after sowing.

[y]Total number of plants in which more than 10 mitotic figures were confirmed in roots.

*,**Significantly different from 0 ppm treatment as 5% (*) and 1% (**) level.