



Fig. 1. Adventitious shoot arising from winged bean storage root grown in the greenhouse.

plants within each watering treatment were cut at the soil line and half were cut immediately below the first node, about 3 cm above the soil line. Pots of each treatment were assigned at random to 8 replications arranged in a randomized complete block.

Slips were pulled at the 2- to 3-leaf stage

after washing the medium away from the slip with a stream of tap water. This method preserved most of the adventitious roots on the stem of the slip and enhanced the vigor of the resulting plant. Medium washed away from the crown was replaced after each harvest. Transplanting was discontinued after 60 slips were transplanted and grown, with the loss of only one plant from infection by a root-rotting pathogen. Slips were produced throughout summer and the last harvest was made on August 27, 1982.

There was extensive crown loss in the first experiment due to soft-rot infections, especially in the treatments with separated crowns. There was little, if any, callusing of the broken root pieces in either curing treatment. This is unlike the response of other crops with storage roots, such as the sweet potato (*Ipomoea batatas* L.). Lack of wound healing probably was a contributing factor in crown loss from root-rotting pathogens.

Only 22% of the crowns in the study produced slips and the largest number produced by an individual crown was 4 slips. Differences in slip production were not significant for either crown separation or curing treatments.

Crowns were not removed from the pots in which they were grown in the 1982 study, and slip production was more successful. Every crown in the 1982 study produced at least one slip and several produced more than 10 slips. Numbers of slips produced were not significantly different for watering treatment or position of cutting the main stem.

The best method for propagation of the winged bean from crowns was to leave the roots undisturbed after plant senescence and harvest the emerging slips. The method described, in conjunction with propagation by stem cuttings (2), gives researchers the capacity to produce large clonal populations of selected winged bean plants.

Literature Cited

- Herklots, G.A.C. 1972. Vegetables in South-East Asia. George Allen and Unwin, Ltd., London. p. 257–260.
- Lawhead, C.W., J.P. Bennett, and M. Yamaguchi. 1979. Propagation of winged bean [Psophocarpus tetragonolobus (L.) D.C.] by stem cuttings. Trop. Agr. 56(3):271-276.
- 3. Mehta, U. and H.Y. Mohan Ram. 1981. Tissue culture and whole plant regeneration in the winged bean (*Psophocarpus tetragonolobus* L.). Ann. Bot. 47:163–166.
- 4. National Academy of Sciences. 1974. The winged bean: a high-protein crop for the tropics. The Academy. Washington, D.C.
- Rachie, K.O. and L.M. Roberts. 1974. Legumes of the lowland tropics. Adv. Agron. 26:88–89.
- Young, L.Y. (ed.). 1978. Wing beans: abstracts of world literature, 1900–1977. The International Grain Legume Information Centre, IITA, Ibadan, Nigeria.

HortScience 18(6):899-900. 1983.

The Effects of Bud Maturity on Fertilization in *Brassica campestris* L.

Leslie Allee¹ and Martha A. Mutschler² Cornell University, Ithaca, NY 14853

Abstract. Pollen tube growth and ovule fertilization was observed in 3- to 7-mm-long pistils in flowers of a rapid cycling population of *Brassica campestris* L. Pollen tubes grew past the ovules to the base of the ovaries in pistils 3- or 4-mm-long. The pollen tubes were guided toward the ovules in buds 5-mm-long or longer and in flowers of compatible or incompatible plants. Brightly florescent spots were observed at the micropyle of ovules in pistils 4-mm or longer, but not in smaller buds.

Commercial production of most of the hybrid crops of *Brassica oleracea* L. uses selfincompatibility to facilitate cross fertilization. Summaries of the characteristics of and procedures for utilizing this sporophytic selfincompatibility are provided by Wallace et al. (4, 5). Sporophytic self-incompatibility can be recognized by the failure of pollen to germinate or of the pollen tubes to penetrate the papillae of the stigma. Populations of *Brassica* species often contain a low percentage of self-compatible individuals (6). *B. campestris* also has a sporophytic homomorphic incompatibility system determined by multiple alleles at the *S* locus (1), with at least one of the multiple alleles conditioning self-compatibility.

A rapid cycling population of *B. campestris* was used to study self-compatibility in this species. While identifying *S* allele stocks, a direct relationship between bud maturity and amount of seed set was suggested. This study investigates this relationship and its cause.

Bud-selfed seed collected from self-compatible and self-incompatible plants of a rapid cycling population of B. campestris L. were grown at 21° to 24°C, 30% to 40% relative humidity in Speedling trays containing Cornell mix (3). Plants flowered 15 to 17 days after planting. Open flowers and buds 2-mm and larger were emasculated and pollinated with self-pollen then harvested 23 hr later. The pistils were isolated, measured, and treated as in (2) and (4), except that the pistils were heated in 1 N NaOH for only 30 min. Pistils from buds ranged from 2 to 7 mm in length. Pistils from flowers varied from 8 to 10 mm in length. Pistils were examined at $128 \times$ and $200 \times$ with a Zeiss WL microscope adapted for UV microscopy. Self-incompatibility vs. compatibility was determined by examining pollen tube growth in pistils from open flowers. Self-incompatible pistils had 0 to a maximum of 10 pollen tubes penetrating the stigma, while those classified self-compatible had a minimum of 20 to over 100 pollen tubes per pistil. Pollen tubes are distinguished easily from other pistilar structures by their morphology and the presence of brightly fluorescent callose plugs spaced irregularly along the length of the pollen tube (Fig. 1). Ovules were examined to see whether fertilization had occurred. Fluorescent spots were observed in a cluster of one to 10 cells in the micropylar regions of ovules before and after fertilization (Fig. 1). Once fluorescent spots had been observed in a number of

Received for publication March 1, 1983. We thank T.E. Ferrari, D.H. Wallace, and E.D. Cobb for technical assistance and use of equipment. 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.

¹Undergraduate Student.

²Assistant Professor, Department of Plant Breeding and Biometry.

Table 1.	Effects	of bud	maturity	on the	e presence	of	micropylar	spots,	pollen	tube	guidance,	and
fertiliz	ation in I	Brassica	i campest	ris.								

Pistil size (mm)	No. ovules	Fertilized ovules (%)	Ovules with spots (%)	Pollen tube growth ²				
		Self-incom						
3	62	0.0	4.9	-				
4	62	0.0	66.7	_				
5	90	10.0	73.3	+				
6	58	8.6	96.6	+				
7	44	9.1	100.0	+				
Flower $(8 +)$	274	0.4	70.1	+				
	Self-compatible flower							
3	216	0.5	13.0	-				
4	169	7.7	49.1	_				
5	205	12.7	47.8	+ /				
6	69	33.3	56.5	+				
7	51	33.3	54.8	+				
Flower $(8 +)$	285	27.4	62.8	+				

z + z = some pollen tubes grow toward ovules. - z = pollen tubes grow past ovules.

ovules, all succeeding ovules were examined for the absence or presence of this distinctive feature.

The frequency of fertilization was very low in 3- or 4-mm buds, despite pollen tube growth in the style (Table 1). Fertilization frequency leveled off in 5- or 6-mm buds and dropped sharply for open flowers of self-incompatible plants. Fertilization frequencies were 9% to 10% in self-incompatible compared to 21% to 23% in self-compatible plants. The average seed set in interpollinated plants from the same population is 8 to 10 seeds per silique, accounting for one third of the ovules per silique.

Pollen tube growth occurred in all pistils of self-compatible plants, and in pistils of 3to 7-mm buds of self-incompatible plants. However, in the majority of 3- or 4-mm buds, and a few 5-mm buds, all the pollen tubes in an ovary grew beyond the ovules to the ovary base rather than diverting towards the ovules (Table 1, Fig. 1). This resulted in a low frequency of fertilization in these buds.



Fig. 1. Ovule of 4-mm pistil from a self-compatible plant $(124 \times)$. Ovule shows florescent spots in micropylar region (M). Pollen tubes, recognizable by presence of callous plug (C), can be seen growing toward base of ovary, but no pollen tubes have grown toward the ovule.

The phenomenon was observed in both selfcompatible and self-incompatible plants. The few pollen tubes present in pistils from selfpollinated, self-incompatible flowers did grow towards the ovules, showing that the guidance mechanism was functional. These observations indicate that a mechanism exists which guides pollen tubes towards ovules, that the mechanism is inactive in very young (3- to 4-mm) buds, is active in more mature (5 + mm) buds and flowers, and is independent of the self-compatibility system.

The appearance of fluorescent micropylar spots is dependent also on bud maturity, since they were seldom found in ovules of 3-mm buds, but usually were found in the larger buds and flowers (Table 1). Appearance of the spots preceeded activation of the system which guides the pollen tubes towards the ovules. These 2 phenomena may be related, but there is no direct evidence that the micropylar spots and the pollen tube guidance system are interdependent. The frequency at which the spots were present was lower in self-compatible than in incompatible plants. However, since the spots appear in the buds and flowers of both, they are probably not related to the self-incompatibility system.

A practical implication of this work is that there is a limited range of bud sizes (maturity) for which bud pollinations will be successful. Buds 5-mm or longer will be effective in the population studied. It is likely that a similar pollen tube guidance occurs in all *Brassica* crops. A study of pollen tube growth in those crops may help select the bud sizes most likely to give good self-seed set.

Literature Cited

- Bateman, A.J. 1955. Self-incompatibility systems in angiosperms. III Cruciferae. Heredity 9:53-68.
- Ferrari, T.E., S.S. Lee, and D.H. Wallace. 1981. Biochemistry and physiology of recognition in pollen-stigma interactions. Phytopathology 71:752–755.
- Sheldrake, R. and J.W. Boodley. 1973. Cornell peat-lite mixes for commercial plant growing. Coop Ext. I.B. 43, N.Y. State College of Agr. & Life Sci., Cornell Univ., Ithaca, N.Y.
- Wallace, D.H. 1979. Procedures for identifying S allele genotypes of *Brassica*. Theor. Appl. Genet. 54:249–265.
- Wallace, D.H. and M.E. Nasrallah. 1968. Pollination and serological procedures for isolating incompatible genotypes in the crucifers. Cornell Univ. Agr. Expt. Station Mem. 406.
- Zuberi, M.I., S. Zuberi, and D. Lewis. 1981. The genetics of incompatibility in *Brassica*.
 Inheritance of self-incompatibility in *Brassica campestris* L. Var. Toria. Heredity 46:175–190.