

UNIVERSITY OF ILLINOIS  
UNITED STATES DEPARTMENT OF AGRICULTURE

1) Effect of grafting date and maturity of the stock on the flowering behavior of soybean scions.

Many crosses made by midwestern U.S. soybean breeders are made between adapted genotypes and genotypes of later maturity. Due to a short growing season, soybean breeders in the northern U.S. are often unable to sufficiently delay planting of adapted genotypes to synchronize flowering with genotypes of later maturity. Photoperiod chambers are expensive and covering plants is time consuming and often produces cleistogamous flowers. Kiihl et al. (1977) demonstrated that grafting soybeans could be used as a tool to facilitate wide crosses.

This research was designed to examine the effect of grafting date and maturity of the stock on the flowering behavior of scions ranging in maturity from Maturity Group V to Maturity Group IX. It was hoped that this research might provide information which would enable soybean breeders to be more successful in using grafting for making wide crosses.

Materials and methods: Experiments were conducted at the Agronomy South Farm at Urbana, IL, during 1977 and 1978. At three different dates during the growing season, scions of 'Essex' (Maturity Group V), 'Ransom' (Maturity Group VII), 'Improved Pelican' (Maturity Group IX), and 'Jupiter' (Maturity Group IX) were grafted onto 'Hodgson' (Maturity Group I) and 'Williams' (Maturity Group III) stocks. Cultivars used as scions were grafted onto themselves (self-grafts) and left undisturbed (non-grafts) to serve as standards. Grafting dates were 7 July, 17 July, and 28 July in 1977 and 30 June, 11 July, and 20 July in 1978. A split-plot arrangement of a randomized complete block design with six replications was used. Grafting dates were considered the whole plots and the grafting treatments were considered the sub-plots. Days to first bloom were recorded.

The unbalanced nature of the data resulting from unsuccessful grafts prevented the valid comparison of the effect of years and scions in a split-plot analysis. As a result, a separate analysis of variance was conducted for each grafting date and year combination.

A modification of the "straw band" technique described by Bezdicek et al. (1972) was used for grafting. The stock was cut immediately above the

last fully expanded leaf. A wedge was made in the scion on the internode above the last fully expanded leaf. All partially expanded leaves were removed from the scion in order to reduce the risk of dessication. In addition, the grafts were made in the late afternoon such that the scion was initially exposed to a period of low-water demand. This eliminated the need for a plastic bag cover over the scion and graft.

Results and discussion: Although 63% of all scions produced flowers, a maximum of 92% of the Essex scions from the 4 July average grafting date produced at least one flower. The percentage of scions producing flowers decreased as the grafting date was delayed. In fact, only 35% of the scions grafted on the Hodgson stocks on the 24 July average grafting date produced flowers. Mean days from grafting to flower initiation decreased as the grafting date was delayed (Table 1). However, the decrease was generally insufficient to compensate for the delay in grafting. As a result, mean days from 1 July to flower initiation increased as the grafting date was delayed (Table 2). The genotype of the stock had a significant effect on the mean days from grafting to flower initiation (Table 1). The absence of significant stock x scion interactions in the analyses of variance indicated that the stock effects were consistent for the scions used in the experiment. Flowers were produced in the fewest number of days on scions grafted on the Hodgson stock on the 4 July average grafting date (Table 1). However, as the grafting date was delayed, scions on the Williams stocks tended to produce flowers in fewer days than scions on the Hodgson stocks (Table 1).

With the exception of the Essex and Ransom scions on the 24 July average grafting date, scions grafted on stocks of earlier maturity produced flowers earlier in the growing season than their non-grafted counterparts (Table 2). In the case of Improved Pelican and Jupiter, non-grafted plants did not initiate flowering before termination of the experiment on 1 September. On the other hand, the Essex and Ransom self-grafts initiated flowering an average of five days after their non-grafted counterparts (Table 2). Improved Pelican and Jupiter scions from the 14 and 24 July grafting dates produced flowers too late in the growing season (after 15 August) to be used for crossing purposes under Illinois conditions.

Summary: Grafting late maturity scions on stocks of earlier maturity appears to be a simple and effective means of hastening flowering of soybeans



grown in the northern U.S. Grafts should be made as early in the growing season as possible (before or near 1 July in central Illinois) on stocks of very early maturity (Group 0 or I) in order to obtain flowers on scions during a period when they can be used for crossing purposes. Under central Illinois conditions, scions as late as Maturity Group IX can be induced to flower by the first week of August.

### References

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Table 1  
Mean days from grafting to flower initiation  
when averaged over two years

Average grafting date	Scion	Stock	
		Hodgson	Williams
		days	
4 July	Essex	26	28
	Ransom	29	33
	Imp. Pelican	34 <sup>a</sup>	41
	Jupiter	33	37
14 July	Essex	21	24
	Ransom	28	30
	Imp. Pelican	36	37
	Jupiter	37	37
24 July	Essex	18	18
	Ransom	24	23
	Imp. Pelican	39	32
	Jupiter	40 <sup>a</sup>	35

<sup>a</sup>Mean based on one year of data.

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Table 2

Mean days from 1 July to flower initiation  
when averaged over two years

Scion	Stock	Not grafted	— Average grafting date —		
			4 July	14 July	24 July
			days		
Essex		36.0			
Essex	Essex		40	42	41
Essex	Hodgson		29	34	41
Essex	Williams		31	37	41
Ransom		47.5			
Ransom	Ransom		40+ <sup>a</sup>	53	54+ <sup>a</sup>
Ransom	Hodgson		32	41	47
Ransom	Williams		36	43	46
Imp. Pelican		*			
Imp. Pelican	Imp. Pelican		*	*	*
Imp. Pelican	Hodgson		37	49	62
Imp. Pelican	Williams		44	50	55
Jupiter		*			
Jupiter	Jupiter		*	*	*
Jupiter	Hodgson		36	50	63
Jupiter	Williams		40	50	58

\*Did not produce flowers before termination of the experiment on 1 September.

<sup>a</sup>Means based on one year of data.

J. S. Beaver  
R. L. Nelson

## 2) An allele at the *rps*<sub>1</sub> locus from the variety 'Kingwa'.

Four genes at the same locus affecting reaction to phytophthora root rot have been previously identified.

Allele	Source	References
<i>rps</i> <sub>1</sub>	Harosoy	Bernard et al. 1957 (as <i>ps</i> )
<i>Rps</i> <sub>1</sub>	Mukden	" " " " (as <i>Ps</i> )
<i>Rps</i> <sub>1</sub> <sup>b</sup>	FC 31745	Hartwig et al. 1968 (as <i>rps</i> <sup>2</sup> )
<i>Rps</i> <sub>1</sub> <sup>c</sup>	Arksoy, PI 54615-1	Mueller et al. 1978

As part of our breeding effort to create adapted varieties with resistance from diverse sources we selected the variety 'Kingwa' which had been reported by Athow et al. (1974) to be resistant to several races of the phytophthora-rot organism. We used it as a donor parent in backcrossing programs with the varieties 'Clark' (Group IV), 'Corsoy' (Group II), 'Wells' (Group II), and 'Williams' (Group III). During backcrossing the resistance appeared to be controlled by a single dominant gene which we tentatively designated  $Rps^k$ . Further evidence of this was obtained during selection and testing in generations after the final backcross and is presented below for Corsoy and Williams.

We hypocotyl-inoculated the progenies of 39  $F_1$  plants of Corsoy<sup>8</sup> x Kingwa with mycelium of race 5 and found 19 to be all-susceptible and 20 to be segregating for resistance (expected = 19.5:19.5, probability of a larger chi-square  $P = 0.9$ ). The 20 segregating families totalled 238 resistant  $F_2$  plants and 87 susceptible ones (expected = 243.8:81.3,  $P = 0.5$ ). Forty-two resistant  $F_2$  plants were grown to maturity and progeny tested with race 5. Twenty-eight segregated and 14 were found to be true-breeding for resistance (expected = 28:14,  $P = 1.0$ ).

Likewise, using race 5 with Williams<sup>7</sup> x Kingwa we found that, of the progenies of 18  $F_1$  plants, there were 11 all-susceptible and 7 segregating (expected = 9:9,  $P = 0.3$ ). The 7 segregating families totalled 59 healthy and 11 infected  $F_2$  plants (expected 52.5:17.5,  $P = .07$ ). Of 32 resistant  $F_2$  plants grown to maturity 20 segregated and 12 produced all-resistant progenies (expected 21.3:10.7,  $P = 0.6$ ).

We then tested resistant progenies from both the Corsoy and Williams backcrosses with other races and found them to be resistant to races 1 through 9. Additional testing here by C. D. Nickell (personal communication) has shown them to be resistant also to races 10, 13, 14, and 15, but to be susceptible to races 12 and 16 (race 11 not available).

We next attempted to combine  $Rps^k$  with other genes for resistance. We crossed a resistant Corsoy isolate from Corsoy<sup>8</sup> x Kingwa (designated L27) with an isolate from Corsoy<sup>6</sup> x Lee 68 with the  $Rps_1^c$  gene, which was released commercially as 'Corsoy 79'. In testing of Corsoy 79 x L27 with race 5, to which Corsoy 79 is susceptible, we found 75 healthy and 30 infected  $F_2$  plants (expected 78.8:26.2,  $P = 0.4$ ). However, all 312  $F_2$  plants tested with race 1 were resistant. Since Corsoy 79 and L27 each have monogenic resistance to race 1 and no susceptible  $F_2$  plants segregated, we concluded that  $Rps^k$  is at



the same locus as  $Rps_1^c$  and should be designated  $Rps_1^k$ .

Similarly, we tested a Williams- $Rps_1^k$  isoline from Williams<sup>7</sup> x Kingwa, designated L24, by crossing with an  $Rps_1^c$  isoline from Williams<sup>6</sup> x Lee 68 released as 'Williams 79'. In tests of Williams 79 x L24 with race 5, to which Williams 79 is susceptible, there were 256 healthy and 89 infected  $F_2$  plants (expected 258.8:86.2,  $P = 0.7$ ). All 165  $F_2$  plants tested with race 3 were resistant.

We also crossed L24 with L26, an isoline from Williams<sup>7</sup> x Harrel, with another allele at locus 1  $Rps_1^b$ . L26 is susceptible to race 2 but resistant to 1 and 3 through 9. When tested with race 2 there were 67 healthy and 30 infected  $F_2$  plants (expected 72.8:24.2,  $P = 0.18$ ), but all 114  $F_2$  plants tested with race 1 and all 108 tested with race 5 were resistant. This agrees with the evidence from the Corsoy isolines that the gene from Kingwa is at the  $rps_1$  locus.

Since the only difference between  $Rps_1^b$  and  $Rps_1^k$  appears to be its reaction to race 2 we again inoculated the Williams isolines and again found  $Rps_1^b$  to cause a susceptible and  $Rps_1^k$  a resistant response to this race.

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R. L. Bernard  
C. R. Cremeens