Pinto Bean Ideotype for the Midwest

M. E. Malburg and J. D. Kelly
Michigan State University
East Lansing, MI 48824

The success of the ideotype concept in the small seeded (20 g/100 seeds) navy bean market class prompted the architectural improvement of the medium seeded (40 g/100 seeds), prostrate pinto bean class. Architectural improvement based on the navy ideotype was limited in the pinto class by negative linkages between seed size and erect plant architecture (Kelly and Adams, 1987). Using recurrent selection, Kelly and Adams (1987) developed a pinto ideotype by combining the upright architectural traits of the navy and black bean germplasm with the seed size of the prostrate pinto.

To investigate the genetic relationship between seed size and architecture, two populations were evaluated; N84004 x UI-114 and Michelite x P89405. The cross N84004 x UI-114 is a navy ideotype crossed to a prostrate pinto. Michelite x P89405 is the reciprocal cross, a prostrate navy crossed to a pinto ideotype. At maturity, plants were rated on a scale of 1 to 9 for plant architecture. A rating of 9 represents the navy ideotype whereas the prostrate pinto was rated 1. Intermediate ratings were designated according to the degree of deviation from the navy ideotype.

In the F_2 generation of both populations, the correlation between seed size and architecture was virtually zero and non-significant, indicating the traits were unlinked. Directional selection experiments were conducted to determine if selection based on plant architecture has any effect on seed weight. For each population, ten F_2 plants with architecture ratings of 6 or greater and ten F_2 plants with architecture ratings of 3 or less were randomly selected for a total of 20 $F_{2:3}$ families. At maturity, families were rated for architecture and average seed weights were taken (g/100 seeds).

Architecture rating and seed weight were non-significantly correlated in the N84004 x UI-114 families. There was a significant but low negative correlation ($r=-0.26^*$, $P=.05$) for the Michelite x P89405 families. But, directional selection for high or low architecture rating did not result in significant differences in mean seed weight for either population. The results of the directional selection studies confirm that architecture and seed weight are not linked in repulsion phase.

Architecture rating was estimated to be highly to moderately heritable using parent/offspring regression of a F_2 parent on a F_3 generation. N84004 x UI-114 had a heritability estimate of 0.85^{**} ($P=.001$) whereas the Michelite x P89405 population had a slightly lower heritability estimate of 0.60^{**} ($P=.005$). The heritability estimates indicate that selection for plant architecture can be effectively conducted in early generations. However, in the early cycles of Kelly and Adams's (1987) recurrent selection, architectural selections invariably had small seed size.

A directional selection study with the population P89405 x N84004 was conducted to investigate why medium seeded, upright beans were not recovered in the initial cycles of recurrent selection. Both parents have type II growth habits so progeny did not segregate for architectural traits but did segregate for yield components X, average number of pods; Y, average number of seeds per pod; and Z, average weight per seed (Adams, 1967).

In the directional selection study, ten F_2 plants with seed weight greater than 30 g/100 seeds and ten F_2 plants with seed weights less than 24 g/100 seeds were randomly selected for a total of 20 $F_{2:3}$ families. At maturity, 15 plants with uniform competition were randomly sampled for each family. Data were collected on the number of pods, the number of seeds, and the weight of 100 seeds.

$F_{2:3}$ families selected for high seed weight had a significantly higher mean seed weight than families selected for low seed weight. Directional selection for high versus low seed weight did not result in significant differences in seed yield (Table 1). Because the pinto ideotype represents a two-fold increase in yield component Z, average weight per seed, one or both of the remaining components must be compensating to preserve yield. Directional selection for high or low seed weight did not cause a significant difference in the average number of pods (yield component X). However, yield component Y, average number of seeds per pod, was significantly different in response to directional selection (Table 1). In the P89405 x N84004 population, the yield component seeds per pod compensates for seed weight to preserve yield.

The mean number of seeds was also significantly different in response to directional selection for high or low seed weight (Table 1). Correlations between seed number and the yield components were all significant. In particular, pod number was highly correlated to seed number ($r=0.82^{**}$, $P=.001$) therefore, number of pods could also compensate for yield.

The data indicate that architecture and seed weight are not linked in repulsion phase. If selection were based visually on pod traits of the navy ideotype, then in effect, one would be selecting for small seed size. Selection for medium seeded, upright plants should be based on the pinto ideotype which is physically different from the navy ideotype due to yield component compensation. The pinto ideotype is defined as having fewer seeds per pod or fewer pods per plant than the navy ideotype.

Table 1. Mean response to directional selection for high and low seed weights.

	Seed Weight			
Trait	High	Low	LSD	P
Seed Weight (g/100 seeds)	30.9	25.2	2.0	.007
Yield (grams)	36.9	35.1	3.5	ns
Number of Pods	29.5	30.7	1.9	ns
Number of Seeds per Pod	4.1	4.6	0.4	.04
Number of Seeds	120.1	140.7	6.6	.005

REFERENCES

Adams, MW. 1967. Basis of yield component compensation in crop plants with special reference to the field bean, *Phaseolus vulgaris*. Crop Sci 7:505-510.

Kelly, JD and MW Adams. 1987. Phenotypic recurrent selection in ideotype breeding of pinto beans. Euphytica 36:69-80.