REPEATABILITY OF MORPHOLOGICAL & PHENOLOGICAL TRAITS USED BY THE CROPGRO-DRY BEAN CROP MODEL

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CROPGRO-dry bean is a process-orientated model that simulates vegetative growth, reproductive development and seed yield of common bean (Hoogenboon et al., 1994). The model uses data on daily weather, soil characteristics and crop management practices to predict crop growth, development and seed yield. The model uses cultivar-specific coefficients to represent different cultivars. Use of simulation models by plant breeders, however, has been limited due to the restricted capability of models to represent genetic differences (Hoogenboom et al., 2004; Hoogenboom and White, 2002). GENEGRO integrated the action of seven genes into the common bean model (White et al., 1996). The GENEGRO model explained >80% of observed variation in days to flowering and maturity but only 31% of variation in seed yield from 14 trials conducted in Colombia, Guatemala, Mexico and Florida. Growth habit (*Fin* gene) had a large effect on seed yield. Determinate lines had low seed yields due to their short life cycles (Hoogenboom et al., 1997). Most of the determinate genotypes in the trials, however, were early-maturity, large-seeded Andean bean lines. The objectives of this research were to 1) estimate repeatability of morphological and phenological traits used in the CROPGRO-dry bean model in a population derived from a cross between parents having different growth habits and 2) determine whether growth habit should be major consideration when using the CROPGRO-dry bean model. Eighty two indeterminate and 36 determinate recombinant inbred lines (RIL) from the cross "ICA Pijao x Montcalm' were evaluated at Isabela, Puerto Rico during 2004 and 2005. Both parents are adapted to Puerto Rico with similar yield potential and days to maturity. ICA Pijao has an indeterminate growth habit and a 19 g hundred seed weight (HSW) whereas Montcalm has a determinate growth habit and a 55 g HSW. Experiments were arranged in four randomized complete blocks each year. The experimental units were single 2 m rows. Genetic coefficients used the CROPGRO model and seed yield components were measured for each RIL. Repeatabilities were calculated to estimate the ratio of genetic variation to phenotypic variation for genetic coefficients and seed yield components. Mean seed yields of determinate and indeterminate RILs were similar in 2004 and 2005 (Table 1). Lower mean seed yields during 2004 were attributed to drought stress caused by higher temperatures, strong trade winds and low rainfall during the growing season. There were significant line x year interactions for seed yield for the determinate and indeterminate lines. Mean photothermal days (PTD) from emergence to first flower (EM-FL) of the determinate lines was 3.7 PTD earlier than the indeterminate lines in 2004 and 6.2 PTD earlier in 2005. The indeterminate lines had lower repeatabilities for EM-FL. The mean period from first flower to the beginning of seed fill (FL-SD) of the determinate RILs was 2.2 PTD shorter than the indeterminate RILs in 2004 but 8.8 days longer than the indeterminate RILs in 2005. The mean period from the beginning of seed fill to physiological maturity (SD-PM) of the indeterminate RILs was 21.2 PTD shorter than the determinate RILs in 2004 but 0.6 PTD longer than the determinate RILs in 2005. Repeatabilities of FL-SD and SD-PM were, with one exception, intermediate in magnitude. The unfavorable growing conditions in 2004 resulted in a reduction of the mean number of pods per plant and mean number of seed per pod of both the determinate and indeterminate RILs. The determinate RILs averaged 0.3 fewer seed per pod than the indeterminate RILs in 2004 and 0.4 fewer seed per pod than the indeterminate lines in 2005. The determinate lines averaged 2.5 more pods per plant than the indeterminate RILs in 2004 but averaged 0.2 fewer pods per plant than the indeterminate RILs in 2005. Repeatabilities of seed per pod and number of pods per plant were generally intermediate in magnitude. Mean individual seed weights of the determinate and indeterminate RILs differed by only 0.02 g both in 2004 and 2005. Although repeatabilities of individual seed weight were large for both growth habits only a few of the determinate RILs had seed weights similar to Montcalm. In this population, individual seed weight and growth habit were not associated with differences in seed yield. However, sensitivity of determinate lines to abiotic stress may make the prediction of seed yield of this growth habit more difficult. Number of pods per plant was the only trait in the study that had large and positive correlations with seed yield for both growth habits during 2004 and 2005 (Table 2).

Table 1. Mean, minimum, maximum and repeatability of genetic coefficients of the CROPGRO–Dry bean model of determinate and indeterminate lines from the cross 'ICA Pijao x Montcalm' tested at Isabela Puerto Rico.

Genetic coefficient	Growth habit	Mean (Minimum, Maximum)		Repeatability estimate	
		2004	2005	2004	2005
EM-FL[1]	Determinate	45.2 (42.4-50.0)	45.3 (36.7-51.7)	0.59	0.83
	Indeterminate	48.9 (44.6-61.3)	51.5 (46.0-59.3)	0.19	0.16
FL-SD[1]	Determinate	15.6 (13.2-22.2)	30.9 (19.5-36.2)	0.24	0.63
	Indeterminate	17.8 (12.6-36.8)	22.1 (17.4-26.9)	0.07	0.63
SD-PM[1]	Determinate	35.7 (18.7-45.4)	34.8 (26.6-48.8)	0.51	0.77
	Indeterminate	14.5 (7.4-25.2)	35.4 (26.6-44.6)	0.35	0.47
Pods per plant	Determinate	21.7 (13.1-34.7)	16.4 (8.3-27.2)	0.58	0.55
	Indeterminate	19.2 (9.8-32.9)	16.6 (7.0-24.0)	0.48	0.60
Seeds per pod	Determinate	3.7 (2.8-5.1)	2.7 (1.5-4.0)	0.91	0.54
	Indeterminate	4.0 (2.5-5.2)	3.1 (1.7-5.0)	0.62	0.22
Individual seed weight (g)	Determinate	0.28 (0.18-0.55)	0.27 (0.20-0.48)	0.91	0.82
	Indeterminate	0.26 (0.16-0.41)	0.25 (0.17-0.39)	0.93	0.82
Seed yield (kg/ha)	Determinate	2174 (1325-3280)	1123 (640-1785)	0.43	0.56
	Indeterminate	1903 (880-3395)	1256 (440-2390)	0.48	0.76

[1] Photothermal days

Table 2. Phenotypic correlations of seed yield components with seed of determinate and indeterminate lines from the cross 'ICA Pijao x Montcalm' tested at Isabela Puerto Rico.

	Indeterminate lines Seed yield		Determinate lines Seed yield	
	2004	2005	2004	2005
Pods per plant	0.85	0.73	0.68	0.73
Seed per pod	0.31	0.35	NS	0.47
Seed weight	NS	NS	0.35	NS

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