RELATIONSHIPS BETWEEN PRODUCTIVE CHARACTERISTICS OF DRY BEAN CULTIVARS IN THE GREEN-HOUSE AND IN THE OPEN AIR.

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INTRODUCTION

Increasing productivity without reducing the size and weight of seeds is one of the fundamental objectives in improving Spanish dry-bean cultivars. The hybridisation programs we are developing. with backcross and genealogical methods. are based on the evaluation and selection of individual plants. This evaluation is carried out in the greenhouse and in the field.

Phenotypical selection per seed yield/plant is inadvisable. at least during the first generations. given the fact that in general low heritability and negative correlation between seed number/plant and weight/seed have been recorded. The main objective was to determine the criteria for selection under our test conditions (greenhouse and open air). The correlation between productive characteristics in both test condition has enabled us to decide on the criteria.

In a previous experiment (Palomares et al., 1992) phenotypical correlations were estimated for greenhouse cultivation using different combinations of substrate + fertilizer + application time (treatments A and B): from the results obtained treatment A was chosen. Those results complement and contrast with these obtained for open air cultivation.

MATERIAL AND METHODS

Three dry bean cultivars (**Africa, Pepa** and **Alaska**) were tested in the open air in Valencia (Spain). All these cultivars correspond to I growth habit, carry genetic resistance to BCMV and are highly productive. They differ in colour and seed, weight and vigor: **Africa** belongs to the "red mottled" type. with a 90-day cycle. it is vigorous and has a medium-size seed (40 gr/100 seeds); **Pepa**. "long white" type. 110-day-long cycle. vigorous and medium-large size (55 gr/100 seeds): **Alaska**, "long white" type, 110-day-long cycle, less vigorous than the others and medium size (40 gr/100 seeds).

The design was in random blocks with 3 repetitions: elemental plot. a 4 metre-long rows. with 40 plants/row planted equidistantly. with a distance of 0.6 between rows (the corresponding growing density of this design is approximately 167,000 plants/hectarea). Characteristics regarding number of seeds/plant. number of pods/plant and seed yield/plant were measured in the 20 plants found at the centre of each row. Growing conditions were as follows: sandy loam soil, direct sowing, thinning out after germination. harvesting dates: 21 April - 12 August. Temperatures were 21 °. 40 ° and 29 °C (min, max and average): HR, 20, 100 and 72 % (min, max and average).

RESULTS AND DISCUSSION

Table 1 gives the average values for all the characteristics analyzed for **Africa** in both greenhouse and outdoor tests. The most notable conclusion is that all characteristics, with the exception of seed number/pod. reached average values which were lower than or equal to those obtained in the greenhouse.

Phenotypical correlations are given in Table 2. The highest correlations are found between: weight seed /plant and seed number/plant; weight seed/plant and number of pods/plant: number of seeds /plant and number of pods/plant. regardless of environment and cultivar. The remaning correlations for the cultivars grown out of doors are similar for all three cultivars: they are lower. and the majority lack statistical significance. When comparing greenhouse results with open air. the main differences are found between the number of seeds/plant and average weight/seed. and the number of pods/plant and average weight/seed (nil in the field and negative in the greenhouse). as well as between the number of seeds/pod and average weight/seed (nil in the field and positive in the greenhouse).

Field cultivation would appear to mask the relationship between characteristics when their correlations are medium or low, although not when they are high. The multiple regression analysis has lead to the following equation for the highest R-squared for all situations: weight seeds/plant = K + a x N° seeds/plant + b x average weight/seed ($0.95 \cdot R^2 \cdot 0.98$). Nevertheless, the different values of the coeficients of the equation for each situation do not allow for a single, general equation. However. in all cases the coeficient signs are kept, and with **Africa** both environments give similar values.

Table 1.- Averages for the productive characteristics of Africa.

		WEIGHT SEEDS/PLANT (gr)	N° PODS/PLANT	N° SEEDS/PLANT	AVERAGE SEEDS/POD	AVERAGE WEIGHT/SEED (gr)
GREENHOUSE	A	20.3 ± 2.06 a	13.2 ± 1.23 a	51.3 ± 5.60 a	4.0 ± 0.18 b	0.4 ± 0.02 a
	B	16.0 ± 2.06 ab	9.9 ± 1.23 ab	42.1 ± 5.60 a	4.4 ± 0.18 ab	0.4 ± 0.02 a
OPEN AIR		11.9 ± 0.84 b	8.2 ± 0.50 b	45.5 ± 2.09 a	4.5 ± 0.07 a	0.3 ± 0.01 b

The letters a, b, c refer to the comparison between means with LSD test (α = 5%)

Table 2.- Correlations between productive characteristics

	WEIGHT SEEDS/PLANT(gr)	N° SEEDS/PLANT	N° PODS/PLANT	AVERAGE SEEDS/POD	AVERAGE WEIGHT/SEED (gr)
WEIGHT SEEDS/PLANT (gr)		0.95 ± 0.02 0.89 ± 0.01	0.78 ± 0.10 0.93 ± 0.01	0.30 ± 0.24 0.21 ± 0.10	-0.07 ± 0.28 0.39 ± 0.09
N° SEEDS/PLANT	0.89 ± 0.01 0.95 ± 0.01 0.97 ± 0.01		0.91 ± 0.04 0.98 ± 0.01	0.06 ± 0.26 0.21 ± 0.10	-0.09 ± 0.23 0.07 ± 0.11
N° PODS/PLANT	0.93 ± 0.01 0.94 ± 0.01 0.90 ± 0.01	0.96 ± 0.01 0.98 ± 0.01 0.92 ± 0.01		-0.32 ± 0.24 -0.05 ± 0.11	-0.12 ± 0.16 0.07 ± 0.11
AVERAGE SEEDS/POD	0.21 ± 0.10 0.00 ± 0.11 0.02 ± 0.11	0.21 ± 0.10 0.14 ± 0.10 0.30 ± 0.10	0.05 ± 0.11 0.15 ± 0.10 0.01 ± 0.11		0.72 ± 0.15 0.92 ± 0.11
AVERAGE WEIGHT/SEED (gr)	0.39 ± 0.09 0.11 ± 0.10 0.02 ± 0.11	0.07 ± 0.11 0.05 ± 0.11 0.02 ± 0.11	0.07 ± 0.11 0.14 ± 0.10 0.01 ± 0.11	0.02 ± 0.11 0.05 ± 0.11 0.02 ± 0.11	

Africa cultivar in the greenhouse (treatment A) and in the open air.

Africa, Alaska and Pepa cultivars in the open air

Taking all this into account, and also bearing in mind the fact that weight/seed heritability is relatively high (Sing, 1991, Palomares and Sanjuán, 1996), we consider the characteristic "average weight/seed" to be main criteria for selection First of all a truncated selection of this characteristic takes place, and then from the plants chosen, those producing the greatest number of seeds are selected. This simple procedure for phenotypical selection has enabled us to obtain a number of improved cultivars from the main Spanish types These have large seeds, BCMV resistance, higher productivity, earliness, and different growing habits Some of these cultivars are in the process of being officially registered.

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