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# Genotype and Environment Effect on Canning Quality of Dry Bean in Saskatchewan

P. Balasubramanian<sup>1</sup>, A. Slinkard<sup>2</sup>, R. Tyler<sup>1</sup>, and A. Vandenberg<sup>1</sup>  
<sup>1</sup>Department of Crop and Horticulture Sciences and Plant Ecology, <sup>2</sup>Crop Development Centre, <sup>3</sup>Department of Applied Microbiology and Food Science, University of Saskatchewan, Saskatoon, S7N 5A8

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## INTRODUCTION

Variation in response among certain production alternatives (e.g., genotypes), when evaluated in different environments, is known in the classical sense as interaction (Crossa, 1990). A knowledge of the type and magnitude of the genotype x environment (G x E) interaction enables plant breeders to decide whether to breed for wide adaptation or for adaptation to several subsets of the environment. It will also help breeders efficiently allocate resources for testing advanced lines across locations and years, It, however, poses problems when selecting the best genotype and/or making cultivar recommendations to farmers. First order interactions (i.e., genotype x year and genotype x location) if present, can be classified as either a qualitative (crossover) interaction, when one or more genotypes undergo a significant change in rank from one environment to another, or a quantitative (noncrossover) interaction, when genotypes may vary in rank, but not significantly from one environment to another (Baker 1988a, 1988b). A significant second order interaction (e.g., genotype x year x location) implies that genotypes responded inconsistently when grown under different environments.

Canning quality traits are influenced by genotype, environment and the G x E interaction effect (Ghaderi *et al.*, 1984; Hosfield *et al.*, 1984; Hosfield, 1991). As the earlier studies were based on evaluation of genotypes in either several locations in one year or several years in one location, the results are biased. Walters *et al.* (1997) in a study conducted at two locations over two years reported a significant first and second order interactions for three canning quality traits (washed drained weight, texture and appearance) they evaluated. The **objective** of this study was to determine the effect of genotype, environment and the genotype x environment interaction on several canning quality traits of selected navy bean, black bean and pinto bean cultivars grown at several locations in Saskatchewan over two years.

## MATERIALS AND METHODS

The dry bean cultivars used in this study were included in the Saskatchewan Dry Bean Regional Trial at 13 locations across the Brown, Dark Brown, and Black soil zones of Saskatchewan in 1995 and 1996. The navy bean cultivars OAC Seaforth, AC Skipper and CDC Whistler; the black bean cultivars UI 906, CDC Espresso and CDC Nighthawk; and the pinto bean cultivars Othello and Fargo were grown in a randomized complete block design (RCBD) with four replicates. However, only those locations in which the cultivars were grown in both years and which had enough seeds for canning quality evaluation on a plot basis in at least three replicates were included. The locations for navy bean were Riverhurst,

Outlook, Scott, Indian Head and Yorkton: for black bean the locations were Riverhurst, Outlook, Scott, and Yorkton; and for pinto bean the locations were Riverhurst, Outlook, Scott, Saskatoon, Yorkton and Wynyard. The Riverhurst and Outlook sites were irrigated and the rest were dryland sites. The date of sowing and harvest varied from location to location in both years.

The 100-seed weight and color of the dry seed was determined prior to processing (Table 1). A fresh-mass equivalent of 96 g of seed solids for navy bean cultivars, 97 g for black bean cultivars, or 95 g for pinto bean cultivars was weighed into individual cotton mesh bags and coded. The seed samples in the bags were soaked for 30 min at room temperature and blanched for 30 min at 70°C (black bean) or 88°C (navy bean and pinto bean) in water containing 10 mg Ca<sup>2+</sup> kg<sup>-1</sup> (10 ppm). The seed samples in the bags were cooled in cold water, drained and weighed to calculate the HC (Table 1). After weighing, the seed sample from each cotton mesh bag was transferred in its entirety to coded 14 fl oz (300 X 407) cans. The cans were filled with brine (prepared using deionized water with a calcium level the same as that of the soak water and blanch water) containing 1.3% NaCl and 1.6%, sugar. The cans were sealed, processed in a still retort using steam at 115.6°C for 45 min and then cooled in tap water at 20°C for 20 min. The processed cans were dried and stored for two weeks prior to opening for evaluation of canning quality traits (Table 1). The two week storage time enabled the bean seeds to equilibrate with the surrounding brine.

Data were subjected to the analysis of variance (ANOVA) appropriate to a RCBD for each bean class separately, using the SAS program. Bartlett's test was used to test the homogeneity of error variances over environments. In the combined ANOVA, cultivar was considered as a fixed effect, and the remaining sources of variation as random effects. To avoid negative F values in testing for the significance of cultivar effect for canning quality traits, an approximate F test, as suggested by Satterthwaite (1946) (cited by Cochran and Cox, 1992), was used.

## RESULTS AND DISCUSSION

Navy bean, black bean and pinto bean cultivars differed significantly for several canning quality traits. All cultivars (except black bean) had an HC > 1.8, a trait much desired by the processors (Table 2), since, fewer soaked, blanched seeds are needed to fill each can if a seed-lot has higher HC compared to a seed-lot with a lower HC. In black bean, however, the hard-to-cook seeds and the low (70°C) blanching temperature decreased the HC. All cultivars (except black bean) had PWDWT > 60%, thus, meeting the processors standard for HC and the legal requirement for PWDWT. Clumping was severe only in black bean, since these hard-to-cook seeds completed hydration in the can during thermal processing, an event which enhances clumping compared to seeds with optimum or high HC. Appearance was poor for all navy bean cultivars and CDC Espresso black bean cultivar. The industry standard for texture of navy bean canned in brine is 72 kg force per 100 g of processed seed (Hosfield and Uebersax, 1980). The TEXT mean of all three navy cultivars (38.5 to 48.7) was well below the canning industry requirement. Nevertheless, navy bean seeds, if canned in tomato sauce should have a high TEXT as observed by Nordstrom and Sistrunk (1977). All black bean cultivars except CDC Espresso had excellent TEXT. In general, seed samples of cultivars from frost-affected locations (Yorkton in 1995 and Scott in 1996) had a higher TEXT than all other locations in the respective years.

Table 1. Processing traits used in evaluating the canning quality of dry beans.

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**Dry seed trait**

100-seed weight: Weight of 100 randomly selected dry seeds.

**Soaked seed trait**

Hydration coefficient (HC): 
$$\frac{\text{Weight of soaked bean seeds}}{\text{Weight of dry bean seeds}}$$

An HC of 1.8 is considered optimal (Hosfield, 1991).

**Processed seed traits**

1. Washed drained weight (WDWT): Weight of rinsed bean seeds drained for five minutes on a 8-mesh screen (Tyler series) positioned at a 15° angle.

2. Percent washed drained weight (PWDWT): 
$$\frac{\text{Washed drained weight} * 100}{\text{Weight of can contents}}$$

The Canada Agricultural Products Standards Act (1978) under The Processed Fruit and Vegetable Regulations states that this value should be no less than 60%.

3. Texture (TEXT): Determined by placing 100 g of washed processed beans into a standard shear compression cell (CS-1) of a Kramer shear press (Food Technology Corporation, Rockville, MD) and shearing them at a rate of 0.62 cm/sec. A texture value of 72 kg per 100 g processed seed is the industry standard for navy bean (Hosfield and Uebersax, 1980).

4. Color (COL): The color of dry bean seed (C1L, C1a, C1b)†, processed bean seed (C2L, C2a, C2b) and cooked liquid (C3L, C3a, C3b) is measured by a HunterLab color meter (Hunter Associates Laboratory Inc., Reston, VA). A 100 g of dry seed, processed seed or cooked liquid is placed on the sample port and L, a, and b values are recorded. The sample is then rotated 90° and the L, a, and b values are recorded. The mean of above two values are used for the analysis.

5. Viscosity (VISC): Viscosity of the cooked liquid in the can is measured using a Brookfield viscometer (Model RVT, Brookfield Engineering Laboratories Inc., Stoughton, MA) with a No. 3 spindle at 100 revolutions per second.

**Subjective traits**

1. Degree of clumping (CL) (1 - 3 scale): 1 = Beans clumped solidly in the bottom of the can; 2 = Beans clumped, but easily decanted; and 3 = No clumping.

2. Appearance (AP) (1 - 5 scale): Bean seeds are evaluated for their wholesomeness, splits, free seed coats, etc. 1 = seeds blown apart, free seed coats present; 2 = seeds split badly, but holding together and no free seed coats; 3 = 60 - 69% of seeds intact and no free seed coats; 4 = 70 - 89% of seeds intact and no free seed coats; and 5 = 90% of seeds intact and no free seed coats.

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† The 'L' value reports lightness (high value = 100) and darkness (low value = 0); the 'a' value reports redness with increasing positive values and greenness with increasing negative values; and the 'b' value reports yellowness with increasing positive values and blueness with increasing negative values (Smith *et al.*, 1997).

Table 2. Means for canning quality traits of navy bean, black bean and pinto bean cultivars grown at several locations in Saskatchewan over two years.

Dry bean cultivars	Quality traits?			
	HC	PWDWT	TEXT	AP
<b><u>Navy bean</u></b>				
OAC Seaforth	1.888	62.1	38.7	2.4
AC Skipper	1.835	60.9	48.7	2.9
CDC Whistler	1.957	62.0	38.5	2.5
<b><u>Black bean</u></b>				
UI 906	1.510	59.9	85.1	3.9
CDC Espresso	1.717	59.6	57.0	2.1
CDC Nighthawk	1.758	59.8	74.8	4.4
<b><u>Pinto bean</u></b>				
Othello	1.827	61.3	45.6	3.3
Fargo	1.903	61.5	52.3	3.6

† Refer to Table 1 for units

The cultivar x year interaction was significant for HC and C2a in navy bean; CL in black bean; and WDWT and PWDWT in pinto bean. The cultivar x location interaction was significant for C3a in navy bean; WDWT and TEXT in black bean; and C3a in pinto bean. This indicates the presence of consistent year or location effect for very few canning quality traits. The cultivar x year x location interaction, was however, significant for most of the quality traits in all three dry bean classes. This indicates that the cultivars responded differently in each combination of year and location.

### CONCLUSIONS

1. The occurrence of early fall frost at several sites resulted in frost-damaged seed which impacted on both the genetic effects (late maturing cultivars) and environmental effects on the canning quality traits.
2. Dry bean seeds from irrigated sites differed very little from those from the dry land sites except in black bean.
3. The differences in soil type across the locations apparently had little or no effect on the canning quality of dry bean cultivars.
4. The presence of a cultivar x location interaction for only a few canning quality traits does not justify dividing the province into subareas for breeding and testing purposes.

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