On-farm Participatory Breeding of Common Bean, *Phaseolus vulgaris* L.

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ABSTRACT

Native Americans domesticated common bean (*Phaseolus vulgaris* L.) landraces under low-input subsistence production systems for thousands of years. In contrast, modern cultivars have been mostly bred at the Agricultural Research and Extension Centers (ARC) under high-inputs and intensive management production systems with little or no participation of producers and consumers during the breeding phase. The latter group of cultivars may have low yield, undesirable seed quality, and limited adoption. The objective of this study was to determine the effects of on-farm participatory (OFP) breeding on yield, seed quality, and adoption of common bean cultivars. Three experiments were carried out between 1999 and 2006. First, 25 cultivars released between 1932 and 1998 were evaluated at Kimberly and Parma ARC and OFP at Hazelton, Idaho from 1999 to 2001. Second, a similar group of 16 cultivars was evaluated at ARC and OFP at Kimberly in 2004 and 2005. Third, 220 families from each of two multiple-parent populations (1WS and 2WS) were selected from F_4 to F_7 independently at ARC and OFP at Kimberly between 2003 and 2006. Seed yield of cultivars in the first two experiments were the lowest at OFP. Furthermore, seed yield at Hazelton OFP was not correlated with either Kimberly or Parma ARC yields. In contrast, a positive association was found between ARC and OFP seed yields at Kimberly in the second experiment. Only partial results are available thus far from the third experiment. However, seed yield of 44 and 10 selected families out of 220 and five parents in both multiple-parent populations was significantly ($P \leq 0.05$) higher at OFP than that of ARC. Seed yield of 44 families between ARC and OFP was not correlated in either population. Of 44 families 11 were common between ARC and OFP in 1WS and 16 in 2WS. Seed yield of 10 selected families was significantly higher than the mean seed yield of unselected families and parents in both populations. But, of 10 selected families only one was common in 1WS and two in 2WS. These preliminary results may justify for OFP breeding for future common bean cultivars.

INTRODUCTION

Native Americans in Mexico, Central America, and South America domesticated common bean (*Phaseolus vulgaris* L.) landraces, from wild ancestors, under low-input subsistence production systems for thousands of years. These landraces are still grown in the Americas and form the basis of modern cultivars around the world.

The inherent genetic variability among wild populations from different geographical regions (Gepts et al., 1986), large edaphic and climatic variations along the domestication range, differences in resistance to abiotic and biotic stresses, and differences in preferences for plant type, maturity, and seed characteristics among the inhabitants resulted in thousands and thousands of distinct landraces often with limited or specific adaptation. In contrast, since organized breeding was initiated a century ago modern cultivars in the U.S. and elsewhere have been bred at the Agricultural Research and Extension Centers (ARC) often under high-input well-managed production systems with little or no participation of producers and consumers, especially during the breeding phase. The lack of participation of producers and consumers is believed to be associated with limited or lack of adoption of modern cultivars. The objective of this study was to determine the effects of on-farm participatory breeding on yield, seed quality, and adoption of common bean cultivars.

MATERIALS AND METHODS

Twenty-five common bean cultivars of great northern, pink, pinto, and red market classes released between 1932 and 1998 were evaluated at Kimberly and Parma ARC and at OFP Hazelton, Idaho from 1999 to 2001 (Singh et al., 2007). Hazelton is 30 km east of Kimberly, and Parma is 290 km west of Kimberly. A similar group of 16 cultivars was evaluated at ARC and OFP at Kimberly in 2004 and 2005. A randomized complete block design with four replicates for the first and three replicates for the second experiment was used. Also, 220 families in F_4 and F_5 (without replication) and 44 families in F_6 and F_7 from each of two multiple-parent populations, namely 1WS = Topaz///Matterhorn/Mesa//Buster/Common Red Mexican and 2WS = LeBaron///VAX 3/Common Red Mexican//Matterhorn/NW 63 were selected independently at ARC and OFP at Kimberly between 2003 and 2006 for the third experiment. In F_6 and F_7 a partially balanced lattice design with three replicates was used. Although the fields kept changing because of crop rotations used, ARC and OFP locations in Kimberly were within 5 km from each other from 2003 to 2006. Therefore, major climatic conditions were similar for ARC and OFP for the second and third experiments. Except for sprinkler irrigation at Hazelton (versus gravity irrigation at other locations) the use of fertilizer, herbicide, and cultivation were according to the local practices and varied depending upon soil tests and the judgment of producers and farm managers. But, no pesticides were used to control diseases and insect pests at any location. The comparative evaluation of breeding lines from 10 selected families from each population from each of ARC and OFP remains to be performed. Therefore, only partial results will be presented for the third experiment.

RESULTS AND DISCUSSION

Mean seed yield of 25 cultivars over the three years was the highest at Parma (3816 kg ha^{-1}) followed by Kimberly (3490 kg ha^{-1}) ARC, and OFP Hazelton had the lowest yield (3089 kg ha^{-1}). While Parma and Kimberly yields were positively correlated (0.60 $P \leq 0.01$) neither yield was correlated with OFP Hazelton yield. Mean ARC seed yield (2739 kg ha^{-1}) was significantly ($P \leq 0.01$) higher than the OFP Kimberly yield (1589 kg ha^{-1}) in the second experiment. But, there was a positive correlation (0.58* $P \leq 0.05$) between the mean seed yield of 16 cultivars at ARC and OFP Kimberly. Seed yield of all 44 and 10 selected families and five parents in both populations was significantly ($P \leq 0.05$) higher at OFP than that of ARC. Seed yield of 44 families between ARC and OFP was not correlated in either population (1WS 0.08 P>0.05; 2WS 0.19 P>0.05), suggesting that, although these families had common parents, the genetic composition of majority of families selected at ARC was different from those of families selected at OFP. Of 44 families 11 were common between ARC and OFP in 1WS and 16 in 2WS. Seed yield of 10 selected families was significantly higher than the mean seed yield of unselected families and parents. But, of 10 selected families only one was common in 1WS and two in 2WS. Differences in soil fertility, moisture availability, other abiotic and biotic factors, and management practices may have been largely responsible for seed yield differences in the first two experiments. In addition, differences in selection criteria probably contributed to seed yield differences in the third experiment. Relatively earlier maturity, upright plant type, and lighter pinto (in 1WS) and deep red (in 2WS) seed coat color were emphasized in OFP breeding while families with comparatively wider range for each of these traits were selected at ARC. But more assertive causes would not be known until a comparative study is carried out and subsequent adoption and impact of cultivars developed at ARC and OFP is assessed. Nonetheless, these preliminary results may strongly justify for OFP breeding for future common bean cultivars.**

Table 1. Mean seed yield (kg ha^{-1}) of five parents, selected 44 and 10 families out of 220 from each of two multiple-parent populations (1WS and 2WS) of common bean at the Agricultural Research and Extension Center (ARC) and on-farm participatory (OFP) breeding evaluated in 2004 and 2005 at Kimberly, Idaho.

Identification	Number	1WS		2WS	
		ARC	OFP	ARC	OFP
Parents	5	2194	2765	2378	2777
Selected families	44	2558	3093	2688	2902
Selected families	10	3265	3717	3141	3642
LSD (0.05)		299	198	156	132

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