Drought Resistance, Water Use Efficiency and Nutrient Uptake by Old and New Dry Bean Cultivars

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Introduction

Moderate to severe drought with increased precipitation deficit has been observed throughout the western United States in the recent years (Cook et al., 2004). In dry beans, drought stress reduces biomass, seed yield and harvest index (Ramirez-Vallejo and Kelly, 1998; Terán and Singh, 2002). Water use efficiency (WUE) was positively correlated with grain yield and harvest index and negatively correlated with drought susceptibility index (DSI) in wheat (Solomon and Labuschagne, 2003). The effect of drought-stress on nutrient uptake by dry bean cultivars is not known with few exceptions. Our objectives were to determine response of old and new dry bean cultivars to drought, WUE, and nutrient uptake.

Materials and Methods

Sixteen medium-seeded dry bean landraces and cultivars of great northern, pinto and red market classes were evaluated under non-stressed (NS) and drought-stressed (DS) conditions at Kimberly, Idaho in 2003. The NS treatment received seven and DS only four gravity irrigations, each of 12-hr run. Each plot consisted of 8 rows, 25 ft long with 4 replicates arranged in a randomized complete block design. The distance between rows was 22 inches. Pre-plant soil samples were taken for nutrient and moisture analyses. Also, plant (10-plants plot^{-1}) and seed (100-seeds plot^{-1}) samples were analyzed for 16 nutrients. WUE was measured for six cultivars under NS and DS conditions. Hansen data-loggers and watermark sensors were installed at three depths (0.23, 0.46, and 0.92 m) to record water potential. In addition, gravimetric soil samples were taken at 11 depths up to 2 m before and after each irrigation. Data were recorded for growth habit, days to flower, days to maturity, 100-seed weight, and seed yield.

Results and discussion

Large differences among dry bean cultivars were observed for seed yield, WUE, percent yield loss due to drought stress (PR), and DSI. The data for three contrasting cultivars, namely Common Red Mexican, UI 259 and UI 320 are given in Table 1. The Common Red Mexican, a landrace grown by the Native Americans in the western United States for thousands of years, had high seed yield and WUE in both NS and DS conditions. Common Red Mexican had drought susceptibility index of 0.88 suggesting that, on average, it yielded higher under DS conditions than other cultivars. Its seed yield in NS was also comparatively high. As summarized for six of 16 elements in Table 1, Common Red Mexican had higher seed uptake of nitrogen, phosphorus, iron, zinc, copper, and manganese in DS and NS conditions than drought-susceptible UI 259 and UI 320. These results may suggest that important genes and/or quantitative trait loci (QTL) that impart drought resistance in Common Red Mexican have been inadvertently lost in some modern cultivars. It is therefore essential to identify and tag the major drought resistance genes and/or QTL present in Common Red Mexican. Common Red Mexican should also be utilized to improve drought resistance, nutrient uptake, and WUE of cultivars such as UI 259 and UI 320.

Table 1. Seed yield (kg ha^{-1}), water use efficiency (kg ha^{-1} mm^{-1} water), seed nutrient uptake (kg ha^{-1}), reduction due to drought stress (%), nutrient uptake and drought susceptibility index (DSI) of old and new dry bean cultivars under non-stressed and drought-stressed conditions at Kimberly, Idaho in 2003.

	Non-stressed								Drought-stressed								Reduction due to drought (%)							
Cultivar	Y[1]	W	N	P	Fe	Cu	Zn	Mn	Y	W	N	P	Fe	Cu	Zn	Mn	Y	N	P	Fe	Cu	Zn	Mn	DSI
CRM[2]	2162	5.1	80	10	53	9	26	12	1164	3.5	50	6	39	5	18	7	46	38	40	26	46	31	44	0.8
UI 320	1850	3.2	48	6	36	5	17	8	471	1.5	33	4	24	4	14	5	75	30	34	33	19	18	40	1.3
UI 259	1407	2.2	79	9	60	8	25	12	502	1.4	19	2	18	2	7	3	64	76	74	70	76	72	75	1.1
Mean[3]	1792	3.6	69	9	49	8	24	11	753	2.1	36	4	27	4	14	5	59	48	50	45	54	42	56	1.0
LSD (0.05)	204	1.1	7	1	8	1	3	1	630	1.3	6	3	21	3	10	4	10	14	13	14	13	15	13	0.2

[1]Y=seed yield, W=water use efficiency, DSI=drought susceptibility index. [2]CRM=Common Red Mexican landrace.
[3]Average for 16 cultivars with exception of water use efficiency that was recorded only for 6 cultivars.

References

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