

Transferring Heat Tolerance and Indeterminacy from Indeterminate Jamaica Red (PI 163122) to Kidney Bean

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Narrow genetic diversity, determinate growth habit, and sensitivity to high temperature contribute to yield plateau in kidney bean (*Phaseolus vulgaris* L.). A heat tolerant landrace cultivar 'Indeterminate Jamaica Red' was crossed with 'Red Hawk' dark red kidney bean in an attempt to increase yield potential of kidney bean.

Indeterminate Jamaica Red (IJR), is a heat tolerant (Baiges et al., 1996) landrace cultivar that was collected from India as PI 163122 (CIAT cat. no. G 8088). It is a small-seeded mottled-light red kidney. It was collected from the same general region as the heat tolerant landrace cultivar 'Jatu Rong' (G 122, PI 163120) (Shonnard and Gepts, 1994). Another landrace from this same region, PI 163118, has also shown heat tolerance. Red Hawk, is a dark red kidney bean, developed by Michigan State University (Kelly et al., 1998). It has good seed size and canning quality and possesses resistance to bean common mosaic virus, anthracnose and halo blight. Red Hawk yields well in both tropical and temperate environments, and exhibits a moderate level of tolerance to high temperature stress in Puerto Rico. To determine inheritance of heat tolerance for the cross Red Hawk / IJR, a generation means analysis was performed on yield components for the parents, F₁, F₂, and BCF₁ grown in the greenhouse in Mayaguez, PR during the summer of 1995. For each subsequent generation we kept only those progeny expressing good yield, seed size, architecture, and maturity. Each generation involved replicated testing for yield performance under high temperature conditions in the greenhouse (Puerto Rico) or field (Puerto Rico; Parlier, CA; Prosser, WA). Thirteen advanced generation dark (DRK) and light (LRK) red kidney bean selections possessing the best yield, seed type, architecture, etc., were yield tested across three moderate temperature environments: Prosser, WA in 1998, Othello, WA in 1999, and Chico, CA in 1999. The same 13 lines were yield tested across three hot temperature environments in 1999: Fortuna and Isabela, Puerto Rico, and Jonesboro, AR.

Indeterminate Jamaica Red had higher yield than Red Hawk in the initial greenhouse heat trial due to greater pod set (data not shown). Red Hawk exhibited more blossom drop and pod abortion. Only yield (seed weight/plant) and pod set (pods/plant), with significant additive effects (Table 1), could be useful for selection for heat tolerance in this population; however, the low heritability suggested that selection should be performed among replicated lines in later generations. Indeterminate and determinate light red and dark red kidney bean lines (Red Hawk/IJR) with high yield in moderate and/or high temperature environments were observed (Table 2). Two indeterminate LRK lines out-yielded California Early Light Red Kidney (CELRK) across the moderate temperature environments, and most LRK lines outperformed CELRK in the high temperature environments. Most of the DRK lines out-yielded Red Hawk across the moderate temperature environments, whereas none out-yielded Red Hawk in the high temperature environments. Overall, indeterminate vine growth habit expressed greater yield potential than determinate bush growth habit, and LRK had greater yield potential than DRK suggesting that genes which condition dark red seed coat color in kidney bean may be associated with lower yield through linkage or pleiotropy.

Table 1. Adequacy of the additive/dominance model, broad sense heritability (h^2), and genetic effects² (SE): d=additive effects and h=dominance effects, obtained from a generation means analysis of heat tolerance in the cross Red Hawk / IJR.

Trait	Model		Genetic effects	
	χ^2 (3df)	h^2	d	h
Seed wt./plant (g)	0.9	0.28	6.7 ± 0.6	NS
Pods/plant (no.)	8.7	0.10	7.1 ± 0.6	NS
Seeds/pod (no.)	0.1	0.27	NS	NS
100 seed wt. (g)	2.0	0.42	NS	NS

Table 2. Field performance of select dark and light red kidney sister lines derived from Red Hawk / Indeterminate Jamaica Red (H9659=F2:8:11) and Red Hawk*2 / IJR (H9667=F4:7) across three normal temperature locations: Prosser, WA (1998), Othello, WA (1999), and Chico, CA (1999) and three hot temperature locations: Fortuna and Isabella, PR (1999) and Jonesboro, AR (1999).

Line	Class	Growth habit	Normal	Heat
			Average	Average
			----- lb/A -----	
H9659-27-7	LRK	vine	2896	773
H9667-86-4	LRK	vine	2804	771
IJR	LRK	vine - parent	2469	949
H9659-23-1	LRK	vine	2446	829
H9659-23-12	LRK	vine	2412	827
CELRK	LRK	bush - check	2215	609
H9667-78-3	LRK	bush	2207	847
H9667-42-11	LRK	vine	2201	969
H9667-63-2	DRK	bush	2186	704
H9667-68-7	DRK	bush	2141	927
H9659-27-10	LRK	vine	2132	1216
H9659-41-5	DRK	vine	2102	852
H9667-56-9	DRK	vine	1864	859
H9667-45-3	DRK	vine	1858	833
REDHAWK	DRK	bush - parent	1692	892
H9659-11-4	LRK	vine	1563	943

Baiges et al. 1996. BIC 39:88-89.

Kelly, et al. 1998. Crop Sci. 38:280-281.

Shonnard and Gepts. 1994. Crop Sci. 34:1168-1175.