'Redcoat' Soldier Bean

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The Michigan Agricultural Experiment Station announces the release of 'Redcoat' soldier (dry) bean (*Phaseolus vulgaris* L.). 'Redcoat' previously coded as MSU breeding line K01234, was released as a productive disease resistant soldier bean cultivar with a determinate Type I growth habit. 'Redcoat' possesses the same combination of desirable agronomic and disease characteristics as is present in the commercial 'Red Hawk' kidney bean cultivar. The seed exhibits the color pattern characteristics of the soldier bean market class in addition to displaying the attractive red color of 'Red Hawk' seed that contrasts with the white background color of the 'Redcoat' seed (Fig. 1).

Origin

'Redcoat' originated from a few off-type seeds found in a Foundation Seed lot of 'Red Hawk', a commercial dark red kidney bean cultivar grown in northern Michigan in 1999. Unlike 'Red Hawk', which has totally colored red seed, 'Redcoat' possesses a white seed with a red virgarcus pattern around the hilum (Fig 1) (Bassett, 1996, 1997). The virgarcus pattern is known commercially as the soldier bean pattern. The only other observed phenotypic difference between the two cultivars is in flower color. The flowers of 'Redcoat' are completely white, while those of 'Red Hawk' (Kelly et al., 1998) are white with faint red veins in the wing petals.

Because the circumstances around the discovery of 'Redcoat' were unusual, preliminary testing was conducted to determine if 'Redcoat' was the result of a rare outcross in the field or was a seedcoat pattern mutant of 'Red Hawk'. When grown in the greenhouse in winter 1999–2000, the few original seeds of 'Redcoat' produced progeny and seed that were true to the virgarcus type and did not segregate, indicating that the off-type seeds were not the result of cross pollination. 'Redcoat' has been planted in the field in Michigan and been compared with 'Red Hawk' over four seasons (2000–03). 'Redcoat' resembled 'Red Hawk' in phenological and agronomic characteristics (Table 1) and continued to breed true for the virgarcus seedcoat pattern.

Since only a few seeds were originally observed in the 'Red Hawk' seed lot, concern

existed that the off-type seed may actually be an inadvertent mixture with commercial soldier bean cultivar(s). No soldier bean cultivars were grown in Northern Michigan, however, where the Foundation seed lot of 'Red Hawk' was produced in 1999, nor did Michigan Crop Improvement Association (MCIA) process (clean or mill) seed of soldier bean cultivars that year. To determine if 'Redcoat' might be the result of a seed mixture a small group of soldier bean cultivars, check cultivars and 'Red Hawk' were inoculated with two common pathogens of bean to compare their reaction to 'Redcoat' (Table 2). The two pathogens used were the NL 3 strain of bean common mosaic necrosis virus (BCMNV) and races 7 and 73 of anthracnose (causal organism, *Colletotrichum lindemuthianum*). The reaction of 'Redcoat' to all three pathogens was identical to the reaction of 'Red Hawk' and different than the reactions of the checks and three commercial soldier bean cultivars (Table 2). 'Red Hawk' carries resistance genes (*I* gene, *Co-1*, *Co-2*), which confer a known reaction to BCMNV and anthracnose (Kelly et al., 1998), and based on disease reactions, 'Redcoat' appears to carry the same genes. We, therefore, concluded that

'Redcoat' arose as a mutant at one or more of the seed color and pattern loci present in 'Red Hawk' and was not the result of an accidental mixture of commercial bean seed classes.

To better understand the origin of the seedcoat color pattern in 'Redcoat', crosses were made between 'Redcoat' and 'Red Hawk' and both cultivars were also crossed to each of three genetic testers for seedcoat pattern provided by M. Bassett and described by Ernest et al. (2005).

1. *t* self-colored BC₃ 5-593;
2. *t cl z g b v* virgarcus BC₃ 5-593; and
3. *t z bip* bipunctata BC₃ 5-593.

The F₂ progeny of the 'Redcoat' × 'Red Hawk' cross segregated in a 3:1 ratio for self-colored to virgarcus seedcoat pattern (chi-square = 0.76, *p* < 0.382; Ernest et al., 2004, 2005). These data suggest that 'Red Hawk' carries a dominant gene conferring a self-colored seedcoat, while 'Redcoat' carries a recessive allele at this locus. A subset of F₂ plants which were recorded as having white flowers with pink veins all produced self-colored seed, whereas those recorded as having pure white flowers all produced virgarcus patterned seed. 'Red Hawk' must possess the dominant *T* allele, which confers self-colored seed and masks other seedcoat pattern genes (Ernest et al., 2005). 'Redcoat' carries a recessive allele at *t* that allows expression of the virgarcus seedcoat pattern genes and has a pleiotropic effect, conferring white flower color. The dominant *T* allele in 'Red Hawk' mutated to a recessive *t*, producing the pure breeding virgarcus seedcoat pattern known as soldier bean, and the white flowers of 'Redcoat'. A complete discussion of the genetic analysis of the 'Redcoat' mutant crossed with seedcoat pattern tester stocks is provided by Ernest et al. (2005).

Fig. 1. Dry seed of commercial 'Red Hawk' dark red kidney bean cultivar (left); and seed of the red virgarcus soldier bean cultivar 'Redcoat' (right).

Table 1. Yield, phenological and agronomic characteristics of 'Redcoat' with four kidney bean cultivars grown over 13 locations in mid-Michigan for 3 seasons (2001–03).

Cultivar	Class	Yield (kg·ha ⁻¹)	100-Seed wt (g ^z)	Days to flower ^z	Days to maturity ^z	Ht (cm ^z)
Redcoat	Soldier	2300 a ^y	53.3 a	38 a	97 a	47 a
Red Hawk	Dark red kidney	2497 ab	52.8 a	40 a	99 a	46 a
Montcalm	Dark red kidney	2235 a	52.8 a	42 a	101 b	46 a
Chinook 2000	Light red kidney	2692 b	51.7 a	38 a	101 b	48 a
Beluga	White kidney	2376 a	51.2 a	42 a	99 a	47 a

^zData on seed weight, days to flower, maturity and height were collected at three locations over the 3 years.

^yMeans within columns followed by the same letter are not significantly different by *t* test (*P* ≤ 0.05).

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Table 2. Reaction of nine bean cultivars to bean common mosaic necrosis virus (BCMNV, strain NL 3) and to races, 7 and 73, of bean anthracnose.

Cultivar	Class	BCMNV	7	73
Redcoat	Soldier	TN ^a	R ^b	R ^b
European	Soldier	M	S	R
Johnson Pen Pod	Soldier	M	S	R
GTS A3X 195W	Soldier	M	R	S
Red Hawk	Dark red kidney	TN	R	R
Michigan	Dark red kidney	M	S	R
Sutter	Pink	M	S	S
Seafarer	Navy	TN	S	R
C-20	Navy	TN	R	S

^aTN = top necrosis indicates presence of the hypersensitive *I* gene resistance and M = mosaic indicates susceptible reaction to BCMNV.

^bR and S are resistant and susceptible reactions to different races of anthracnose, caused by *Colletotrichum lindemuthianum*.

Since the color pattern variant in 'Redcoat' is recessive to 'Red Hawk' the mutation must have occurred before the production of foundation class seed of 'Red Hawk' in Michigan in 1999. Breeder seed of 'Red Hawk' was produced in Texas in Spring 1999. The breeder seed was hand picked to ensure purity before planting in Michigan in 1999 and no off-type seeds were observed or planted. The absence of any off-type seed would confirm that the mutation is recessive and actually occurred during the production of breeder seed in Texas. The recessive mutation was expressed a generation later when the foundation seed of 'Red Hawk' was grown and harvested in Michigan in 1999.

Description and performance

Yield, and agronomic traits of 'Redcoat' were compared to 'Red Hawk' to determine if the seedcoat pattern mutant would have any indirect effects on other traits such as yield, agronomic traits, disease resistance and quality characteristics. 'Redcoat' has been tested in replicated yield trials in mid-Michigan for 3 years (2001–03) and been compared to commercial kidney cultivars because there is no commercial production of soldier beans in Michigan. 'Redcoat' yielded 2300 kg·ha⁻¹ over 13 locations in 3 years. There was a small significant difference in yield between 'Redcoat' and 'Red Hawk' that could be attributed to differences in seed quality between the cultivars because the 'Redcoat' seed was grown in Michigan and became infected with

seed borne diseases. The lack of disease free seed of 'Redcoat' may have contributed to lower yields at some locations because disease free seed of all commercial kidney bean cultivars was used in the trials. 'Redcoat' was competitive in yield with other kidney cultivars except 'Chinook 2000'. No comparative testing was done with other soldier bean cultivars due to their low productivity.

'Redcoat' flowered 38 d after planting and matured in 97 d and was not significantly different from 'Red Hawk' in both phenological traits. The plant type of 'Redcoat' is an erect, determinate type I bush habit that is 47 cm in height and is similar in structure, height and appearance to 'Red Hawk'. Many of the commercial soldier beans have an indeterminate growth habit. 'Redcoat' carries the single dominant hypersensitive *I* gene for resistance to bean common mosaic virus (BCMV), but is sensitive to the temperature-insensitive necrosis-inducing strains of BCMNV such as NL 3 and NL 8. 'Redcoat' is resistant to races 7 and 73 of anthracnose, which would suggest that it resistant to all currently known races of anthracnose in North America because it possesses the *Co-1* and *Co-2* gene combination present in 'Red Hawk'. 'Redcoat' and 'Red Hawk' are susceptible to common bacterial blight (*Xanthomonas axonopodis* pv. *phaseoli*), and both are assumed to have similar reactions to rust (*Uromyces appendiculatus*) and white mold (*Sclerotinia sclerotiorum*; Kelly et al., 1998).

Seed size of 'Redcoat' is 53 g/100 seeds and is similar in size and shape to that of 'Red

Hawk' (Table 1). No commercial canning of soldier beans is conducted currently in the U.S. so no criteria exist to make valid comparisons. 'Redcoat' retains its whole bean integrity after canning similar to 'Red Hawk' and the red virgarcus seedcoat pattern persists after canning. Since the attractive color pattern of the dry seed is retained after canning, 'Redcoat' produces a very desirable cooked bean appearance. The major outlet for this bean class, however, is the dry pack market.

Availability

'Redcoat' soldier bean was released by Michigan Agricultural Experiment Station, East Lansing, and is available under license from Michigan State University, with the option that 'Redcoat' may be sold for seed by name only under the Foundation and Certified Seed classes. A research fee will be assessed on each hundredweight unit of Foundation Seed sold. Parties interested in licensing 'Redcoat' may contact the MSU Office of Intellectual Property at (517) 355-2186. Breeder Seed is maintained by the Michigan Agricultural Experiment Station under license with the MCIA. Small quantities of 'Redcoat' seed for testing can be obtained from the author JDK.

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