Single-Plant Selection at Ultra-Low Plant Density within a Natto Soybean Cultivar to Improve Seed Yield and Quality

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Abstract

Natto soybean [*Glycine max* (L.) Merr.] cultivars are small seeded and seed yield is generally lower than oilseed cultivars. They are primarily grown for export to Japan to produce a fermented soyfood called Natto. 'MFS-591' has been the dominant natto soybean cultivar in the Mid-Atlantic region for over 10 years. Compared to oilseed cultivars, it is small-seeded, has acceptable high water absorption, higher protein, but lower seed yield, and late maturity. Anecdotal evidence suggests MFS-591 yields have declined since its release. The main objective of this study was to perform single-plant selection for higher seed yield within the natto soybean cultivar MFS-591. A secondary objective was to investigate the existence of genetic variation for seed size, maturity, and quality characteristics within the selections. In 2008, a total of 2000 single plants from foundation seed of the soybean cultivar MFS-591 were grown at the Virginia Tech Kentland College Farm in Blacksburg in a honeycomb design using a plant spacing of 0.9 m (1.4 plants/m^2). Plants were harvested individually and their yield was adjusted based on the mean yield of 54 surrounding plants according to the honeycomb design. A total of 116 plants were selected and grown in single row plots in 2009 in a randomized complete block design with 3 replications. Data were recorded on seed yield and other agronomic and natto quality traits. Preliminary analysis suggests that variation within the single plants of the cultivar exists for seed yield, maturity, height, water absorption, and seed size. The most promising selections will be grown in 2010 in two locations in order to assess the benefits of single plant selection and identify lines with improved performance over the original MFS-591 cultivar.

Rationale

- Variation for agronomic and quality traits exists within soybean cultivars.
- Within a long-lived soybean cultivar, small but significant improvements in agronomic or quality traits, or both, justifies the effort of this approach to genetic improvement.

Fig. 1 2008 single plant honeycomb selection experiment.

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Table 1. Summary for select traits of 120 sublines of soybean cultivar MFS-591 grown in a one-row yield test in one environment in three replications in 2009. The best four sublines are considered by trait. Controls are unselected Foundation Seed.

		Yield (bu/ac)		Water Absorption (%)		Maturity (days after 8/31)		Seed Size (g/100 sds)	
		mean	max	mean	max	mean	min	mean	min
Performance of Best Lines	Best Four Sublines	64.0	66.5	222.2	222.5	34.8	25.7	6.9	6.6
	Controls	59.6	61.3	218.3	218.2	42.0	41.7	7.7	7.5
	P value t-test*	0.006		0.0001		0.0006		0.0096	
Overall	mean	57.3 ±3.8		218.5 ±1.7		40.9 ±1.9		7.7 ±0.3	
	min	46.2		215.4		25.7		6.6	
	max	66.5		222.5		43.0		8.4	
ANOVA for Fixed Effects	*P* value 'subline'	<.0001		<.0001		<.0001		<.0001	

* t-test compares the best four selected sublines to the four unselected sublines of Foundation Seed of the cultivar.

Germplasm, Experiment, and Analysis

MFS-591 is a proprietary natto cultivar released in 1999 by Glenn R. Buss through the Virginia Agricultural Experiment Station (PVP 9900256) and is still widely cultivated under contract. It is a maturity group V, seed size is 8g/100 seeds, hilum is buff, leaves are ovate, and it is estimated to yield 80% of conventional cultivars. MFS-591 originated from a single F_4 plant from the cross Camp x Rocky. The origin of Rocky is uncertain, and it is MG V with small seeds. Camp is a MG V small seed cultivar that is a subselection of Vance. Vance originated from the cross Essex x *G. soja*. The *soja* parent was an unknown Plant Introduction with a typical *soja* plant type. The first MFS-591 Foundation Seed was F_9 and was produced in 1997. Foundation Seed obtained in 2008 from the Virginia Crop Improvement Association Foundation Seed Farm was used for this experiment.

In 2008, approximately 2000 single plants were cultivated under drip irrigation in a honeycomb design (Fig. 1). Individuals which shattered were eliminated. Plants were selected using a moving ring of 54 surrounding plants to minimize the masking effect of soil heterogeneity on single plant yields [1, 2 ,3]. Thus, the yield of each plant was divided by the mean yield of the 54 surrounding plants according to the design to assess the yield superiority or inferiority. A total of 116 were selected based on their seed yield and maturity. 116 sublines of MFS-591 and 4 control lines consisting of unselected Foundation Seed of MFS-591 were included in an agronomic test in 2009 in one-row yield plots replicated 3 times. Rows were harvested with a plot combine. In addition to yield, data were collected for maturity, height, lodging, seed size and quality, and water absorption. Water absorption was assayed for each plot by soaking a 20g sample, and is expressed as percent weight gained [4]. Data were analyzed in SAS with PROC MIXED using the model 'trait'=subline and rep and subline*rep were considered random effects. Tukey's means separations were calculated at the 0.05 level.

Results

The 2009 agronomic trial was excellent and extremely uniform. Low overall variation was observed (Table 1), which is expected for sublines of a cultivar. Variation among sublines was highly significant for traits (Table 1). Significant differences between lines for agronomic traits were detected (means separations are not presented). Nine sublines absorbed more water. For seed size, four sublines were significantly smaller and four sublines were significantly larger than the unselected controls. For yield and maturity, no sublines were significantly higher yielding or earlier maturing than the unselected controls. However, it should be noted that the highest yielding subline yielded 6.9 bu/ac above the mean of the unselected controls, 1.8 times the standard deviation, and 11% higher. For maturity, the earliest subline was 16.3 days earlier than the mean of the unselected controls. Comparing the four best performing sublines by trait to the four unselected sublines of Foundation Seed of the cultivar(controls), t-tests showed significant differences among groups for all traits (Table 1).

Conclusions

Results from one environment have shown that variation for agronomic and quality traits exists within a soybean cultivar. Sublines were identified with better performance for the quantitative traits of yield, maturity, water absorption, and seed size. Shattering may also have been reduced within the sublines compared to the unselected cultivar. This approach has improved a cultivar possessing a unique suite of quality traits that has proven difficult to reassemble in higher yielding germplasm.

Next Steps

In 2010, 23 sublines (including low-yielding lines) were tested for agronomic and quality traits in two environments. Sublines will be released that offer improvements in yield, maturity, and/or quality traits. A set of these sublines could represent quantitative introgression NILs for identification of genomic regions associated with quantitative traits [5].

References

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