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CULTIVAR

Registration of 'Roberts' Soybean with High Yield and Good Quality

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ABSTRACT

Soybean [*Glycine max* (L.) Merr.] cultivar Roberts (Reg. No. CV-510, PI 667737) was developed at South Dakota State University (SDSU), Brookings, SD, and released by the South Dakota Agricultural Experiment Station in April 2013. It was released because of its high yield potential, good seed quality, and resistance to Phytophthora root rot (*Phytophthora sojae* Kaufmann & Gerdemann), as well as adaptability to South Dakota and similar latitudes. Roberts, originally designated as SD03-2154, is a maturity group (MG) 0 cultivar (relative maturity 0.7–0.8). It originated from the F_5 progeny of a single F_4 plant derived from the cross of 'Surge' × A96-492041 with early generations advanced by a modified single-seed descent method. It was initially evaluated for yield and quality in the SDSU soybean breeding program, and advanced testing was further conducted in the USDA Northern Regional Uniform Tests (UTs) and the South Dakota Crop Performance Tests (CPTs) during 2006 to 2012. Over 35 environments, the yield of Roberts averaged 3404.6 kg ha^{-1}, which was 4.3% higher than the check cultivar Surge (3264.2 kg ha^{-1}). In the UTs (23 year-locations), Roberts averaged a 4.3% higher yield than the check cultivar Sheyenne. Average protein and oil concentrations of Roberts were 351.1 and 178.6 g kg^{-1} at 13% moisture, compared with Surge (362.0 and 175.9 g kg^{-1}) and Sheyenne (339.1 and 178.7 g kg^{-1}). In addition, it exhibited resistance to races 4 and 7 of *P. sojae*. Roberts is a conventional, high-yield, good-quality, MG 0 cultivar with the allele *Rps1k* for resistance to *P. sojae*, and thus it is a good replacement for Surge for producers of non–genetically modified soybeans in South Dakota and similar latitudes.

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'Roberts' soybean [*Glycine max* (L.) Merr.] (Reg. No. CV-510, PI 667737) is a conventional maturity group (MG) 0 cultivar that was developed at South Dakota State University (SDSU), Brookings, SD. It originated from a cross of 'Surge' × A96-492041 and was tested as SD03-2154 and released by the South Dakota Agricultural Experimental Station in April 2013. It was named after the name of Roberts County, according to the nomenclature of soybean cultivars in South Dakota. The segregating population derived from the cross made in 1998 was advanced from the F_2 to F_4 generation by a modified single-seed descent method (Fehr, 1991). The $F_{4:6}$ line, derived from an F_4 single plant and composited in the F_5 generation, was planted in preliminary yield trials (PYTs) in 2004 and advanced yield trials (AYTs) in 2005 and subsequent years at multiple locations in South Dakota. SD03-2154 was also tested in the USDA Northern Regional Uniform Tests (UTs) and the South Dakota Crop Performance Tests (CPTs) from 2006 to 2012. Roberts was released because of its high-yield potential in group 0 maturity, relatively high oil and protein contents, resistance to *Phytophthora sojae* (races 4 and 7), and good adaptability to South Dakota and similar latitudes in other U.S. states and Canada.

Materials and Methods

Parental Selection and Pedigree Information

Roberts was derived from the cross Surge × A96-492041. Surge, a MG 0 cultivar, was from a cross between A86-204022 and 'Kato' and was developed and released jointly by South Dakota State University and University of Minnesota (Scott and Orf, 1998). It was used as a parent because of its superior performance in yield and good seed quality. A96-492041 was a breeding line developed by Iowa State University from a cross between 'Northrup King S24-92' and 'North King S19-90'.

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Abbreviations: AYT, advanced yield test/trials; CPT, Crop Performance Test; MG, maturity group; PYT, preliminary yield test/trials; RCBD, randomized complete block design; SDSU, South Dakota State University; UT, Uniform Soybean Test.

Population and Line Development

The cross Surge × A96-492041 was made in the field on the SDSU Agricultural Research Farm at Aurora, SD, in summer 1998. The F_1 plants were grown at Aurora in 1999, and the F_2 through F_4 generations were advanced in South Dakota by a modified single-seed descent method (i.e. single-pod descent) (Fehr, 1991) from 2000 to 2002. F_4 single plants were harvested in fall 2002. In 2003, $F_{4:5}$ progeny rows from the segregating population were grown in nonreplicated, 3.05-m-long single-row plots. Thirteen $F_{4:6}$ lines derived from the cross were selected and subsequently entered in a multiple-location preliminary yield test (PYT) in 2004 and as $F_{4:7}$ lines in an advanced yield test (AYT) in 2005 in South Dakota. The experimental line SD03-2154 was further evaluated in subsequent generations in both the regional UTs and the state CPTs from 2006 to 2012 as well as in AYTs in South Dakota.

Evaluation of Yield and Other Traits

In 2004 and 2005, Roberts was evaluated in PYTs and AYTs in South Dakota, respectively. Both the PYTs and AYTs were conducted in a randomized complete block design (RCBD) in two locations, Aurora and Watertown, SD. For the PYTs, plots were two rows in two replications. Plots for the AYTs were four rows in four replications with data taken from the central two rows of each plot. Plots in both years and subsequent years were 4.42 m long with a 0.76 m row-spacing. In all tests, seed yield, plant height, and maturity were recorded. Diseases and/or pests were also scored if symptoms were obvious. At maturity, plots were harvested with a plot combine, and seed weights recorded for each plot. Seed yields were converted to kilograms per hectare at 13% seed moisture. Protein and oil contents were determined using a DA7200 NIR analyzer (Perten Instruments, Sweden) and presented as grams per kilogram at 13% seed moisture.

Roberts was further evaluated for a total of 41 year-locations, in the USDA Northern Regional Uniform Group 0 Preliminary Test in 2006 (six locations) and Uniform Group 0 Test (UT 0) from 2007 to 2009 (23 year-locations) (Abney and Crochet, 2007, 2008, 2009), and in the South Dakota CPT in 2006 to 2008 (six year-locations) and 2010 to 2012 (six year-locations) (Hall and Kirby, 2006, 2007, 2008, 2010, 2011). In the regional uniform tests, seed yield, protein and oil contents were determined and presented on a 13% moisture basis (Abney and Crochet, 2009). Maturity (days to maturity after planting) and lodging (1–5 scale) were recorded. For the regional UTs, plant height (cm), seed size (g 100-seed^{-1}) and seed quality (1–5 scale) were also determined according to the protocol outlined in the USDA Northern Regional Uniform Soybean Tests (Abney and Crochet, 2009). In addition, iron deficiency chlorosis (1–5 scale), green stem (1–5 scale), shattering (1–5 scale), and northern stem canker (0–10 scale) were scored at locations where ratings of these variables could be assessed. Evaluation of resistance to *P. sojae* was performed by Purdue University at Lafayette, IN (Abney and Crochet, 2007, 2008, 2009).

Statistical Analysis

Seed yield data from PYTs and AYTs were statistically analyzed using AgroBase II (Agronomix Software, 2009). Yield data and other quantitative traits from UTs and CPTs were analyzed using SAS software (SAS Institute, 2011) for a RCBD. Within any individual environment (year-location), replications were considered random effects and cultivars and/or lines fixed effects. Because raw data for plots were not available, entry means from each year-location were used for comparison across environments. Locations with a coefficient of variation (CV) greater than 15% were excluded from the overall yield means (Abney and Crochet, 2007, 2008). Comparisons of Roberts were made only to check cultivars and promising lines that were included in multiple years of testing (Abney and Crochet, 2007, 2008, 2009). Thus, multiple-year analysis was performed on the basis of a subset of the original data. Entries or genotypes (cultivars and lines) were treated as fixed effects and environments (years and locations) as random effects. Analysis of variance was performed with Type I error $\alpha = 0.05$. Least significant difference (LSD) was used to compare means when the overall genotypic effect was significant at $P < 0.05$ in F-test.

Seed Purification and Increase

To produce breeder seed, 50 phenotypically uniform plant-rows were harvested separately in 2007 (F_9) and then bulked, according to morphological characteristics as well as seed color and hilum color. Off-type plants in the field were removed depending on their flower color, pubescence color, pod color, plant height, and maturity. Breeder seed was further examined and off-type seeds were discarded depending on seed color and hilum color. The breeder seed was further increased in 2008–2009. To minimize the proportion of off-types, breeder seed was repurified and reproduced in 2011 (i.e., 200 plant-rows from the breeder seed were planted again and bulked to produce new breeder seed by further removing the off-types as described above). Foundation seed was produced by SDSU Foundation Seed Stocks Division in 2012.

Characteristics

Agronomic and Botanical Description

Roberts is a MG 0 cultivar, relative maturity 0.7 to 0.8, and it generally matures 1 to 2 d earlier than Surge (Table 1, 2, and 3). Plants of Roberts are indeterminate in growth habit with purple flowers, gray pubescence, and brown pods at maturity. Seeds have dull yellow seed coats with gray hila (Table 4). Average lodging scores of Roberts were 1.3 to 1.7 and similar to Surge (Tables 1, 2, and 3). Plant height averaged 80.9 cm in the regional UTs, compared with Surge (78.8 cm) and 'Sheyenne' (Helms et al., 2008) (78.1 cm). However, Roberts averaged a 7.4 cm shorter plant height ($P < 0.05$) than the MG I check cultivar MN1410 (Table 2). Roberts had a lower average rating of green stem than check cultivars (Table 4) except 'Traill' (Helms and Nelson, 1998). Its shattering score was 1.0 and similar to other cultivars.

Yield Performance

Over 23 environments in the Northern Regional UTs 2007 to 2009, the average yield of Roberts was 3627.1 kg ha^{-1}, which was 4.6% higher than Surge and 4.3% higher than Sheyenne ($P < 0.05$), respectively, but it yielded 4.4% less than the MG I check cultivar MN1410 (Table 1). The CV in yield over 23 environments for Roberts was 23.5%, which was smaller than those of all the check cultivars (25.5–31.5%). This indicates

that Roberts is relatively more stable in seed yield across environments, in addition to having a higher yield potential.

In the 2006 to 2008 South Dakota CPTs (six environments), the average yield of Roberts was 2577.9 kg ha^{-1}, which was 3.6% higher than Surge (Table 2). In the 2010 to 2012 South Dakota CPTs (six environments), Roberts yielded 3378.2 kg ha^{-1}, 3.8% higher than Surge and 4.8% higher than the early MG I cultivar Deuel (Table 3). Over all 35 environments for both UTs and CPTs, the yield of Roberts averaged 3404.6 kg ha^{-1}, which was 4.3% higher than that of the check cultivar Surge (3264.2 kg ha^{-1}).

Seed Weight and Quality, Protein Content, and Oil Content

Roberts seeds averaged 17.4 g in 100-seed weight in the Northern Regional UTs, which was 2.4 g lower than Surge but 1.5 g higher ($P < 0.05$) than Sheyenne (Table 1). Its seed quality rating (1.6) was equal to Surge but slightly better than Sheyenne (1.8).

Over 21 tests in the Northern Regional UTs, at 13% moisture, the average seed protein concentration of Roberts was 351.1 g kg^{-1}, which was slightly lower than Surge but higher than Sheyenne ($P < 0.05$) and comparable to MN1410 (Table 1). In the South Dakota CPTs, its protein content was also lower than Surge but comparable to Deuel (Table 2 and 3). In most cases, however, Roberts exhibited a higher oil concentration (177.5–183.1 g kg^{-1}) than Surge. Roberts was comparable to the MG I check MN1410 in overall quality (seed quality, protein content, and oil content).

Disease Resistance

The reports of the USDA Northern Regional Uniform Soybean Tests indicated that Roberts was moderately tolerant to iron deficiency chlorosis and comparable to Surge and MN1410

Table 1. Mean seed yield, quality, and agronomic performance of 'Roberts' soybean and check cultivars in the Northern Regional Uniform Tests (maturity group 0), 2007 to 2009.

Cultivar	Yield	CV†	Maturity‡	Lodging score§	Plant height	Seed size	Seed quality score¶	Protein	Oil
No. of tests	23		24	25	21	22	22	21	21
	kg ha^{-1}	%	d	1–5	cm	g 100-seed^{-1}	1–5	g kg^{-1}	
Roberts	3627.1	23.5	121.6	1.7	80.9	17.4	1.6	351.1	178.6
Sheyenne (0)#	3477.7	31.5	122.5	1.3	78.1	15.9	1.8	339.1	178.7
MN1410 (I)	3793.2	25.5	130.0	1.8	88.3	17.4	1.7	353.5	179.1
Surge (L)	3468.7	26.3	123.3	1.6	78.8	19.8	1.6	362.0	175.9
Traill (E)	2822.5	31.2	115.1	1.5	71.2	16.9	1.6	364.7	172.0
$LSD_{0.05}$	140.0		1.9	0.3	3.9	0.6	0.2	4.7	2.9

† Coefficient of variation for yield over 23 environments.

‡ Days to maturity after planting.

§ 1–5 scale: 1 = almost all plants erect, 5 = almost all plants prostrate.

¶ 1–5 scale: 1 = very good, 5 = very poor.

Maturity indicated in parentheses: 0 and I represent maturity group (MG) 0 and I, respectively, and E and L represent early and late MG 0.

Table 2. Mean yield, maturity, lodging score, seed protein and oil contents of Roberts and check cultivars in the South Dakota Crop Performance Tests in 2006–2008 (6 year-locations).

Cultivar	Yield	Maturity†	Lodging‡	Protein	Oil
	kg ha^{-1}	d	1–5	g kg^{-1}	
Roberts	2577.9	118.8	1.3	339.7	177.5
Hamlin	2577.9	120.0	1.2	352.4	173.6
SURGE	2488.3	118.3	1.3	352.4	173.6
$LSD_{0.05}$	138.3	2.2	0.5	4.5	2.0

† Days to maturity after planting.

‡ 1–5 scale: 1 = almost all plants erect, 5 = almost all plants prostrate.

Table 3. Mean yield, maturity, lodging score, seed protein and oil contents of Roberts and check cultivars in the South Dakota Crop Performance Tests in 2010–2012 (6 year-locations).

Cultivar	Yield	Maturity†	Lodging‡	Protein	Oil
	kg ha^{-1}	d	1–5	g kg^{-1}	
Roberts	3378.2	113.3	1.6	341.6	183.1
SD04CV-611	3157.4	115.4	1.5	353.7	180.4
SD07CV-539	3336.7	116.4	1.4	331.9	183.7
SURGE	3256.0	113.3	1.5	360.6	179.8
Deuel	3223.5	117.3	2.1	347.1	171.7
$LSD_{0.05}$	248.1	1.9	0.5	8.8	3.4

† Days to maturity after planting.

‡ 1–5 scale: 1 = almost all plants erect, 5 = almost all plants prostrate.

Table 4. Descriptive traits and resistance performance of Roberts and check cultivars in the Northern Regional Uniform Tests in 2007 to 2009.

Cultivar	Descriptive code†	Chlorosis score‡	Green stem score§	Shattering score¶	NSC score#	PR††	
						Race 4	Race 7
No. of tests		5	2	3	1	3	3
		1–5	1–5	1–5	1–10		
Roberts	PGBDYGI	3.1	2.4	1.0	4.0	R	R
Sheyenne (0)‡‡	PGBDYYI	2.6	2.8	1.0	4.2	S	R
MN1410 (I)	WGBDYBfI	2.9	3.6	1.0	6.0	S	S
Surge (L)	PGBDYIbI	3.0	2.5	1.0	4.8	S	S
Traill (E)	PTBIYYI	2.6	2.1	1.0	5.3	S	S

† Adapted from Abney and Crochet (2007, 2008, 2009): (1) flower color: P = purple and W = white; (2) pubescence color: G = gray, T = tawny, Lt = light tawny; (3) pod color: B = brown, T = tan; (4) seed coat luster: D = dull, S = shiny, I = intermediate; (5) seed coat color: Y = yellow, G = gray, Lg = light gray, Gn = green; (6) hilum color: Bl = black, Bf = Buff, Br = brown, G = gray, Ib = imperfect black, Y = yellow; and (7) stem termination, D = determinate, I = indeterminate and SD = semideterminate.

‡ 1–5 scale: 1 = no chlorosis, 5 = severe chlorosis.

§ 1–5 scale: 1 = almost all plant stems yellowing or have ripened as indicated by their mature stem color, 5 ≥ 50% plants with green stems.

¶ 1–5 scale: 1 = no shattering, 5 ≥ 50% shattered.

0–10 northern stem canker (NSC) rating: presented as the mean number of plants killed by girdling stem canker lesions based on 10 plants per plot inoculated by toothpick method with SD isolate DP-138 (*Diaporthe phaseolorum* var. *caulivora*) in 2007.

†† Phytophthora rot (*P. sojae*): R = resistant, S = susceptible.

‡‡ Maturity indicated in parentheses: 0 and I represent maturity group (MG) 0 and I, respectively, and E and L represent early and late MG 0.

(Table 4). It had a lower rating of northern stem canker than all the check cultivars. It seems that Roberts may have moderate resistance to northern stem canker. Additional tests will be helpful to verify its resistance. Roberts possesses the resistance gene *Rps1k* to *P. sojae* and exhibited a resistant reaction to races 4 and 7 (Table 4), whereas all the check cultivars were susceptible to Phytophthora rot, except Sheyenne, which showed resistance to race 7.

Availability

Foundation seed of Roberts will be available from the SDSU Foundation Seed Stocks Division, Box 2207A, Brookings, SD 57007, USA. Limited quantities of seed may be obtained on written request for research purposes only. Seed of this release has been deposited in the National Plant Germplasm System, where it will be available for research purposes and for use as parental stock in development of new cultivars and germplasm. Application and contribution of the cultivar to scientific research and the development of a new cultivar or breeding line should be appropriately acknowledged.

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References

Abney, T.S., and W.D. Crochet. 2007. The uniform soybean tests, northern region. USDA–ARS, West Lafayette, IN. http://www.btny.purdue.edu/pubs/usda/2007UniformTestReport.pdf (accessed April 2013)

Abney, T.S., and W.D. Crochet. 2008. The uniform soybean tests, northern region. USDA–ARS, West Lafayette, IN. http://www.btny.purdue.edu/pubs/usda/2008UniformTestReport.pdf (accessed April 2013)

Abney, T.S., and W.D. Crochet. 2009. The uniform soybean tests, northern region. USDA-ARS, West Lafayette, IN. http://www.btny.purdue.edu/pubs/usda/2009UniformTestReport.pdf (accessed April 2013)

Agronomix Software. 2009. AgroBase generation II, Version 18. Agronomix Software, Inc., Winnipeg, Canada.

Fehr, W.R. 1991. Principles of cultivar development. Vol. 1. Theory and technique. Macmillan, New York.

Hall, R.G., and K.K. Kirby. 2006, Soybean variety performance trials—2006 reports. SDSU Cooperative Extension Service, Brookings, SD. http://igrow.org/up/resources/EC775-06.pdf (accessed April 2013)

Hall, R.G., and K.K. Kirby. 2007, Soybean variety performance trials—2007 reports. SDSU Cooperative Extension Service, Brookings, SD. http://igrow.org/up/resources/EC775-07.pdf (accessed April 2013)

Hall, R.G., and K.K. Kirby. 2008, Soybean variety performance trials—2008 reports. SDSU Cooperative Extension Service, Brookings, SD. http://igrow.org/up/resources/EC775-08.pdf (accessed April 2013)

Hall, R.G., and K.K. Kirby. 2010, Soybean variety performance trials—2010 reports. SDSU Cooperative Extension Service, Brookings, SD. http://igrow.org/up/resources/EC775-10.pdf (accessed April 2013)

Hall, R.G., and K.K. Kirby. 2011, Soybean variety performance trials—2011 reports. SDSU Cooperative Extension Service, Brookings, SD. http://igrow.org/up/resources/03-3000-2011.pdf (accessed April 2013)

Helms, T.C., and B.D. Nelson. 1998. Registration of 'Traill' soybean. Crop Sci. 38:549. doi:10.2135/cropsci1998.0011183X003800020071x

Helms, T.C., B.D. Nelson, and R.J. Goos. 2008. Registration of 'Sheyenne' soybean. J. Plant Reg. 2:20. doi:10.3198/jpr2007.03.0146crc

SAS Institute. 2011. The SAS system for Windows. Release 9.3. SAS Institute, Inc., Cary, NC.

Scott, R.A., and J.H. Orf. 1998. Registration of 'Surge' soybean. Crop Sci. 38:893.