Published September, 2007

CULTIVAR

Registration of 'Osage' Soybean

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ABSTRACT

'Osage' soybean [*Glycine max* (L.) Merr.] (Reg. No. CV-495, PI 648270) was developed and released by the Arkansas Agricultural Experiment Station as a Maturity Group V conventional cultivar in March 2007. It was derived from the cross 'Hartz 5545' × 'KS4895' and has been evaluated in 130 field tests in several southern states. Osage is widely adapted to areas between 33 and 37°N latitude and has high yield potential and moderately high protein content. Overall, when grown in southern environments, Osage had seed yield 3.2% greater than the check '5601T' and 3.3% greater than the check '5002T'. Seed protein of Osage is 3.1% and 5.4% greater than 5601T and 5002T, respectively. Osage is resistant to several important diseases in the Mid-South USA, including southern stem canker, sudden death syndrome, soybean mosaic virus, and frogeye leaf spot.

'Osage' soybean [*Glycine max* (L.) Merr.] (Reg. No. CV-495, PI 648270) was developed by conventional breeding from a cross of two conventional cultivars, 'Hartz 5545' and 'KS4895'. The plant population derived from the cross was advanced by single pod bulk descent, and single plants were pulled from the F_4 population in 1997. Osage traces back to a single F_5 progeny row selected in 1998. As a breeding line, R98-1821, Osage was tested in multiple environments in Arkansas and the U.S. Mid-South from 1999 to 2006, where it exceeded the check cultivars for both yield and protein content in most of the environments. Osage is a conventional soybean cultivar choice with outstanding yield potential and improved protein content.

Methods

Hybrid Seed Development

Osage was originated from the cross between Hartz 5545 and KS4895. Hartz 5545 was a selection from H78-168 × 'Narow' (Caviness et al., 1985). H78-168 originated from the cross D70-3115 × 'Forrest' (Hartwig and Epps, 1973). The parents of D70-3115 were D64-4636 and 'Lee' (Johnson, 1958). D64-4636 was selected from 'Hill' × D58-3311 (Johnson, 1960). KS4895 was derived from the cross 'Sherman' × 'Bay' (Schapaugh and Dille, 1998). The cross between Hartz 5545 and KS4895 was performed in the field in 1993, and the F_1 plants were space-planted (30 cm apart) in the field in 1994 at Fayetteville, AR.

Early Generation Population Development

Osage was developed using a single pod bulk method (Fehr, 1991), and the early generation populations were grown in Fayetteville, AR. Seeds from the hybrid plants were bulked and planted in the field from 1995 to 1997, for the development of segregating populations from F_2 to F_4. The F_2 to F_4 populations, each consisting of approximately 2000 plants, were grown in 6.1-m rows with 0.97-m row spacing. One hundred ten single plants were visually selected in the F_4 generation for 5% selection intensity. The $F_{4:5}$ lines were grown as 3-m single-row progeny rows in Keiser, AR, in 1998.

Line Selection and Evaluation

A selection intensity of 7% was performed on the progeny rows by visual selection for uniformity and agronomic performance. Seeds from the selected lines were bulked as pure lines for subsequent yield trials. Osage was one of the eight selected lines from the cross and was tested as experimental line R98-1821 in a total of 48 Arkansas environments and 72 environments in several other states for seed yield, protein content, and agronomic performance from 1999 to 2006.

Seed yield and other agronomic traits were evaluated in field experiments with randomized complete block design. The field plots consisted of four rows 6.1 m in length and 0.76 m in row spacing (effective plot area 4.64 m^2). The two center rows were harvested for seed yield and seed quality attribute measurements. The plant population was estimated to be 650 plants per plot, approximately 330,000 plants per hectare. Agronomic traits evaluated in the yield trials included

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Published in the Journal of Plant Registrations 1:89–92 (2007).
doi: 10.3198/jpr2007.04.0224crc

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lodging, shattering, maturity, plant height, seed quality, seed size, and disease reactions. In more advanced testing stages, seed protein and seed oil content were estimated using near-infrared spectroscopy.

Osage was first tested together with other selected breeding lines for seed yield in 1999 in a nonreplicated experiment planted at three locations: Keiser, Marianna, and Pine Tree, AR. Maturity, plant height, lodging, and shattering data were also recorded. A selection intensity of 50% was applied, and Osage and 24 other lines were selected for further yield trials.

During years 2000 to 2002, Osage was tested along with other selected lines in replicated multilocation yield trials. Randomized complete block design experiments with three replications were planted in five environments in 2000, six environments in 2001, and five environments in 2002. Seed yield, seed protein and oil, visual rating for agronomic performance, and agronomic trait data were used for the selection of the top 30% of lines.

Osage was entered into the 2003 and 2004 intermediate-stage yield trials, planted in randomized complete block experiments with three replications in a total of nine environments in five Arkansas locations (Keiser, Marianna, Pine Tree, Rohwer, and Stuttgart). Seed yield, seed protein and oil content, agronomic traits, and visual agronomic performance were evaluated. Selection was applied to pick the top 30% of lines.

The advanced-stage yield trials were grown with a randomized complete block design and three replications in 2005 and 2006 in a total of 18 environments in five Arkansas locations (Keiser, Marianna, Pine Tree, Rohwer, and Stuttgart). Seed yield, agronomic traits, visual agronomic performance, and seed protein and seed oil content were evaluated. Osage was entered in the 2002 Maturity Group 5 USDA Southern States Preliminary Soybean Tests that were conducted at 10 southern U.S. locations (Paris, 2002). On the basis of yield-trial analysis, Osage was introduced in the 2003, 2004, and 2005 Maturity Group 5 USDA Southern States Uniform Soybean Tests. The Uniform Tests were grown at 21 locations in the southern USA in 2003 and at 23 locations in 2004 and 2005. The plot length was 6.1 m, with row spacing of 0.76 m for the majority of the locations (Paris, 2003, 2004; Paris and Shelton, 2005).

Osage was also evaluated in the Arkansas State Variety Testing Program in 2005. The line was tested in two environments in a randomized complete block design with three replications. Plot dimensions were 6.1 m length and 0.76 m row spacing, for a 4.64 m^2 effective plot area (Dombek et al., 2005).

As a result of the improved protein content, Osage was evaluated in the Midwest and the South in 2004 and 2005 as part of the Regional Quality Traits Test. The experiment was designed as a randomized complete block with two replications and conducted in a total of 16 midwestern and southern environments. Plot dimensions were 6.1 m length and 0.76 m row spacing (Graef, 2004, 2005).

Seed Purification and Increase

Seed purification of Osage began in 1999 and continued until 2006, as plots from the yield trials were rogued to remove off-type plants. Breeder seed ($F_{5:12}$) was planted in 2005 in a 400-m^2 area at Fayetteville, AR. One hectare of foundation seed ($F_{5:13}$) was planted in Stuttgart, AR, in 2006, and 20 ha of foundation seeds ($F_{5:14}$) were planted in Stuttgart in 2007. Plants were rogued for off-types on flower color, pubescence color, growth habit, maturity, plant height, and seed hilum color.

Statistical Analyses

Seed yield, agronomic traits, and seed protein and oil content were evaluated by analysis of variance using Agrobase Generation II (Agronomix Software, Inc., Winnipeg, MB), and means were separated by *t* test and Fischer's protected LSD, with $\alpha = 0.05$. Statistical model for single location analysis included genotypes as fixed factors. In the case of multilocation experiments, genotype was considered as fixed factor and location a random factor. Genotype-by-environment interaction was tested using the cultivar superiority measure statistic.

Data from USDA uniform tests, Arkansas state soybean variety trials, and regional quality traits were analyzed using SAS (SAS Institute, Cary, NC), with genotype considered a fixed factor and location a random factor. Analysis of variance was performed with $\alpha = 0.05$, and means were separated by *t* tests and Fischer's protected LSD.

Characteristics

Agronomic and Botanical Description

Osage is a determinate cultivar with a relative maturity of 5.6, maturing 1 d earlier to 1 d later than the check '5601T'. It has purple flowers, gray pubescence, and tan pod wall. Osage is about 2 cm taller in height than the check '5002T'. Seeds of Osage have yellow cotyledons with dull yellow seed coat and imperfect black hila, with an average seed size of 12.4 g 100 $seeds^{-1}$, being slightly smaller than 5601T (13.6 g 100 $seeds^{-1}$) (Paris, 2003, 2004; Paris and Shelton, 2005; Graef, 2004, 2005). Lodging, shattering, and seed quality scores are slightly better than those of 5601T.

Disease Resistance

Screenings for the most important diseases in the South indicated that Osage is resistant to southern stem canker (caused by *Diaporthe phaseolorum* var. *meridionalis*), sudden death syndrome [caused by *Fusarium solani* (Mart.) Sacc. f. sp. *glycines*], *Soybean mosaic virus*, and frogeye leaf spot [caused by *Cercospora sojina* K. Hara.]. It is susceptible to root knot nematode [*Meloidogyne arenaria* (Neal) Chitwood, *M. incognita* (Kofoid & White) Chitwood] and soybean cyst nematode (*Heterodera glycines* Ichinohe) races 2, 3, and 14 (Paris and Shelton, 2005).

Field Performance

During the preliminary yield trials (1999–2002), Osage yielded 3716 kg ha^{-1} on average, 10% significantly higher than 'Caviness' (Asgrow 5403 × Hutcheson) (3373 kg ha^{-1}) in a total of 19 Arkansas environments (Table 1). In the intermediate yield trials (2003–2004), seed yield of Osage was 2.5% greater than 'UA 4805' (Chen et al., 2006) in three environments in 2003 (4085 kg ha^{-1} vs. 3984 kg ha^{-1}, respectively) and 2.5% greater than 'Manokin' (Kenworthy, 1996) in six environments in 2004 (3251 kg ha^{-1} vs. 3044 kg ha^{-1}, respectively), although these differences are not statistically significant. In the advanced yield trials (2005–2006), Osage was evaluated in nine environments using 5002T as a check (Pantalone et al., 2004), and in nine other environments with 'Ozark' (Chen et al., 2004)

Table 1. Summary of seed yield and protein data for Osage soybean in comparison with check cultivars evaluated in 122 environments from 1999 to 2006.

Experiment	No. environments	Year	Check	Osage yield	Check yield	Osage protein	Check protein	Reference
				Mg ha^{-1}		%		
Preliminary	19	1999–2002	'Caviness'	3.72a†	3.37b			
Intermediate	3	2003	'UA 4805'	4.08a	3.98a			
	6	2004	'Manokin'	3.25a	3.04a			
Advanced	9	2005–2006	'5002T'	3.49a	3.21b			
	9	2006	'Ozark'	3.86a	3.76a			
AR state variety testing	2	2005	'5002T'	4.35a	4.41a			Dombek et al. (2005)
USDA preliminary	10	2002	'5601T'	3.53a	3.35a	42.8a	41.8a	Paris (2002)
USDA uniform	56	2003–2005	'5601T'	3.55a	3.44b	43.0a	41.7b	Paris (2003, 2004); Paris and Shelton (2005)
Regional quality trait	16	2004–2005	'5601T'	3.70a	3.52a	44.2a	43.1b	Graef (2004, 2005)

†Means followed by the same letter within a row are not significantly different at $p \leq 0.05$.

as a check. Osage had a seed yield 8.8% significantly higher than 5002T (3494 kg ha^{-1} vs. 3212 kg ha^{-1}, respectively), and 2.5% higher, although not statistically significant, than Ozark (3857 kg ha^{-1} vs. 3763 kg ha^{-1}, respectively) (Table 1).

Osage was also evaluated in the Arkansas State Variety Testing Program in two environments during 2005, averaging 1.8% less, but not significantly different, than the check cultivar 5002T (4334 kg ha^{-1} vs. 4411 kg ha^{-1}, respectively) (Dombek et al., 2005). In addition, Osage was evaluated in eight environments in the Midwest and the South during 2004 and 2005 as part of the Regional Quality Traits Test, yielding 5.2% more than 5601T (Pantalone et al., 2003) on average (3702 kg ha^{-1} vs. 3521 kg ha^{-1}, respectively), although this difference was not statistically significant (Graef, 2004, 2005). In a 10-location USDA preliminary trial in 2002, yield of Osage was 5.6% higher, but not significantly different, than the check 5601T (Paris, 2002). In addition, Osage was included in the USDA Southern Regional Uniform Group V tests during 2003, 2004, and 2005 and had seed yield that was 3.1% greater than 5601T (3545 kg ha^{-1} vs. 3440 kg ha^{-1}, respectively). When a matched-pair *t* test analysis was performed on a balanced data set including Osage and 5601T seed yields, the difference in seed yields was statistically significant at $p \leq 0.05$ (Paris, 2003, 2004; Paris and Shelton, 2005). Osage ranked first in yield and protein in the combined analysis of variance across locations in the 2005 USDA Uniform Trials MG-5 (Paris and Shelton, 2005). Overall, Osage outyielded the respective checks in 34 of the 48 environments in Arkansas. When grown in the Mid-South, Osage had seed yield greater than the check 5601T in 36 of the 66 environments of the USDA MG-5 tests and in 12 of the 16 environments of the regional quality tests. On average, Osage had seed yield of 3538 kg ha^{-1} in the USDA MG-5 tests, 3.2% greater than 5601T (3427 kg ha^{-1}) and 3.3% greater than 5002T (3424 kg ha^{-1}). Osage had an overall yield 10.2% greater than Caviness (3716 kg ha^{-1} vs. 3373 kg ha^{-1}, respectively), and 2.5% greater than UA 4805 (4085 kg ha^{-1} vs. 3984 kg ha^{-1}, respectively) and Ozark (3857 kg ha^{-1} vs. 3763 kg ha^{-1}, respectively) (Table 1).

Seed Composition

When grown in southern environments, the average protein content of Osage was 430 g kg^{-1}, 3.1% higher than that of 5601T (417 g kg^{-1}) and 5.4% higher than 5002T (408 g kg^{-1}), whereas the oil content of Osage (189 g kg^{-1}) was 1% lower than 5601T (191 g kg^{-1}) and 6% lower than that of 5002T (202 g kg^{-1}) (Paris, 2002, 2003, 2004; Paris and Shelton, 2005). When Osage was tested in the Midwest and South in the Regional Quality Trait Tests during 2004 and 2005, Osage averaged 442 g kg^{-1} protein, 2.5% higher than 5601T (431 g kg^{-1}) and 5.5% higher than 5002T (419 g kg^{-1}); whereas the oil content of Osage (204 g kg^{-1}) was 2% lower than 5601T (208 g kg^{-1}) and 7.3% lower than that of 5002T (220 g kg^{-1}) (Graef, 2004, 2005). Overall, Osage had seed protein greater than 5601T in 40 of the 43 environments tested (433 g kg^{-1} vs. 421 g kg^{-1}, respectively) and greater than 5002T in 32 out of 33 environments (433 g kg^{-1} vs. 421 g kg^{-1}, respectively) (Table 1).

Availability

The Arkansas Foundation Seed Program (Rice Research and Extension Center, 2900 Hwy. 130 East, Stuttgart, AR 72160) will produce and distribute Foundation seed. The Arkansas Agricultural Experiment Station will be responsible for maintenance of Breeder seed. For breeding and research use, small quantities of Osage seeds can be obtained from the corresponding author for at least five years from the date of this publication. Seed of Osage was deposited in the National Plant Germplasm System. Protection for Osage under the U.S. Plant Variety Protection Act Title V will be sought.

Acknowledgments

We would like to acknowledge Caroline Gray, Tina Hart, and Carla Parker for their technical support in the development of Osage. This research was supported in part by the United Soybean Board.

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