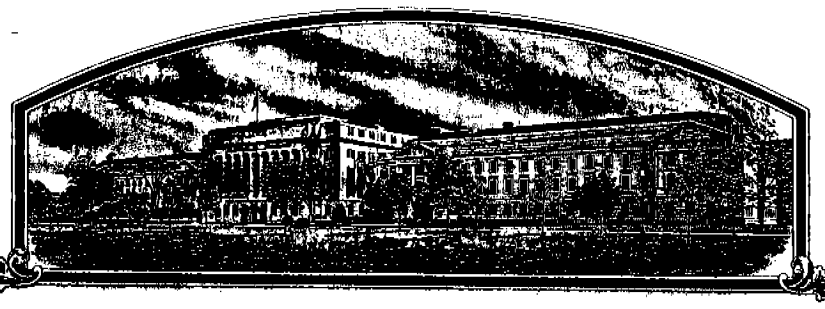


No. 7300058

# THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

## Mississippi Agricultural and Forestry Experiment Station

Whereas, THERE HAS BEEN PRESENTED TO THE

**Secretary of Agriculture**

AN APPLICATION REQUESTING A CERTIFICATE OF PROTECTION FOR AN ALLEGED NOVEL VARIETY OF SEXUALLY REPRODUCED PLANT, THE NAME AND DESCRIPTION OF WHICH ARE CONTAINED IN THE APPLICATION AND EXHIBITS, A COPY OF WHICH IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED HAVE BEEN COMPLIED WITH, AND THE TITLE THERETO IS, FROM THE RECORDS OF THE PLANT VARIETY PROTECTION OFFICE, IN THE APPLICANT(S) INDICATED IN THE SAID COPY, AND WHEREAS, UPON DUE EXAMINATION MADE, THE SAID APPLICANT(S) IS (ARE) ADJUDGED TO BE ENTITLED TO A CERTIFICATE OF PLANT VARIETY PROTECTION UNDER THE LAW.

NOW, THEREFORE, THIS CERTIFICATE OF PLANT VARIETY PROTECTION IS TO GRANT UNTO THE SAID APPLICANT(S) AND THE SUCCESSORS, HEIRS OR ASSIGNS OF THE SAID APPLICANT(S) FOR THE TERM OF seventeen YEARS FROM THE DATE OF THIS GRANT, SUBJECT TO THE PAYMENT OF THE REQUIRED FEES AND PERIODIC REPLENISHMENT OF VIABLE BASIC SEED OF THE VARIETY IN A PUBLIC REPOSITORY AS PROVIDED BY LAW,* (THE RIGHT TO EXCLUDE OTHERS FROM SELLING THE VARIETY, OR OFFERING IT FOR SALE, OR REPRODUCING IT, OR IMPORTING IT, OR EXPORTING IT, OR USING IT IN PRODUCING A HYBRID OR DIFFERENT VARIETY THEREFROM,) TO THE EXTENT PROVIDED BY THE PLANT VARIETY PROTECTION ACT. THE UNITED STATES SEED OF THIS VARIETY (1) SHALL BE SOLD BY VARIETY NAME ONLY AS A CLASS OF CERTIFIED SEED AND (2) SHALL CONFORM TO THE NUMBER OF GENERATIONS SPECIFIED BY THE OWNER OF THE RIGHTS. (84 STAT. 1542, AS AMENDED, 7 U.S.C. 2321 ET SEQ.)

*(Waived)

SOYBEAN

'Forrest'

In Testimony Whereof, *I have hereunto set my hand and caused the seal of the* Plant Variety Protection Office *to be affixed at the City of* Washington *this* eighth *day of* August *in the year of our Lord one thousand nine hundred and* seventy-five

Attest:

L. J. Rollin
Commissioner
Plant Variety Protection Office
Grain Division
Agricultural Marketing Service

Earl L Butz
Secretary of Agriculture

FORM GR-470
(2-12-71)

UNITED STATES DEPARTMENT OF AGRICULTURE
CONSUMER AND MARKETING SERVICE
GRAIN DIVISION
HYATTSVILLE, MARYLAND 20782

FORM APPROVED
OMB NO. 40-R3712

# APPLICATION FOR PLANT VARIETY PROTECTION CERTIFICATE

**INSTRUCTIONS:** *See Reverse.*

| 1. VARIETY NAME OR TEMPORARY DESIGNATION | 2. KIND NAME | FOR OFFICIAL USE ONLY |
|---|---|---|
| Forrest | Common | PVPO NUMBER 73058 |
| 3. GENUS AND SPECIES NAME: Glycine max | 4. FAMILY NAME *(Botanical)*: Leguminoseae | FILING DATE: 2-15-72 / TIME: 3:30 P.M. |
| | 5. DATE OF DETERMINATION | FEE RECEIVED: $ 750 / CHARGES |

| 6. NAME OF APPLICANT(S) | 7. ADDRESS *(Street and No. or R.F.D. No., City, State, and ZIP Code)* | 8. TELEPHONE AREA CODE AND NUMBER |
|---|---|---|
| Dr. Edgar E. Hartwig<br>USDA - Breeder | Delta Branch Experiment Station<br>Stoneville, Ms. 38776 | 601<br>686-9311 |

| 9. IF THE NAMED APPLICANT IS NOT A PERSON, FORM OF ORGANIZATION: *(Corporation, partnership, association, etc.)* | 10. STATE OF INCORPORATION | 11. DATE OF INCORPORATION |
|---|---|---|
| Mississippi Agricultural & Forestry Exp. Sta. | | |

12. Name and mailing address of applicant representative(s), if any, to serve in this application and receive all papers:

Foundation Seed Stocks
P.O. Box 5267
Mississippi State, Ms. 39762

**13. CHECK BOX BELOW FOR EACH ATTACHMENT SUBMITTED:**

☒ 12A. Exhibit A, Origin and Breeding History of the Variety *(See Section 52, P.L. 91-577)*

☒ 12B. Exhibit B, Botanical Description of the Variety

☒ 12C. Exhibit C, Objective Description of the Variety

☒ 12D. Exhibit D, Data Indicative of Novelty

☒ 12E. Exhibit E, Statement of the Basis of Applicant's Ownership R15

The applicant declares that a viable sample of basic seed of this variety will be deposited upon request before issuance of a certificate and will be replenished periodically in accordance with such regulations as may be applicable. *(See Section 52, P.L. 91-577).*

14A. Does the applicant(s) specify that seed of this variety be sold by variety name only as a class of certified seed? *(See Section 83(a), P.L. 91-577) (If "Yes," answer 14B and 14C below.)* ☒ YES ☐ NO

14B. Does the applicant(s) specify that this variety be limited as to number of generations? ☒ YES ☐ NO

14C. If "Yes," to 14B, how many generations of production beyond breeder seed? Three, Foundation, Registered and certified

Applicant is informed that false representation herein can jeopardize protection and result in penalties.

*The undersigned applicant(s) of this sexually-reproduced novel plant variety believes that the variety is distinct, uniform, and stable as required in Section 41 and is entitled to protection under the provisions of Section 42 of the Plant Variety Protection Act (P.L. 91-577).*

Jan. 26, 1973
(DATE)

Edgar E. Hartwig
(SIGNATURE OF APPLICANT)

Jan 31, 1973
(DATE)

James W. Anderson
(SIGNATURE OF APPLICANT)

73058

12A. Origin and Breeding History of Forrest Soybean

1965 - Cross made between D63-7320 (Dyer) and Bragg
1965-66 (winter) - $F_1$ plants grown in greenhouse at Stoneville.
1966 - $F_2$ plants planted in soil infested with race 3 of the soybean cyst nematode in the greenhouse at Jackson, Tenn. Plants free of cysts transplanted to a nematode-infected field near Ridgely, Tenn. Single plants harvested and progeny retested in greenhouse against cyst nematodes. $F_3$ plants free of cysts grown to maturity in greenhouse.
1967 - $F_4$ lines grown in field at Stoneville and lines selected on the basis of agronomic qualities and disease reaction. Single plant selections made from selected lines.
1968 - $F_5$ lines grown in single 9-foot rows and selected rows harvested. Lines ranged in maturity from late September to late October.
1969 - Replicated tests grown for yield evaluation at Stoneville and at Ridgely, Tenn. Greenhouse tests run at Jackson for reaction to root-knot nematode and field plantings in west Florida for root-knot nematode evaluation. D68-128 was the best early maturing line.
1970 - Grown in regional uniform nurseries at 30 locations across South. Evaluated for reaction to reniform nematodes at Baton Rouge, La.
1971 - Grown in regional uniform nurseries. On the basis of excellent performance in 1970, the 60 pounds of seed available was used to plant approximately 4-1/2 acres at Jackson, Tenn. Approximately 130 bushels of seed was harvested.
1972 - Increase plantings made in Tennessee, Kentucky, Missouri, Arkansas, Oklahoma, Mississippi, and North Carolina. Name Forrest announced September 15.

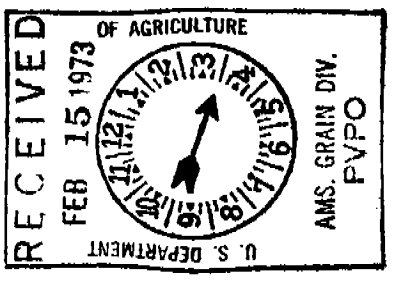
12B. Botanical Description of Variety

Forrest is of Group V maturity, similar in maturity to Dare. When planted from May 10 to 25 at Stoneville these varieties will mature about October 1. Forrest has a determinate growth type, white flowers, and brown pubescence. Seed is shiny, yellow, with black hila. Plant type resembles Bragg but maturity is 3 weeks earlier.

12C. ~~Objective~~ B R/S Description of Variety

Forrest combines resistance to races 1 and 3 of the soybean cyst nematode with resistance to root-knot nematodes and reniform nematodes. It is resistant to the foliar diseases beacterial pustule, wildfire, and target spot and moderately resistant to phytophthora rot. It has excellent resistance to shattering. It has exceeded Dare in seed yield in the absence of nematodes.

FORM GR-470 (REVERSE)




## INSTRUCTIONS

GENERAL: Send an original copy of the application, exhibits and $50.00 fee to U.S. Dept. of Agriculture, Consumer and Marketing Service, Grain Division, Hyattsville, Maryland 20782. Retain one copy for your files. All items on the face of the form are self-explanatory unles noted below.

ITEM

5 Insert the date the applicant determined that he had a new variety.

12a First, give the genealogy, including public and commercial varieties, lines, or clones used, and the breeding method. Second, give the details of subsequent stages of selection and multiplication. Third, indicate the type and frequency of variants during reproduction and multiplication and state how these variants may be identified. Fourth, provide evidence on stability.

12b First, give any special characteristics of the seed and of the plant as it passes through the seedling stage, flowering stage and the fruiting stage. Second, describe the mature plant and compare it with a similar commercial variety grown under the same conditions, and indicate the differences.

12c A supplemental form will be furnished by the PVPO to describe in detail a variety for each kind of seed.

12d Provide complete data indicative of novelty. Seed and plant specimens may be submitted and seeds submitted may be sterile. Where possible, include photographs of plant comparisons, chemical tests, etc.

12e Indicate whether applicant is the actual breeder, the employer of the breeder, the owner through purchase or inheritance, etc.

FORM GR-470-2
(6-15-72)

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
GRAIN DIVISION
HYATTSVILLE, MARYLAND 20782

EXHIBIT C
*(Soybean)*

# OBJECTIVE DESCRIPTION OF VARIETY

**INSTRUCTIONS:** *See Reverse.*

**SOYBEAN** *(GLYCINE MAX)*

NAME OF APPLICANT(S)
Mississippi Agricultural & Forestry Experiment Station

ADDRESS *(Street and No., or R.F.D. No., City, State, and ZIP Code)*
Drawer ES
Mississippi State, Ms. 39762

**FOR OFFICIAL USE ONLY**

PVPO NUMBER
73058

VARIETY NAME OR TEMPORARY DESIGNATION

Place the appropriate number that describes the varietal character of this variety in the boxes below.

**1. SEED SHAPE:** Slightly Elongated
[4] 1 = SPHERICAL 2 = SPHERICAL FLATTENED 3 = ELONGATE 4 = OTHER *(Specify)* Spherical

**2. SEED COAT COLOR:**
[1] 1 = YELLOW 2 = GREEN 3 = BROWN 4 = BLACK 5 = OTHER *(Specify)* _____

**SHADE:** [2] 1 = LIGHT 2 = MEDIUM 3 = DARK

**3. SEED COAT LUSTER:**
[2] 1 = DULL 2 = SHINY

**4. SEED SIZE**
[1][4] GRAMS PER 100 SEEDS

**5. HILUM COLOR:**
[6] 1 = BUFF 2 = YELLOW 3 = BROWN 4 = GRAY 5 = IMPERFECT BLACK 6 = BLACK 7 = OTHER *(Specify)* _____

**SHADE:** [2] 1 = LIGHT 2 = MEDIUM 3 = DARK

**6. COTYLEDON COLOR:**
[1] 1 = YELLOW 2 = GREEN

**7. LEAFLET SIZE** *(See Reverse)*:
[2] 1 = SMALL 2 = MEDIUM 3 = LARGE

**8. LEAFLET SHAPE:**
[1] 1 = OVATE 2 = OBLONG 3 = LANCEOLATE 4 = ELLIPTICAL 5 = OTHER *(Specify)* _____

**9. LEAF COLOR** *(See reverse)*:
[2] 1 = LIGHT GREEN 2 = MEDIUM GREEN 3 = DARK GREEN

**10. FLOWER COLOR:**
[1] 1 = WHITE 2 = PURPLE 3 = OTHER *(Specify)* _____

**11. POD COLOR:**
[1] 1 = TAN 2 = BROWN 3 = BLACK

**12. POD SET:**
[2] 1 = SCATTERED 2 = CONCENTRATED

**13. PLANT PUBESCENCE COLOR:**
[2] 1 = GRAY 2 = BROWN 3 = OTHER *(Specify)* _____

**SHADE:** [2] 1 = LIGHT 2 = MEDIUM 3 = DARK

**14. PLANT TYPES** *(See Reverse)*:
[2] 1 = SLENDER 2 = BUSHY 3 = INTERMEDIATE

**15. PLANT HABIT:**
[1] 1 = DETERMINATE 2 = INDETERMINATE 3 = OTHER *(Specify)* _____

**16. HYPOCOTYL COLOR:**
[1] 1 = GREEN 2 = PURPLE

**17. SEED PROTEIN:**
[ ] 1 = A 2 = B

**18. NUMBER OF DAYS TO FLOWERING** *(Place a zero in first box (e.g. [0][9]) when days are 9 or less.)*
[ ][ ]

**19. MATURITY GROUP:**
[7] 1 = 00 2 = 0 3 = I 4 = II 5 = III 6 = IV 7 = V 8 = VI 9 = VII 10 = VIII

**20. SIZE OF 10 DAY OLD SEEDLING GROWN UNDER CONSTANT LIGHT** *(Growth Chamber)* **AT 25° C.** *(Place a zero in first box (e.g. [0][2]) when size is 9 mm. or less.)*
[ ][ ][ ] MM. LENGTH OF SEEDLING
[ ][ ] MM. LENGTH OF COTYLEDON
[ ][ ] MM. WIDTH OF COTYLEDON

**21. DISEASE:** *(Enter 0 = Not Tested; 1 = Susceptible; 2 = Resistant)* 3 Moderately Resistant

| | | | | | |
|---|---|---|---|---|---|
| [2] BACTERIAL PUSTULE | [2] SOYBEAN CYST | [1] DOWNY MILDEW | [0] PURPLE STAIN | [0] POD AND STEM BLIGHT | [2] ROOT KNOT |
| [0] FROGEYE | [0] STEM CANKER | [3] PHYTO-PHTHORA | [0] BROWN STEM ROT | [2] TARGET SPOT | [0] BROWN SPOT |
| [0] BUD BLIGHT | [2] WILDFIRE | [0] RHIZOCTONIA ROT | [2] OTHER *(Specify)* _____ | | |

PV# 73058

## EXHIBIT D

Data Indicative of Novelty

'Forrest' is ~~very similar to its one parent, 'Dyer,' except it has (1) white flowers, and (2) superior seed holding. Plant growth characteristics are very~~ most similar to its Bragg parent, but it differs from Bragg in that it is (1) 21 days earlier in maturity, (2) resistant to races 1 and 3 of the soybean cyst nematode, and (3) resistant to reniform nematodes.

CORRECTION PER TELEPHONE CALL TO DR. HARTWICK 9/19/75 RJS

FORM GR-470-2 (REVERSE)

73058

**22. INDICATE WHICH VARIETY MOST CLOSELY RESEMBLES THAT SUBMITTED.**

| CHARACTER | NAME OF VARIETY | CHARACTER | NAME OF VARIETY |
|---|---|---|---|
| Plant shape | | Petiole angle | |
| Leaf shape | | Seed size | |
| Leaf color | | Seed shape | |
| Leaf surface | | Seedling pigmentation | |

**23. GIVE DATA FOR SUBMITTED AND SIMILAR STANDARD VARIETY:**

| VARIETY | Date of Maturity | LODGING SCORE | PLANT HEIGHT CM | LEAF SIZE | | CONTENT | | AVERAGE NO. OF PODS PER PLANT | IODINE NO. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Width | Length | Protein | Oil | | |
| Submitted | Oct. 1 | 2.3 | 86 34'' | - | - | 39.2 | 21.9% | - | - |
| Name of similar variety Dare | Oct. 1 | 2.7 | 86 34'' | - | - | 39.0 | 23.0 | - | - |

## INSTRUCTIONS

**GENERAL:** The following publications may be used as a reference aid for completing this form:

1. Scott, Walter O. and Samuel R. Aldrich, 1970, Modern Soybean Production, The Farmer Quarterly.
2. Norman, A. G., 1963, The Soybean: Genetics, Breeding, Physiology, Nutrition, Management.
3. McKie, J. W., and K. L. Anderson, 1970, The Soybean Book.

**LEAF COLOR:** Nickerson's or any recognized color fan may be used to determine the leaf color of the described variety. The following Soybean varieties may be used as a guide to identify the colors listed on the form.

| COLOR | VARIETY |
|---|---|
| Light Green | "Ada" |
| Medium Green | "Wilkin" |
| Dark Green | "Swift" |

**LEAF SIZE:** The following varieties may be used as a guide to identify the relative size leaves.

| SIZE | VARIETY |
|---|---|
| Small | "Amsoy" |
| Medium | "Bonus" |
| Large | "Anoka" |

**PLANT TYPE:** The following varieties may be used as a guide to identify the plant type.

| TYPE | VARIETY |
|---|---|
| Slender | "Vansoy" |
| Intermediate | "Wirth" |
| Bushy | "Adelphia" |

73058

EXHIBIT E

Statement of Applicant's Ownership

The breeder, Edgar E. Hartwig, is Research Agronomist, Agricultural Research Service, U. S. Department of Agriculture, working in cooperation with the Delta Branch, Mississippi Agricultural and Forestry Experiment Station, Stoneville, Mississippi. The research leading to the development of the soybean variety Forrest was conducted in cooperation with Mr. James Epps, Research Nematologist, ARS, USDA, working in cooperation with the West Tennessee, Agricultural Experiment Station, Jackson, Tennessee, in a research program directed toward developing a high productive soybean variety resistant to nematodes.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D.C. 20250

#73058
'FORREST'
EXHIBIT E rfs.

JUL 15 1974

Director James H. Anderson
Agricultural and Forestry Experiment Station
Mississippi State University
P.O. Drawer ES
Mississippi State, Mississippi 39762

Dear Dr. Anderson:

Inasmuch as your request of June 20 to Dr. H. O. Graumann for a letter of consent regarding plant variety protection issues reflects on and could set the stage for final policy on jointly developed varieties, it has been determined appropriate for the response to be from the Administrator's office.

Our Department legal staff advises us that USDA policy as to protection of such varieties is expressed in the "inventions" clause in our Cooperative Agreement with the University (see General Provisions, paragraph 17b).

The policy is sufficiently flexible to allow the University to be listed as a sole or joint owner of each Certificate. However, just as you have pointed out, it will be necessary for the University to waive its rights as provided in Chapter 8, Section 83(a) of the Plant Variety Protection Act. To accomplish this, the Department would require that the University request the Plant Variety Protection Office to print such a waiver on each Certificate, and it should be worded as follows:

> "The right to exclude others from selling, offering for sale, reproducing, importing, or exporting the variety covered by this Certificate, or using it in producing a hybrid or different variety is hereby waived."

Furthermore, if the University elects sole ownership of the Certificates, they must also request the Plant Variety Protection Office to include a printed notice on each Certificate that the variety was developed under joint Department-University funding.

With the understanding that the above stated conditions are agreeable to you and can be met, we give our consent for the University to move ahead in clarifying "Statement of Ownership" in Exhibit E of application Nos. 73058 and 7400062 now pending in the Plant Variety Protection Office.

Sincerely,

Ralph J. McCracken

Ralph J. McCracken
Acting Administrator

**Table 1. Reaction of soybean differentials and parents to four races of *Phytophthora megasperma* var. *sojae*.**

| | Reaction† | | | |
|---|---|---|---|---|
| | Race 1 | Race 2 | Race 3 | Race 4 |
| Harosoy | S | S | S | S |
| D60-9647 | R | S | R | R |
| Harosoy 63 | R | R | S | S |
| Mack | R | R | R | S |
| PI 171442 | R | R | R | R |
| Tracy | R | R | R | R |
| Forrest | S | S | S | S |
| D55-1492 | S | S | S | S |

† S = susceptible; R = resistant.

**Table 2. Reaction of $F_3$ lines from the crosses Tracy × D55-1492 and Forrest × Tracy inoculated individually with four races of *Phytophthora megasperma* var. *sojae*.**

| | No. of $F_3$ lines | | |
|---|---|---|---|
| | Resistant or segregating | Susceptible | $X^2$ probability |
| Race 1 | | | (15:1 ratio) |
| Tracy × D55-1492 | 225 | 21 | 0.10–0.25 |
| Forrest × Tracy | 537 | 39 | 0.50–0.75 |
| Race 2 | | | (3:1 ratio) |
| Tracy × D55-1492 | 182 | 64 | 0.75–0.90 |
| Forrest × Tracy | 446 | 130 | 0.10–0.25 |
| Race 3 | | | (15:1 ratio) |
| Tracy × D55-1492 | 231 | 15 | >0.99 |
| Forrest × Tracy | 538 | 38 | 0.50–0.75 |
| Race 4 | | | (15:1 ratio) |
| Tracy × D55-1492 | 232 | 14 | 0.75–0.90 |
| Forrest × Tracy | 541 | 35 | 0.90–0.95 |

of the strong evidence from the $F_3$ lines in two crosses that Tracy has two genes for resistance to race 1.

An objective of screening the backcross families was to identify those segregating for resistance to all four races, allowing an opportunity for selection within those populations. Table 4 shows that 22 families segregated for resistance to all four races. This number is consistent with that expected if Tracy has one gene giving resistance to all four races and one gene giving resistance to races 1, 3, and 4, but susceptibility to race 2. The combination of genes for resistance from D60-9647 and PI 171442 (Table 1), both in the pedigree of Tracy, would be expected to give the results shown in this paper. The reaction of the backcross families suggests that one would not have needed to screen for all four races. The necessity of screening for resistance against race 2 is obvious from the results presented when Tracy is used as the resistant parent. Screening against any one of the other three races should be equally effective in selecting populations segregating for resistance to all four races. One family (Table 4) classified as being uniformly susceptible to race 3 and segregating for races 1, 2, and 4, would have been retained for further selection if races 2 and either 1 or 4 had been used. It would have been discarded if screened against only races 2 and 3. An occasional escape could perhaps be tolerated in most plant breeding programs, especially because another

**Table 3. Reaction of 50 $F_3$ families from the backcross Forrest (2) × Tracy inoculated individually with four races of *Phytophthora megasperma* var. *sojae*.**

| | No. of families | | $X^2$ probability |
|---|---|---|---|
| | Segregating | Susceptible | |
| Race 1 | 31 | 19 | (3:1 ratio) 0.025–0.05 |
| Race 2 | 23 | 27 | (1:1 ratio) 0.50–0.75 |
| Race 3 | 39 | 11 | (3:1 ratio) 0.50–0.75) |
| Race 4 | 39 | 11 | (3:1 ratio) 0.50–0.75 |

**Table 4. Uniformly susceptible or segregating families from the backcross Forrest (2) × Tracy inoculated individually with four races of *Phytophthora megasperma* var. *sojae*.**

| Reaction† | | | | No. of BC $F_3$ families |
|---|---|---|---|---|
| Race 1 | Race 2 | Race 3 | Race 4 | |
| SEG | SEG | SEG | SEG | 22 |
| S | S | S | S | 5 |
| S | S | SEG | S | 6 |
| S | S | S | SEG | 5 |
| S | S | SEG | SEG | 3 |
| SEG | S | SEG | SEG | 8 |
| SEG | SEG | S | SEG | 1 |

† SEG = segregating; S = uniformly susceptible.

screening would be required to select homozygous resistant lines from segregating families. In selecting families segregating for resistance to races 1, 2, 3, and 4, there is no assurance that both of the genes for resistance in Tracy have been retained. However, selecting families having a large resistant/susceptible ratio when tested against races 1, 3, or 4 should increase the chance of successfully selecting for both genes.

## ACKNOWLEDGMENT

The author thanks B. L. Keeling and E. L. Jackson for providing the four races of the pathogen used in the study.

## REFERENCES

1. Haas, J. H., and R. I. Buzzell. 1976. New races 5 and 6 of *Phytophthora megasperma* var. *sojae* and differential reactions of soybean cultivars for races 1 to 6. Phytopathology 66:1361-1362.
2. Hartwig, E. E. 1973. Registration of Forrest soybeans. Crop Sci. 13:287.
3. ———. 1974. Registration of Tracy soybeans. Crop Sci. 14: 777.
4. Keeling, B. L. 1976. Personal communication.
5. Kilen, T. C. 1977. Additional genes for resistance to phytophthora rot in soybeans. Agron. Abstr. p. 62.
6. ———, E. E. Hartwig, and B. L. Keeling. 1974. Inheritance of a second major gene for resistance to phytophthora rot in soybeans. Crop Sci. 14:260-262.
7. ———, and B. L. Keeling. 1977. Simultaneous screening of soybeans against three races of *Phytophthora megasperma* var. *sojae*. Crop Sci. 17:185-186.
8. Laviolette, F. A., and K. L. Athow. 1977. Three new physiologic races of *Phytophthora megasperma* var. *sojae*. Phytopathology 67:267-268.

# Selection for Resistance to Four Races of *Phytophthora megasperma* var. *sojae* in Soybean[1]

T. C. Kilen[2]


## ABSTRACT

**Phytophthora rot is a serious disease of soybean [*Glycine max* (L.) Merr.] incited by the fungus *Phytophthora megasperma* Drechs var. *sojae* Hildeb. Screening for resistance to this disease is complex because of the genetic variability for virulence in the pathogen. The cultivar 'Tracy' was used as the resistant parent in crosses with a very susceptible breeding line, D55-1492, and the cultivar 'Forrest'. These crosses were used to study the genetics of resistance to physiologic races 1, 2, 3, and 4 of the pathogen in order to find more efficient screening methods. $F_2$ lines from the crosses Tracy × D55-1492 and Forrest × Tracy and $F_2$ populations from 50 backcross families of Forrest (2) × Tracy were evaluated. The plants were grown hydroponically and were infested with race 1, 2, 3, or 4 of the pathogen. Data from the Tracy × D55-1492 and Forrest × Tracy crosses indicated a two-gene segregation ratio when challenged by races 1, 3, and 4 and a one-gene ratio with race 2. The reaction of the backcross families suggests that testing with race 2 and any one of the other three races would have been sufficient to select the 22 families that were segregating for all four races and would thus be an efficient screening method.**


***Additional index words:*** **Glycine max (L.) Merr., Segregation ratios.**

NINE physiologic races of *Phytophthora megasperma* Drechs. var. *sojae* Hildeb. have been reported to cause a root and stem rot of soybean [*Glycine max* (L.) Merr.]. Haas and Buzzell (1) reported on races 5 and 6 and cited references describing races 1 through 4. Laviolette and Athow (8) have published data on three additional races.

The development of soybean cultivars with resistance to a large number of races becomes difficult as the number of genes required to confer resistance increases. The time and space required for screening large populations segregating for two or more genes with resistance to several races of the pathogen make it essential that efficient screening techniques be developed.

The cultivar 'Tracy' (3) has two major genes for resistance (5) and is resistant to all nine reported races of the pathogen (8). The objective of the research reported in this paper was to study the genetics of resistance to four races of the pathogen and find more efficient methods of screening for multiple-race resistance.

## MATERIALS AND METHODS

Tracy, selected as the source of resistance for this study, was crossed with a very susceptible soybean strain, D55-1492, and the cultivar, 'Forrest'. The parentage of D55-1492 has been reported previously (6). Although Forrest has no major genes for resistance to phytophthora rot, and is killed when inoculated with the pathogen in the greenhouse, it is classified as moderately resistant (2) in field plantings. $F_1$ seed of the crosses and backcrosses were produced by hand-pollination. Segregating populations were derived from $F_1$ plants grown in a greenhouse and $F_2$ plants grown in a field with sandy loam soil, where injury by phytophthora rot does not occur. $F_1$ plants from the backcrosses were grown in a similar field area. Plants were harvested individually for progeny testing.

All seed were treated with a fungicide before they were germinated in vermiculite. When the total length of the seedlings was about 10 cm, they were washed to remove the fungicide and vermiculite and were transferred to tanks containing a modified (Mo and B were deleted) Hoagland's culture solution reduced to 25% strength. Sheets of polystyrene about 2.5 cm thick having holes spaced about 5 cm apart were placed on the surface of the solution for supporting the seedlings. Seedlings were inserted into the holes with the cotyledons resting on the surface of the polystyrene. About 800 plants were grown in each tank, which contained 190 liters of culture solution at the beginning of a test. The tanks were lined with plastic sheeting that was incinerated along with all plant material at the end of a test. The sheets of polystyrene were sterilized with propylene oxide before they were reused.

In previous experiments, the disease developed more rapidly when diseased plant material was used as the inoculum than when a slush culture of the pathogen was used (4). Therefore, a culture of each race of the pathogen growing in a 10-day-old cornmeal agar slush (2.5 g of cornmeal agar per liter of water) was added individually to separate small tanks in which susceptible plants were growing. Diseased hypocotyls and roots from these plants were used to inoculate the experimental population 3 days after it was transplanted to large tanks. All inoculations were made in a greenhouse during the winter. The tanks were shaded as described by Kilen and Keeling (7). Humidity was not controlled. The night temperature was set at 21 C, and day temperatures ranged from 20 to 30 C. The soybean differentials and parents listed in Table 1 were grown with the experimental populations to monitor the purity of each individual race and the uniformity of infection in each test. Ten days after inoculation, plants were classified as susceptible (dead or having lesions on the hypocotyl) or resistant.

Backcross $F_1$ plants were classified on the basis of the reaction of their $F_2$ progeny. Population size for the 50 backcross families of Forrest (2) × Tracy was 40 for each race if the seed supply was large enough; a few families had a population size of 20 for each race. Each $F_2$ plant was evaluated by the reaction of 11 $F_3$ plants. Because 11 plants provided too small a sample to distinguish uniformly resistant families from segregating families, emphasis was placed upon the identification of uniformly susceptible families. An $F_2$ plant was considered to be susceptible if all of its progeny were killed or had lesions.

## RESULTS AND DISCUSSION

The soybean differentials and parents listed in Table 1 reacted to each race as expected; therefore, they are not listed in the tables with segregating populations. The data from the Tracy × D55-1492 and Forrest × Tracy crosses (Table 2) indicate a two-gene segregation ratio when challenged by races 1, 3, and 4 and a one-gene ratio with race 2. The reaction of the 50 families from the backcross Forrest (2) × Tracy (Table 3) also indicated one gene for resistance to race 2 and two genes for resistance to races 3 and 4. However, the data for race 1 indicate a poor fit to a two-gene segregation ratio. No satisfactory explanation can be given for the discrepancy in reaction to inoculation between $F_3$ lines of Forrest × Tracy and the backcross families of Forrest (2) × Tracy. The poor fit to a 3:1 ratio was probably due to chance because

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