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tercrossing, and selection for transfer from diploids into agronomically acceptable tetraploid cotton (5,6,7).

The discovery of a glandless seed–glanded plant hexaploid and the production of fertile F_1 pentaploid plants from crossing the hexaploid × tetraploid plants reported in the present paper are two important steps in the transfer of this phenotype into tetraploid cotton. The F_1 pentaploid plants appeared to be as fertile as either the hexaploid or tetraploid parents. Therefore, completing the transfer of the glandless seed–glanded plant trait into *G. hirsutum* appears to be a promising but challenging research area.

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TECHNIQUES FOR IDENTIFYING TOLERANCE OF SOYBEAN TO PHYTOTOXIC SUBSTANCES IN WHEAT STRAW[1]

L. L. Herrin, F. C. Collins, and C. E. Caviness[2]

Abstract

Experiments have shown that substances in wheat (*Triticum aestivum* L.) straw are phytotoxic to soybean [*Glycine max* (L.) Merr.]. We evaluated techniques for screening soybean germplasm to these growth-reducing substances and studied factors affecting this trait. Techniques used were: i) pots in a greenhouse, ii) large wooden flats in a greenhouse, and iii) field evaluations. The soil mixture in the greenhouse contained 20 g straw/kg soil. Results from the flat technique were highly correlated with the pot method, the technique commonly used. Field evaluations were not highly correlated with greenhouse results. Seed age and seed source affected the tolerant response, whereas seed size was not an important factor.

***Additional index words:* *Glycine max* (L.) Merr., Allelopathy, Seed source and age, Wheat residue.**

Farmers in areas where the growing season is of sufficient length can better utilize their land and increase production by growing a small grain during the cool season and soybean, [*Glycine max* (L.) Merr.] during the summer. The major environmental factors limiting yields of double cropped soybean are length of the growing season and amount of rainfall. Another factor that has been shown to limit yield, but to a lesser extent, is the allelopathic effect of wheat (*Triticum aestivum* L.) or oat (*Avena sativa* L.) residue on soybean (4). Collins and Caviness (3) compared several soybean cultivars for tolerance and phytotoxic effects of wheat residue and found that cultivars differed significantly.

For many years it has been known that residues from one crop can give rise to phytotoxic effects on succeeding crops (1,12,13,14,15,16). A wide range of injurous effects on plants due to phytotoxins has been reported, with the most common effects being reduced growth, low seedling vigor, chlorosis, reduced germination, and suppression of root elongation.

A major question in phytotoxicity research is whether the compounds are breakdown products in plant tissue or materials synthesized by microorganisms (7,9). Some researchers have suggested that the phytotoxic effects may result from a combination of both (8,10). Guenzi and McCalla (6) reported in 1966 that phenolic com-

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pounds reduce germination and plant growth. They identified ferulic, p-coumaric, syringic, vanillic, and p-hydroxybenzoic acids in hydrolyzed extracts of mature corn (*Zea mays* L.), wheat, sorghum, and oat residues. Lynch (8) subjected wheat straw to anerobic and aerobic decomposition in soil suspension in the laboratory and found organic acids such as acetic, propionic, and butyric as the primary phytotoxins. Cochran et al. (2) conducted research on wheat residue and found a cyclic appearance of toxins with periods of stimulation and inhibition. They concluded that microbial activity was needed for toxin production.

It is clearly evident that wheat residue may produce products that are toxic to many plants including soybean. But, before breeding programs are initiated to develop soybean cultivars tolerant to the phytotoxic effects of wheat residue, it appears that improved screening techniques and information on the tolerance reaction are needed. The objectives of this research were: i) to evaluate different techniques for screening soybean germplasm to growth reducing factors in wheat residue, and ii) to determine the major factors causing variation in tolerance of soybean genotypes to these phytotoxins.

MATERIALS AND METHODS

The effects of wheat straw residue on growth of soybean plants were evaluated using: i) pots in a greenhouse, ii) large wooden flats in a greenhouse, and iii) field plots. The straw used in all experiments, except the field studies, was a composite sample of the most widely grown wheat cultivars in Arkansas. A description of the methods used in these studies follow:

i) Pots in a greenhouse—Initial screening for tolerance to growth-reducing factors in wheat straw was done in the greenhouse using 15-cm plastic pots containing a Captina silt loam (fine-silty, mixed, mesic, Typic Fragiudults). Plants of each soybean cultivar were grown in soil amended with 20 g wheat straw/kg soil. Ten seeds were planted in each pot at a depth of 2.5 cm and, after emergence, seedlings were thinned to four plants per pot. At the V6 growth stage (5), the total dry matter production of the aboveground portion of the plants in each pot was determined. Degree of tolerance was calculated as the proportion of soybean dry matter produced in pots with straw divided by soybean dry matter produced in pots without straw. The experimental design was a randomized complete block with eight replications.

ii) Large wooden flats—Flats, 120 × 45 × 30 cm, were used in the greenhouse in an attempt to develop a more efficient technique for evaluating a large number of soybean cultivars. Each box contained 54 kg of Captina silt loam with or without 20 g wheat straw/kg soil. Soybean cultivars were evaluated in 11-cm rows with seven plants per row and 11 rows per box. Boxes with and without wheat straw were paired, and the rows were planted directly across from each other. Fifteen seeds of each cultivar were planted in each box at a depth of 2.5 cm and after emergence thinned to seven seedlings per row. Dry matter was determined at the V6 growth stage and a ratio was calculated from growth of soybean in flats amended with wheat straw divided by growth of soybean without wheat straw.

iii) Field study—Experiments were conducted at the Main Experiment Station, Fayetteville, AR, on a Captina silt loam to evaluate the response of soybean cultivars to phytotoxic substances in wheat residue. Alternating strips of fallow and wheat planted the previous year were used in these studies. The strips were approximately 5 m wide. After the wheat was harvested, a seedbed was prepared by double disking in the direction of the strips, thereby minimizing incorporation of wheat straw into the fallow soils. Soybean cultivars were planted across the alternating strips on 3 July 1982 using a plot planter with a double disk opener. Rows were spaced 46 cm apart in plots 4.6 m long. Planting was at the rate of 34 seeds/m. Plots were kept weed free by hoeing and were sprinkler irrigated twice with 5 cm of water applied at each irrigation. A plant sample from a meter length of row was harvested at the V6 stage of growth and dried in a forced-air oven at 60°C.

Studies were also conducted using greenhouse pots to determine factors that can cause variation in the response to phytotoxic substances in wheat straw. Pots were handled in the same manner as previously described for the greenhouse test. The factors examined included age, source, and size of soybean seed.

i) Effect of seed age—Seeds were obtained that had been produced at Marianna, AR during 3 different yrs (1979, 1980, and 1981). The seed had been stored after harvest in a heated laboratory until 1982 when they were planted in a randomized complete block design with eight replications.

ii) Effect of seed source—Seed was obtained from plants grown at three locations (Marianna, Stuttgart, and Rohwer) during the summer of 1982. The experimental design was a 2 × 3 factorial, with two cultivars and three locations arranged in a randomized complete block design with 10 replications.

iii) Effect of seed size—The effect of seed size on tolerance to phytotoxins in wheat straw was evaluated using four cultivars and four different seed sizes within each cultivar. Appropriate screens were used to divide seed samples of the cultivars into four size classes: large, medium, small, and very small.

Results and Discussion

Significant differences were found among the nine soybean cultivars tested with the standard greenhouse pot technique (Table 1). 'Davis' and 'Centennial' were the most tolerant and 'Mack', 'Forrest', and 'Tracy M' were least tolerant to the phytotoxic substances in wheat straw. Tolerance ranged from a low of 62% for Forrest to a high of 82% for Davis.

The studies comparing the greenhouse pot method to: a) the large wooden flat method, and b) the field plots clearly showed that results from the large wooden flat method were similar to those obtained in green-

Table 1. Tolerance of soybean cultivars to wheat straw using the standard greenhouse pot procedure for evaluation.

	Dry wt		
	Straw treatment		
Cultivar	With straw	Without straw	Tolerance†
	g/pot		%
Davis	3.17	3.83	82
Centennial	4.38	5.50	79
Pickett 71	3.39	4.77	72
Lee 74	3.96	5.64	70
Dare	3.56	5.18	69
Bragg	3.76	5.60	67
Mack	3.22	4.95	65
Tracy M	3.51	5.44	65
Forrest	2.77	4.40	62
LSD (0.05)			10
CV, %			17

† Tolerance was calculated as weight of soybeans at the V6 growth stage grown with straw ÷ weight of soybeans grown without straw × 100.

Table 2. Influence of seed age on soybean tolerance to phytotoxins in wheat straw using the greenhouse method for evaluation.

	Tolerance†			
	Cultivar			
Seed age	Davis	Lee 74	Tracy M	Average
years	%			
3	51a‡	67a	44a	54a
2	77b	71a	72b	73b
1	72b	75a	75b	74b

† Tolerance was calculated as weight of soybeans at the V6 stage grown with straw + weight of soybeans grown without straw × 100.
‡ Means in the same column followed by the same letter do not differ significantly according to Duncan's multiple range test ($P = 0.05$).

house pots. A significant positive correlation ($r = 0.826$; 54 df) was found between results obtained in the wooden flats and results from the greenhouse pot method. Dry weight of plants of commercial soybean cultivars grown under field conditions was not highly correlated ($r = 0.516$; 54 df) with results obtained in pots in the greenhouse. This may be explained by better control in the greenhouse of environmental factors such as temperature, moisture, soil variation, and concentration of inhibiting substances. As pointed out by Patrick et al. (11), toxic extracts may not be obtained from different fields at all times and the degree and duration of the toxic period may vary with the location even in a given field. They reported that soil type, soil moisture, and soil microbial populations are major factors contributing to this variability.

Experiments were conducted to study factors that are capable of causing variation in the tolerance response to phytotoxic substances in wheat straw. There were significant differences among years; the 3-yr-old seed produced plants that were less tolerant to the phytotoxic substances in wheat straw than plants from either 1- or 2-yr-old seed (Table 2). Tolerance of plants produced from 3-yr-old seed was 54%, compared to values of 74 and 73% for 1- and 2-yr-old seed, respectively. The same general pattern was found for the three cultivars even though there was a significant cultivar × seed age interaction. Tolerance of 'Lee 74' plants to the phytotoxic substances did not appear to be affected as much by seed age as the other cultivars.

Research was conducted to determine the effect of location where soybean seeds were produced on tolerance of that seed to phytotoxic substances in wheat straw. There were no significant differences among the three locations (Marianna, Stuttgart, Rohwer) where seeds of the tolerant Davis cultivar were used; however, there were significant differences among locations for the Mack cultivar. Davis is more tolerant than Mack to growth-reducing substances in wheat straw. It is evident, therefore, that seeds for screening cultivars for tolerance to phytotoxic substances in wheat straw should be produced at the same location.

Studies were conducted to determine the influence of seed size on soybean tolerance to phytotoxic substances in wheat straw. Tolerance levels, as determined by the greenhouse pot method, were not significantly affected by seed size within a cultivar. The data clearly showed that variation in seed size was not a factor affecting tolerance of any of the four cultivars (Davis, 'Deltapine 246', 'Dare', 'Ring Around 680') used in this study.

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ALFALFA TRIPLOIDS WITH FUNCTIONAL MALE AND FEMALE FERTILITY[1]

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Abstract

Alfalfa (*Medicago sativa* L.) triploids ($2n=3x=24$) were produced by crossing tetraploid cultivated alfalfa with cultivated alfalfa at the diploid level (CADL) derived by haploidy. Alfalfa triploids usually function only as seed parents in crosses; however, eight of nine triploids in this study functioned as the pollen parent in $3x$-$3x$, $4x$-$3x$, or $6x$-$3x$ crosses. Moreover, two triploids produced self-progeny. In $3x$-$3x$ crosses, most progeny had 31 or 32 chromosomes, but progeny with 29, 35, 45, 46, 47, 48, and 58 chromosomes were also produced. Triploid self-progeny had 31, 32, 36, 45, 46, 47, 48, and 52 chromosomes. Several hexaploids ($2n=48$) and near hexaploids ($2n=45$–52) were produced by sexual polyploidy in $3x$ self, $3x$-$3x$, $3x$-$6x$, and $6x$-$3x$ matings.

Additional index words: ***Medicago sativa*** **L., Gamete, Diploid, Tetraploid, Hexaploid, Octoploid.**

CROSSING behavior of triploid ($2n=3x=24$) alfalfa (*Medicago sativa* L.) has been studied by several researchers (1,2,7,8,17,18). Most triploids in previous studies were obtained from $4x$-$2x$ crosses involving

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