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A was made from 0.625 × 6.3 cm (1/4 × 2 1/2 in.) strap iron.

A pitch fork handle was bolted to unit A at y in Fig. 1d. The handle (z in Fig. 1d) bolted to unit B was shaped from a piece of 1 × 4 pine lumber 7.5 cm wide and 2 cm thick except for the handle at the top. The slightly tapered chute for guiding the plant down the handle on unit B was made from 28-gauge galvanized iron fitted about 1 cm inside the top of unit B and nailed to the sides of the wooden handle.

The plants we used to test the transplanter were produced from seed planted in December in rows in flats of fertilized steam-sterilized soil.[3] In early February the seedlings were transplanted to the same soil in 5-cm clay pots placed on greenhouse benches. Optimum growing conditions were maintained until mid-April, when we transplanted the plants into the field. By this time, the plants were large and when pulled from the pots their roots completely surrounded and held the soil in which they grew as if they were growing in peat pots. For field planting, plants were pulled from their pots and placed in bags or buckets to keep them from drying until they could be set in the field. We transplanted the plants to a field of freshly prepared soft, moist soil that was cross marked at right angles 0.6 or 0.9 m apart for bahiagrass, *Paspalum notatum* Flugge., and 2 or 3 m apart for bermudagrass, *Cynodon sp.* L.

In the transplanting operation, the operator forces the planter into the soil at a crossmark with the handles spread apart (Fig. 1a) and an assistant drops a plant into the chute on the handle of unit B. The operator brings the handles together (Fig. 1b) making a hole about 8 × 8 × 8 cm into which the plant drops. The operator then moves the transplanter to the next crossmark in the row, and pushes soil with his feet around the roots of the plant just set while the assistant drops another plant into the transplanter chute. A second assistant pushing soil around the roots of the plant speeds the whole operation, particularly when plants are set more than 1 m apart. As soon as all plants are set, the field is irrigated to complete the operation.

We used this transplanter in mid-April 1975 to transplant about 6,500 bahiagrass seedlings that we planned to use for recurrent restricted phenotypic selection (RRPS)[4]. The men who set the plants were delighted with the ease of the operation. These plants were transplanted with less shock and grew off faster and more uniformly than those planted less precisely in previous years. By late July, the plants were large enough and were producing enough heads that we could visually select the five best in each 5 × 5 block.

When 2 years/cycle are used in RRPS breeding, bahiagrass plants must be set 0.9 m apart in each direction. With one cycle/year, made possible by the transplanter described here, we can set the plants 0.6 m apart and reduce by more than half, the land required to grow the crop and the labor required to keep it free of weeds.

[3] Burton, Glenn W. 1965. A planter for seeding rows in flats. Agron. J. 57:632-633.

[4] Burton, Glenn W. 1974. Recurrent restricted phenotypic selection increases forage yields of Pensacola bahiagrass. Crop Sci. 14:831-835.

ESTIMATING FUSARIUM WILT REACTION OF COTTON GENOTYPES[1]

A. J. Kappelman, Jr.[2]

ABSTRACT

Fusarium wilt reaction of certain cultivars of cotton (*Gossypium hirsutum* L.) were estimated for years in which they were not actually tested. Actual and estimated or predicted values were then compared as were methods of prediction. Estimated values of the percentage of wilting due to *Fusarium oxysporum* Schlect. f. *vasinfectum* (Atk.) Snyd. & Hans. for a given cultivar of cotton, calculated as ratios of the susceptible check 'Rowden,' were not greatly different from observed wilting percentages. When Rowden was used as the predictive base, only four of 48 values calculated using the ratio method of estimating means fell outside of the 95% confidence limits of estimates made using the least squares regression technique. When the resistant check, 'Auburn 56,' was used as the predictive base, 29 of 48 means were outside the 95% confidence limits. However, since Rowden was planted much more frequently in all tests, wilting for the cultivar was based on a much larger number of plants grown over the widest range of environments. Reliable estimates of wilting percentages for cotton cultivars not actually grown a given year can then be made using simple ratios based on Rowden.

***Additional index words:* *Gossypium hirsutum* L., *Fusarium oxysporum vasinfectum*, Nematodes, Wilt predictions.**

DISEASE losses in cotton (*Gossypium hirsutum* L.) due to infection by *Fusarium oxysporum* Schlect. f. *vasinfectum* (Atk.) Synd. & Hans. occur in many of the cotton-growing states (1). Greatest losses from fusarium wilt have occurred in the southeastern cotton-growing states where nematodes (usually species of the genus *Meloidogyne*) are also a problem. However, wilt losses in other areas have increased during recent years. Many lines and cultivars of cotton are tested yearly in the Regional Fusarium Wilt Screening Test (which has been conducted for 23 years) and individual yearly performance has been reported previously (2). However, desired comparisons between given entries occasionally cannot be made in a certain year if one of the entries was not tested that year.

Kappelman and Sappenfield (3) suggested that comparison of results from different locations could be made by including a common susceptible and resistant check in each test and then making comparisons relative to these checks. Since their results were reported over both years and locations, valid comparisons of entries also may possibly be made between actual and predicted wilt reaction relative to a given check.

The present study was conducted to compare fusarium wilt reaction computed by ratios and by least squares with each other and to observed wilt reaction.

MATERIALS AND METHODS

Seven cotton cultivars were evaluated for reaction to fusarium wilt over a period of 8 years. Four of these cultivars, including 'Auburn 56' and 'Rowden,' were evaluated every year. Seed of cultivars evaluated were planted in single-row plots 9.1 m in length with 1 m between rows. Two hundred seeds were used

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Table 1. Observed and predicted wilting by years and relative ranking of cotton cultivars over years based on predicted values made using ratios.

	Year															
	1967				1968				1969				1970			
Cultivar	A	PLS	PR	PA†	A	PLS	PR	PA	A	PLS	PR	PA	A	PLS	PR	PA
Rowden	78	66		8§	98	94		67§	97	90		29§	97	108		188§
Stoneville 7A	56	59	72	8§	94	88	91	62§	94	83	90	27§	94	101	90	179§
Stoneville 213	42	48	63	7§	98	76	79	54§	86	71	79	23§	95	89	79	156§
Coker 310		25	39	3§		54	50	26§		49	49	11§	56	67	49§	75
Deltapine 16	19	19	33	4	32	47	42	28§	31	43	42	13§	84	61	42§	83§
McNair 511		18	29	2		47	36	19§		42	35	8§		60	35§	54
Auburn 56	2	4	19		16	32	23		7	28	23		46	46	23§	

	Year																	
	1971				1972				1973				1974				Rel. Rkg.	
Cultivar	A	PLS	PR	PA	A	PLS	PR	PA	A	PLS	PR	PA	A	PLS	PR	PA	PR	PA‡
Rowden	92	89		76	67	64		71	70	83		147§	56	61		76§		
Stoneville 7A	76	83	85	70		57	62	66	80	76	65	136§	50	54	52	70§	5	5
Stoneville 213	52	71	78	61	31	45	54	58	76	64	57	119§	27	42	45	61§	4	4
Coker 310	71	48	47	29§	10	23	34	27	47	42	35	57	16	20	28	29	2	3
Deltapine 16	56	42	39	32	26	17	29	31	17	36	30	63§	14	14	24	32§	3	2
McNair 511	37	41	33	21§	14	16	25	20	32	35	26	41	22	13	21	21	1	1
Auburn 56	18	27	22		17	2	16		35	21	17		18	−1	13			

† A = actual wilting (%), PLS = predicted wilting based on least squares regression techniques, and PR and PA = predicted wilting based on ratios using Rowden and Auburn 56, respectively. ‡ Relative ranking (Rel. Rkg.) of cultivars, eliminating the two cultivars used to predict values based on ratios, where 5 = susceptible and 1 = resistant.
§ Predicted values based on ratios did not fall within the 95% confidence limits of values predicted on the basis of least squares analyses.

per row. The number of replications of the susceptible check, Rowden, varied from a low of 84 in 1967 to 124 in 1972; thus, yearly means were based on large numbers of plants. Values for the other cultivars studied are based on results from at least four replications each year; however, in some cases a given cultivar was evaluated more extensively. In such cases, means were calculated over all observations. In no case were more than 12 plots of the resistant check, Auburn 56, evaluated during 1 year. All tests were conducted in central Alabama at Tallassee.

From 1967 through 1971, wilted plants were counted and removed at about 10-day intervals starting in mid-June. Remaining live plants were counted at the end of the season. From 1972 through 1974, live plant counts were made in June or July, and again in late August or early September. In 1973 and 1974 wilted plants were also counted and pulled during August. During these 3 years, differences between initial and final live plant counts were attributed to wilt losses.

Percent wilting per row was calculated and mean wilting per cultivar was determined in each year. Because only four of the seven cultivars were evaluated every year, cultivar means calculated over the period of years they were actually grown were used to predict missing values. Means and relative rankings for cultivars over all years were then made using both observed and estimated values.

Estimated wilt reaction was calculated in two ways based on: 1) an analysis of variance using least squares regression techniques, and 2) a ratio technique using either the mean wilt percentage for Auburn 56 or Rowden as the predictive base. Values for missing data using the second method were calculated as follows: $A/B = C/D$ where

A = mean wilt percentage for a given cultivar for a particular year;

B = mean wilt percentage for the check for the same year;

C = mean wilt percentage for the given cultivar over years tested in common with the predictive check; and

D = mean wilt percentage for the predictive check (Rowden or Auburn 56) over same years as in C.

Using the ratio method and Rowden as the predictive base, the wilt reaction of 'Stoneville 7A' in 1972, A would be calculated as follows:

$$A/66.7 : 77.9/84.0.$$

Thus, wilt percentage for Stoneville 7A would be predicted as 62%. However, if Auburn 56 were used as the predictive base, 66% of the plants of Stoneville 7A would have been predicted to wilt during 1972.

RESULTS AND DISCUSSION

Percent wilting of the seven cultivars varied over years (Table 1). When Rowden was used to predict missing values, "susceptible" cultivars had slightly lower, and "resistant" cultivars higher, wilting percentages than when Auburn 56 was used as the predictive base for the ratio method of estimating missing value.

With the exception of 1973, wilting was always greatest in Rowden. In general, Auburn 56 was the most resistant cultivar although 'Coker 310' in 1972 and 'Deltapine 16' in 1973 and 1974 were the most resistant. However, mean wilting and the relative rankings for Auburn 56 and Rowden were lowest and highest, respectively, regardless of method of calculating predicted values for other cultivars during years they were not grown or which predictive base was used.

While numerical differences occurred between means predicted using either Rowden or Auburn 56 and resulted in differences in relative rankings, either check probably could be used to predict values for missing data. This would allow breeders to make broad classifications of materials into either "resistant" or "susceptible" groupings.

Only four estimated values calculated using the ratio method of estimating wilting with Rowden as the predictive base were outside the 95% confidence limits of estimates made using the least squares regression technique (Table 1). In all of these cases, percent wilting for cultivars calculated using the ratio method was lower than actual and/or predicted values based on the least squares regression technique.

The accuracy of this method when Rowden was used as the predictive base was probably greatly enhanced due to the more accurate estimates of wilting in Rowden as a result of the large number of plants evaluated over a wide range of environments.

When Auburn 56 was used as the predictive base, 29 of the predicted values were outside the 95% confidence limits of least squares regression estimates. These values were both greater and lower than actual and/or predicted values based on the least squares regression technique. Using this technique to estimate wilting and Auburn 56 as the predictive base, greater wilting as predicted to occur on a given cultivar when actual wilting of Auburn 56 was high relative to that of Rowden. Conversely, when Rowden was used as the predictive base, estimated values were below those made using least squares estimates when greater wilting actually occurred in Auburn 56 relative to that in Rowden.

Theoretically, estimated means based on an analysis of variance using least squares regression techniques are the best possible estimates which can be made based on data available. However, unless a computer and the appropriate program are readily available, such calculations can be made only with difficulty after a considerable amount of time. On the basis of experimental results reported here, estimates of wilting percentages of cotton cultivars (not grown a given year) can be made rapidly, simply, and with considerable accuracy by using the ratio method and Rowden as the predictive base.

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INHERITANCE OF A LIGHT SEED COAT COLOR IN SAFFLOWER[1]

G. H. Abel[2]

ABSTRACT

Information was needed on the inheritance of seed coat color in safflower, *Carthamus tinctorius* L. Darker seed coats yield darker colored oils whereas the lighter colored ones yield the more desirable lighter colored oils.

A cream-colored seed coat parent was crossed to two dark seed coat parents. The inheritance was studied in the F_1, F_2, F_3, and BC_1 progeny. The data corroborate the hypothesis of a previous author that the trait for brown seed coat color, *Lt*, is dominant over that for light, *lt*. In addition, minor genes are present which influence color intensity. Current cultivars having dark to intermediate colored seed coats can be converted to light colored ones, however, the interaction of seed coat color to environmental is not known.

Additional index words: **Seed hull, *Carthamus tinctorius* L.**

THE hull of the 4-ribbed, obpyramidal-shaped safflower (*Carthamus tinctorius* L.) seed (an achene), includes an outer pericarp and an inner seed coat. The pericarp is tightly attached to the seed coat, although the two tissues can be separated with a pointed needle.

The seed coat color ranges from white through yellow and light green or light brown to dark brown (Kursel, 1939). Seeds that have light seed coat colors yield a lighter colored oil than do seeds with dark coats. Rubis (1956) believed that a single, recessive mutant gene caused light seed coat in two Indian selections, PI 199,889 and PI 199,890 (D. D. Rubis, personal communication). Patel (1960), from F_1 and F_2 data, showed that brown seed coat, *Lt*, was dominant to light seed coat, *lt*. Lockwood (1966) found that the seed coat consists of a thick outer epidermis, a very thin middle layer, and a thick inner epidermis. The outer and middle layers are derived from the outer layer of the young integument and they form a few days after fertilization. The inner layer is derived from both the nutritive layer and part of the outer layer of the young integument. The light seed coat is expressed by the very light color of the outer epidermis of the integument. In normal achenes, all three layers are dark colored.

Ebert and Knowles (1968) report that cell division in tissues of the ovary and the integuments of the ovule appeared to cease at the time of anthesis. By the 5th day after fertilization, growth of the multiple-layered integument of the developing kernel resulted from cell enlargement and cell wall thickening except for the large inner nutritive layer. The inner nutritive layer degenerated 2 days after fertilization and became crushed to a thin layer by the outward force of the developing embryo. By the 10th day the stronger layer of sclerenchymatous cells of the pericarp began crushing the weaker layer of parenchymatous cells of the inner integumentary tissue which developed into the three-layered seed coat in about 25 days or at maturity.

The purpose of this report is to describe the inheritance of a light yellow (cream) color in all three layers of the seed coat in two crosses of safflower and their backcrosses. A second purpose is to determine whether my results corroborate those of Patel.

MATERIALS AND METHODS

Crosses in this study were B69563 × 14154-119-8 ($P_1 \times P_2$), its backcross to P_1, B69563 × 'Gila' ($P_1 \times P_3$), and its backcross to P_1. The outer and inner epidermises (Lockwood, 1966) of B69563 are cream colored and those of 14154-119-8 and Gila are dark brown and light brown, respectively.

B69563 was a selection from PI 273,877 from Ethiopia. The 14154 line was a selection from a purple striped-hull mutant. Gila was a normal-hull selection from a cross of 'N10' × 'W.O. 14' (Rubis and Black, 1958).

The single-crosses were made in 1971 at the Mesa branch station of the Univ. of Arizona. In 1972, hybrid plants were grown and backcrossed. The hybrid plants were caged during flowering to prevent outcrossing. About 40 seeds from each of 40 to 75 F_2 plants in the single-cross and all of the seed from the F_2 plants of the backcrosses were space-planted in rows 75 cm wide and 270 cm long.

Seed of parents, hybrids, the F_2 and F_3 progenies, and the backcrosses were classified for seed coat color. A stereoscopic microscope with 7×, 15×, and 30× magnifications was used to aid classification. To facilitate observation of seed coat, about 30 achenes from each plant were cut transversely, the meats were removed, and the oval halves were mounted in columns on oil-free plastic caulk. The caulk was molded on 7 × 80 × 0.5 cm wood trays. Strips of black malleable art wire were used to line divide the entries.

RESULTS AND DISCUSSION

Table 1 shows segregation ratios of the progenies from the single-crosses and backcrosses for seed coat color. Seed coat colors of the parents were uniform except for small differences in shade of the two prominent layers. The seed coat color of the F_1 hybrid plants was brown in both crosses but $P_1 \times P_2$ was darker brown than $P_1 \times P_3$. The brown color of each F_1 population varied in intensity among the hybrid seeds. Seed coat color of the F_2 progenies segregated in a 3:1 ratio of brown to cream in both crosses, but the intensity of the color still varied among the F_2 plants. Both epidermises were essentially the same color in a given seed, although the thick inner epidermis next to the thin endosperm layer was slightly lighter colored.

The F_3 progeny rows of $P_1 \times P_2$ identified the homozygous brown and the heterozygous brown-cream genotypes in a 1:2:1 ratio. The 17 segregating lines gave 190 browns to 61 creams which fits the 3:1 ratio ($0.50 < P < 0.80$).

[1] Cooperative investigation of the USDA, ARS, Western Region, and the Univ. of Arizona Agric. Exp. Stn., Tucson, Ariz. Published with the approval of the Director of the Arizona Agric. Exp. Stn. as Paper No. 2541. Received 25 Oct. 1975.

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