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# Lint Yield and Resistance to Pink Bollworm in Early-maturing Cotton[1]

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## ABSTRACT

**Moderately early maturing breeding stocks and cultivars of cotton, *Gossypium hirsutum* L., grown at Tempe, Ariz. in plots untreated with insecticide yielded slightly less to substantially more lint by mid-September than long-season cultivars did by mid-October. Seed damage percentages caused by pink bollworm (PBW), *Pectinophora gossypiella* (Saunders), were lower in the moderately early and the very early cottons than in the long-season cultivars. The very early maturing cottons, however, had lower yield potential than the moderately early or long-season ones. Because all cottons suffered losses in yield from PBW, earliness is viewed only as one factor in assisting cotton cultivars to escape damage. Earliness would have to be combined with other resistance characters to produce cultivars that possibly could be grown without protecting them from PBW damage with insecticide.**


**Additional index words:** *Gossypium hirsutum* L., *Pectinophora gossypiella* (Saunders), Host plant resistance.

FULL-SEASON cultivars of cotton, *Gossypium hirsutum* L., (commonly called Deltatype cultivars because they were developed in the Mississippi Delta) produce high lint yields in the irrigated desert valleys of Arizona and southern California. These high yields require large investments of irrigation water and insecticides. Much effort has been expended to study the consequences of terminating the crop early, thus reducing expenses and overwintering populations of insects, particularly pink bollworm (PBW), *Pectinophora gossypiella* (Saunders).

Several methods have been used to produce an earlier crop, such as chemical termination (5, 6), early irrigation cutoff (2), narrow-row spacing (8), early defoliation (4), early-maturing cultivars (7), and combinations of methods (1, 2, 3). Whatever combination of methods is chosen, an early-maturing cultivar will be an important component of the production system. Many early-maturing cultivars, however, are short-statured, determinate plants that do not make full use of the resources available, at least when they are grown in conventionally spaced rows. Thus, the most desirable cultivar for the irrigated deserts would mature bolls earlier than the deltatype cultivars but would also have a high yield potential.

We have harvested seedcotton sequentially and have measured seed damage by PBW from many breeding stocks and cultivars for several years. We therefore have an effective method of comparing yields and seed damage at any given harvest date of cottons varying in maturity. The objective of this paper is to discuss the possibility of the use of certain of these cottons in a shortened growing season in the irrigated southwestern desert.

## MATERIALS AND METHODS

Cotton breeding stocks and cultivars were grown at the Arizona State Univ. Farm, Tempe, from 1975 to 1979, and at the Univ. of Arizona Cotton Research Center, Phoenix, in 1978. Insecticides were not applied except to check plots in test 1979-3. In most tests, plots were four rows, 1 × 9.1 m, except in tests 1976-3 and 1976-4, which were 110 rows, 1 × 46.5 m. Experimental design was a randomized complete block with four or five replications. Seedcotton was harvested sequentially from one row/plot every 2 weeks for four or five times, August to October. Seedcotton was weighed and ginned. Lint and seed samples were weighed and the latter were x-rayed to provide estimates of PBW damage (11).

Over the 5-year period, 168 entries were tested. Breeding stocks and cultivars tested specifically because they were early maturing came from Bulgaria, Greece, USSR, and the USA (the latter came from Ariz., Calif., Miss., N. M., Okla., S. C., and Tex.). Also, many Okra-leaf and Super Okra-leaf stocks (mostly from Louisiana) were early maturing.

We defined an early maturing cotton as one that yields significantly more cumulative lint than the check cultivar at any harvest before the final one. This definition thus applies to certain cottons not usually considered early maturing. (For example, compare third and fourth harvest lint yields of Deltapine 7146N with those of 'Deltapine 16' in test 1976-4, Table 2). Because plots (except in 1979-3) were not sprayed for insect control, it was not possible to determine what lint yields would have been in the absence of PBW damage. To establish those yields for a representative group of cottons, we regressed

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lint/boll on seed damage percentages for four entries grown in 1979. We compared calculated yields from regression analysis with actual yields in sprayed and unsprayed plots in test 1979-3.

## RESULTS AND DISCUSSION

Thirty-seven of the 168 entries (22%) tested, 1975 to 1979, outyielded their respective check cultivar at first harvest, which was early to mid-August. By second harvest, 2 weeks later, 20% of the test cottons outyielded the checks. By fourth harvest, only 8% yielded more lint than the checks (Table 1).

Lint yields at first and second harvest were too low to be of economic importance, except for second-harvest yield of 'Stoneville 213'[3] (St-213) and 'Stoneville 731N' (St-731N) in test 1976-3 (Table 2). By third harvest (mid-September), cumulative lint yields were approaching or exceeding 1,000 kg/ha for some entries. Before the 1979 tests, the only entries that outyielded the checks at third harvest were 'DES 56', St-731N, Deltapine 7146N, and Stoneville 213 frego-bract. The latter three cottons also outyielded their respective check cultivars at fourth harvest. DES 56 and the two N(nectariless) cottons had

[3]Mention of a trademark name or proprietary product does not constitute endorsement by the USDA and does not imply its approval to the exclusion of other products that may also be suitable.

**Table 1. Cotton cultivars and breeding stocks tested for yield and seed damage by pink bollworm, Tempe and Phoenix, Ariz., 1975 to 1979.**

| Year | Entries tested | Entries yielding more cumulative lint than check† at harvest | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | no. | no. | | | | |
| 1975 | 34 | 12 | 4 | 1 | 1 | - |
| 1976 | 35 | 4 | 12 | 2 | 2 | - |
| 1977 | 34 | 5 | 3 | 1 | 1 | 0 |
| 1978 | 26 | 4 | 0 | 0 | 0 | - |
| 1979 | 39 | 12 | 14 | 9 | 9 | 9 |

† Check cultivar was one of the following: 'Deltapine 16,' 'Deltapine 61,' 'Stoneville 7A,' 'Stoneville 213,' 'Stoneville 256.'

**Table 2. Cumulative lint yields and seed damage percentages for cotton cultivars and breeding stocks, Tempe and Phoenix, Ariz., 1975 to 1979.**

| Entry | Cumulative lint yield: Harvest 1 | 2 | 3 | 4 | 5 | Seasonal seed damage |
|---|---|---|---|---|---|---|
| | kg/ha | | | | | % |
| **1975-1 (30 entries)** | | | | | | |
| Deltapine 16 (ck) | 43 | 430 | 807 | 1,036 | - | 34.2 |
| AZ 6608-27 | 239* | 628* | 792 | 857 | - | 35.5 |
| Tamcot SP-37 | 209* | 555 | 642 | 675 | - | 23.5* |
| Greece 10E | 208* | 542 | 725 | 829 | - | 27.1* |
| DES 56 | 162* | 660* | 962* | 1,028 | - | 28.8* |
| AET-5 | 129* | 610* | 866 | 996 | - | 21.1* |
| L.S.D.$_{0.05}$ | 76 | 135 | 128 | 141 | | 4.3 |
| **1976-1 (10 entries)** | | | | | | |
| Deltapine 16 (ck) | - | 53 | 434 | 639 | - | 27.0 |
| Greece 10E | - | 166* | 513 | 598 | - | 19.9 |
| DES 56 | - | 156* | 623* | 775 | - | 23.2 |
| L.S.D.$_{0.05}$ | | 84 | 185 | NS | | NS |
| **1976-2 (8 entries)** | | | | | | |
| Stoneville 7A (ck) | 67 | 540 | 736 | 835 | - | 44.0 |
| TM-1 Okra-leaf | 178* | 638 | 760 | 795 | - | 31.3* |
| St 7A Okra-leaf | 147* | 642* | 696 | 725 | - | 35.0* |
| L.S.D.$_{0.05}$ | 55 | 100 | NS | 108 | - | 4.9 |
| **1976-3 (4 entries)** | | | | | | |
| Stoneville 213 (ck) | 421 | 1,147 | 1,199 | 1,236 | - | 36.8 |
| Stoneville 731 N | 274 | 1,259* | 1,401* | 1,453* | - | 28.3 |
| L.S.D.$_{0.10}$ | 97 | 103 | 187 | 189 | | NS |
| **1976-4 (2 entries)** | | | | | | |
| Deltapine 16 (ck) | 35 | 344 | 768 | 872 | - | 35.9 |
| Deltapine 7146N | 33 | 318 | 1,210* | 1,413* | - | 20.2* |
| L.S.D.$_{0.05}$ | NS | NS | 233 | 249 | - | 7.0 |
| **1977-1 (6 entries)** | | | | | | |
| Deltapine 16 (ck) | 17 | 121 | 456 | 547 | 606 | 4.1 |
| Bulgaria 4521 | 60 | 226* | 361 | 365 | 462 | 7.4 |
| Tamcot SP-37 | 40 | 220* | 393 | 405 | 427 | 5.2 |
| L.S.D.$_{0.05}$ | 41 | 86 | NS | 101 | 52 | NS |
| **1977-2 (10 entries)** | | | | | | |
| Stoneville 7A (ck) | 13 | 197 | 571 | 645 | 886 | 8.6 |
| Stoneville 213 Frego | 39 | 266 | 735* | 852* | 950 | 8.5 |
| Tamcot ORH-77-75 | 82* | 303* | 429 | 433 | 445 | 3.5 |
| L.S.D.$_{0.05}$ | 35 | 82 | 121 | 122 | 153 | NS |
| **1978-1 (6 entries)** | | | | | | |
| Deltapine 61 (ck) | 109 | 555 | 648 | 653 | - | 42.2 |
| 1 × 6-56 | 265* | 533 | 573 | 609 | - | 34.8 |
| Tamcot SP-37 | 244* | 536 | 573 | 614 | - | 30.4 |
| Westburn M | 227* | 666 | 718 | 731 | - | 35.3 |
| 1209 × 407-38 | 216* | 561 | 619 | 649 | - | 31.9 |
| AET-5 | 167 | 694 | 782 | 821 | - | 29.3 |
| L.S.D.$_{0.05}$ | 76 | NS | 154 | NS | - | NS |
| **1979-1 (27 entries)** | | | | | | |
| Deltapine 61 (ck) | 21 | 423 | 665 | 710 | 737 | 33.3 |
| Tamcot CAMD-E | 285* | 654* | 695 | 721 | 741 | 22.1* |
| D3-75 | 192* | 580* | 668 | 689 | 699 | 20.6* |
| DES 24 | 191* | 551 | 774 | 825 | 863 | 32.3 |
| GH8-10-75 | 171* | 598* | 724 | 763 | 795 | 28.3 |
| AET Br 2-1 | 151* | 581* | 733 | 775 | 792 | 29.5 |
| AET-5 | 144* | 578* | 774 | 832 | 845 | 17.2* |
| AET Br 2-7 | 121* | 721* | 874* | 935* | 952* | 20.2* |
| 7203-14-104 | 70 | 573* | 825* | 892* | 926* | 20.7* |
| Stoneville 825N | 55 | 624* | 905* | 988* | 1,010* | 24.3 |
| Stoneville 213 | 50 | 656* | 917* | 964* | 982* | 35.7 |
| Stoneville 887N | 48 | 534 | 845* | 947* | 982* | 24.3 |
| AET Br 2-8 | 46 | 512 | 874* | 928* | 951* | 35.9 |
| Deltapine 70 | 43 | 557* | 840* | 894* | 919* | 31.8 |
| Stoneville 701N | 30 | 623* | 924* | 986* | 1,014* | 24.9 |
| Stoneville 506 | 22 | 574* | 865* | 937* | 951* | 24.1 |
| L.S.D.$_{0.05}$ | 99 | 130 | 156 | 169 | 173 | 10.2 |
| **1979-2 (12 entries)** | | | | | | |
| Stoneville 7A (ck) | 20 | 411 | 762 | 894 | 997 | 31.8 |
| AET-5 | 151* | 630* | 861 | 959 | 980 | 15.3* |
| ORMAR-S-2-75 | 130* | 555* | 736 | 765 | 787 | 6.9* |
| ORS-75-75 | 85* | 568* | 658 | 689 | 711 | 8.6* |
| 7207-14-101 | 79* | 607* | 769 | 827 | 870 | 34.1 |
| AZ Super Okra-leaf | 74* | 493 | 686 | 754 | 789 | 10.7* |
| ORS-13 | 71* | 453 | 658 | 691 | 715 | 14.4* |
| St 7A Okra-leaf | 40 | 476 | 823 | 961 | 1,103 | 19.0* |
| L.S.D.$_{0.05}$ | 39 | 137 | 167 | 184 | 197 | 5.7 |
| **1975 to 1979 means** | | | | | | |
| All early entries | 129 | 545 | 757 | 818 | 833 | 19.8 |
| All check entries | 83 | 422 | 705 | 807 | 807 | 29.8 |

* Lint yield significantly higher, or seed damage significantly lower, than the check cultivar at the 0.05 level of probability (0.10 in test 1976-3); NS means that yield and/or seed damage was not significantly different than the check.

less PBW damage than the checks. The high yields and low seed damage of the nectariless entries in the large plots in 1976-3 and 1976-4 were attributed to the nectariless condition (12), rather than to early maturity. In later tests, however, the nectariless condition probably did not contribute to reduced seed damage because plots were too small.

In test 1979-1, nine entries yielded more cumulative lint than the check cultivar 'Deltapine 61' (DPL-61) at third, fourth, and fifth (final) harvests. One of these nine, AET Br-2-7, yielded more lint than the check at all five harvests, and six other entries yielded more at second through fifth harvests. However, none outyielded the other commercial cultivar, St-213. AET Br-2-7, 7203-14-104 and seven other entries had less seed damage than both DPL-61 and St-213. 'Tamcot CAMD-E', D3-75, and AET-5 had less seed damage than the DPL-61 check but did not differ significantly in lint yield (Table 2).

**Table 3. Lint yield and seed damage in test entries compared with check cultivars.**

| Test entry/check | Year | Cumulative lint yield: Third/ total | Cumulative lint yield: Total/ total | Mean seed damage: Third/ seasonal | Mean seed damage: Seasonal/ seasonal |
|---|---|---|---|---|---|
| | | % of check | | | |
| DES-56/DPL-16 | 1975 | 92.9 | 99.2 | 61.6 | 84.2 |
| DES-56/DPL-16 | 1976 | 97.5 | 121.3 | 86.2 | 85.9 |
| St-731N/St-213 | 1976 | 113.3 | 117.6 | 61.5 | 76.9 |
| DPL-7146N/DPL-16 | 1976 | 138.8 | 162.0 | 37.0 | 56.3 |
| Westburn M/DPL-61 | 1978 | 106.3 | 111.9 | 68.8 | 83.6 |
| St-701N/DPL-61 | 1979 | 125.4 | 137.6 | 39.1 | 74.8 |
| St-701N/St-213 | 1979 | 94.1 | 103.3 | 36.1 | 69.9 |
| St-213/DPL-61 | 1979 | 124.4 | 133.2 | 61.3 | 107.0 |
| St-213/St-213 | 1979 | 93.4 | 100.0 | 56.6 | 100.0 |
| St-825N/DPL-61 | 1979 | 122.8 | 137.0 | 30.5 | 72.8 |
| St-825N/St-213 | 1979 | 92.2 | 102.9 | 28.2 | 68.1 |
| AET Br 2-8/DPL-61 | 1979 | 118.6 | 129.0 | 43.0 | 107.7 |
| AET Br 2-8/St-213 | 1979 | 89.0 | 96.8 | 39.7 | 100.7 |
| AET Br 2-7/DPL-61 | 1979 | 118.6 | 129.2 | 27.9 | 60.6 |
| AET Br 2-7/St-213 | 1979 | 89.0 | 96.9 | 25.8 | 56.6 |
| St-506/DPL-61 | 1979 | 117.4 | 129.0 | 31.9 | 72.2 |
| St-506/St-213 | 1979 | 88.1 | 96.8 | 29.5 | 67.5 |
| St-887N/DPL-61 | 1979 | 114.7 | 133.2 | 37.4 | 72.9 |
| St-887N/St-213 | 1979 | 86.0 | 100.0 | 34.6 | 68.1 |
| DPL-70/DPL-61 | 1979 | 114.0 | 124.7 | 53.3 | 95.4 |
| DPL-70/St-213 | 1979 | 85.5 | 93.6 | 49.2 | 89.2 |
| 7203-14-104/DPL-61 | 1979 | 111.9 | 125.6 | 36.3 | 62.2 |
| 7203-14-104/St-213 | 1979 | 84.0 | 94.3 | 33.9 | 58.0 |
| AET-5/DPL-61 | 1979 | 105.0 | 114.7 | 23.1 | 51.6 |
| AET-5/St-213 | 1979 | 78.8 | 86.0 | 21.3 | 48.2 |
| St7A-Okra/St 7A | 1979 | 82.6 | 110.6 | 29.3 | 59.7 |
| All early/DPL-checks | 1975 to 1979 | 114.1 | 127.3 | 44.3 | 75.4 |
| All early/St-checks | 1975 to 1979 | 89.3 | 99.9 | 35.4 | 69.4 |

In test 1979-2, no entry yielded significantly more lint than the check cultivar, 'Stoneville 7A', (St-7A) after the second harvest. The yield of Stoneville 7A Okra-leaf (La Okra-2), however, was 10 to 11% higher than that of the check in the second to fifth harvests. Seasonal seed damage was lower in six entries than in St-7A. The two Okra-leaf, frego-bract, Smoothleaf stocks ORMAR-S-2-75 and ORS 75-75, had lower seed damage than the PBW-resistant AET-5 (Table 2).

Results in 1979 (Tables 2 and 3) suggest that St-213, AET Br-2-8, and DPL-70 had more tolerance to PBW than DPL-61. They sustained as much seed damage but produced significantly more lint than this check cultivar.

The advantage of moderately early cottons is emphasized in Table 3. Stoneville 701N is a good example of a moderately early stock that yielded as much or more lint at third harvest (early to mid-September) than the check did over the entire season 4 to 6 weeks later. In 1979, at third harvest it yielded 25% more lint but had 61% less seed damage than DPL-61 did over the season. Its lint yield was 94% of that of St-213 but it had 64% less seed damage. Furthermore, mean seed damage at harvest in St-701N was only 13%, not much above the economic level of 7 to 12% (10). Moderately early cottons also had advantages over the check for the entire season (Table 3). Stoneville 701N, for example, yielded 38% more lint than DPL-61 and 3% more than St-213, but had 25 and 30% less seed damage, respectively.

The advantages of other resistance mechanisms coupled with those of earliness also are shown in Table 3. For example, AET-5, which had shown antixenosis and antibiosis types of resistance to PBW (9), yielded 5% more lint and had only 23% as much seed damage at third harvest as DPL-61 did over the season. Over all five harvests, it yielded 15% more lint but had only 52% as much seed damage as DPL-61. On the other hand, it yielded 70 and 86% as much lint by the third and fifth harvests, respectively, as St-213, but had 21 and 48% as much seed damage.

Cottons such as Tamcot CAMD-E and D3-75 performed well relative to the DPL-61 check in 1979 but did not seem to have the high yield potential of some of the other entries. 'Tamcot SP-37' and other very early-maturing stocks grown in the previous year's tests, also suffered from this deficiency (Table 2). These early, small-statured, determinate cottons would possibly perform well if grown in higher plant populations.

Regression of lint/boll on seed damage provided estimates of yields expected in the absence of damage. In Table 4 we present results from regressing lint/boll on seed damage for the DPL-61 check cultivar and for three other entries in test 1979-1. Expected lint yield of St-

**Table 4. Observed and expected lint yields and seed damage percentages in four cottons.**

| | Cumulative lint yield: Third harvest Obs. | Third harvest Exp. | Third harvest Obs./Exp. | Seasonal Obs. | Seasonal Exp. | Seasonal Obs./Exp. | Seed damage: Third harvest | Seed damage: Seasonal |
|---|---|---|---|---|---|---|---|---|
| | kg/ha | | % | kg/ha | | % | % | |
| DPL-61 | 665 | 879 | 75.7 | 737 | 1,150 | 64.1 | 24.7 | 33.3 |
| St-213 | 917 | 1,124 | 81.6 | 982 | 1,448 | 67.8 | 20.4 | 35.7 |
| St-701N | 924 | 1,089 | 84.8 | 1,014 | 1,430 | 70.9 | 13.0 | 24.9 |
| AET-5 | 774 | 852 | 90.8 | 845 | 1,063 | 79.5 | 7.7 | 17.2 |

701N at third harvest was 95% of that of DPL-61 over the season (1,089/1, 150 kg/ha), but was only 75% of that of St-213 (1,089/1,448 kg/ha). Expected lint yield of AET-5 at third harvest was 74% of that of DPL-61 and 59% of that of St-213 over the season. Full season expected yields of St-701N were 124 and 99% of those of DPL-61 and St-213, respectively. Full-season expected yields of AET-5 were 92 and 73% of those of the two cultivars.

According to our regression analysis, all four entries would have suffered yield losses, even the most PBW-resistant stock, AET-5, when not protected by insecticides. Calculated yield reduction varied from 9% in AET-5 to 24% in DPL-61 at third harvest and from 20% in AET-5 to 36% in DPL-61 over the season (Table 4).

We obtained yield data from unsprayed and sprayed plots of DPL-61 and AET-5 in test 1979-3 (data not shown in Tables) to compare with results from regression analyses. In the unsprayed plots, AET-5 yielded 20% more lint than DPL-61 (1,077 vs. 896 kg/ha; seed damage 16.6% in AET-5, 29.4% in DPL-61). In the sprayed plots, AET-5 yielded 10% less lint than DPL-61 (1,149 vs. 1,278 kg/ha; seed damage 2.4% in AET-5, 2.2% in DPL-61). These results agreed well with observed yields (15% more in AET-5 than in DPL-61) and expected yields (8% less in AET-5 than in DPL-61) in test 1979-1 (Table 4).

We have shown that, in unsprayed plots, certain moderately early stocks sustained much less seed damage from PBW and yielded slightly less to substantially more lint at an early harvest than commercial check cultivars yielded over the season. These same stocks also sustained less seasonal seed damage and yielded as much or more total lint than the check cultivars.

On the other hand, the mid-September yield, or even the total yield of the early stocks grown in unsprayed plots was significantly lower than full-season yields of cultivars protected with insecticide. Probably a better comparison of early vs. full-season cultivars would be economic yield (output/input ratio) rather than merely total yield, because early cultivars would require less water and insecticide. Also, as plant breeders develop new early-maturing cultivars, we might expect that the yield discrepancy will diminish. At any rate, earliness is a valuable factor assisting the plant to escape some insect damage but it cannot stand alone. Possibly, earliness combined in improved cultivars with other PBW-resistance characters might provide a level of resistance that would allow the grower to produce a crop without using insecticide for PBW control (10).

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