# BOLL WEIGHT, YIELD AND QUALITY RELATIONSHIPS, IRRIGATED AND DRYLAND COTTON, TEXAS 1986-1997, UPDATE

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## Abstract

Preharvest cotton crop sampling has successfully predicted crop length, micronaire, strength, and yield per acre on the Texas Southern High Plains, Coastal Bend and Upper Coast areas. Results show large year-to-year variation in average boll weights for seed cotton, lint, and seed, and in percent lint. Most years on the Texas High Plains, irrigated fields produce higher yields, heavier bolls, and longer fiber length than dryland fields. The spread between irrigated and dryland yield, boll weights, and length widen during years of low subsoil moisture and lower than average growing season rainfall such as 1993, 1994 and 1995. Stressful conditions appear to lower seed weight relatively more than lint weight. From year to year, micronaire of dryland and irrigated cotton move up and down together with irrigated fields having slightly lower micronaire. Strength has shown a steady increase over the past twelve years with very little difference between irrigated and dryland strength for any given year. Early September subjective observation of boll size, stage of maturity, moisture stress, and level of irrigation relates well to resulting boll weights, fiber properties, and yield potential. Likewise, boll weights and quality variations exist in and between the Texas Coastal Bend and Upper Coast areas.

## Introduction

A project was initiated in the summer of 1980 with two objectives: (1) to develop a technique for determining fiber properties of the Southern High Plains cotton crop prior to harvest, and (2) to implement the successful usage of the procedure on an annual basis. These objectives were achieved and results reported at several Beltwide conferences (Gipson and Shaw 1986, 1987, 1988, 1989; Shaw and Gipson 1987; Sigmund, Gannaway and Gipson 1983) by the late Dr. Jack R. Gipson.

This preharvest sampling procedure, with minor modifications, has been continued on the High Plains and expanded to the Texas Coastal Bend and Upper Coast areas by Plains Cotton Cooperative Association (PCCA) (Figure 1). The objectives of the PCCA crop studies are to obtain fiber quality and yield estimates as early as possible for the overall areas (Shaw 1995). The goal is to estimate what will be harvested, ginned, and end up in a bale.

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Boll size, seed weight, and lint turnout are of interest and importance to producers, plant breeders, and seed suppliers and are included in most research on variety development and evaluation (Gannaway et. al., 1996; Rayburn, et. al., 1997). Many factors affect boll size, seed and lint weight, and quality. Variety, production location, soil fertility, planting date, plant population, weather, especially temperature, moisture and relative freeze date, and plant termination chemicals all impact boll size, weight, overall yield and quality.

The objectives of this paper are to review and summarize the Plains crop study boll weight and quality relationships over the 1986-1997 crops, look at the 1997 crop in more detail, and review the Coastal Bend and Upper Coast 1991-1997 crop results.

## Sampling Procedure

Field selection, sampling, and boll harvesting, handling, and processing are presented in detail in previous reports (Gipson and Shaw 1986, 1987, 1988) and discussed only briefly here. About 115 High Plains fields are selected and flagged each year in early September in proportion to historical dryland and irrigated bale production in 11 counties surrounding Lubbock (Figure 2).

A modified sampling procedure is used to select fields in late June for the Coastal Bend and Upper Coast crop study (Figure 3). The sampling universe used is those producers from the two areas who participate in the PCCA South Texas marketing pool. Fields are selected in proportion to PCCA pool acres per county.

To the extent possible, the same farms/fields are normally used from year to year. About 53 percent of the Texas Highs Plains District 1 1992 crop planted acres was destroyed by adverse late May and early June weather and not replanted to cotton. The 48 fields sampled were all of the 120 locations visited that remained in cotton (Table 1). The 1996 crop lost considerable dryland acreage to drought. Fields and sampling locations within fields are carefully selected to be representative of the area. The first harvest is made as bolls begin to open in the earliest fields. Bolls are harvested from 39 inches of row, and subjective visual observations are recorded related to moisture, stage of growth and development, boll size, rankness, regrowth, planting patterns and row width, for each field. Open and green bolls are counted, processed and ginned separately; seed cotton, lint and seed weights and fiber properties are determined. Some analysis uses the open and green boll data separately. The open and green boll data are combined for each sample location for the analysis presented in this paper.

Each sample of seed cotton is weighed (in grams) before ginning and the lint and seed are weighed after ginning. The number of bolls in the ginned sample is determined as the total bolls harvested minus the immature non-open bolls after drying and the insect-destroyed bolls. Average lint weight per boll ginned is lint weight divided by bolls ginned; average seed and seed cotton weight per boll and percent lint are also calculated for each sample. One or two subsequent harvests are made from the same row adjacent to the prior harvest location at three to four week intervals to monitor seasonal crop development and changes.

All bolls in the 39-inch row segments are harvested, to simulate what the producer will harvest, if it appears they have any chance to contribute to the final overall yield. Damaged bolls with two or more good locks are counted as well as misshapen and partially-developed bolls at all boll positions. As expected, this results in 15 to 20 percent lower average boll weights than most variety test results which include only a sample of undamaged, fully-developed mainly first position bolls (Gannaway et. al., 1996; Rayburn et. al., 1997).

## Plains Findings 1986-1997

Preharvest sampling fiber qualities were compared to the Lubbock and Lamesa classing office quality for the 1982-1988 crops (Gipson and Shaw 1989) and it was concluded that preharvest sampling can provide very acceptable estimates for length, strength and micronaire. The 1989 through 1997 crop studies have produced similar results. Tables 2, 3, and 4 show the 1980-1997 results for length, micronaire and strength, respectively.

Length was overestimated most years.. Classing office averages show a general increase in length of the Plains crop over time. Micronaire was overestimated each year and shows no particular trend over time. Strength was overestimated most years. Classing office average values show substantial increases in strength, especially since 1988. The tendency for the samples to overestimate fiber quality may be partially due to less field weathering, hand harvesting, and no lint cleaning. The biggest "quality miss" was the 1992 crop and 1995 crop strength.

### Weights Per Boll

Seed cotton weight, in grams per boll, for the 1986-1997 Plains crop study are shown in Figure 4. Seed cotton weight ranges from a low of 3.31 grams for 1986 dryland to a high of 4.94 for 1996 irrigated. Irrigated bolls were heavier than dryland bolls except in 1989. The spread between irrigated and dryland boll weights increased dramatically in 1993 to 0.94 (25%) and again in 1994 to 1.20 grams (35%), reflecting the extreme dryness of these two seasons (Shaw 1995).

Lint weight per boll shows a similar pattern to seed cotton (Figure 5), ranging from a low of 1.19 for 1986 dryland to a high of 1.89 for 1996 irrigated. Irrigated fields had more lint per boll than dryland fields each year. Per boll seed weight shows a pattern very similar to the seed cotton weights (Figure 6). Figure 7 shows the irrigated minus dryland boll weight differences for seed cotton, lint and seed. The 1989 crop had the least boll weight differences followed by 1991 and 1992, the greatest differences were in the 1994 and 1993 crops.

The percent lint ranged from a low of 35.6 for 1986 irrigated to a high of 40.1 for 1993 dryland with considerable year-to-year variation (Figure 8). Dryland showed a higher percent lint than irrigated eight of the twelve years. The greatest spreads between irrigated and dryland were 1988 at -1.7 percent, 1995 at -1.4, 1991 at +1.2, 1993 at -1.2, and 1994 at -1.1. Is this an indication of relatively more dryland lint per boll or fewer and/or lighter seed per boll? It appears that conditions that cause stress impact (reduce) the seed weight relatively more than the lint weight per boll. This subject will be addressed again later in the paper.

Figure 9 shows dryland and irrigated pounds per acre lint yield for USDA Texas crop reporting District 1, High Plains (1-N+1-S). Irrigated yields were higher than dryland yields all years, with differences ranging from 122 pounds (22%) in 1992 to 449 pounds (64%) in 1994. Dryland and irrigated yields moved up and down together until the 1993 crop when irrigated yield increased to a record high of 710 pounds, while dryland yield decreased. The cause of these year-to-year and irrigated versus dryland yield variations is not easily attributable to a single moisture factor. Figure 10 shows Lubbock's annual rainfall from October through September of each crop year. The average is 18.0 inches, but four years had 22.7 inches and higher and six years were 15.5 inches or less. Annual rainfall overlaid on the yields show little relationship of overall yields to Lubbock rainfall (Figure 11). The timing of rainfall is extremely important, as well as the accompanying adverse effects of hail, wind, blowing sand, and cold temperatures which induce seedling disease and slow growth.

### Fiber Properties

Crop study sample length is longer for irrigated than dryland each year, ranging from 0.1 32nds in 1988 to 2.7 in 1994, 2.6 in 1995 and 2.1 in 1993 (Figure 12). Sample micronaire shows large year-to-year changes but relatively little difference between irrigated and dryland for any given year (Figure 13). Irrigated micronaire is slightly lower than dryland except in 1986, 1987 and 1996. Sample strength shows an increase over the twelve years (Figure 14) from 23 to 29 grams per tex. Dryland strength was highest for five years and irrigated for seven years, with relatively small differences any given year.

## 1997 Crop Details

This section looks at selected 1997 Plains crop study results in more detail. The 1997 crop does not show as consistent or as severe moisture stress relationship as the dry 1994 crop (Shaw 1995).

**Observed Visual Boll Size**

Much trade and media discussion and producers' concern about the 1994 crop centered on the small size of the stressed dryland bolls. Subsequently, a subjective observed visual boll size code was assigned to each sample field during the early September harvest each year. Table 5 shows the 1997 crops results of the early November harvest values with the early September extra large, large, normal, small, and tiny green boll size classification. Note that no fields were classified as having tiny boll size in 1997.

There is strong relationship of boll size with moisture stress, boll number, yield potential, seed cotton, lint and seed weights per boll, and percent lint. The small bolls show the results of moisture stress during the growing season. They have shorter length and the highest strength. The small bolls weighed 76 percent of extra large bolls and 88 percent of the normal bolls. In 1994 the tiny bolls weighed 60 percent of the extra large bolls and 73 percent of the normal bolls.

**Observed Moisture Stress**

Also assigned during the early September harvest was a subjective observed visual growing season accumulated moisture stress code. Coding used is 0 for none or no stress, 1 for slight stress, 2 for moderate, 3 for severe, and 4 for extreme. Table 6 shows the results of early November harvest values summarized by observed early September moisture stress classifications. Similar to the boll size classifications, the severe stressed fields showed the fewest bolls, lowest yield potential, lightest weight per boll, and shortest length. The no moisture stressed had the best of everything. The early September 1997 accumulated moisture stress was not nearly as severe as in 1993, 1994 and 1995 crops. However, September moisture stress was severe, especially in many irrigated fields due to little to no rainfall.

**Level of Irrigation**

Plains sample fields were selected in proportion to historical dryland and irrigated production by county. During the early September harvest, the irrigated fields were visually classified as having full irrigation, less than full, or supplemental irrigation. The early November harvest values are shown in Table 7, for the three levels of irrigation, dryland, and then all irrigated combined.

Dryland-irrigated show typical relationships. Irrigated fields were later maturing in early September but had caught up by early November. The 1997 irrigated crop showed the same amount of early September moisture stress as the dryland crop. This was due to many irrigated fields running out of moisture due to lack of rain and early termination of irrigation applications. Also, the dryland area had good subsoil moisture and some of it received very beneficial summer rains. Irrigated sample fields had over 1.4 times the bolls and 1.5 times the yield potential, and 11 percent heavier boll weights (1.734 vs. 1.562), with longer length (34.8 vs. 33.9), lower micronaire (3.97 vs. 4.21) and the same strength (29.0). These 1997 crop dryland-irrigated relationships are much smaller than those reported for 1994 (Shaw 1995).

## Coastal Bend and Upper Coast of Texas

The 1991-1997 Coastal Bend and Upper Coast results show considerable year to year and location differences also. Boll weights were slightly lighter than on the Plains, especially for the 1996 and 1997 crops due to drought. Seed cotton weights were heavier in the Upper Coast than in the Coastal Bend (Figure 15). Lint weight per boll was highest in the Upper Coast (Figure 16). The Upper Coast seed weight was less than the Coastal Bend for the 1993 crop (Figure 17). Percent lint was highest in the Upper Coast five of the seven years (Figure 18).

Sample length was longer in the Upper Coast, ranging from 0.1 32nds longer in 1993 to 3.3 in 1991 (Figure 19). Sample micronaire tends to move up and down together most years (Figure 20). The 1997 Coastal Bend crop had the lowest micronaire of the seven years (3.69) due to extreme late season drought, while the Upper Coast had near normal micronaire (4.47) for a difference of 0.78. Sample strength also moved together, and like on the Plains shows increasing grams per tex (Figure 21).

## Summary and Conclusion

Preharvest crop sampling can provide acceptable estimates of crop length, micronaire, strength, and yield per acre. Boll weights, fiber properties and yields vary from year to year mainly due to climatic conditions. For a given year, dryland and irrigated crops can be nearly identical or they can have tremendous variations. From year to year, micronaire of dryland and irrigated cotton moves up and down together with irrigated fields having slightly lower micronaire. Strength has shown a steady increase over the past twelve years with very little difference between irrigated and dryland strength for any given year.

As observed 1997 crop growing season moisture stress increased, physical boll size and all boll weights decreased and the number of bolls harvested decreased. The combined effects of fewer bolls and lower weight per boll resulted in declines in pounds per acre yield potential as moisture stress increased. Fiber length and micronaire decreases with increasing moisture stress. Strength showed little relationship to boll size in the 1997 crop.

Even when reasonable per acre yield estimates can be developed, the proportion of dryland and irrigated acres planted and left for harvest, as well as total acres becomes critical to successfully predicting total bale production for a geographic area. The 1996 Plains District 1 crop set an overall all time record high yield per acre of 591 pounds, however neither the dryland nor the irrigated yields were records. This overall record occurred because, the proportion of the crop acres grown as dryland was extremely low due to drought at planting time.

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Table 1. Number of fields sampled, Plains Cotton Cooperative Association, crop studies 1986-1997.

| Crop Year | High Plains | Coastal Bend & Upper Coast |
|---|---|---|
| 1986 | 112 | --- |
| 1987 | 118 | --- |
| 1988 | 120 | --- |
| 1989 | 109 | --- |
| 1990 | 106 | --- |
| 1991 | 109 | 52 |
| 1992 | 48 | 55 |
| 1993 | 118 | 53 |
| 1994 | 117 | 55 |
| 1995 | 122 | 57 |
| 1996 | 112 | 50 |
| 1997 | 117 | 54 |

Table 2. Length values from preharvest sampling compared to USDA classing office average values. (32nds).

| Crop Year | Final Preharvest Determination | Classing Office Average | Difference |
|---|---|---|---|
| 1980 | 31.47 | 31.90 | -0.43 |
| 1981 | 33.40 | 31.50 | +1.90 |
| 1982 | 29.90 | 31.30 | -1.40 |
| 1983 | 31.60 | 32.40 | -0.80 |
| 1984 | 33.00 | 32.00 | +1.00 |
| 1985 | 32.20 | 31.93 | +0.27 |
| 1986 | 32.90 | 33.12 | -0.22 |
| 1987 | 34.00 | 33.50 | +0.50 |
| 1988 | 32.43 | 32.33 | +0.10 |
| 1989 | 32.40 | 32.41 | -0.01 |
| 1990 | 32.60 | 32.40 | +0.20 |
| 1991 | 32.50 | 32.32 | +0.18 |
| 1992 | 34.60 | 33.45 | +1.15 |
| 1993 | 33.90 | 33.68 | +0.22 |
| 1994 | 34.20 | 33.70 | +0.50 |
| 1995 | 34.10 | 33.90 | +0.20 |
| 1996 | 35.00 | 34.50 | +0.50 |
| 1997* | 34.40 | 33.90 | +0.50 |

*1997 Based on 72.8% (2,585,000/3,550,000) of expected total classed through December 11, 1997 at Lubbock and Lamesa.

Table 3. Micronaire values from preharvest sampling compared to USDA classing office average values.

| Crop Year | Final Preharvest Determination | Classing Office Average | Difference |
|---|---|---|---|
| 1980 | 3.96 | 3.73 | +0.23 |
| 1981 | 3.40 | 3.33 | +0.07 |
| 1982 | 4.00 | 3.84 | +0.16 |
| 1983 | 3.86 | 3.67 | +0.19 |
| 1984 | 3.22 | 3.09 | +0.13 |
| 1985 | 3.76 | 3.63 | +0.13 |
| 1986 | 3.16 | 3.12 | +0.04 |
| 1987 | 3.50 | 3.44 | +0.06 |
| 1988 | 4.25 | 3.98 | +0.27 |
| 1989 | 3.48 | 3.27 | +0.21 |
| 1990 | 3.95 | 3.74 | +0.21 |
| 1991 | 3.87 | 3.53 | +0.34 |
| 1992 | 3.68 | 3.30 | +0.38 |
| 1993 | 4.21 | 4.10 | +0.11 |
| 1994 | 4.09 | 3.98 | +0.11 |
| 1995 | 3.79 | 3.70 | +0.09 |
| 1996 | 3.96 | 3.70 | +0.26 |
| 1997* | 4.06 | 3.88 | +0.18 |

*1997 Based on 72.8% (2,585,000/3,550,000) of expected total classed through December 11, 1997 at Lubbock and Lamesa.

Table 4. Strength values from preharvest sampling compared to USDA classing office average values (grams per tex).

| Crop Year | Final Preharvest Determination | Classing Office Average | Difference |
|---|---|---|---|
| 1980 | 25.63 | 22.80 | +2.83 |
| 1981 | 24.10 | 22.80 | +1.30 |
| 1982 | 24.20 | 24.40 | -0.20 |
| 1983 | 26.00 | 25.60 | +0.40 |
| 1984 | 25.10 | 25.60 | -0.50 |
| 1985 | 25.30 | 24.74 | +0.56 |
| 1986 | 22.90 | 24.78 | -1.88 |
| 1987 | 24.70 | 25.99 | -1.29 |
| 1988 | 25.50 | 25.32 | +0.18 |
| 1989 | 25.50 | 25.47 | +0.03 |
| 1990 | 26.20 | 26.03 | +0.17 |
| 1991 | 26.70 | 26.14 | +0.56 |
| 1992 | 29.80 | 27.20 | +2.60 |
| 1993 | 29.10 | 29.00 | +0.10 |
| 1994 | 29.50 | 29.01 | +0.49 |
| 1995 | 32.90 | 29.30 | +3.60 |
| 1996 | 28.40 | 27.70 | +0.70 |
| 1997* | 29.00 | 29.28 | -0.28 |

*1997 Based on 72.8% (2,585,000/3,550,000) of expected total classed through December 11, 1997 at Lubbock and Lamesa.

Table 5. Early September boll size classification with early November values, 1997 Plains crop study.

| | Subjective Boll Size | | | | |
|---|---|---|---|---|---|
| | X-Large | Large | Normal | Small | Tiny |
| Number of Samples | 3 | 21 | 78 | 15 | 0 |
| Percent of Locations | 2.6 | 17.9 | 66.7 | 12.8 | 0.0 |
| Observed Sep. Moist. Stress | 0.0 | 1.1 | 1.0 | 1.8 | . |
| Number of Bolls Harvested | 78.0 | 64.5 | 47.4 | 37.0 | . |
| Yield Estimate - lbs./ac. | 863 | 673 | 469 | 345 | . |
| Seed Cotton per Boll - grams | 4.933 | 4.656 | 4.282 | 3.707 | . |
| Lint Per Boll - grams | 1.908 | 1.791 | 1.666 | 1.459 | . |
| Seed Per Boll - grams | 3.025 | 2.865 | 2.615 | 2.249 | . |
| Percent Lint | 38.7 | 38.5 | 38.9 | 39.6 | . |
| Avg. Length | 35.3 | 35.1 | 34.4 | 33.4 | . |
| Avg. Micronaire | 4.03 | 3.81 | 4.13 | 4.05 | . |
| Avg. Strength | 28.4 | 28.5 | 29.1 | 29.4 | . |

Table 6. Early September moisture stress with early November values, 1997 Plains crop study.

| | Subjective Moisture Stress | | | | |
|---|---|---|---|---|---|
| | None | Slight | Moderate | Severe | Extreme |
| Number of Samples | 15 | 41 | 39 | 22 | 0 |
| Percent of Locations | 12.8 | 35.1 | 33.3 | 18.8 | 0.0 |
| Observed Sep. Moist. Stress | 0 | 0.5 | 1.5 | 2.2 | . |
| Number of Bolls Harvested | 67.8 | 52.1 | 48.4 | 36.2 | . |
| Yield Estimate - lbs./ac. | 717 | 521 | 486 | 338 | . |
| Seed Cotton per Boll - grams | 4.673 | 4.322 | 4.394 | 3.794 | . |
| Lint Per Boll - grams | 1.842 | 1.672 | 1.710 | 1.469 | . |
| Seed Per Boll - grams | 2.831 | 2.650 | 2.684 | 2.326 | . |
| Percent Lint | 39.4 | 38.7 | 38.9 | 38.7 | . |
| Avg. Length | 34.7 | 34.7 | 34.6 | 33.3 | . |
| Avg. Micronaire | 4.19 | 4.07 | 4.12 | 3.85 | . |
| Avg. Strength | 29.1 | 29.3 | 28.7 | 29.1 | . |

Table 7. Early September level of irrigation with early November values, 1997 Plains crop study.

| | Irrigation Levels | | | | |
|---|---|---|---|---|---|
| | Full | Less Than Full | Supple-mental | None Dryland | All Irrigated |
| Number of Samples | 58 | 11 | 3 | 45 | 72 |
| Percent of Locations | 49.6 | 9.4 | 2.5 | 38.5 | 61.5 |
| Observed Sep. Moist. Stress | 0.9 | 1.7 | 2.3 | 1.1 | 1.1 |
| Number of Bolls Harvested | 59.2 | 41.0 | 40.7 | 40.8 | 55.6 |
| Yield Estimate - lbs./ac. | 608 | 402 | 392 | 392 | 567 |
| Seed Cotton per Boll - grams | 4.562 | 4.250 | 4.182 | 3.961 | 4.498 |
| Lint Per Boll - grams | 1.758 | 1.647 | 1.593 | 1.562 | 1.734 |
| Seed Per Boll - grams | 2.804 | 2.603 | 2.589 | 2.399 | 2.764 |
| Percent Lint | 38.5 | 38.8 | 38.1 | 39.4 | 38.6 |
| Avg. Length | 35.1 | 33.5 | 33.3 | 33.9 | 34.8 |
| Avg. Micronaire | 3.95 | 4.03 | 4.03 | 4.21 | 3.97 |
| Avg. Strength | 29.0 | 29.4 | 28.7 | 29.0 | 29.0 |

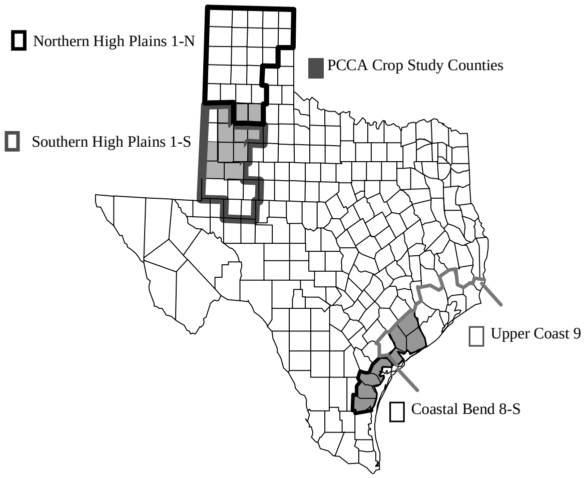



Figure 1. Texas crop reporting districts and PCCA crop study counties.

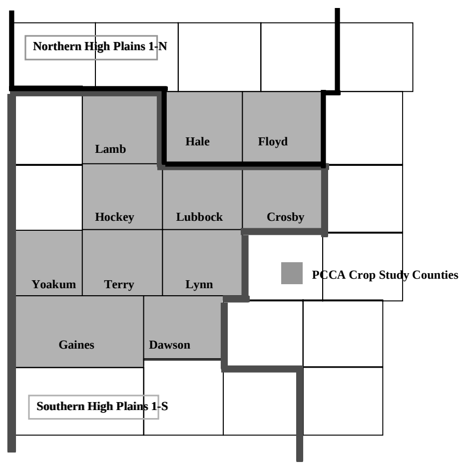



Figure 2. Plains crop study counties, 1986-1997.

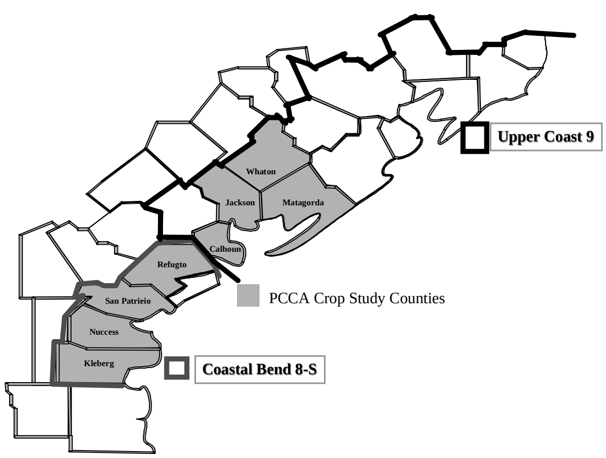



Figure 3. Coastal Bend and Upper Coast crop study counties 1991-1997.

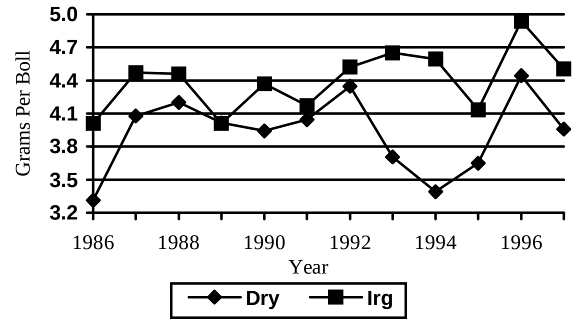



Figure 4. Seed cotton weight per boll, Plains crop study 1986-1997.

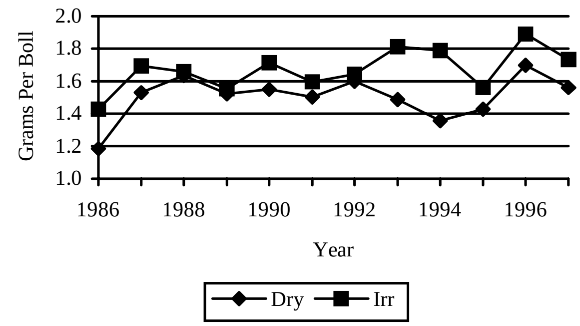



Figure 5. Lint weight per boll, Plains crop study 1986-1997.

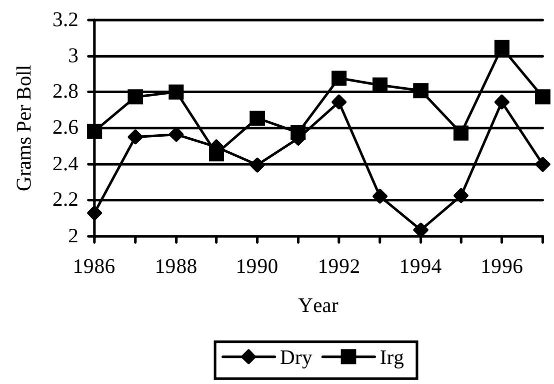



Figure 6. Seed weight per boll, Plains crop study 1986-1997.

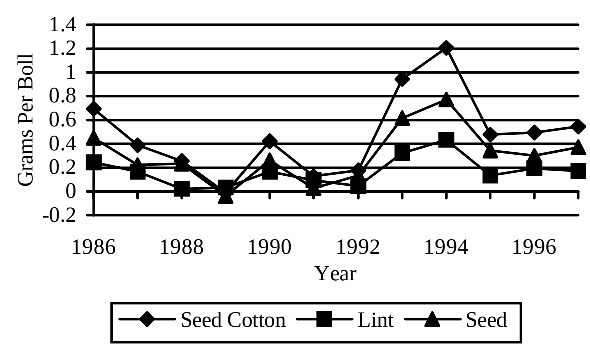



Figure 7. Boll weight differences irrigated minus dryland, Plains crop study 1986-1997.

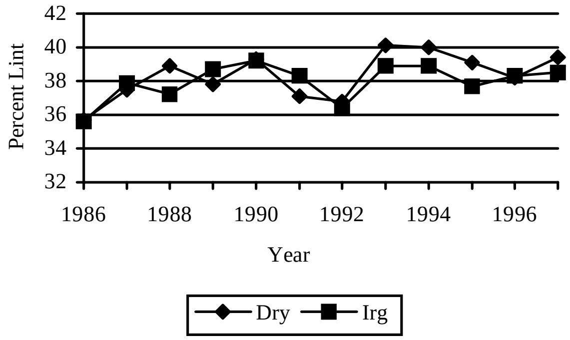
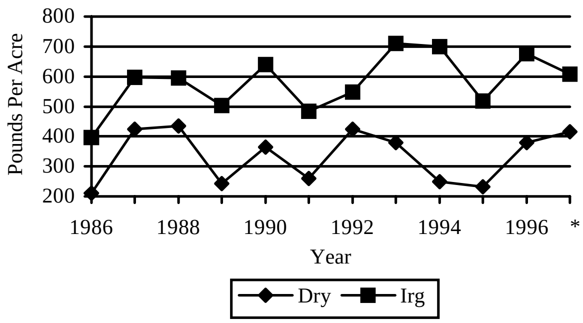



Figure 8.  Percent lint, Plains crop study 1986-1997.




*Shaw's yield estimates Nov. 1997 for 1997 crop.

Figure 9.  Lint yield per acre, USDA crop reporting District 1, 1986-1997.

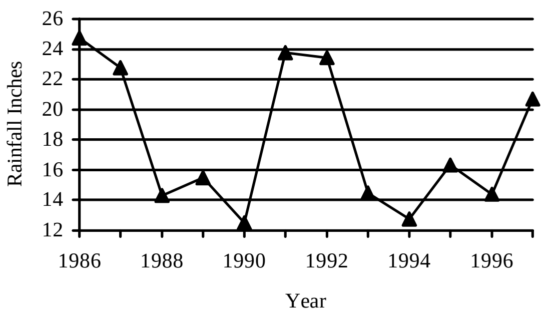
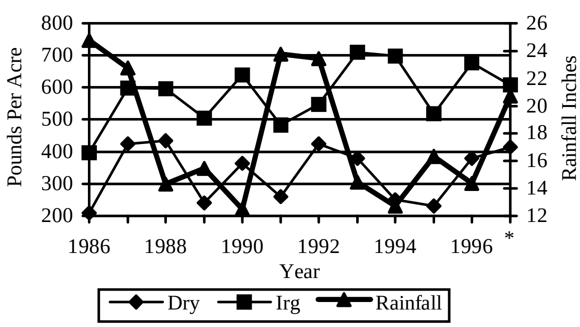



Figure 10.  Lubbock rainfall, 1986-1997 October through September crop year.




*Shaw's yield estimates Nov. 1997 for 1997 crop.

Figure 11.  Lubbock rainfall compared to district 1 yield 1986-1997.

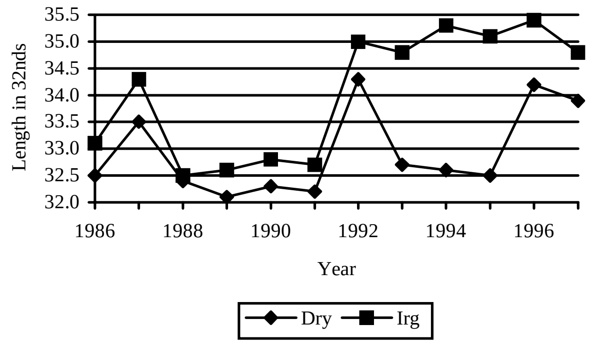



Figure 12.  Sample length in 32nds, Plains crop study 1986-1997.

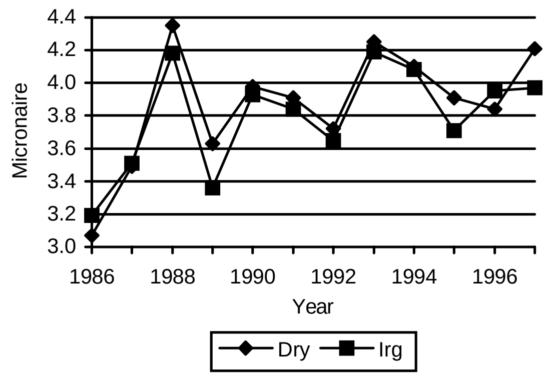



Figure 13.  Sample micronaire, Plains crop study 1986-1997.

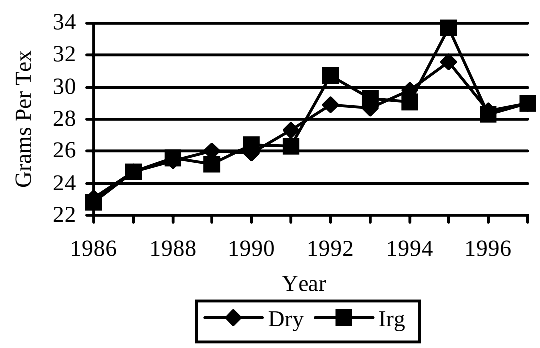



Figure 14.  Sample strength, Plains crop study 1986-1997.

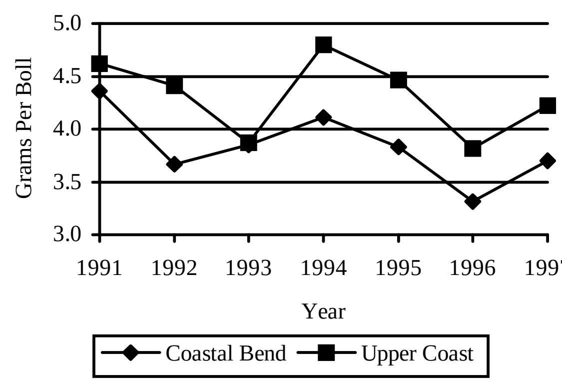



Figure 15.  Seed cotton weight per boll, Coastal Bend and Upper Coast crop study 1991-1997.

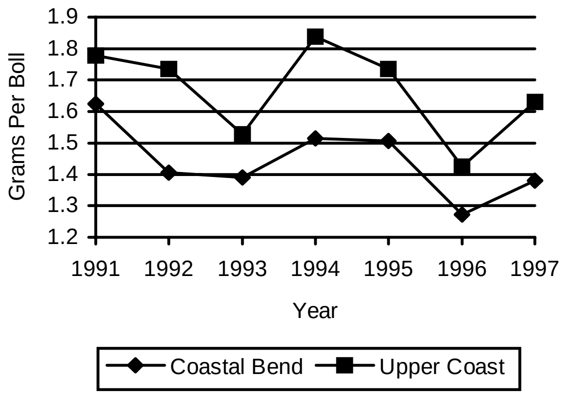



Figure 16. Lint weight per boll, Coastal Bend and Upper Coast crop study 1991-1997.

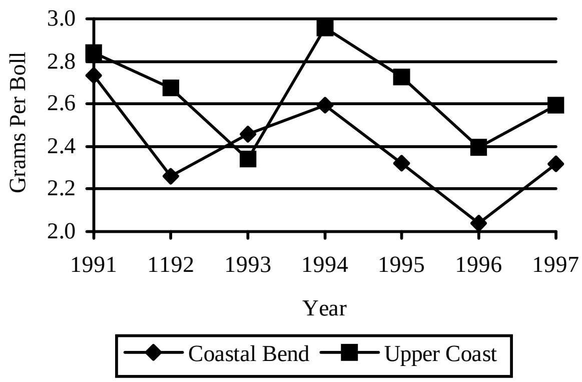



Figure 17. Seed weight per boll, Coastal Bend and Upper Coast crop study 1991-1997.

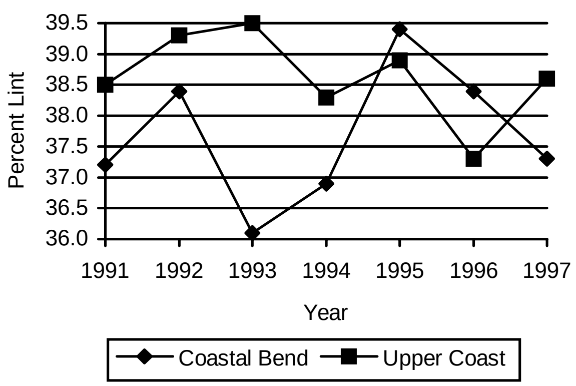



Figure 18. Percent lint, Coastal Bend and Upper Coast crop study 1991-1997.

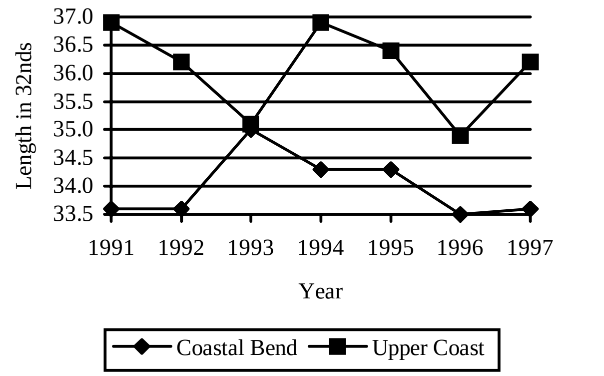



Figure 19. Sample length in 32nds, Coastal Bend and Upper Coast crop study 1991-1997.

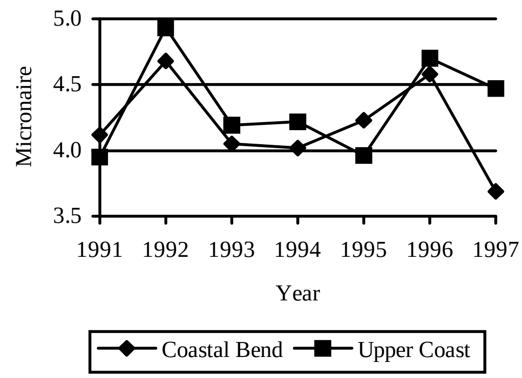



Figure 20. Sample micronaire, Coastal Bend and Upper Coast crop study 1991-1997.

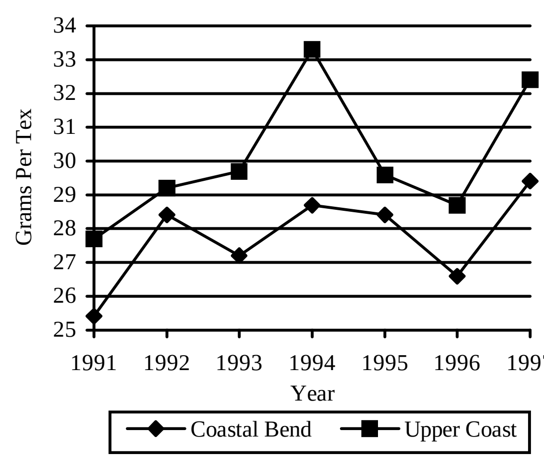



Figure 21. Sample strength, Coastal Bend and Upper Coast crop study 1991-1997.