# WHEAT RESPONSE TO VARIOUS ROW SPACINGS IN RELAY INTERCROPPING SYSTEMS

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## INTRODUCTION

In the southern USA there is considerable research interest in relay intercropping of soybeans and cotton into wheat before harvest. Sequentially doublecropped soybeans or cotton after wheat harvest delays the planting of those crops, and can result in poor stands (Beatty et al.. 1982) and reduced yields (Coale and Grove, 1990; Garner et al., 1992). Numerous relay intercropping systems involving different planting schemes and associated equipment have been developed and successfully tested (Hood et al., 1991). The systems usually involve controlled-traffic for planting, fertilization, pesticide applications, and wheat harvest. Because controlled-traffic causes soil compaction only in non-cropped traffic lanes, spring tillage operations usually necessary on Coastal Plain soils before planting the summer crop are not required, resulting in the potential for reduced fuel requirements (Khalilian et al., 1991a and 1991b) for the intercropping system as compared to conventional doublecropping systems Elimination of tillage operations prior to summer crop planting and inhibition of weed emergence by shading from the wheat crop can reduce herbicide inputs for the summer crop in the interseeding system (Buehring et al., 1990; Khalilian et al., 1990).

Clemson University has been developing equipment and planting schemes to interseed soybeans and cotton into standing wheat using controlled-traffic production methods since 1985. Hood et al. (1992) describes the evolution of the Clemson Interseeder. a planter which can be modified to plant wheat, cotton and soybeans with a variety of row spacings

One of the problems in conducting controlled-traffic operations is that the wheel spacings can vary for the equipment employed for planting, combining, and fertilizer and pesticide applications. Many farmers in the Southeast currently are using tractors with a 1.93 m center wheel spacing and combines with a 2.44 m center wheel spacing.

One interseeding scheme employs 1.93 m wheel centers to match the wheel traffic of many of the tractors currently used in the Southeast as well as several models of older combines. This planting scheme provides for planting 11 rows of wheat spaced 33.0 cm apart with two zones of 61.0 cm provided for the tractor, interseeder and combine wheel traffic. With this system, up to eight rows of soybeans or four rows of cotton can be planted (Fig. 1a). The cotton can be picked with a conventional 96.5 cm four-row cotton picker.

Several newer model combines use a wheel center spacing of at least 2.44 m., and thus another interseeding scheme was designed to accommodate those combines (Hood et al., 1992). This scheme involves planting 14 rows of wheat with 5 row widths of 30.5 cm to accommodate the interseeding of 5 rows of cotton or soybeans, 2 row widths of 61.0 cm to accommodate the tractor, interseeder and combine wheel traffic zones, and 7 row widths of 15.2 cm (Fig. 1b).

This study compared the yield and yield component response of wheat produced with these interseeding production schemes to the yield and yield component response of conventionally grown wheat.

## MATERIALS AND METHODS

The study was conducted at the Edisto Research and Education Center near Blackville, SC, on a Varina loamy sand. It involved four planting systems with six replications in a randomized complete block design. Treatment descriptions are detailed in Table 1. Treatment A involved conventionally planted wheat with row widths equally spaced. Treatment **B** utilized the Clemson Interseeder and the 11-row planting system (Fig. 1a). Treatments C & D utilized the Clemson Interseeder and the 14-row planting system (Fig. 1b). A paraplow and French Durou plow was employed for deep tillage prior to wheat planting for treatments C and D,

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Table 1. Treatment descriptions of a two-year study conducted at the Edisto Research and Education Center near Blackville, SC.

| | **Trt A** | | **Trt B** | | **Trt C** | | **Trt D** | |
|---|---|---|---|---|---|---|---|---|
| **Harvest year** | **1992** | **1993** | **1992** | **1993** | **1992** | **1993** | **1992** | **1993** |
| Planting date | Nov. 21 | Dec. 14 | Nov. 21 | Dec. 14 | Nov. 21 | Dec. 14 | Dec. 3 | Dec.14 |
| Harvest date | June 1 | June 7 | June 1 | June 7 | June 1 | June 7 | June 1 | June 7 |
| Number of wheat rows | 16 | 24 | 11 | | 14 | | 14 | |
| Row width (cm) | 19.6 | 15.2 | 33.0 & 61.0 | | 15.2, 30.5 & 61.0 | | 15.2, 30.5 & 61.0 | |
| Seeding rate[1] | | | | | | | | |
| kg $ha^{-1}$ | 112.1 | 112.1 | 112.1 | | 112.1 | | 112.1 | |
| seed (linear $m)^{-1}$ | 64.4 | 50.3 | 125.6 | | 93.3 | | 93.3 | |
| Planter[2] | Drill | | Clemson I. | | Clemson I. | | Clemson I. | |
| Fall tillage[3] | Chisel | | Paraplow | | Paraplow | | Durou plow | |
| Tire spacing (cm) | 193 | | 193 | | 244 | | 244 | |

[1] Number of seeds planted per meter of row was calculated using an average seed weight of 0.034 g $seed^{-1}$.
[2] Trt A (conventionally planted wheat) was planted with 16-row Amazone in 1991 and a 24-row JD450 in 1992. All other treatments were planted with the Clemson Interseeder.
[3] The chisel plow had 30 cm shank spacings and operated 28 cm deep, the paraplow had 53 cm shank spacings and operated 30 to 33 cm deep, and the French Durou plow had 96 cm shank spacings and operated 33 to 36 cm deep.

respectively, to compare the effect of these two new conservation tillage implements for wheat production in coastal plain soils.

The experimental area was limed with 2.24 Mg $ha^{-1}$ on Oct. 8, 1991 and disked. On Oct. 18 the area was fertilized with 30.8 kg N $ha^{-1}$ and 106.5 kg K $ha^{-1}$, and again disked. Plots in three of the four treatments were deep tilled on Nov. 19 and planted with 'NK Coker 9835' wheat on Nov. 21. The other treatment (Durou plow) was tilled to 35.6 cm and planted on Dec. 3, after the tillage equipment had arrived. Wheat was top dressed on Feb. 5, 1992 with 67.3 kg N $ha^{-1}$. The second year of the study, 67.3 kg K $ha^{-1}$ was applied on Dec. 8 and disked to 20.3 cm. Deep tillage occurred on Dec. 14, and the same day all plots were planted. Planting occurred later than normal because of the extremely wet conditions in Nov. and Dec. of 1992. The nitrogen application was split with 33.6 kg N $ha^{-1}$ applied as S-25 on Dec. 16, 1992 and Feb. 18 and Mar. 2, 1993. Weeds and diseases were controlled using appropriate pesticides. Soybeans were interseeded into appropriate plots on May 19, 1992 and May 20, 1993. Wheat harvest occurred on June 1. 1992 and June 7. 1993. with 61.0 cm of each row cut at ground level, and oven dried at 60°C for 48 hours. Above-ground dry matter and number of heads with viable seeds were determined. After threshing the wheat in an Almaco plot combine, the weight and number of seeds from each harvest row were determined.

For each year, and for the 2-year combined data, statistical analysis comparing individual rows within each of the four treatments was conducted. In addition, a system analysis of the four treatments was conducted employing two methods: a) using the entire set of individual row data, except the outside rows, to eliminate the border effect of leaving 0.61 m between two adjacent plots, and b) using the entire set of individual row data. The area for the outside row was calculated by adding 30.5 cm to one-half the distance between the outside row and the adjacent row, and multiplying that sum by the harvest length. SAS was employed for the statistical analysis, and the LSD reported only if the significance level was at $a \leq 0.05$.

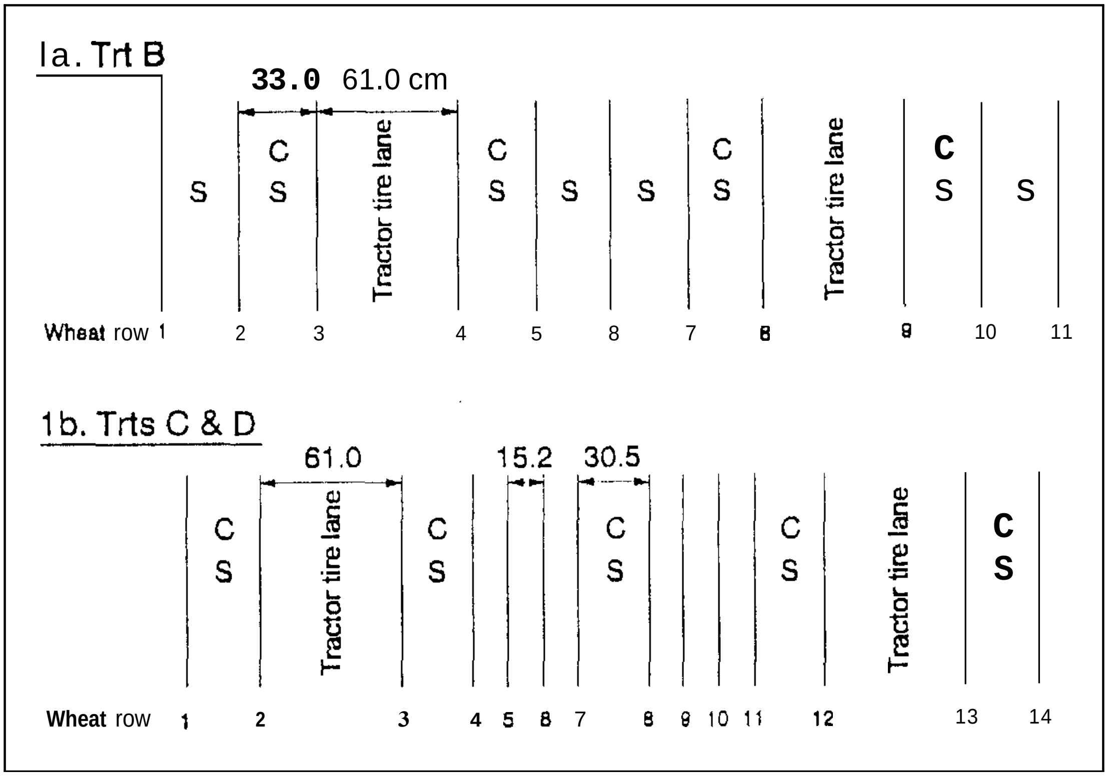


Figure 1. Planting pattern for wheat, cotton (C) and soybeans (S) for a) the 1.93 m tractor wheel spacing, and b) the 2.44 m tractor wheel spacing schemes.

## RESULTS AND DISCUSSION

### System Analysis

Analysis of the entire system, whether including or excluding the outside rows in the analysis, did not affect the interpretation of the results for the yield and yield components measured (Tables 2 and 3). The climatic conditions were better for the 1992 growing season as compared to the 1993 growing season, and there was a significant year effect for all yield and yield components measured. There was no significant year by treatment interactions for above-ground dry matter yield, seed yield, kernels per unit area, or kernel weight. However, there were year by treatment interactions for heads per unit area and kernels per head.

In 1992, 1993 and for the 2-year combined data, there was no significant difference between the four treatments for the above-ground dry matter yield, seed yield, kernels per unit area or kernel weight. Whether or not the outside row on each side of the plot was included in the analysis did not change the interpretation of the results (Tables 2 and 3). These data indicate wheat yields were not adversely affected by wide row planting under the given experimental parameters.

In 1992 and the 2-year combined data, treatment D had fewer heads per unit area but more kernels per head than the other treatments. In the 1992 season, treatment D was planted two weeks later than the other treatments. Delaying the planting date probably resulted in poor tillering, and caused the reduction in heads per unit area and increase in kernels per head as compared to the other treatments. The next season, when all treatments were planted on the same date, these differences were not observed.

In 1992 and the 2-year combined data, the conventionally planted wheat (treatment A) had more heads per unit area than the other treatments. Both years treatment A had the lowest number of kernels per head. For the

Table 2. Statistical analysis of wheat yields for entire system including outside rows.

| Trt | Total dry wt. | Kernel wt. | Kernels per $m^2$ | Heads per $m^2$ | Wt. per kernel | Kernels per head |
|---|---|---|---|---|---|---|
| | $g\ m^{-2}$ | $g\ m^{-2}$ | | | 9 | |
| 1992 | | | | | | |
| A | 1079 | 516 | 17246 | 549a | 0.0299 | 31.4b |
| B | 964 | 483 | 15750 | 468b | 0.0307 | 33.9b |
| C | 992 | 490 | 16106 | 464b | 0.0305 | 34.8b |
| D | 932 | 466 | 15494 | 383c | 0.0300 | 40.3a |
| mean | 992 | 489 | 16149 | 466 | 0.0303 | 35.1 |
| CV | 10.6 | 10.7 | 9.7 | 9.3 | 2.6 | 8.4 |
| Analysis of variance | | | | | | |
| Trt effect | NS | NS | NS | *** | NS | *** |
| FLSD | | | | 53.2 | | 3.6 |
| 1993 | | | | | | |
| A | 618 | 282 | 8580 | 371 | 0.0328 | 23.1b |
| B | 607 | 285 | 8754 | 346 | 0.0325 | 25.3a |
| C | 604 | 284 | 8882 | 349 | 0.0320 | 25.5a |
| D | 566 | 264 | 8240 | 336 | 0.0320 | 24.6ab |
| mean | 599 | 279 | 8614 | 351 | 0.0323 | 24.6 |
| CV | 10.6 | 10.3 | 9.2 | 7.5 | 2.6 | 5.5 |
| Analysis of variance | | | | | | |
| Trt effect | NS | NS | NS | NS | NS | ** |
| FLSD | | - | | | | 1.7 |
| 2-year combined data | | | | | | |
| A | 848 | 399 | 12913 | 460a | 0.0314 | 27.3c |
| B | 786 | 384 | 12252 | 407b | 0.0316 | 29.6b |
| C | 798 | 387 | 12494 | 406b | 0.0312 | 30.1b |
| D | 749 | 365 | 11867 | 360c | 0.0310 | 32.5a |
| mean | 795 | 384 | 12302 | 408 | 0.0313 | 29.9 |
| CV | 10.9 | 11.0 | 10.1 | 8.8 | 2.6 | 7.7 |
| Analysis of variance | | | | | | |
| Trt effect | NS | NS | NS | *** | NS | *** |
| Year effect | *** | *** | *** | *** | *** | *** |
| Trt*Year | NS | NS | NS | ** | NS | *** |
| Trt FLSD | | | | 29.9 | | 1.9 |

***, **, • and NS refer to $P \leq 0.001$, 0.01, 0.05, and $P \geq 0.05$, respectively.

combined 2-year data, the number of kernels per head was significantly lower than for the other treatments. These data can be explained by looking at the individual row data and the effect of tire-traffic on the wheat rows of the conventionally planted wheat.

**Individual Row Analysis**

For the conventionally planted wheat, the seed yield on both a linear and area basis, kernel weight and kernels per head all decreased dramatically in the rows where tire compaction occurred (rows 4 & 14 in 1992, and rows 6 & 7

Table 3. Statistical analysis of wheat yields for entire system excluding outside rows.

| Trt | Total dry wt. | Kernel wt. | Kernels per $m^2$ | Heads per $m^2$ | Wt. per kernel | Kernels per head |
|---|---|---|---|---|---|---|
| | $g\ m^{-2}$ | $g\ m^{-2}$ | | | g | |
| **1992** | | | | | | |
| **A** | **1061** | **514** | **17140** | **569a** | **0.0301** | **30.1b** |
| **B** | **953** | **482** | **15668** | **473b** | **0.0308** | **33.5b** |
| **C** | **968** | **484** | **15899** | **471b** | **0.0305** | **33.8b** |
| **D** | **970** | **489** | **16240** | **401c** | **0.0300** | **40.4a** |
| **mean** | **988** | **492** | **16237** | **479** | **0.0303** | **34.5** |
| **CV** | **11.5** | **11.3** | **10.1** | **10.8** | **3.2** | **9.2** |
| **Analysis of variance** | | | | | | |
| **Trt effect** | **NS** | **NS** | **NS** | *** | **NS** | *** |
| **FLSD** | - | - | - | **63.8** | - | **3.9** |
| 1993 | | | | | | |
| A | 639 | 292 | 8828 | 387 | 0.0329 | 22.7b |
| B | 633 | 296 | 9043 | 356 | 0.0326 | 25.4a |
| C | 622 | 290 | 9057 | 367 | 0.0320 | 24.8a |
| D | 587 | 273 | 8473 | 355 | 0.0322 | 24.0ab |
| mean | 620 | 288 | 8851 | 366 | 0.0324 | 24.2 |
| CV | 10.5 | 10.2 | 9.2 | 8.7 | 2.9 | 5.4 |
| Analysis of variance | | | | | | |
| Trt effect | NS | NS | NS | NS | NS | • |
| FLSD | | | | | | 1.6 |
| 2-year combined data | | | | | | |
| A | 850 | 403 | 12984 | 478a | 0.0315 | 26.4c |
| B | 793 | 389 | 12356 | 414b | 0.0317 | 29.5b |
| C | 795 | 387 | 12478 | 419b | 0.0312 | 29.3b |
| D | 779 | 381 | 12357 | 378c | 0.0311 | 32.2a |
| mean | 804 | 390 | 12544 | 422 | 0.0314 | 29.4 |
| CV | 11.5 | 11.4 | 10.4 | 10.2 | 3.0 | 8.3 |
| Analysis of variance | | | | | | |
| Trt effect | NS | NS | NS | *** | NS | *** |
| Year effect | *** | *** | *** | *** | ** | *** |
| Trt*Year | NS | NS | NS | *** | NS | *** |
| FLSD | | | - | 35.9 | | 2.0 |

***, **, • and NS refer to $P \leq 0.001$, 0.01, 0.05, and $P \geq 0.05$, respectively.

and 18 & 19 in 1993) (Fig. 2a-d, treatment A). Tire-traffic rows had more, but smaller and later maturing heads than the other rows. The tire compaction was a result of three passes over the wheat plots for application of a herbicide, spring N and a fungicide. In the other treatments no wheat was run over by those passes over the plots because of the wheat-row spacing allowance for the tire track (Fig. 1a and 1b).

For the 11-row wheat system (Fig. 1a, treatment B) the rows most widely spaced (rows 1, 3, 4, 8, 9 & 11) tended to have the highest

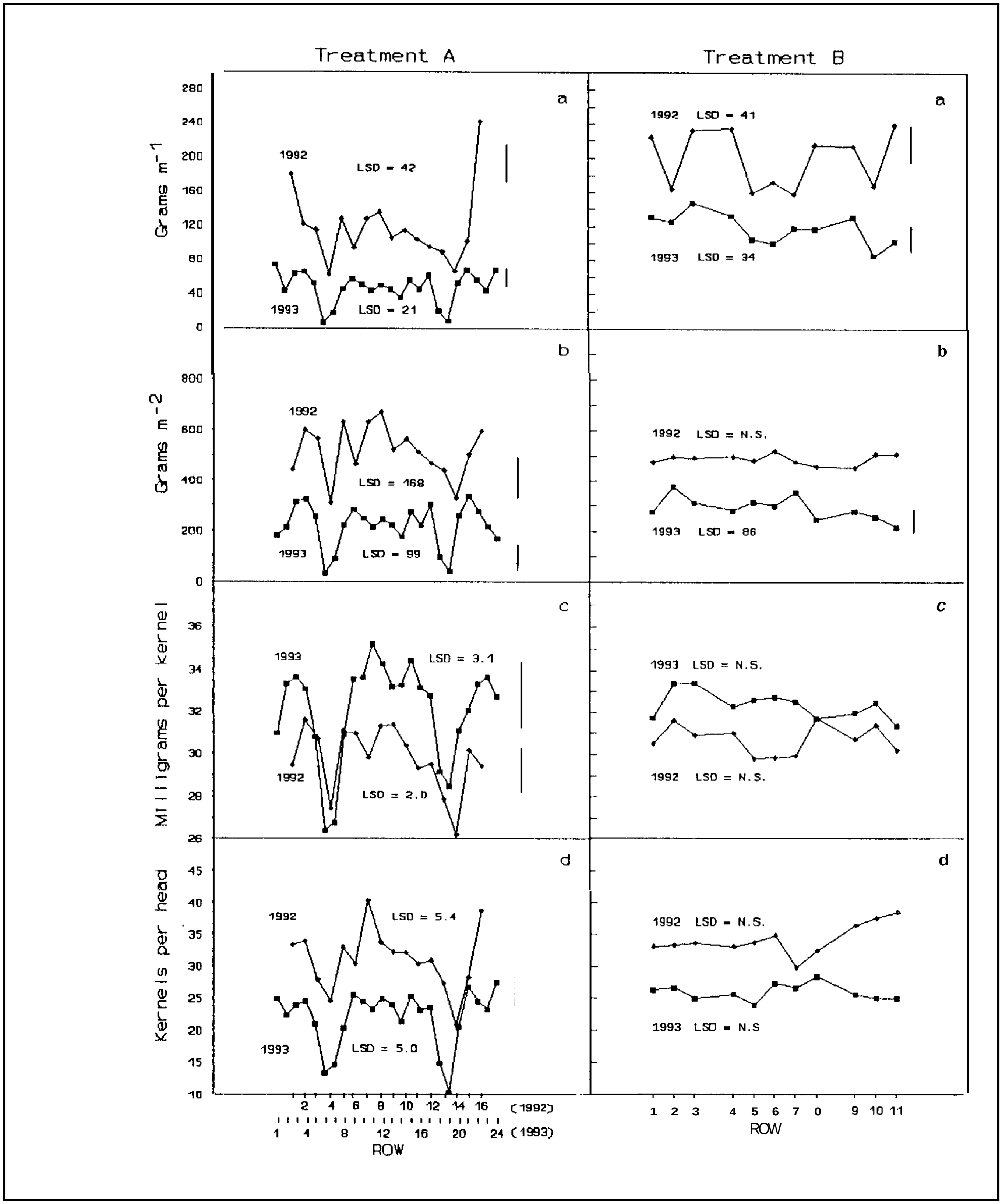


**Figure 2. Seed yield on a linear basis (a) and area basis (b), kernel weight (c), and kernels per head (d) from individual wheat rows of treatments A and B.**

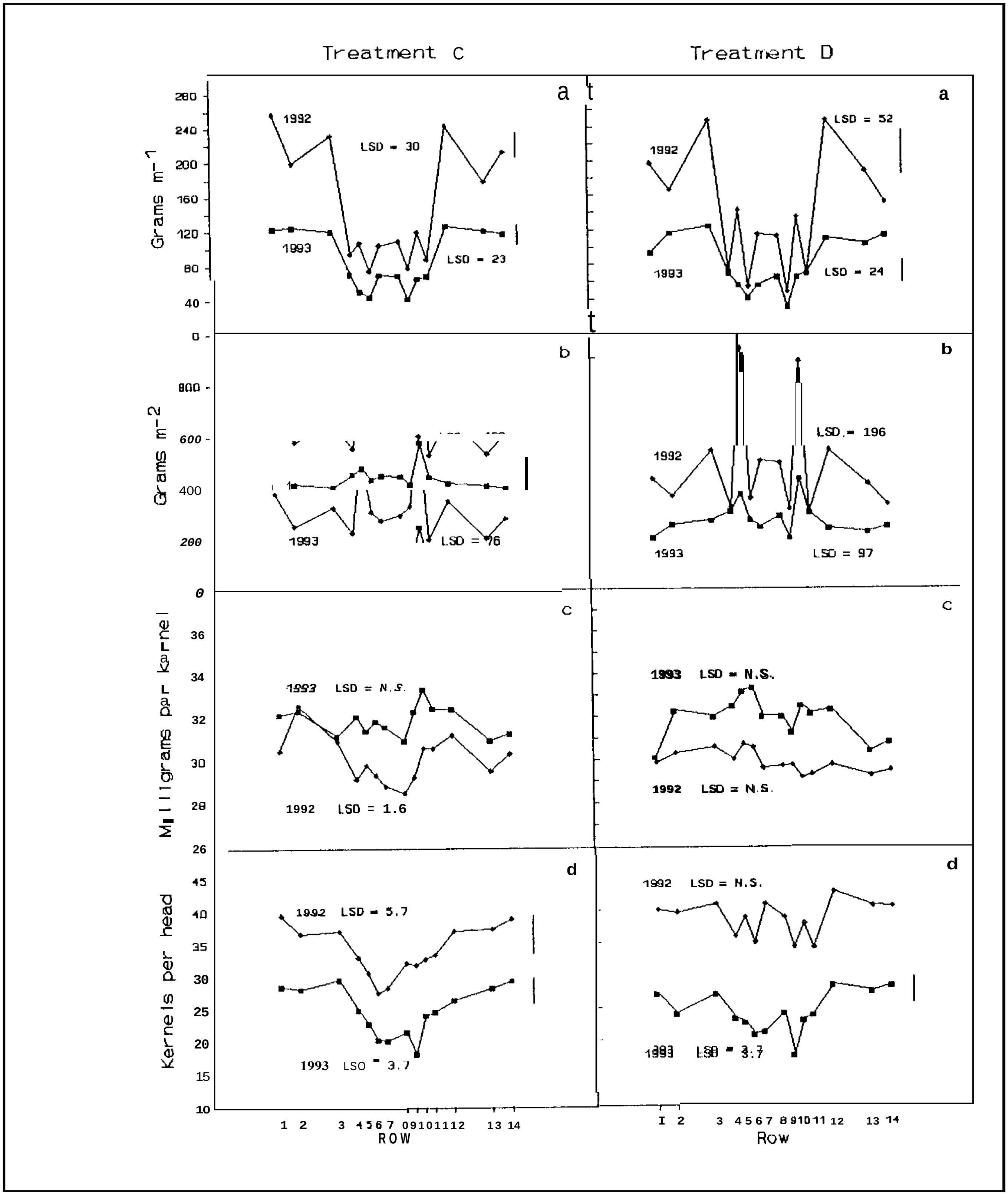


**Figure 3. Seed yield on a linear basis (a) and area basis (b), kernel weight (c), and kernels per head (d) from individual wheat rows of treatment C and D.**

seed yield on a linear basis (Fig. 2a. treatment B), but when calculated on an area basis, the row spacing did not affect yield Fig. 2b. treatment B). Kernel weight and the number of kernels per head were unaffected by row spacing (Fig. 2c & 2d. treatment B).

For the two 14-row wheat systems (Fig. 1b), the rows most widely spaced (rows 1, 2, 3, 12, 13 & 14) consistently yielded more than the other rows on a linear and area basis (Fig. 3a and 3b. treatments C & D). Kernel weight was generally unaffected by row spacing (Fig. 3c. treatments C & D), but the rows most widely spaced tended to have more kernels per head than the narrower spaced rows (Fig. 3d. treatments C & D).

In summary, yield of conventionally planted wheat was not significantly different from yields of skip-row schemes designed to allow for relay intercropping of either soybeans or cotton. For the conventionally planted wheat, tractor traffic on top of certain wheat rows reduced yields of those rows as compared to non-traffic rows. Wheat grown in wider-spaced rows adjacent to the controlled-traffic tire lanes in the schemes designed to allow for relay intercropping compensated yield-wise on an area basis as compared to narrower-spaced rows.

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