

## **Final Report**

# **An Evaluation of Equipment used by Willamette Valley Grass Seed Growers as a Substitute for Open-field Burning**

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## Acknowledgment

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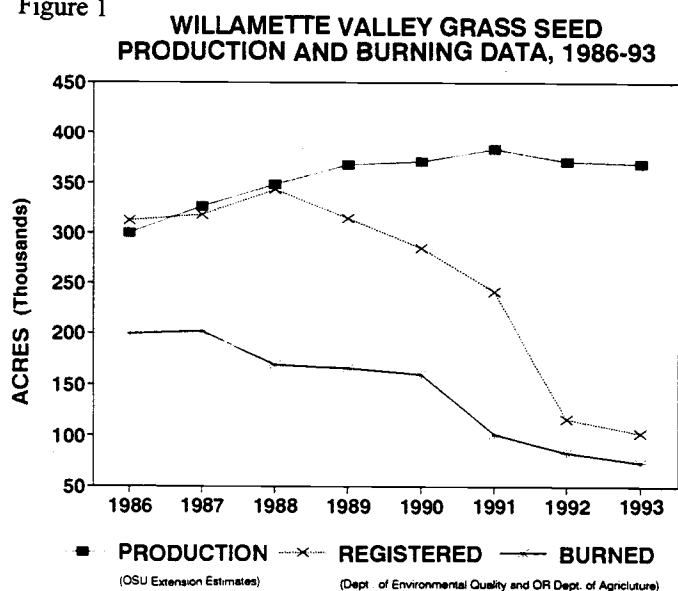
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## Introduction

This program was initiated to evaluate various straw and stubble management techniques being commercially used by grass seed growers as alternatives to burning crop residue after harvest. The incentive for this study was based on growers reduced dependence on open-field burning and their uncertainty in regard to the long-term maintenance of seed yield and seed quality when using alternative methods for crop residue disposal.

Burning of post-harvest crop residue had been an established cultural practice in the Willamette Valley of Oregon since the late 1940's for control of disease and disposal of residue. As recently as between 1980 and 1985, 75 to 80% of the total grass seed production was open-field burned. However, between 1986 and 1993 the percentage of grass seed crops open-field burned dropped to 20% (Figure 1).

Figure 1



Growers drastic reduction in the acres open-field burned during the last eight years has occurred due to a one-third increase in acres planted to grass seed crops and stricter rules established by State smoke management authorities, reducing the opportunity to achieve timely, early-season burns. More formidably, in August 1991 the Oregon Legislature signed into law a measure sharply reducing the acres of open-field burning allowed in grass seed production. This bill declares that Oregon's public policy is to reduce the practice of thermal sanitation, and decreases to 40,000 acres the area allowed for open-field burning after 1997.

By 1990 many seed producers were already adopting alternative methods for removal of post-harvest straw and stubble residue. New equipment innovations and increased grower acceptance of nonthermal production systems allowed for on-farm testing of techniques previously studied in small research plots. Our objective has been to follow these sites over a several year period to evaluate the effects of nonthermal residue treatments as grass seed stands age.

## Procedure

In 1990-91, nonthermal treatments were evaluated at 13 different locations, mostly in the south valley, and focused on tall fescue and perennial ryegrass. These results were summarized in a previous report (Ext/CrS 87, February 1992). In 1991-92, treatments were repeated for a second year at 10 of the 13 original sites, and three new locations were added to the program. Second-year results and analyses of the two year database have been reported (Ext/CrS 94, April 1993). In 1992-93, six locations were continued in fields where evaluations had begun either one of two years earlier. The subject of this report is our 1993 data and a summary presentation of results over the complete course of this study.

Test sites were selected to evaluate post-harvest residue removal treatments where growers had established large-scale, single-replication plots within a uniform block in their field. The size of these plots (100 x 400-600 ft) allowed for standard harvest techniques, i.e., swathing and combining with grower equipment. Most locations began as new stands where first-year seed crop harvest was taken the summer that plots were established.

When seed crops matured, four swaths from each treatment were combine harvested and sub-sampled for a purity analysis (weed seeds, other crop species, inert matter) at the Oregon State University Seed Laboratory. Purity test results were used to convert combine plot yield to an equivalent clean seed weight. In addition, an assessment for the presence of ergot (*Claviceps purpurea*) and blind seed disease (*Gloeotinia temulenta*) was made by the USDA-ARS National Forage Seed Production Research Center.

Four nonthermal post-harvest residue management techniques have been common to most locations throughout this survey-type project. These treatments were:

- 1) Chop all straw back: Flail chop all straw and stubble back on the field three times to reduce size of straw particles so that decomposition on the soil surface can occur; stubble height approximately 3 - 4 in.

- 2) Bale-only: Baling and removal of straw with no subsequent stubble management; stubble height approximately 4 - 6 in.
- 3) Bale and flail: Baling and removal of straw followed by flail chopping the stubble back on the soil surface; stubble height approximately 3 - 4 in.
- 4) Vacuum-sweep: Baling and removal of straw followed by close cutting and removal of stubble; stubble height approximately 1 - 2 in.

In the second year of the program a needle-nose wheel rake—designed to remove all the straw from the field or to remove residue remaining after baling off the straw and chopping the stubble, was included at some sites following harvest of the 1991 seed crop. In our tests the needle-nose rake was used for secondary stubble management after baling of straw. Interest in the rake has remained strong with growers as a lower cost stubble management technique and it was observed at several sites in 1992-93.

Post-harvest treatments other than those discussed above evaluated in on-farm trials included: 1) Lely dethatcher; 2) reclip and loaf; 3) propane burning; 4) special machine burn; 5) open-field burning; and 6) several combinations of the above. However, in many situations there was only one or two sites where a particular treatment was employed. Because of variation in seed yield from field to field (due to soil

type, variety, grower management, etc.) direct comparison among these less commonly used treatments is not possible.

All totaled, 20 different post-harvest residue management combinations for perennial ryegrass, and 13 for tall fescue, were included in the survey during three years of study. (See Appendix Tables 1, 2 and 3 for list of fields and residue management treatments followed in during the 1990-91, 1991-92 and 1992-93 crop years, respectively.)

#### 1992-93 Results

Nine post-harvest treatment combinations were represented in this year's survey (Table 1). Seed yield data from the four tall fescue sites have been recorded for three years, and the two perennial ryegrass sites for two years. Although not all plots have been consistently governed with the same residue management treatment over time, these data do provide information on the long-term use of nonthermal production methods.

Averaged yield data across all six sites for the first four residue management treatments do not vary greatly. The highest yielding treatment is bale + vacuum-sweep (1637 lb/a) and the lowest is flail chop full straw (1460 lb/a). Other treatments in the survey are represented by only one of two observations making direct comparisons impossible due to variation in seed yield from field to field (due to soil type, variety, grower management, etc.).

Table 1. Effect of post-harvest residue management on tall fescue (TF) and perennial ryegrass (PR) clean seed yield, 1993.

| TREATMENT                               | Carefree TF<br>(Falk) | 8855 TF<br>(Glaser) | Cochise TF<br>(Pugh) | Arid TF<br>(Wirth) | 8990 PR<br>(Glaser) | Statesman PR<br>(VanLeeuwen) | Treatment<br>Avg. |
|---|-----------------------|---------------------|----------------------|--------------------|---------------------|------------------------------|-------------------|
| Bale-only                               | 983                   |                     |                      | 1451               | 1703                | 1983                         | 1530              |
| Bale + Flail chop                       | 913                   | 1605                |                      | 1385               |                     | 2253                         | 1539              |
| Flail chop full straw                   | 741                   | 1532                | 1365                 | 1501               | 1731                | 1890                         | 1460              |
| Bale + Vacuum-sweep                     | 942                   | 1544                | 1299                 | 1617               | 1734                | 2687                         | 1637              |
| Bale + Flail-chop<br>+ Needle-nose rake |                       |                     |                      | 1491               | 1694                |                              | 1592              |
| Bale + Needle-nose rake                 |                       | 1395                |                      |                    |                     | 2623                         | 2009              |
| Bale + Vacuum-sweep<br>+ Propane        |                       |                     | 1059                 |                    | 1744                |                              | 1401              |
| Bale + Reclip & loaf +<br>Propane burn  |                       |                     |                      |                    |                     | 2397                         | 2397              |
| Open burn                               | 1417                  |                     |                      |                    |                     |                              | 1417              |

### Seed purity and disease

Samples of threshed seed (field run) were taken from each combined swath for a purity and germination analysis by the OSU Seed Laboratory. No deleterious effect on germination was observed at any of the test sites (data not shown). Purity data are reported in Tables 2 and 3. In most situations the pure seed component was between 95 and 98%, and never lower than 92%. However, a variety of weed seeds were apparent in samples from most fields, although the total percentage of weed seeds was generally quite low (0.1% or less) regardless of post-harvest residue management. Nevertheless, the number of annual bluegrass (*Poa annua*) weed seeds per pound was noticeably quite high at several sites. Lack of control, however, does not appear to be consis-

tently linked to any particular residue management program.

The above data present a concern that standard herbicide practices employed by seed growers may not provide effective control of annual bluegrass where nonthermal post-harvest residue practices are employed over the normal life of a grass seed stand. Furthermore, these data do not provide any information on the control of volunteer seedlings. Visual observations noted that weed-seedling control was poorest where residue was chopped back on the field. Vacuum-sweep gave superior weed-seedling control by removing the majority of seeds on the soil, particularly in the swather and or combine trails.

Table 2. Effect of post-harvest residue management on the appearance of weed seed content and purity analysis in field run samples of tall fescue fields, 1993.

| Field (Grower)                    | Post-Harvest Residue Management |                                |                         |                            |                        |
|-----------------------------------|---------------------------------|--------------------------------|-------------------------|----------------------------|------------------------|
| Carefree<br>tall fescue<br>(Falk) | Flail chop<br>full straw        | Bale-<br>only                  | Bale +<br>flail<br>chop | Bale +<br>Vacuum-<br>sweep | Open-<br>field<br>burn |
| <u>Weed seeds: (no./lb)</u>       |                                 |                                |                         |                            |                        |
| Sticky chickweed                  | 0                               | 22                             | 0                       | 0                          | 0                      |
| <u>Other crop:</u>                |                                 |                                |                         |                            |                        |
| Ryegrass                          | 22                              | 43                             | 21                      | 0                          | 43                     |
| Bentgrass                         | 0                               | 0                              | 0                       | 43                         | 21                     |
| Fine fescue                       | 0                               | 0                              | 22                      | 0                          | 0                      |
| <u>Purity analysis (%):</u>       |                                 |                                |                         |                            |                        |
| Pure seed                         | 98.8                            | 98.6                           | 98.8                    | 98.9                       | 98.7                   |
| Other crop seed                   | 0.0                             | 0.0                            | 0.0                     | 0.0                        | 0.0                    |
| Inert Matter                      | 1.2                             | 1.3                            | 1.2                     | 1.1                        | 1.3                    |
| Weed Seed                         | 0.0                             | 0.0                            | 0.0                     | 0.0                        | 0.0                    |
| <hr/>                             |                                 |                                |                         |                            |                        |
| 8855<br>tall fescue<br>(Glaser)   | Flail chop<br>full straw        | Bale +<br>needle-<br>nose rake | Bale +<br>flail<br>chop | Bale +<br>vacuum<br>sweep  |                        |
| <u>Weed seeds:</u>                |                                 |                                |                         |                            |                        |
| Annual bluegrass                  | 370                             | 0                              | 22                      | 0                          |                        |
| <u>Other crop:</u>                |                                 |                                |                         |                            |                        |
| Ryegrass                          | 22                              | 0                              | 43                      | 0                          |                        |
| <u>Purity analysis (%):</u>       |                                 |                                |                         |                            |                        |
| Pure seed                         | 95.2                            | 94.2                           | 95.4                    | 94.8                       |                        |
| Other crop seed                   | 0.0                             | 0.0                            | 0.0                     | 0.0                        |                        |
| Inert Matter                      | 4.7                             | 5.8                            | 4.6                     | 5.2                        |                        |
| Weed Seed                         | 0.0                             | 0.0                            | 0.0                     | 0.0                        |                        |

Table 2. (continued)

| Cochise<br>tall fescue<br>(Pugh) | Flail chop<br>full straw | Bale +<br>Vacuum-<br>sweep | Bale +<br>Vacuum-<br>sweep +<br>propane |
|----------------------------------|--------------------------|----------------------------|---|
| <u>Weed seeds:</u>               |                          |                            |   |
| Annual bluegrass                 | 0                        | 22                         | 0                                       |
| Lesser snapdragon                | 218                      | 0                          | 43                                      |
| Prickly sowthistle               | 0                        | 22                         | 0                                       |
| <u>Other crop:</u>               |                          |                            |   |
| Orchardgrass                     | 86                       | 0                          | 0                                       |
| Kentucky bluegrass               | 87                       | 0                          | 0                                       |
| Rough bluegrass                  | 0                        | 22                         | 0                                       |
| <u>Purity analysis (%):</u>      |                          |                            |   |
| Pure seed                        | 96.7                     | 97.5                       | 97.5                                    |
| Other crop seed                  | 0.0                      | 0.0                        | 0.0                                     |
| Inert Matter                     | 3.3                      | 2.5                        | 2.5                                     |
| Weed Seed                        | 0.0                      | 0.0                        | 0.0                                     |

| Arid<br>tall fescue<br>(Wirth) | Flail chop<br>full straw | Bale -<br>only | Bale +<br>flail<br>chop | Bale +<br>flail chop<br>+ needle-<br>nose rake | Bale +<br>Vacuum<br>sweep |
|--------------------------------|--------------------------|----------------|-------------------------|--|---------------------------|
| <u>Weed seeds:</u>             |                          |                |                         |  |                           |
| Annual bluegrass               | 29                       | 0              | 0                       | 172  | 1197                      |
| Common sowthistle              | 29                       | 29             | 0                       | 0  | 0                         |
| Curly dock                     | 144                      | 0              | 0                       | 0  | 0                         |
| Mountain brome                 | 29                       | 0              | 0                       | 0  | 0                         |
| Bedstraw                       | 29                       | 0              | 0                       | 0  | 57                        |
| <u>Other crop:</u>             |                          |                |                         |  |                           |
| Ryegrass                       | 172                      | 29             | 0                       | 64   | 114                       |
| Rough bluegrass                | 0                        | 0              | 0                       | 0  | 29                        |
| Orchardgrass                   | 29                       | 0              | 0                       | 0  | 0                         |
| <u>Purity analysis (%):</u>    |                          |                |                         |  |                           |
| Pure seed                      | 96.7                     | 97.8           | 96.6                    | 97.2   | 97.2                      |
| Other crop seed                | 0.1                      | 0.0            | 0.0                     | 0.0  | 0.0                       |
| Inert Matter                   | 3.1                      | 2.2            | 3.4                     | 2.8  | 2.5                       |
| Weed Seed                      | 0.1                      | 0.0            | 0.0                     | 0.0  | 0.1                       |

Table 3. Effect of post-harvest residue management on weed seed content and purity analysis in field run samples of perennial ryegrass fields, 1993.

| Field (Grower)                         | Post-Harvest Residue Management |               |  |                          |   |
|--|---------------------------------|---------------|--|--------------------------|---|
| 8990<br>perennial ryegrass<br>(Glaser) | Flail chop<br>full straw        | Bale-<br>only | Bale +<br>flail chop<br>needle-<br>nose rake | Bale<br>+vacuum<br>sweep | Bale<br>+ vacuum<br>-sweep<br>+ propane |
| <u>Weed seeds: (no./lb)</u>            |                                 |               |  |                          |   |
| Annual bluegrass                       | 0                               | 409           | 323  | 129                      | 452                                     |
| Foxtail                                | 0                               | 0             | 22   | 0                        | 0                                       |
| Prickly sowthistle                     | 0                               | 0             | 21   | 0                        | 0                                       |
| <u>Other crop: (no./lb)</u>            |                                 |               |  |                          |   |
| Annual ryegrass <sup>1</sup>           | 4106                            | 4737          | 5148   | 6214                     | 3305                                    |
| Kentucky bluegrass                     | 22                              | 0             | 215  | 129                      | 0                                       |
| <u>Pure analysis (%):</u>              |                                 |               |  |                          |   |
| Pure seed                              | 93.0                            | 92.7          | 92.4   | 93.2                     | 94.5                                    |
| Other crop seed                        | 2.2                             | 2.5           | 2.7  | 3.2                      | 1.7                                     |
| Inert Matter                           | 4.8                             | 4.8           | 4.8  | 3.5                      | 3.8                                     |
| Weed Seed                              | 0.0                             | 0.0           | 0.0  | 0.0                      | 0.0                                     |

| Statesman<br>perennial ryegrass<br>(VanLeeuwen) | Flail chop<br>full straw | Bale-<br>only | Bale +<br>flail<br>chop | Bale +<br>needle-<br>nose rake | Bale +<br>Vacuum<br>sweep | Bale+<br>reclip<br>& loaf<br>+ propane |
|---|--------------------------|---------------|-------------------------|--------------------------------|---------------------------|--|
| <u>Weed seeds:</u>                              |                          |               |                         |                                |                           |  |
| Annual bluegrass                                | 43                       | 29            | 0                       | 86                             | 43                        | 0                                      |
| Field groundsel                                 | 43                       | 58            | 43                      | 0                              | 0                         | 0                                      |
| Lesser snapdragon                               | 0                        | 87            | 22                      | 22                             | 21                        | 0                                      |
| Prickly sowthistle                              | 22                       | 86            | 22                      | 22                             | 0                         | 0                                      |
| <u>Other crop:</u>                              |                          |               |                         |                                |                           |  |
| Annual ryegrass <sup>1</sup>                    | 697                      | 447           | 660                     | 442                            | 58                        | 825                                    |
| Bentgrass                                       | 86                       | 0             | 0                       | 0                              | 0                         | 0                                      |
| Orchardgrass                                    | 0                        | 0             | 21                      | 0                              | 0                         | 0                                      |
| Rough bluegrass                                 | 0                        | 0             | 0                       | 22                             | 0                         | 43                                     |
| <u>Purity analysis (%):</u>                     |                          |               |                         |                                |                           |  |
| Pure seed                                       | 93.3                     | 93.1          | 92.7                    | 94.8                           | 94.6                      | 95.0                                   |
| Other crop seed                                 | 0.4                      | 0.2           | 0.3                     | 0.2                            | 0.0                       | 0.4                                    |
| Inert Matter                                    | 6.5                      | 6.5           | 7.0                     | 4.9                            | 5.4                       | 4.5                                    |
| Weed Seed                                       | 0.0                      | 0.0           | 0.0                     | 0.0                            | 0.0                       | 0.0                                    |

<sup>1</sup>Number of seeds was calculated following a fluorescence test to detect the presence of annual ryegrass in each perennial ryegrass sample.

In addition to the purity analysis, an assessment for presence of blind seed disease was made by the USDA-ARS National Forage Seed Production Research Center from field run samples. No blind seed disease had been observed from plots at any location in 1991 or 1992. Dr. Steve Alderman, USDA Research Pathologist, did not assess 1993-harvested seed from this study for blind seed disease based on his finding no significant presence of this disease in his larger survey efforts.

Ergot sclerotia, however, have been found in some plots harvested in 1992 and 1993. These samples were analyzed by Dr. Steve Alderman in his laboratory at the National Forage Seed Production Research Center. Of the 13 study sites harvested in 1992 (seven perennial ryegrass and six tall fescue), ergot was observed in only three fields. At two locations, the actual count of ergot sclerotia was so low that no analysis of variance could be performed. The third site, Regal (Manning) perennial ryegrass, had a much larger number of ergot, however, all were observed to have been sclerotia from annual bluegrass (Table 4). These data reflect more on the difficulty of controlling annual bluegrass weeds in the presence of increased straw residue on the soil surface than a concern for ergot.

Table 4. Presence of annual bluegrass-formed ergot as influenced by post-harvest residue management in Regal perennial ryegrass, 1992.

| Treatment                               | Mean number<br>of sclerotia<br>per sample | Weight<br>of<br>sclerotia | Percent<br>ergot by<br>weight |
|---|---|---------------------------|-------------------------------|
|   | (no.)                                     | (mg)                      | (%)                           |
| Bale only                               | 117 a*                                    | 69 a                      | 0.23                          |
| Bale + Flail chop                       | 314 b                                     | 187 b                     | 0.62                          |
| Flail chop full straw                   | 387 b                                     | 187 b                     | 0.62                          |
| Bale + Vacuum-sweep                     | 109 a                                     | 65 a                      | 0.21                          |
| Bale + Flail chop +<br>Needle-nose rake | 64 a                                      | 38 a                      | 0.13                          |

\*Means followed by the same letter are not significantly different by Fisher's protected LSD ( $P < 0.05$ )

No significant amount of ergot was found in seed harvested at the six locations in 1993. However, samples with ergot in them comprised 6% of the total samples analyzed (7 out of 112). Of the six sites harvested, ergot was observed at four: three tall fescue and one perennial ryegrass location. Each of the tall fescue sites had only one sample where ergot was found. In the perennial ryegrass field, ergot was present in four out of twenty samples. The amount of ergot in all of the samples was at or below 0.03% by weight (Table 5). Fur-

thermore, there is no apparent correlation between post-harvest residue management and presence of ergot.

Table 5. Ergot observed in tall fescue (TF) and perennial ryegrass (PR) managed with nonthermal post-harvest methods, and percent ergot by weight in seed of harvest samples, 1993.

| Variety<br>and<br>species | Frequency<br>per<br>treatment | Post harvest residue management <sup>1</sup> |      |      |      |
|---------------------------|-------------------------------|--|------|------|------|
|                           |                               | 3X   | Bale | Rake | VS   |
| ----- (%) -----           |                               |  |      |      |      |
| Carefree TF               | 1 of 4                        |  | .011 |      |      |
| 8855 TF                   | 1 of 4                        |  |      |      | .030 |
| Cochise TF                | 1 of 4                        |  |      |      | .012 |
| 8990 PR                   | 1 of 4                        | .021   |      |      |      |
| "                         | 1 of 4                        |  | .014 |      |      |
| "                         | 2 of 4                        |  |      | .024 | .020 |

<sup>1</sup>3X = flail chop (3 times) straw and stubble back on field

Bale = bale-only

Rake = bale, flail chop stubble and needle-nose rake

VS = bale and vacuum-sweep

#### Soil test data

Following seed harvest in 1993, soil samples were taken to evaluate the effect of residue management on soil fertility factors. Soil was collected at four sampling depths, 0-1", 1-2", 2-3", and 3-6" and analyzed for pH, phosphorus, calcium, magnesium, and percent organic matter. Two treatments (vacuum-sweep and flail chop full straw) common to five sites (three tall fescue and two perennial ryegrass) were selected to compare the effect of complete residue removal versus full straw residue left in the field. Data were analyzed as a RCB with five replications (sites).

Sampling for potassium (K) was delayed until rainfall in an amount similar to that received in the interim between seed harvest and sampling in 1992 had occurred. Also, only four sites were available and only the Arid (Wirth) and Cochise (Pugh) tall fescue sites still had flail chop full straw plots from which to sample. At the other sites, growers had removed straw by baling following termination of our program on their farms. The delayed sampling was necessary in order for K to be leached out of straw by rain.

Potassium concentration (ppm) throughout the surface 0-6" profile sampled was found to be significantly lower where crop residue had been removed mechanically (Table 6). No significant difference was observed in the other analyses. These data confirm earlier reports that the physical removal of straw may present the need to adjust K management. Conversely, growers should be able to reduce potash ( $K_2O$ )



fertilizer inputs where the full straw load has been chopped back for several years, at least on fields where the soil test K was at an adequate level (above 100 ppm) at stand establishment.

Table 6. Effect of residue management on soil fertility. Data comparing flail chopping full straw and vacuum-sweep treatments are the average of five site locations. Soil samples taken on August 20, 1993, except as noted.

| Soil Test                | Depth<br>(in.) | Sample Residue Treatment |                  | Mean | LSD<br>(P<0.05) |
|--------------------------|----------------|--------------------------|------------------|------|-----------------|
|                          |                | Flail chop<br>full straw | Vacuum-<br>Sweep |      |                 |
| pH                       | 0-1            | 4.9                      | 5.0              | 5.0  | NS              |
|                          | 1-2            | 4.8                      | 4.9              | 4.9  | NS              |
|                          | 2-3            | 4.8                      | 4.8              | 4.8  | NS              |
|                          | 3-6            | 4.7                      | 4.8              | 4.8  | NS              |
| Phosphorus<br>(ppm)      | 0-1            | 72                       | 73               | 73   | NS              |
|                          | 1-2            | 65                       | 70               | 67   | NS              |
|                          | 2-3            | 64                       | 69               | 66   | NS              |
|                          | 3-6            | 65                       | 69               | 67   | NS              |
| Potassium <sup>1</sup>   | 0-1            | 433                      | 283              | 358  | *               |
|                          | 1-2            | 238                      | 135              | 186  | *               |
|                          | 2-3            | 180                      | 103              | 142  | *               |
|                          | 3-6            | 147                      | 107              | 127  | *               |
| Calcium<br>(meq/100g)    | 0-1            | 6.3                      | 6.4              | 6.3  | NS              |
|                          | 1-2            | 4.6                      | 5.7              | 5.2  | NS              |
|                          | 2-3            | 4.8                      | 4.8              | 4.8  | NS              |
|                          | 3-6            | 4.6                      | 5.1              | 4.9  | NS              |
| Magnesium<br>(meq/100g)  | 0-1            | 0.74                     | 0.69             | 0.71 | NS              |
|                          | 1-2            | 0.57                     | 0.55             | 0.56 | NS              |
|                          | 2-3            | 0.59                     | 0.56             | 0.58 | NS              |
|                          | 3-6            | 0.65                     | 0.68             | 0.66 | NS              |
| Organic<br>Matter<br>(%) | 0-1            | 4.3                      | 4.1              | 4.2  | NS              |
|                          | 1-2            | 3.8                      | 3.8              | 3.8  | NS              |
|                          | 2-3            | 3.8                      | 3.8              | 3.8  | NS              |
|                          | 3-6            | 3.7                      | 3.7              | 3.7  | NS              |

<sup>1</sup>Average of 4 sites, resampled on December 16, 1993.

#### Seed yield summary

Multi-year seed yield data (where available) from all locations in the research program from its beginning are shown graphically in Figures 2 - 13. In addition to the bar-graphed data for each year, a two or three year averaged seed yield line (—▲—) is plotted. The actual seed yield data (lb/a) for each post-harvest residue management treatment are given

Figure 2 Arid Tall Fescue - Wirth Farm 1991, 1992 & 1993 Seed Yields

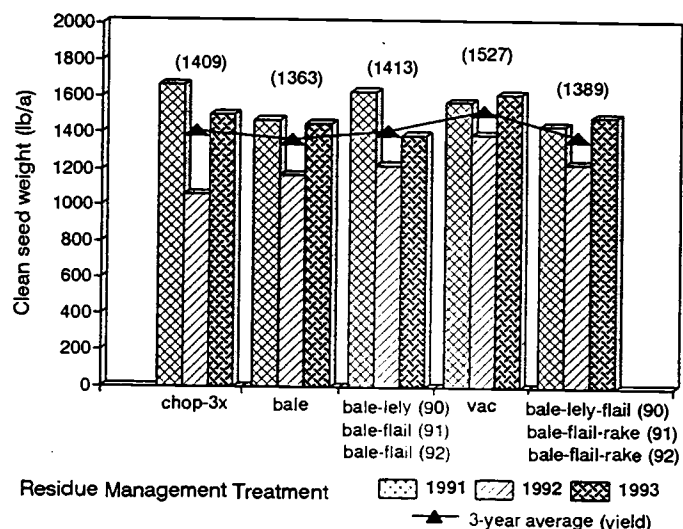


Figure 3 Carefree Tall Fescue - Falk Farm 1991, 1992 & 1993 Seed Yields

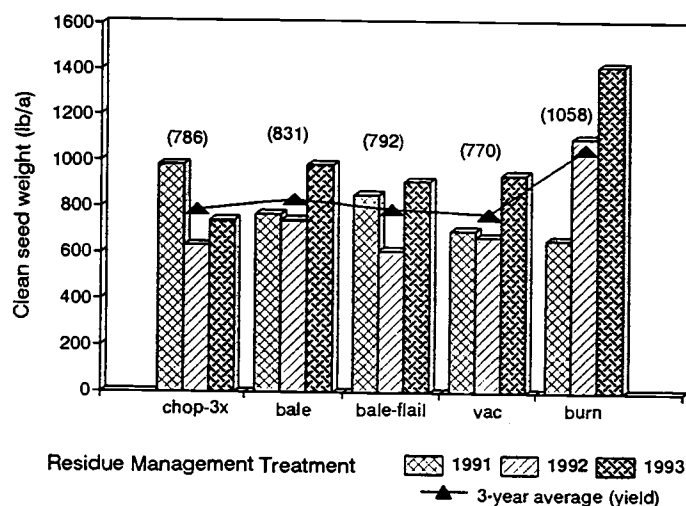


Figure 4 8855 Tall Fescue - Glaser Farm 1991, 1992 & 1993 Seed Yields

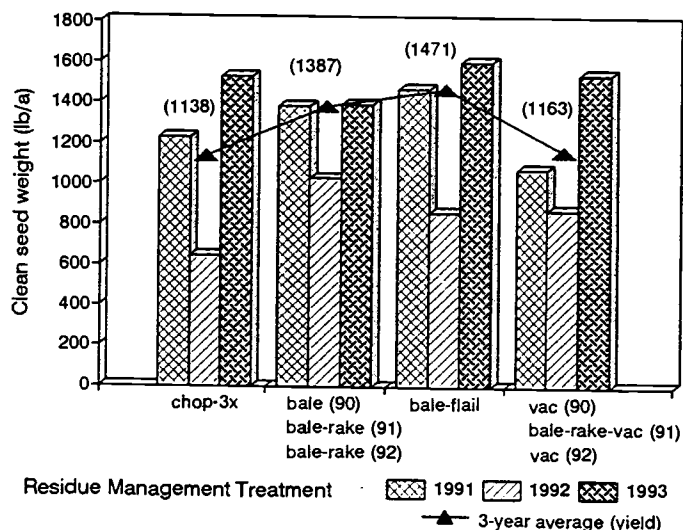


Figure 5 Cochise Tall Fescue - Pugh Farm  
1991, 1992 & 1993 Seed Yields

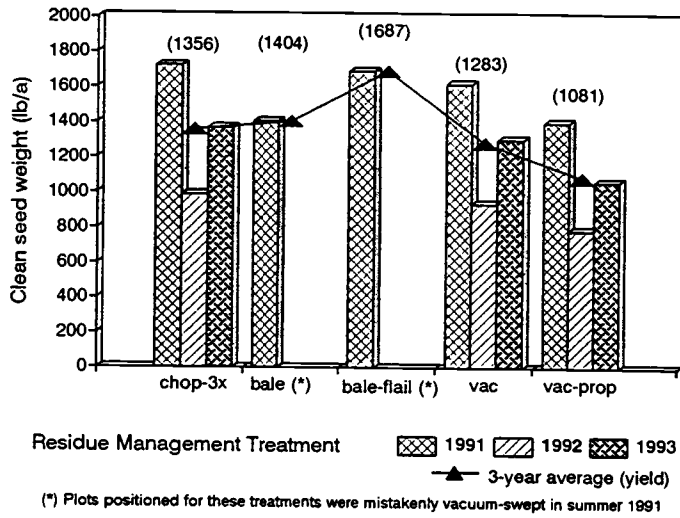


Figure 8 8990 Perennial Ryegrass - Glaser Farm  
1992 & 1993 Seed Yields

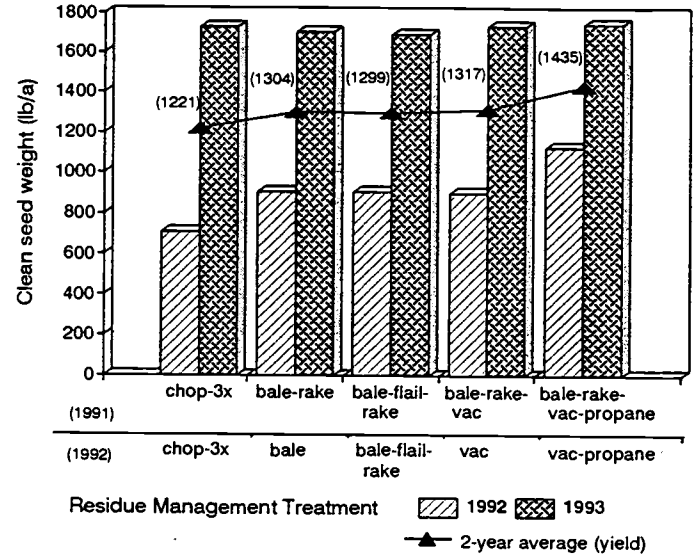


Figure 6 Silverado Tall Fescue - Rose Farm  
1991 & 1992 Seed Yields

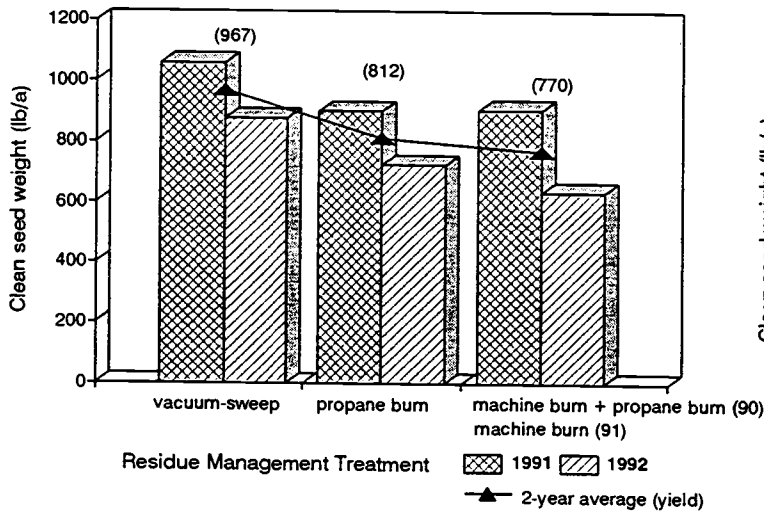


Figure 9 Statesman Perennial Ryegrass  
VanLeeuwen Farm  
1992 & 1993 Seed Yields

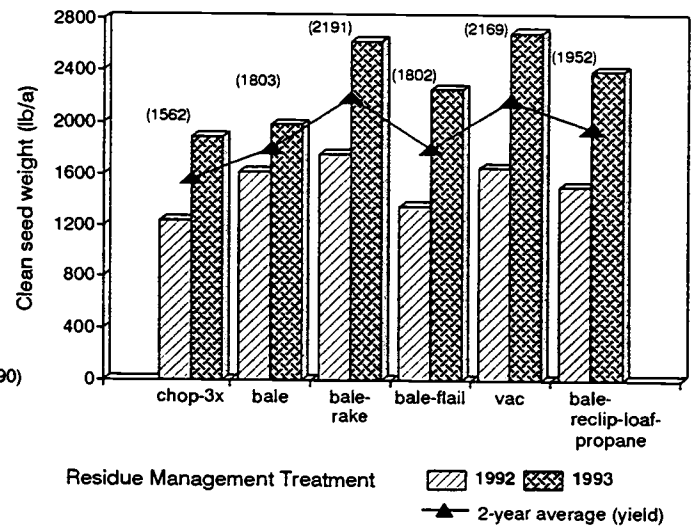


Figure 7 Mojave Tall Fescue - Venell Farm  
1990, 1991 & 1992 Seed Yields

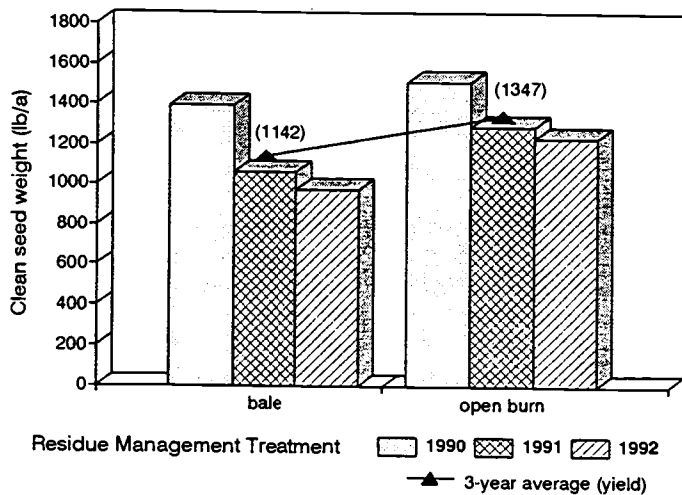


Figure 10 SR 4100 Perennial Ryegrass - Wirth Farm  
1991 & 1992 Seed Yields

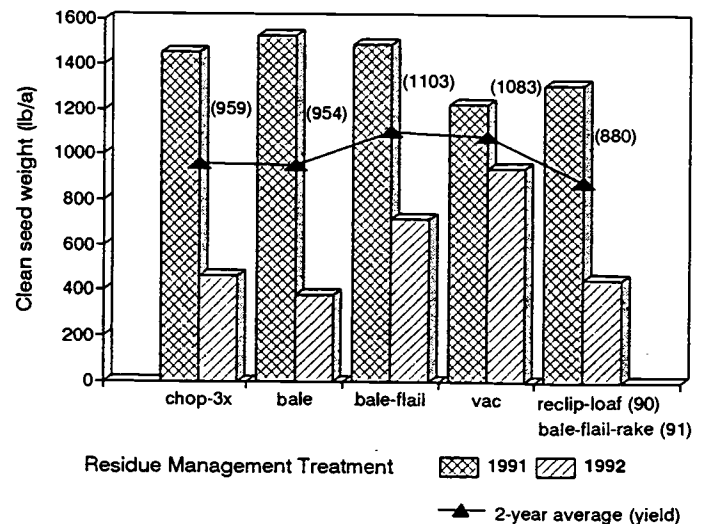
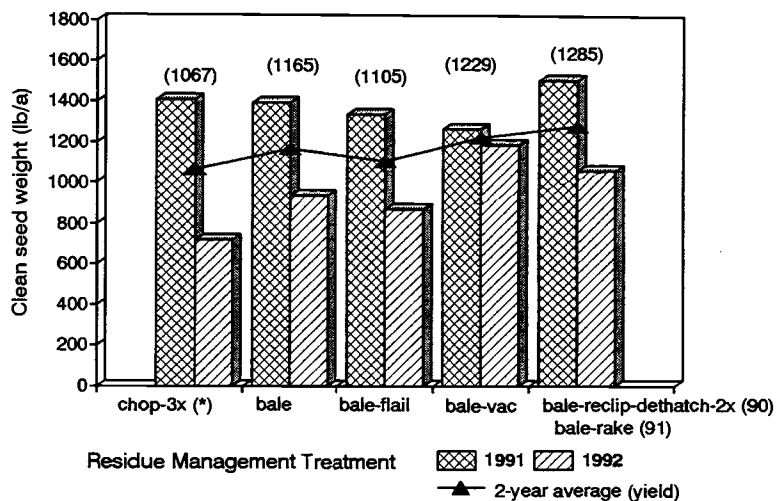


Figure 11 **Regal Perennial Ryegrass - Manning Farm**  
1991 & 1992 Seed Yields



(\*) In 1990-91 crop year this plot received 2x rate of spring N; no additional N was applied in 1991-92

Figure 12 **Regency Perennial Ryegrass - Sayer Farm**  
1991 & 1992 Seed Yields

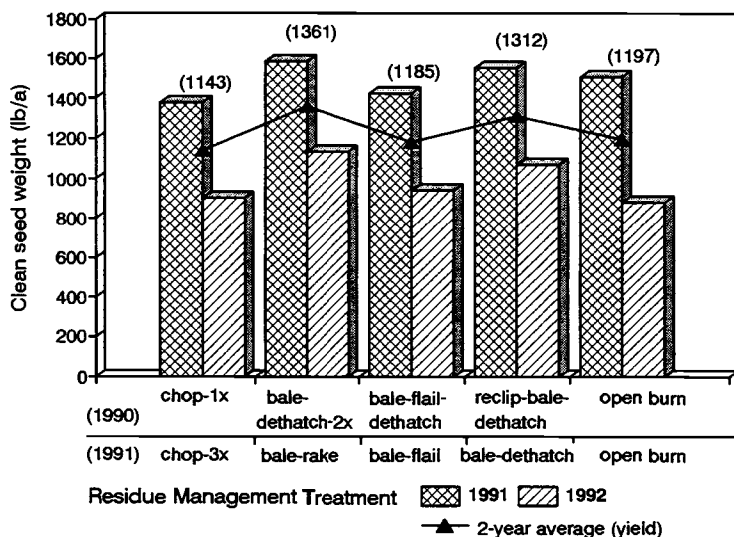
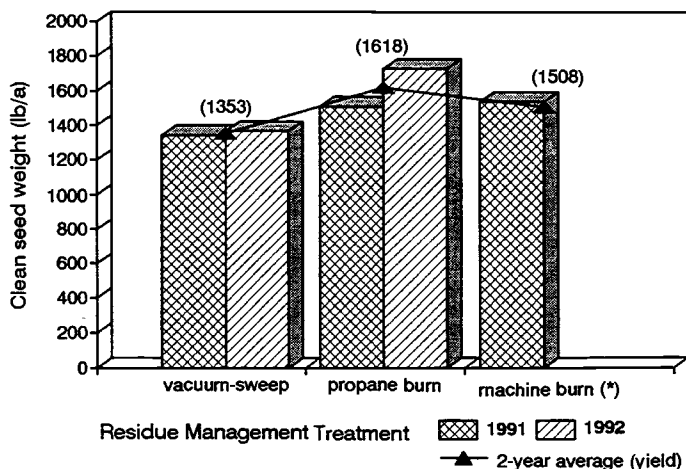


Figure 13 **Manhattan IIE Perennial Rye - Rose Farm**  
1991 & 92 Seed Yields



(\*) No machine burn treatment was made in summer 1991

for six perennial ryegrass and six tall fescue sites in Appendix Tables 4 and 5, respectively.

In order to statistically evaluate residue management options across time and locations, treatments were also grouped so that similar residue management techniques could be analyzed. Appendix Table 6 shows how 20 residue management combinations evaluated in perennial ryegrass were grouped into seven. Similarly, Appendix Table 7 shows how 13 treatments in tall fescue were also grouped into seven. Treatment averages for perennial ryegrass and tall fescue are shown graphically in Figures 14 and 15, respectively.

Figure 14 **Perennial Ryegrass - Grouped Treatments**  
1991, 1992 & 1993 Seed Yield Average

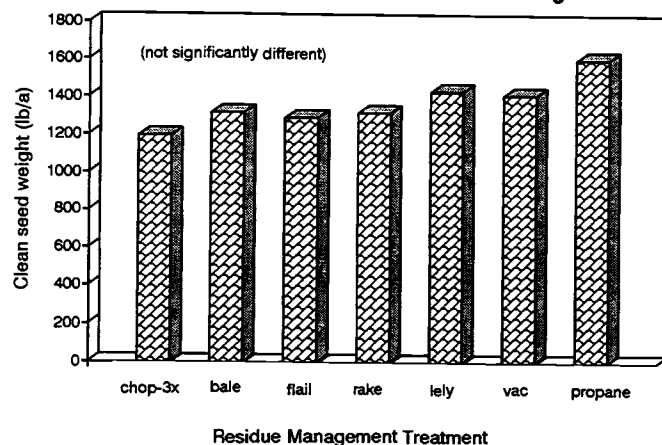
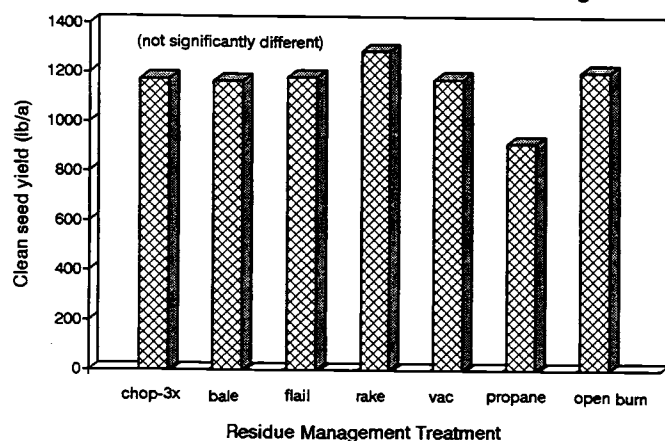


Figure 15 **Tall Fescue - Grouped Treatments**  
1990, 1991, 1992 & 1993 Seed Yield Average



Analysis of variance (ANOVA) using a completely random design (CRD) with unequal replication was performed on grouped data sets for both perennial ryegrass and tall fescue. As noted (Figures 14 and 15), no significant difference in seed yield due to post-harvest residue management was observed.

## Discussion

Results observed from the most commonly used residue removal treatments in this program are discussed below.

Chop all straw back - Although chopping all of the straw and stubble back on the field three times after harvest in 1990-91 was a superior treatment in most of the plots, particularly in tall fescue, the results with this treatment in 1991-92 were less favorable. Two of the four tall fescue sites showed lower seed yield where all of the straw and stubble was chopped back, and at the other two sites no difference among treatments could be noted. Chopping all straw back resulted in yields that were lower than other treatments at the ryegrass sites, even for the new sites established in 1991. Similarly, the trend observed in 1992-93 showed plots with full straw yielding less seed, although this varied across sites. It appears that in ryegrass, with its lower crown, the straw tends to shade the stands to a greater extent than is the case with tall fescue and the stand took longer to grow through the straw load. Straw left on the soil surface in tall fescue stands was nearly completely decomposed at harvest. In general, decomposition of residue appeared to take longer in the perennial ryegrass sites as compared to the tall fescue sites. Weed-seedling control in the chop all back treatment was less effective at most of the sites.

Bale-only - In perennial ryegrass, baling the straw and leaving the stubble resulted in generally lower yields than doing some form of residue treatment to the remaining stubble. However, tall fescue yields were not similarly affected by a lack of further residue management. More aerial tillers were noted in perennial ryegrass where the longer stubble contributed more sites for aerial tiller development. No deleterious effect on seed yield was observed due to aerial tillers. Weed-seedling control was better than chop all back, but was still a problem for this treatment.

Bale and Flail - Our results have shown this treatment to be slightly better than chopping all of the straw back in both tall fescue and perennial ryegrass. However, generally speaking, no advantage over bale-only has been observed. Weed-seedling control was somewhat better than for chop all straw back.

Dethatching - This technique received limited testing during 1990-91 and 1991-92, but only on perennial ryegrass. The results found that Lely dethatching after reclipping and baling compared favorably with other more intensive stubble management treatments.

Needle-nose rake - This machine, designed to remove all the straw from the field or to remove residue remaining after baling the straw and chopping the stubble, was tested in 1991-92 and 1992-93. It compared well with other treatments in both tall fescue and perennial ryegrass, ranking quite close to vacuum-sweep. Crop regrowth and weed-seedling control was good with this treatment, particularly in tall fescue.

Vacuum-sweep - The more complete removal of crop residue and shattered seed with this treatment resulted in superior weed-seedling control and in most cases equal or increased seed yield when compared to other residue removal treatments. Seed yield from the vacuum-sweep plots was more consistent across sites in 1991-92 and 1992-93, probably due to treatments being more timely, thus, avoiding late defoliation that may have affected results in 1990-91.

Propane flaming - Flaming fields with propane burners after residue removal has had varied results in comparisons with nonthermal methods. However, seed yield data summarized over three years identifies a trend showing an advantage to propane flaming perennial ryegrass stubble. In tall fescue, propane flaming appears to have caused some reduction in seed yield.

## Appendix Table 1

Residue management field sites and treatments studied, 1990-91. Noted in parentheses is the treatment date for each residue management option used in the summer of 1990.

### PERENNIAL RYEGRASS

#### SR4100 perennial ryegrass

Don Wirth

Flail chop (3 times) straw and stubble back on field (August 20)  
Bale-only (August 15)  
Bale and flail chop stubble (August 20)  
Bale and vacuum-sweep (September 20)  
Reclip and loaf (Hesston Stakhand) residue (September 25)

#### F7 perennial ryegrass

Dennis Glaser

Flail chop (3 times) straw and stubble back on field (September 7)  
Bale-only (August 2)  
Bale and flail chop stubble (August 4)  
Bale and vacuum-sweep (September 2)  
Bale, vacuum-sweep and propane burn (September 7)

#### SR4200 perennial ryegrass

Clarence Venell

Flail chop (3 times) straw and stubble back on field (August 10)  
Bale-only (August 3)  
Bale and flail chop stubble (August 10)  
Bale and vacuum-sweep (August 22)

#### Regency perennial ryegrass

Ken and Jack Sayer

Flail chop (1 time) straw and stubble back on field (October 1)  
Bale (August 15) and Lely dethatch 2 times (September 14)  
Bale (August 15), flail chop stubble and Lely dethatch (September 14)  
Bale, reclip & bale (August 15), and Lely dethatch (September 14)  
Open-field burn (September 14)

#### Regal perennial ryegrass

Wendell Manning

Flail chop (4 times) straw and stubble back on field (July 20)  
Bale-only (July 20)  
Bale and flail chop stubble (July 20)  
Bale and vacuum-sweep (September 19)  
Bale, reclip and Lely dethatch 2 times (September 24)

#### Manhattan II perennial ryegrass

Bill Rose

Bale and vacuum-sweep (September 10)  
Bale and propane burn (September 15)  
Bale and machine (improved mobile sanitizer) burn (September 15)

Appendix Table 1. (continued)

**TALL FESCUE**

Arid tall fescue

Don Wirth

Flail chop (3 times) straw and stubble back on field (July 25)  
Bale only (July 30)  
Bale and Lely dethatch (August 23)  
Bale and vacuum-sweep (September 18)  
Bale, Lely dethatch and (later) flail chop regrowth (September 25)

Carefree tall fescue

Aart Falk

Flail chop (3 times) straw and stubble back on field (August 15)  
Bale-only (August 20)  
Bale and flail stubble (August 25)  
Bale and vacuum-sweep (September 19)  
Open-field burn—late (October 2)

8855 tall fescue

Dennis Glaser

Flail chop (3 times) straw and stubble back on field (September 14)  
Bale-only (September 14)  
Bale and flail stubble (August 10)  
Bale and vacuum-sweep (August 4)

Cochise tall fescue

George Pugh

Flail chop (3 times) straw and stubble back on field (July 20)  
Bale-only (July 20)  
Bale and flail stubble (July 20)  
Bale and vacuum-sweep (August 2)  
Bale, vacuum-sweep and propane burn (August 28)

Mojave tall fescue

Clarence Venell

Bale-only (July 24)  
Open-field burn (August 16)

Silverado tall fescue

Bill Rose

Bale and vacuum-sweep (September 10)  
Bale and propane burn (September 15)  
Bale, propane burn and machine burn (September 15 and 20)

**BLUEGRASS**

Challenger bluegrass

Bill Rose

Bale and vacuum-sweep (September 10)  
Bale and machine (improved mobile sanitizer) burn (September 15)



## Appendix Table 2

Residue management field sites and treatments studied, 1991-92. Noted in parentheses is the treatment date for each residue management option used in the summer of 1991.

### PERENNIAL RYEGRASS

#### SR4100 perennial ryegrass

Don Wirth

Flail chop (3 times) straw and stubble back on field (August 15)  
Bale-only (August 15)  
Bale and flail chop stubble (August 15)  
Bale and vacuum-sweep (August 19)  
Bale, flail chop stubble and needle-nose rake (August 19)

#### F7 perennial ryegrass (site abandoned due to chemical damage)

Dennis Glaser

#### SR4200 perennial ryegrass (field plowed out by grower)

Clarence Venell

#### Statesman Perennial ryegrass (new location in 1991)

Jim VanLeeuwen

Flail chop (3 times) straw and stubble back on field (August 20)  
Bale-only (August 20)  
Bale and flail chop stubble (August 27)  
Bale and vacuum-sweep (September 3)  
Bale and needle-nose rake (September 19)  
Bale, reclip and loaf, and propane burn (September 9)

#### 8990 Perennial ryegrass (new location in 1991)

Dennis Glaser

Flail chop (3 times) straw and stubble back on field (August 30)  
Bale straw and needle-nose rake (September 2)  
Bale, flail chop stubble and needle-nose rake (September 2)  
Bale, needle-nose rake, and vacuum-sweep (September 6)  
Bale, needle-nose rake, vacuum-sweep and propane burn (September 12)

#### Manhattan IIE Perennial ryegrass (new location in 1991)

Neal Reiling

Bale, Kuhnflex rake and rebale (September 11)  
Bale, Kuhnflex rake, rebale, propane burn (September 11)  
Bale and vacuum-sweep (September 11)  
Bale, vacuum-sweep and propane burn (September 11)

#### Regency perennial ryegrass

Ken and Jack Sayer

Flail chop (3 times) straw and stubble back on field (August 12)  
Bale and needle-nose rake (September 19)  
Bale and flail chop stubble (August 12)  
Bale and Lely dethatch (August 14)  
Open-field burn (August 12)

Appendix Table 2. (continued)

Regal perennial ryegrass

Wendell Manning

- Flail chop (3 times) straw and stubble back on field (September 3)
- Bale-only (August 5)
- Bale and flail chop stubble (September 3)
- Bale and needle-nose rake (September 5)
- Bale and vacuum-sweep (August 20)

Manhattan II perennial ryegrass

Bill Rose

- Bale and vacuum-sweep (August 22)
- Bale and propane burn (September 20)

**TALL FESCUE**

Arid tall fescue

Don Wirth

- Flail chop (3 times) straw and stubble back on field (August 28)
- Bale-only (July 27)
- Bale and flail chop stubble (August 28)
- Bale and vacuum-sweep (August 19)
- Bale, flail chop stubble and needle-nose rake (September 20)

Carefree tall fescue

Aart Falk

- Flail chop (3 times) straw and stubble back on field (August 9)
- Bale-only (July 26)
- Bale and flail chop stubble (August 9)
- Bale and vacuum-sweep (August 19)
- Open-field burn (August 12)

8855 tall fescue

Dennis Glaser

- Flail chop (3 times) straw and stubble back on field (September 2)
- Bale and needle-nose rake (August 6)
- Bale and flail chop stubble (September 2)
- Bale, needle-nose rake and vacuum-sweep (August 16)

Cochise tall fescue

George Pugh

- Flail chop (3 times) straw and stubble back on field (August 13)
- Bale-only (treatment lost in 1991-92)
- Bale and flail chop stubble (treatment lost in 1991-92)
- Bale and vacuum-sweep (August 13)
- Bale, vacuum-sweep and propane burn (September 16)

Appendix Table 2. (continued)

Mojave tall fescue

Clarence Venell

Bale only (July 28)

Open-field burn (August 28)

Silverado tall fescue

Bill Rose

Bale and vacuum-sweep (August 22)

Bale and propane burn (September 20)

Bale and machine (improved mobile sanitizer) burn (September 20)

**BLUEGRASS**

Challenger bluegrass (Treatments not applied in 1991)

Bill Rose

### Appendix Table 3

Residue management field sites and treatments studied, 1992-93. Noted in parentheses is the treatment date for each residue management option used in the summer of 1992.

#### PERENNIAL RYEGRASS

##### Statesman Perennial ryegrass

Jim VanLeeuwen

Flail chop (3 times) straw and stubble back on field (August 12)  
Bale-only (August 4)  
Bale and flail chop stubble (August 12)  
Bale and vacuum-sweep (August 13)  
Bale and needle-nose rake (August 12)  
Bale, reclip and loaf, and propane burn (August 17)

##### 8990 Perennial ryegrass

Dennis Glaser

Flail chop (3 times) straw and stubble back on field (July 30)  
Bale-only (July 27)  
Bale, flail chop stubble and needle-nose rake (July 30)  
Bale and vacuum-sweep (July 30)  
Bale, vacuum-sweep and propane burn (September 1)

#### TALL FESCUE

##### Arid tall fescue

Don Wirth

Flail chop (3 times) straw and stubble back on field (July 17)  
Bale-only (July 12)  
Bale and flail chop stubble (July 29)  
Bale and vacuum-sweep (July 29)  
Bale, flail chop stubble and needle-nose rake (July 29)

##### Carefree tall fescue

Aart Falk

Flail chop (3 times) straw and stubble back on field (July 27)  
Bale-only (July 27)  
Bale and flail chop stubble (July 27)  
Bale and vacuum-sweep (July 27)  
Open-field burn (July 24)

##### 8855 tall fescue

Dennis Glaser

Flail chop (3 times) straw and stubble back on field (September 11)  
Bale (July 17) and needle-nose rake (September 11)  
Bale (July 17) and flail chop stubble (September 11)  
Bale (July 17) and vacuum-sweep (September 11)

##### Cochise tall fescue

George Pugh

Flail chop (3 times) straw and stubble back on field (August 6)  
Bale and vacuum-sweep (August 13)  
Bale, vacuum-sweep and propane burn (September 1)

Appendix Table 4

Perennial Ryegrass Cleaned Seed Yield (lb/a), 1991, 1992, and 1993.

| TREATMENT  | F-7      | SR 4200  | SR 4100 |      | 8990     |      | Regal     |      | Regency |      | Manhattan IIE |           |              | Statesman |      | Treatment average | (n) |
|--|----------|----------|---------|------|----------|------|-----------|------|---------|------|---------------|-----------|--------------|-----------|------|-------------------|-----|
|  | (Glaser) | (Venell) | (Wirth) |      | (Glaser) |      | (Manning) |      | (Sayer) |      | (Rose)        | (Reiling) | (VanLeeuwen) |           |      |                   |     |
|  | 1991     | 1991     | 1991    | 1992 | 1992     | 1993 | 1991      | 1992 | 1991    | 1992 | 1991          | 1992      | 1992         | 1992      | 1993 |                   |     |
| (#)  |          |          |         |      |          |      |           |      |         |      |               |           |              |           |      |                   |     |
| (1) Bale only  | 761      | 1545     | 1526    | 382  |          | 1703 | 1393      | 937  |         |      |               |           |              | 1623      | 1983 | 1317              | 9   |
| (2) Bale + Vacuum-sweep                                      | 716      | 1660     | 1227    | 939  |          | 1734 | 1270      | 1187 |         |      | 1340          | 1366      | 1659         | 1650      | 2687 | 1453              | 12  |
| (3) Bale + Flail chop +<br>Needle-nose rake                  |          |          |         | 447  | 903      | 1694 |           |      |         |      |               |           |              |           |      | 1015              | 3   |
| (4) Bale + Flail chop  | 1094     | 1569     | 1485    | 720  |          |      | 1336      | 873  |         | 942  |               |           |              | 1350      | 2253 | 1291              | 9   |
| (5) Flail chop full straw                                    | 934      | 1520     | 1455    | 463  | 711      | 1731 | 1411      | 722  | 1383    | 903  |               |           |              | 1234      | 1890 | 1196              | 12  |
| (6) Bale + Needle-nose rake                                  |          |          |         |      | 905      |      |           | 1063 |         | 1134 |               |           |              | 1759      | 2623 | 1497              | 5   |
| (7) Bale + Needle-nose rake +<br>Vacuum-sweep                |          |          |         |      | 899      |      |           |      |         |      |               |           |              |           |      | 899               | 1   |
| (8) Bale + Needle-nose rake +<br>Vacuum-sweep + Propane burn |          |          |         |      | 1126     |      |           |      |         |      |               |           |              |           |      | 1126              | 1   |
| (9) Bale + Lely dethatcher                                   |          |          |         |      |          |      |           |      | 1588    | 1068 |               |           |              |           |      | 1328              | 2   |
| (10) Bale + Flail chop +<br>Lely dethatcher                  |          |          |         |      |          |      |           |      | 1427    |      |               |           |              |           |      | 1427              | 1   |
| (11) Bale + Reclip + Lely dethatcher                         |          |          |         |      |          |      | 1506      |      |         |      |               |           |              |           |      | 1506              | 1   |
| (12) Reclip & bale + Lely dethatcher                         |          |          |         |      |          |      |           |      | 1555    |      |               |           |              |           |      | 1555              | 1   |
| (13) Open burn   |          |          |         |      |          |      |           |      | 1512    | 881  |               |           |              |           |      | 1197              | 2   |
| (14) Bale + Propane burn                                     |          |          |         |      |          |      |           |      |         |      | 1508          | 1727      |              |           |      | 1618              | 2   |
| (15) Machine burn  |          |          |         |      |          |      |           |      |         |      | 1538          |           |              |           |      | 1538              | 1   |
| (16) Bale + Reclip & loaf                                    |          |          | 1312    |      |          |      |           |      |         |      |               |           |              |           |      | 1312              | 1   |
| (17) Bale + Reclip & loaf +<br>Propane burn                  |          |          |         |      |          |      |           |      |         |      |               |           |              | 1506      | 2397 | 1952              | 2   |
| (18) Bale + Vacuum-sweep +<br>Propane burn                   | 875      |          |         |      |          | 1744 |           |      |         |      |               | 1691      |              |           |      | 1437              | 3   |
| (19) Bale + Kuhn-flex & rebale                               |          |          |         |      |          |      |           |      |         |      |               | 1853      |              |           |      | 1853              | 1   |
| (20) Bale + Kuhn-flex & rebale +<br>Propane burn             |          |          |         |      |          |      |           |      |         |      |               | 1866      |              |           |      | 1866              | 1   |

Appendix Table 5

Tall Fescue Cleaned Seed Yield (lb/a), 1990, 1991, 1992, and 1993.

| TREATMENT  | Carefree<br>(Falk) |      |      | 8855<br>(Glaser) |      |      | Cochise<br>(Pugh) |      |      | Arid<br>(Wirth) |      |      | Silverado<br>(Rose) |      | Mojave<br>(Venell) |      |      | Treatment<br>average |     |
|--|--------------------|------|------|------------------|------|------|-------------------|------|------|-----------------|------|------|---------------------|------|--------------------|------|------|----------------------|-----|
|  | 1991               | 1992 | 1993 | 1991             | 1992 | 1993 | 1991              | 1992 | 1993 | 1991            | 1992 | 1993 | 1991                | 1992 | 1990               | 1991 | 1992 |                      |     |
| (#)  |                    |      |      |                  |      |      |                   |      |      |                 |      |      |                     |      |                    |      |      |                      | (n) |
| (1) Bale only                                      | 767                | 742  | 983  | 1387             |      |      | 1404              |      |      | 1466            | 1173 | 1451 |                     |      | 1393               | 1060 | 972  | 1163                 | 11  |
| (2) Bale + Flail chop                              | 852                | 611  | 913  | 1471             | 860  | 1605 | 1687              |      |      |                 | 1224 | 1385 |                     |      |                    |      |      | 1179                 | 9   |
| (3) Flail chop full straw                          | 982                | 636  | 741  | 1231             | 650  | 1532 | 1717              | 985  | 1365 | 1665            | 1061 | 1501 |                     |      |                    |      |      | 1172                 | 12  |
| (4) Bale + Vacuum-sweep                            | 967                | 670  | 942  | 1073             |      | 1544 | 1617              | 934  | 1299 | 1553            | 1390 | 1617 | 1058                | 876  |                    |      |      | 1195                 | 13  |
| (5) Bale + Needle-nose rake +<br>Vacuum-sweep      |                    |      |      |                  | 871  |      |                   |      |      |                 |      |      |                     |      |                    |      |      | 871                  | 1   |
| (6) Open burn                                      | 658                | 1100 | 1417 |                  |      |      |                   |      |      |                 |      |      |                     |      | 1511               | 1294 | 1235 | 1203                 | 6   |
| (7) Bale + Needle-nose rake                        |                    |      |      |                  | 1028 | 1395 |                   |      |      |                 |      |      |                     |      |                    |      |      | 1212                 | 2   |
| (8) Bale + Vacuum-sweep +<br>Propane burn          |                    |      |      |                  |      |      | 1399              | 785  | 1059 |                 |      |      |                     |      |                    |      |      | 1081                 | 3   |
| (9) Bale + Flail chop +<br>Needle-nose rake        |                    |      |      |                  |      |      |                   |      |      |                 | 1233 | 1491 |                     |      |                    |      |      | 1362                 | 2   |
| (10) Bale + Machine burn                           |                    |      |      |                  |      |      |                   |      |      |                 |      |      | 904                 | 636  |                    |      |      | 770                  | 2   |
| (11) Bale + Propane burn                           |                    |      |      |                  |      |      |                   |      |      |                 |      |      | 899                 | 724  |                    |      |      | 812                  | 2   |
| (12) Bale + Lely dethatcher                        |                    |      |      |                  |      |      |                   |      |      | 1629            |      |      |                     |      |                    |      |      | 1629                 | 1   |
| (13) Bale + Lely dethatcher +<br>(late) Flail chop |                    |      |      |                  |      |      |                   |      |      | 1442            |      |      |                     |      |                    |      |      | 1442                 | 1   |



Appendix Table 6

Perennial Ryegrass Cleaned Seed Yield (lb/a) for Grouped Treatments, 1991, 1992, and 1993.

| TREATMENT                   | F-7<br>(Glaser)<br>1991 | SR 4200<br>(Venell)<br>1991 | SR 4100<br>(Wirth)<br>1991 1992 | 8990<br>(Glaser)<br>1992 1993 | Regal<br>(Manning)<br>1991 1992 | Regency<br>(Sayer)<br>1991 1992 | Manhattan IIE<br>(Rose)<br>1991 1992 1992 | Statesman<br>(VanLeeuwen)<br>1992 1993 | Treatment<br>average | (n) |
|-----------------------------|-------------------------|-----------------------------|---------------------------------|-------------------------------|---------------------------------|---------------------------------|---|--|----------------------|-----|
| (1) Bale only               | 761                     | 1545                        | 1526 382                        | 1703                          | 1393 937                        |                                 |   | 1623 1983                              | 1317                 | 9   |
| (2) Bale + Vacuum-sweep     | 716                     | 1660                        | 1227 939                        | 899 1734                      | 1270 1187                       |                                 | 1340 1366 1659                            | 1650 2687                              | 1410                 | 13  |
| (3) Bale + Flail chop       | 1094                    | 1569                        | 1485 720                        |                               | 1336 873                        | 942                             |   | 1350 2253                              | 1291                 | 9   |
| (4) Flail chop full straw   | 934                     | 1520                        | 1455 463                        | 711 1731                      | 1411 722                        | 1383 903                        |   | 1234 1890                              | 1196                 | 12  |
| (5) Bale + Needle-nose rake |                         |                             | 447                             | 905 903 1694                  | 1063                            | 1134                            |   | 1759 2623                              | 1316                 | 8   |
| (6) Bale + Lely dethatcher  |                         |                             |                                 |                               | 1506                            | 1427 1588 1555 1068             |   |  | 1429                 | 5   |
| (7) Bale + Propane burn     | 875                     |                             |                                 | 1126 1744                     |                                 |                                 | 1508 1727 1866 1691                       | 1506 2397                              | 1604                 | 9   |

|   |   |                             |
|---|---|-----------------------------|
| (2) Bale + Vacuum-sweep                                   | > | (2) Bale + Vacuum-sweep     |
| (7) Bale + Needle-nose rake + Vacuum-sweep                | > |                             |
| (3) Bale + Flail chop + Needle-nose rake                  | > | (5) Bale + Needle-nose rake |
| (6) Bale + Needle-nose rake                               | > |                             |
| (9) Bale + Lely dethatcher                                | > |                             |
| (10) Bale + Flail chop + Lely dethatcher                  | > | (6) Bale + Lely dethatcher  |
| (11) Bale + Reclip + Lely dethatcher                      | > |                             |
| (12) Reclip & bale + Lely dethatcher                      | > |                             |
| (8) Bale + Needle-nose rake + Vacuum-sweep + Propane burn | > |                             |
| (14) Bale + Propane burn                                  | > |                             |
| (17) Bale + Reclip & loaf + Propane burn                  | > | (7) Bale + Propane burn     |
| (18) Bale + Vacuum-sweep + Propane burn                   | > |                             |
| (20) Bale + Kuhn-flex & rebale + Propane burn             | > |                             |
| (13) Open burn  | > |                             |
| (15) Machine burn   | > |                             |
| (16) Bale + Reclip & loaf                                 | > | Deleted from this summary   |
| (19) Bale + Kuhn-flex & rebale                            | > |                             |

Appendix Table 7

Tall Fescue Cleaned Seed Yield (lb/a) for Grouped Treatments, 1990, 1991, 1992, and 1993.

| TREATMENT                   | Carefree<br>(Falk) |      |      | 8855<br>(Glaser) |      |      | Cochise<br>(Pugh) |      |      | Arid<br>(Wirth) |      |      | Silverado<br>(Rose) |      | Mojave<br>(Venell) |      |      | Treatment<br>average |
|-----------------------------|--------------------|------|------|------------------|------|------|-------------------|------|------|-----------------|------|------|---------------------|------|--------------------|------|------|----------------------|
|                             | 1991               | 1992 | 1993 | 1991             | 1992 | 1993 | 1991              | 1992 | 1993 | 1991            | 1992 | 1993 | 1991                | 1992 | 1990               | 1991 | 1992 |                      |
| (#)                         |                    |      |      |                  |      |      |                   |      |      |                 |      |      |                     |      |                    |      |      | (n)                  |
| (1) Bale only               | 767                | 742  | 983  | 1387             |      |      | 1404              |      |      | 1466            | 1173 | 1451 |                     |      | 1393               | 1060 | 972  | 1163 11              |
| (2) Bale + Flail chop       | 852                | 611  | 913  | 1471             | 860  | 1605 | 1687              |      |      |                 | 1224 | 1385 |                     |      |                    |      |      | 1179 9               |
| (3) Flail chop full straw   | 982                | 636  | 741  | 1231             | 650  | 1532 | 1717              | 985  | 1365 | 1665            | 1061 | 1501 |                     |      |                    |      |      | 1172 12              |
| (4) Bale + Vacuum-sweep     | 967                | 670  | 942  | 1073             | 871  | 1544 | 1617              | 934  | 1299 | 1553            | 1390 | 1617 | 1058                | 876  |                    |      |      | 1172 14              |
| (5) Open burn               | 658                | 1100 | 1417 |                  |      |      |                   |      |      |                 |      |      |                     |      | 1511               | 1294 | 1235 | 1203 6               |
| (6) Bale + Needle-nose rake |                    |      |      |                  | 1028 | 1395 |                   |      |      |                 | 1233 | 1491 |                     |      |                    |      |      | 1287 4               |
| (7) Bale + Propane burn     |                    |      |      |                  |      |      | 1399              | 785  | 1059 |                 |      |      | 899                 | 904  | 724                | 636  |      | 915 7                |

- (4) Bale + Vacuum-sweep >  
>  
(5) Bale + Needle-nose rake + Vacuum-sweep > (4) Bale + Vacuum-sweep
- (7) Bale + Needle-nose rake >  
>  
(9) Bale + Flail chop + Needle-nose rake > (6) Bale + Needle-nose rake
- (8) Bale + Vacuum-sweep + Propane burn >  
>  
(10) Bale + Machine burn > (7) Bale + Propane burn  
>  
(11) Bale + Propane burn >
- (12) Bale + Lely dethatcher >  
>  
(13) Bale + Lely dethatcher + (late) Flail chop > Deleted from this summary

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