Progress Report II

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

W.C. Young III, T.B. Silberstein and D.O. Chilcote

Department of Crop and Soil Science
Oregon State University

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The Authors

W.C. Young III is Assistant Professor and Extension Seed Production Specialist; T.B. Silberstein is a former Research Assistant; D.O. Chilcote is Professor Emeritus of Crop Physiology, all in the Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331.

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Introduction

Burning of post-harvest crop residue has been an established cultural practice in the Willamette Valley of Oregon since the late 1940's for control of disease and disposal of residue. Between 1980 and 1985, 75 to 80% of the total grass seed production was open-field burned. However, between 1985 and 1990 the percentage of grass seed crops open-field burned dropped to 40%. This change 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.

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. Many seed producers are already adopting alternative methods for removal of post-harvest straw and stubble residue. In 1992, only 83,000 acres of the Willamette Valley's 370,000 acres were open-field burned.

Reduced dependence on open-field burning has created uncertainty within the seed industry in regard to the long-term maintenance of seed yield and seed quality, and provided new incentive for research using alternative methods for crop residue disposal. New equipment innovations and increased grower acceptance of non-thermal production systems have allowed for on-farm testing of techniques previously studied in small research plots.

This program was initiated to evaluate various straw and stubble management techniques used commercially by grass seed growers as alternatives to burning crop residue after harvest. On-farm 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.

In 1990-91, nonthermal treatments were evaluated at 13 different locations, mostly in the south valley, and focused on tall fescue and perennial ryegrass. Most locations began as new stands where first-year seed crop harvest was taken the summer that plots were established. More detailed information on vegetative and reproductive tiller development, and seed quality parameters was collected at several locations designated as long-term sites. Our objective is to follow these sites over a several year period to evaluate the effects of nonthermal residue treatments as grass seed stands age. The results summarized in this report provide a two year database for several nonthermal treatments. (See Appendix Tables 1 and 2 for list of fields and residue management treatments followed in during the 1990-91 and 1991-92 crop years.)

1990-91 Results

In 1990-91, seven on-farm test sites (three perennial ryegrass and four tall fescue) where four nonthermal post-harvest residue treatments were common to all locations were identified. These treatments were:

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

Tiller samples from each treatment were collected in the fall, spring, and just prior to harvest to determine the number per area. Tiller samples taken at harvest were separated into vegetative or fertile classes. Observations of weed control were made periodically during the fall, winter and spring.

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 and blind seed disease was made by the USDA-ARS National Forage Seed Production Research Center.

Data collected during the 1990-91 crop year from these seven sites were summarized by using a randomized complete block (RCB) analysis of variance (ANOVA). Locations were used as blocks (three for perennial ryegrass and four for tall fescue).

Differences in seed yield were not apparent across these residue removal treatments when applied to new stands (Tables 1 and 2). Even chopping all straw back on the soil surface resulted in good seed yields and straw decomposed on the surface prior to subsequent harvest. Bale and flail was also an effective treatment. Both of these techniques chop the stubble close to the soil surface which may be important to subsequent tiller development and seed yield. Bale-only provided no additional stubble management, which resulted in a greater number of aerial tillers, but this had no deleterious effect on seed yield.

Vacuum-sweep removal of crop residue and shattered seed is much more complete in comparison with the other mechanical methods. As a result, superior weed and seedling control was observed through harvest. Although no significant reduction in seed yield was observed, at two locations (one perennial ryegrass and one tall fescue site) the vacuum-sweep was both later than usual and close enough to the ground to cause scalping in the plant crown. This late-season residue removal with the vacuum-sweep equipment delayed fall regrowth. No significant change in tiller number occurred, however, delayed tiller regrowth in the fall appeared to have a greater impact on fertile tiller number at harvest in tall fescue than with perennial ryegrass. In addition, seed yield appeared to have been reduced in both species when compared with other treatments that were applied earlier in the season.

Weed and volunteer seedling control was poorest where residue was chopped back on the soil surface. Herbicide effectiveness was reduced in these situations; however, no differences in seed purity were observed in harvested samples. In addition, no presence of ergot or blind seed disease was found.

Table 1. Effect of post-harvest residue management on tiller population at maturity, clean seed yield, total dry weight, and harvest index of perennial ryegrass, 1991.

Residue management treatment	Tiller population at maturity: total fertile	percent fertile	percent vegetative	Clean-seed yield	Total dry weight	Harvest index
	(no./ft^2)	---------(%)--------		(lb/a)	(ton/a)	(%)
Chop all straw	243	63	37	1332	5.9	12
Bale-only	247	57	43	1305	5.4	13
Bale and flail	247	66	34	1415	5.5	14
Vacuum-sweep	231	60	40	1231	4.8	13
LSD 0.05	NS	NS	NS	NS	NS[1]	NS

[1]Probability-value 0.09; significant at $P < 0.10$

Table 2. Effect of post-harvest residue management on tiller population at maturity, clean seed yield, total dry weight, and harvest index of tall fescue, 1991.

Residue management treatment	Tiller population at maturity: total fertile	percent fertile	percent vegetative	Clean-seed yield	Total dry weight	Harvest index
	(no./ft^2)	---------(%)--------		(lb/a)	(ton/a)	(%)
Chop all straw	69	34	66	1424	6.0	13
Bale-only	63	32	68	1301	5.5	13
Bale and flail	62	30	70	1364	5.6	13
Vacuum-sweep	59	31	69	1263	5.2	12
LSD 0.05	NS	NS	NS	NS	NS	NS

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 site 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.

Nevertheless, an averaging and grouping technique was used to present several additional comparisons. In this situation, the average seed yield of all residue management treatments at each site was calculated and then used to express treatment seed yield as a percent of each site's average. Therefore, seed yield at all sites were expressed relative to 100%. These percentage values were subjected to ANOVA as though they were from a completely random design (CRD) with unequal replication. Using the above technique, however, no significant treatment differences were observed.

1991-92 Results

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 (Appendix Tables 1 and 2). In addition to treatments discussed above, 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. All totaled, 15 different treatment combinations for perennial ryegrass (Table 3), and 11 for tall fescue (Table 4), were included in the survey during the second year.

Table 3. Effect of post-harvest residue management on perennial ryegrass clean seed yield, 1992.

TREATMENT	SR 4100 (Wirth)	8990 (Glaser)	Regal (Manning)	Regency (Sayer)	Manhattan IIE (Rose)	(Reiling)	Statesman (VanLeeuwen)	Treatment Avg.
Bale-only	382		937				1623	981
Bale + Vacuum-sweep	939		1187		1366	1659	1650	1360
Bale + Flail chop + Needle-nose rake	447	903						675
Bale + Flail chop	720		873	942			1350	971
Flail chop full straw	463	711	722	903			1234	807
Bale + Needle-nose rake		905	1063	1134			1759	1215
Bale + Needle-nose rake + Vacuum-sweep		899						899
Bale + Needle-nose rake + Vacuum-sweep + Propane burn		1126						1126
Bale + Lely dethatcher				1068				1068
Open burn				881				881
Bale + Propane burn					1727			1727
Bale + Reclip & loaf + Propane burn							1506	1506
Bale + Vacuum-sweep + Propane burn						1691		1691
Bale + Kuhn-flex & rebale						1853		1853
Bale + Kuhn-flex & rebale + Propane burn						1866		1866
Site Average	590	909	956	986	1547	1767	1520	

Table 4. Effect of post-harvest residue management on tall fescue clean seed yield, 1992.

TREATMENT	Carefree (Falk)	8855 (Glaser)	Cochise (Pugh)	Arid (Wirth)	Silverado (Rose)	Mojave (Venell)	Treatment Avg.
Bale-only	742			1173		972	962
Bale + Flail chop	611	860		1224			898
Flail chop full straw	636	650	985	1061			833
Bale + Vacuum-sweep	670		934	1390	876		968
Bale + Needle-nose rake + Vacuum-sweep		871					871
Open burn	1100					1235	1168
Bale + Needle-nose rake		1028					1028
Bale + Vacuum-sweep + Propane			785				785
Bale + Flail-chop + Needle-nose rake				1233			1233
Bale + Machine burn					636		636
Bale + Propane burn					724		724
Site Average	752	852	901	1216	745	1104	

As discussed above for 1991 results, an averaging technique was used to make treatment comparisons in 1992. Treatments were also grouped so that any residue management combination ending with the use of a vacuum-sweep treatment was analyzed as that treatment. Similarly, any combination ending with a propane burn or a needle-nose rake was so labeled. ANOVA on perennial ryegrass showed no significant difference among treatments (Table 5).

For tall fescue, open-field burning was the highest yielding treatment; all others did not significantly differ (Table 6). However, only two sites included an open-field burn treatment. One site (Venell's Mojave), where the eighth seed crop was harvested in 1992, compared continuous use of burning (8 years) with continuous bale-only management (field has never been burned). Burning has consistently yielded better than bale-only in the last three years. Seed yield decline due to stand age can be noted in both treatments.

The second field (Falk's Carefree), was burned quite late (October 2) in 1990 and was the lowest yielding treatment in 1991. The same plot was burned early in 1991 (August 12) and was the highest yielding treatment in 1992. Reasons for this rebound in seed yield for the open-field burn treatment are not clearly evident, however, a fewer number of larger panicles with more seeds per inflorescence were observed in this treatment in 1992.

Table 5. Seed yield of post-harvest residue management treatments expressed as a percent of site average in perennial ryegrass, 1992.

Treatment	No. of obs.	Treatment average
Flail chop full straw	5	81%
Bale-only	3	90%
Bale + Needle-nose rake	4	110%
Bale + Flail Chop	4	100%
Bale + Lely dethatcher	1	108%
Bale + Flail Chop + Needle-nose rake	2	88%
Bale + Kuhn-flex & rebale	1	105%
Bale + Vacuum-sweep	6	112%
Bale + Vacuum-sweep + Propane burn	2	110%
Bale + Propane burn	3	106%
Open burn	1	89%
LSD 0.10		NS

Table 6. Seed yield of post-harvest residue management treatments expressed as a percent of site average in tall fescue, 1992.

Treatment	No. of obs.	Treatment average
Flail chop full straw	4	89%
Bale-only	3	94%
Bale + Flail chop	3	94%
Bale + Needle-nose rake	2	111%
Bale + Vacuum-sweep	5	105%
Bale + Propane burn	2	92%
Bale + Machine burn	1	85%
Open burn	2	129%
LSD 0.10		22%

Finally, treatments were further grouped to avoid single-replications in the ANOVA, and to better meet the objective of evaluating alternatives to open-field burning, by combining several mechanical treatments and eliminating open-field burning. For perennial ryegrass, "Bale + Semi-aggressive" includes flail chop, Kuhn-flex rake, and Lely dethatching equipment (Table 7). In this analysis, bale-only and flail chopping the full straw were significantly lower yielding; there was no significant difference among the stubble management treatments. For tall fescue, propane burning the stubble and flail chopping the full straw were the lowest yielding treatments (Table 8). The needle-nose rake and vacuum-sweep treatments had the highest seed yield, while bale-only and bale plus flail chop were intermediate.

Table 7. Seed yield of grouped post-harvest residue management treatments expressed as a percent of site average in perennial ryegrass, 1992.

Treatment	No. of obs.	Treatment average
Flail chop full straw	5	80%
Bale-only	3	90%
Bale + Semi-aggressive[1]	6	101%
Bale + Needle-nose rake	6	102%
Bale + Vacuum-sweep	6	112%
Bale + Propane burn[2]	5	107%
LSD 0.10		17%

[1]Includes: flail chop, Kuhn-flex rake and Lely dethatcher treatments.

[2]Includes any interim treatment that ended in propane burn, i.e., needle-nose rake, vacuum-sweep, reclip and loaf and Kuhn-flex rake.

Table 8. Seed yield of grouped post-harvest residue management treatments expressed as a percent at site average in tall fescue, 1992.

Treatment	No. of obs.	Treatment average
Flail chop full straw	4	93%
Bale-only	3	104%
Bale + Flail chop	3	99%
Bale + Needle-nose rake	2	113%
Bale + Vacuum-sweep	5	107%
Bale + Propane burn	2	89%
LSD 0.10		13%

Tiller Development

Tiller number - The tillering pattern was similar in 1992 (Appendix Figures 1-7) to that observed in 1991 (see December 31, 1991 Final Report to Oregon Seed Council, later published as Ext/Crs 87, February 1992). The expected increase in vegetative tiller numbers from fall to spring, and the loss of tillers (mortality due to shading and or lodging) prior to harvest was again observed. Total tiller number did not vary greatly as a result of the residue removal treatment used.

As in 1991, perennial ryegrass had a higher tiller population per unit area. However, in 1992, there were fewer fall tillers, more spring tillers, and a greater total number of tillers at harvest. This was true for both perennial ryegrass and tall fescue. Weather conditions could well explain these results, and it should be noted that the weather conditions were quite different in 1991-1992. A dry fall (1991) followed by a warm winter and spring, led into a hot, dry summer. Warmer temperatures and greater sunlight reception would favor tillering in grass seed stands.

Fertile tiller production - As was expected, perennial ryegrass had a higher number of fertile tillers per unit area than tall fescue. The number of fertile tillers, however, was generally lower in 1992 in all of the test sites and particularly in some of the tall fescue locations. Residue removal treatments that enhanced seed yield was almost always the result of a greater number of seeds per inflorescence and not fertile tiller number. In fact, fertile tiller number was often lower in the high yielding treatments. This appears to be the basis for an enhanced seed yield from open-field burning the Carefree tall fescue in 1992. Weather conditions may have played a role in this response.

The percent of fertile tillers (ratio of fertile to vegetative tillers) was smaller in 1992 in both species due to the larger number of vegetative tiller and fewer fertile tillers at harvest. There was little difference among the residue removal treatments in terms of number of tillers at harvest or in the percent of fertile tillers.

Aerial tillers - As was observed in 1991, aerial tillers do not survive and are not present at harvest. Propane flaming greatly reduced the numbers of aerial tillers at one perennial ryegrass location, but little effect on seed yield was observed. Under the conditions of these tests it remains to be established what effect preventing aerial tillering has on seed production. With greater sunlight present during the fall and spring of 1992, aerial tillering may not have had any impact on tiller development.

Tiller size classes - The size class distribution was not greatly different among the various residue removal treatments in 1992. This was also the result found in 1991. There were, however, differences between 1991 and 1992. There were fewer 3mm and larger tillers in 1992 than in 1991. The large tillers became reproductive, but were a small segment of the reproductive tiller population at maturity. Axillary tillers, formed from the larger tillers, appeared to make a more substantial contribution to seed yield.

Seed purity and disease

Samples of threshed seed (field run) were taken from each combined swath for analysis (mill check) by the OSU Seed Laboratory. These data are reported in Tables 9 and 10. In all situations the pure seed component was greater than 95%, and in many cases greater than 98%. A variety of weed seeds were apparent in samples from some fields, however, the total percentage of weed seeds was generally quite low regardless of post-harvest residue management.

These data suggest that standard herbicide practices employed by seed growers are effectively controlling most weeds across those post-harvest residue treatments in this survey. Mill check data, however, 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/combine trails.

In addition, an assessment for the presence of blind seed disease was made by the USDA-ARS National Forage Seed Production Research Center from field run samples. No blind seed was observed from plots at any location.

Table 9. Effect of post-harvest residue management on the appearance of weed seeds and purity analysis in field run samples of perennial ryegrass fields, 1992.

Field (Grower)	Post-Harvest Residue Management				
SR-4100 perennial ryegrass (Wirth)	Flail chop full straw	Bale-only	Bale + flail chop	Bale + Vacuum sweep	Bale + flail chop + needle-nose rake
Weed seeds[1]:					
Nipplewort	4	4	4	3	4
Roundleaf fluvellin	3	4	2	1	3
Lesser snapdragon	4	4	4	3	1
Field groundsel	4	3	4	3	4
Annual bluegrass		2			
Spike bentgrass	1	1			
Wild carrot	2	1		1	
Prickly sowthistle	1	1			
Bedstraw		1			
Rippleseed plantain		1			
Barbed witchgrass					1
Common chickweed			1		
Speedwell	1				
Purity analysis (%):					
Pure seed	95.33	98.35	98.38	99.02	98.80
Other crop seed	0.00	0.00	0.00	0.02	0.01
Inert Matter	1.30	1.15	1.24	0.86	1.08
Weed Seed	3.38	0.50	0.38	0.10	0.12

(continued)

Table 9. (continued)

8990 perennial ryegrass (Glaser)	Flail chop full straw	Bale+ needle-nose rake	Bale + flail chop needle-nose rake	Bale + needle-nose rake +vacuum sweep	Bale + needle-nose rake + vacuum -sweep + propane
Weed seeds:					
Annual bluegrass	3	4	2		
Prickly sowthistle	1				
Pure analysis (%):					
Pure seed	95.84	96.28	96.37	95.89	97.16
Other crop seed	0.00	0.00	0.00	0.00	0.00
Inert Matter	4.14	3.68	3.63	4.11	2.85
Weed Seed	0.02	0.04	0.01	0.00	0.00

Statesman perennial ryegrass (VanLeeuwen)	Flail chop full straw	Bale-only	Bale + flail chop	Bale + needle-nose rake	Bale + Vacuum sweep	Bale+ reclip & loaf + propane
Weed seeds:						
Field groundsel	1			1	1	
Prickly sowthistle	1					1
Purity analysis (%):						
Pure seed	97.13	96.96	96.61	97.56	97.05	96.82
Other crop seed	0.01	0.00	0.00	0.00	0.00	0.00
Inert Matter	2.85	3.04	3.39	2.44	2.95	3.18
Weed Seed	0.01	0.00	0.00	0.01	0.01	0.01

Manhattan IIE perennial ryegrass (Reiling)	Bale + Kuhn-flex rake and rebale	Bale + Kuhn-flex rake and rebale + propane	Bale + vacuum-sweep	Bale + vacuum-sweep + propane
Weed seeds:				
(none found)				
Purity analysis (%):				
Pure seed	98.20	98.35	98.41	98.18
Other crop seed	0.00	0.00	0.00	0.01
Inert Matter	1.80	1.65	1.60	1.81
Weed Seed	0.00	0.00	0.00	0.00

[1]Four field run samples (combined swaths) were taken prior to cleaning for purity analysis (mill check) at the OSU Seed Laboratory. Data shown in the table note the presence of weed seeds in 1, 2, 3, or all 4 samples analyzed. No entry denotes no weed seed in sample.

Table 10. Effect of post-harvest residue management on the appearance of weed seeds and purity analysis in field run samples of tall fescue fields, 1992.

Field (Grower)	Post-Harvest Residue Management				
Carefree tall fescue (Falk)	Flail chop full straw	Bale-only	Bale + flail chop	Bale + Vacuum-sweep	Open-field burn
Weed seeds[1]:					
Field groundsel			1		
Speedwell					1
Purity analysis (%):					
Pure seed	98.96	99.16	99.14	99.09	99.32
Other crop seed	0.05	0.01	0.00	0.01	0.03
Inert Matter	1.00	0.84	0.86	0.91	0.65
Weed Seed	0.00	0.00	0.00	0.00	0.00

8855 tall fescue (Glaser)	Flail chop full straw	Bale + needle-nose rake	Bale + flail chop	Bale + needle-nose rake + vacuum sweep
Weed seeds:				
Annual bluegrass		3		
Spotted catsear			1	
Field groundsel	1			
Purity analysis (%):				
Pure seed	97.48	98.31	98.05	97.85
Other crop seed	0.04	0.00	0.01	0.02
Inert Matter	2.47	1.69	1.94	2.14
Weed Seed	0.02	0.00	0.00	0.00

Cochise tall fescue (Pugh)	Flail chop full straw	Bale + Vacuum-sweep	Bale + Vacuum-sweep + propane
Weed seeds:			
Field groundsel	1		3
Annual bluegrass	1	1	
Lesser snapdragon		1	3
Rattail fescue			1
Purity analysis (%):			
Pure seed	98.66	98.64	98.12
Other crop seed	0.02	0.04	0.03
Inert Matter	1.32	1.31	1.83
Weed Seed	0.01	0.01	0.03

(continued)

Table 10. (continued)

Arid tall fescue (Wirth)	Flail chop full straw	Bale - only	Bale + flail chop	Bale + flail chop + needle-nose rake	Bale + Vacuum sweep
Weed seeds:					
Annual bluegrass	1	1	1	1	3
Field groundsel	1		1		1
Sticky chickweed	1				
Rattail fescue	1				
Scarlet pimpernel	1				
Bedstraw		1			
Foxtail			1		
Purity analysis (%):					
Pure seed	99.46	99.54	99.46	99.31	99.31
Other crop seed	0.03	0.01	0.04	0.02	0.02
Inert Matter	0.51	0.44	0.50	0.66	0.66
Weed Seed	0.01	0.02	0.01	0.01	0.02

[1]Four field run samples (combined swaths) were taken prior to cleaning for purity analysis (mill check) at the OSU Seed Laboratory. Data shown in the table note the presence of weed seeds in 1, 2, 3, or all 4 samples analyzed. No entry denotes no weed seed in sample.

Soil test data

In the fall of 1992, 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, potassium, 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).

Potassium (ppm) and magnesium (meq/100g) concentration in the surface 0-3" samples was found to be significantly lower where crop residue had been removed mechanically (Table 9). 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.

Summary

Multi-year seed yield data (where available) from all locations in the research program are shown graphically in Figures 1 - 13. Results observed to date 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. 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.

Table 11. Effect of residue management on soil fertility. Data comparing flail chopping full straw and vacuum-sweep treatments are the average of five site locations. All soil samples taken on November 16, 1992.

Soil Test	Sample Depth (in.)	Residue Treatment: Flail chop full straw	Residue Treatment: Vacuum-Sweep	Mean	LSD 0.05 (LSD 0.10)
pH	0-1	5.3	5.5	5.4	NS
	1-2	4.9	5.1	5.0	NS
	2-3	4.8	4.9	4.9	NS
	3-6	4.9	5.0	4.9	NS
Phosphorus (ppm)	0-1	77	73	75	NS
	1-2	65	65	65	NS
	2-3	65	65	65	NS
	3-6	66	67	66	NS
Potassium	0-1	531	320	426	119
	1-2	248	152	200	77
	2-3	185	135	160	(48)
	3-6	172	141	156	NS
Calcium (meq/100g)	0-1	5.8	7.0	6.4	NS
	1-2	4.8	5.5	5.1	NS
	2-3	4.8	4.8	4.8	NS
	3-6	5.0	5.3	5.2	NS
Magnesium (meq/100g)	0-1	0.87	0.62	0.75	0.16
	1-2	0.65	0.55	0.60	(0.8)
	2-3	0.63	0.57	0.60	NS
	3-6	0.67	0.64	0.66	NS
Organic Matter (%)	0-1	4.10	3.64	3.87	NS
	1-2	3.72	3.53	3.62	NS
	2-3	3.60	3.62	3.61	NS
	3-6	3.90	3.62	3.76	NS

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 to more sites for aerial tiller development. However, no effect on seed yield was observed. Weed-seedling control was better than chop all back, but was still a problem for this treatment.

Bale and Flail - The results in 1991-92 showed this treatment to be generally better than chopping all of the straw back in both tall fescue and perennial ryegrass. However, no advantage over bale-only was observed in 1991-92 for tall fescue. Weed-seedling control was somewhat better than for chop all straw back.

Dethatching - This technique was tested again in 1991-92, but on only one site of perennial ryegrass. The results found that Lely dethatching after reclipping and baling compared favorably with other treatments in this older field of perennial ryegrass. In this test, the needle-nose rake compared favorably with dethatching.

Needle-nose rake - This experimental machine, designed to remove all the straw from the field or to remove residue remaining after baling the straw and chopping the stubble, was first tested in 1991-92. It was compared with other treatments in a tall fescue field and ranked quite close to vacuum-sweep at this site. In a perennial ryegrass field it also compared favorably with the better residue removal treatments. Crop regrowth and weed-seedling control was good with this treatment, particularly at the tall fescue site.

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. Comparisons of vacuum-sweep and burning (propane or special machine burn) in perennial ryegrass and tall fescue showed an advantage for vacuum-sweep in tall fescue. Yields from the vacuum-sweep plots were more consistent in 1991-92, probably due to treatments being more timely in 1991, thus, avoiding late defoliation that may have affected results in 1990-91.

Propane flaming - Flaming fields with propane burners after residue removal is practiced by some seed growers. Comparisons with nonthermal methods were made in three test sites and varied results were obtained. In one test on perennial ryegrass an increase in seed yield was observed while at another site no effect on yield was observed. Aerial tillering at both perennial ryegrass sites was reduced with propane flaming. In tall fescue, propane flaming after a vacuum-sweep reduced subsequent seed yield. The reason for this result is not clear, however, it is suspected that the propane flaming was simply an additional stress imposed on the grass stand in a year when stress was already great due to dry weather conditions.

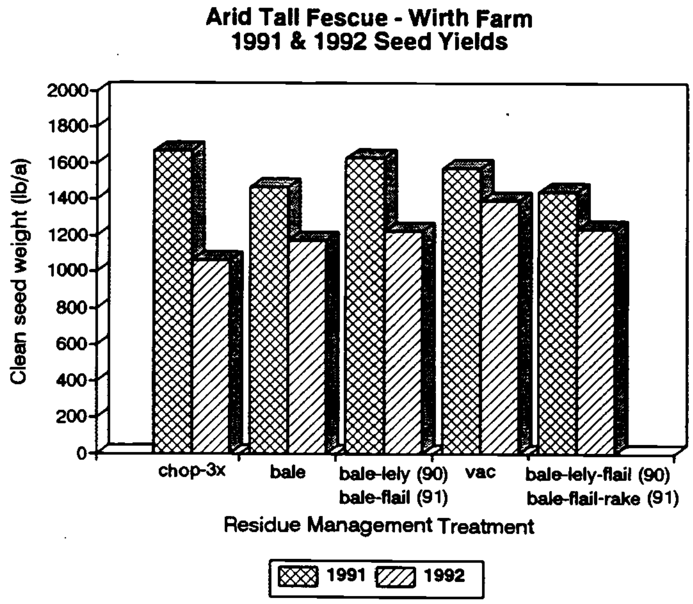


Figure 1

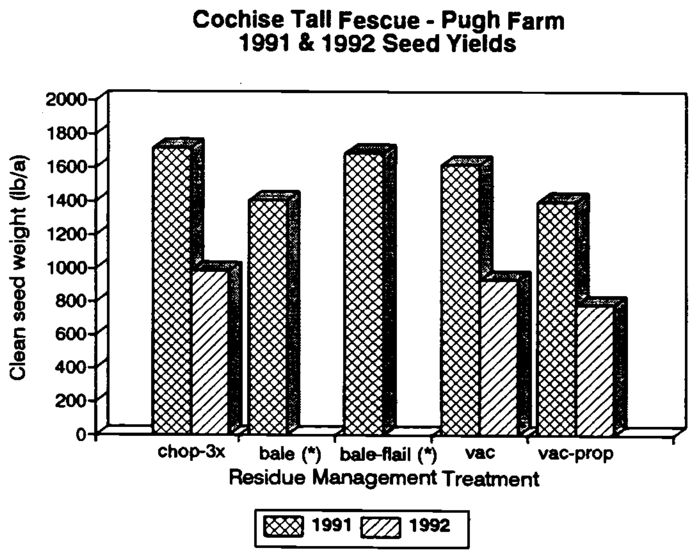


Figure 2

(*) Plots positioned for these treatments were mistakenly vacuum-swept in summer 1991

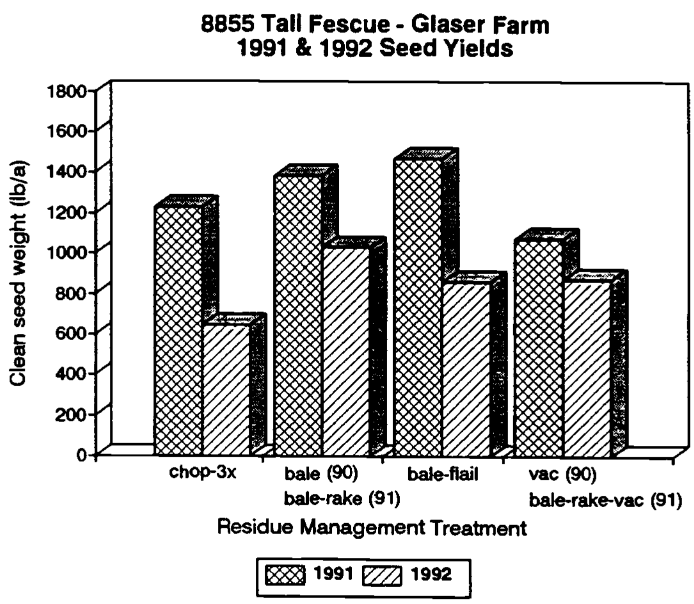


Figure 3

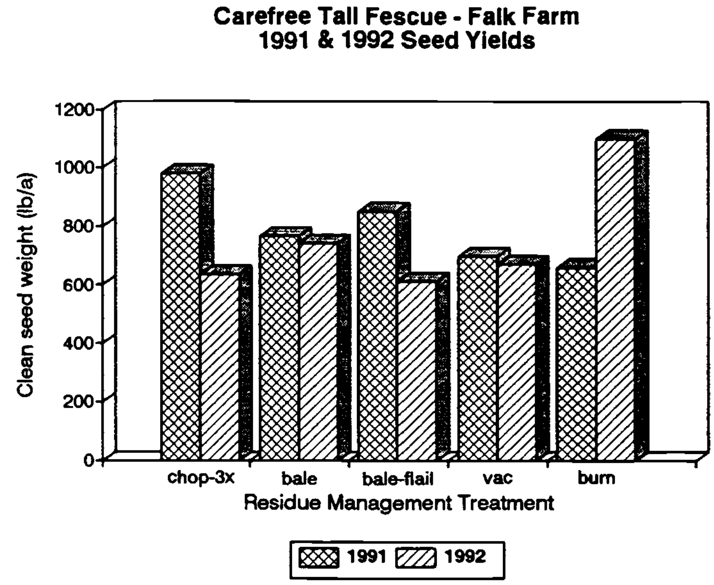


Figure 4

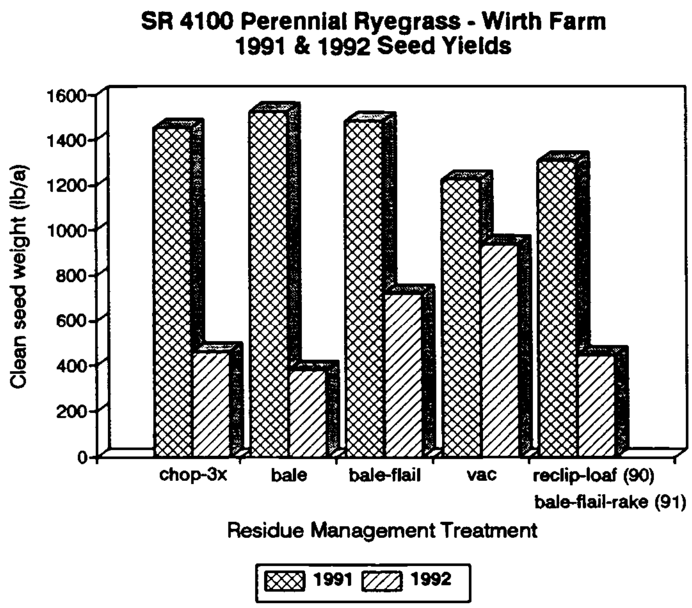


Figure 5

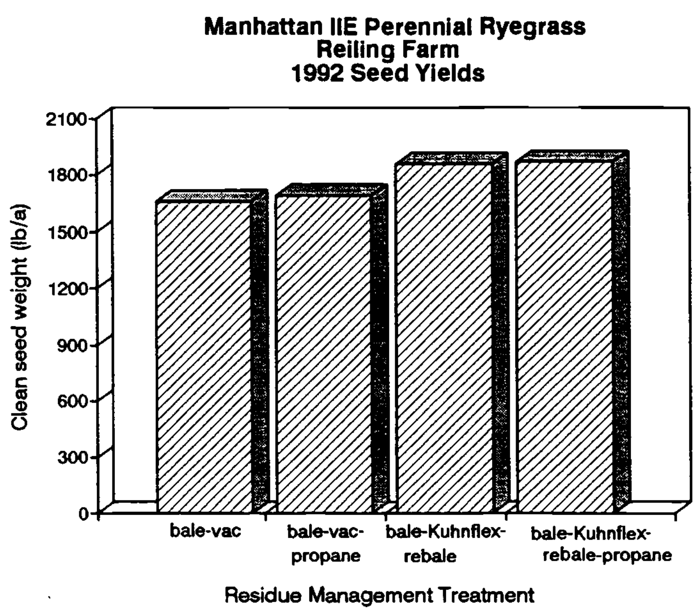


Figure 6

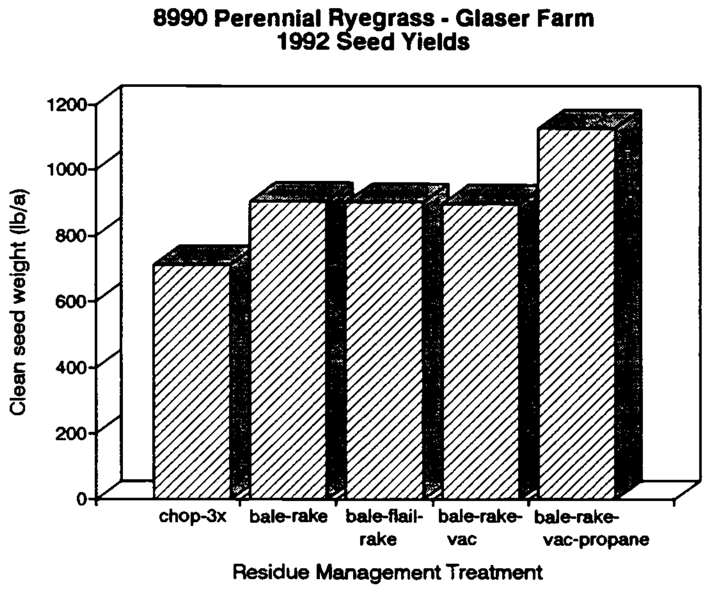


Figure 7

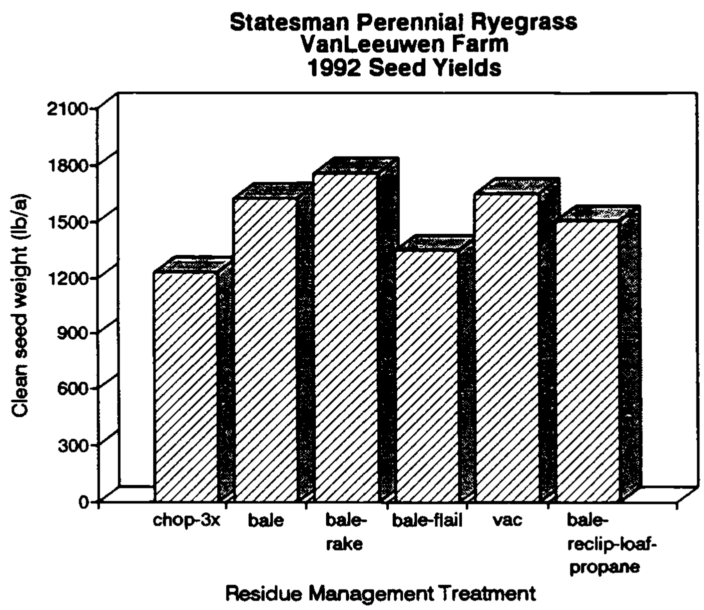


Figure 8

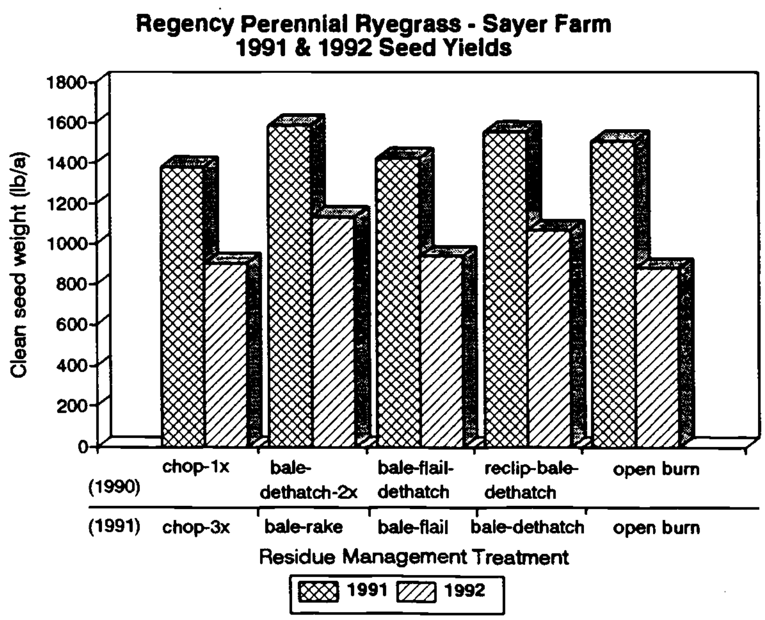


Figure 9

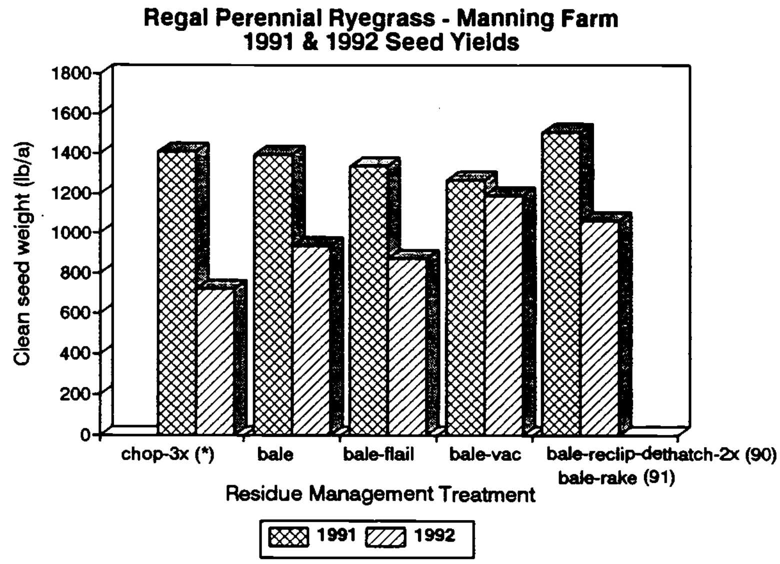


Figure 10

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

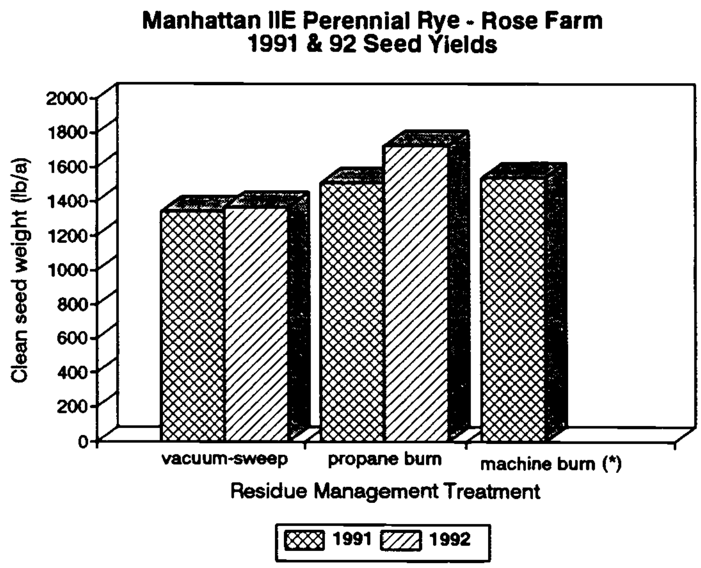


Figure 11

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

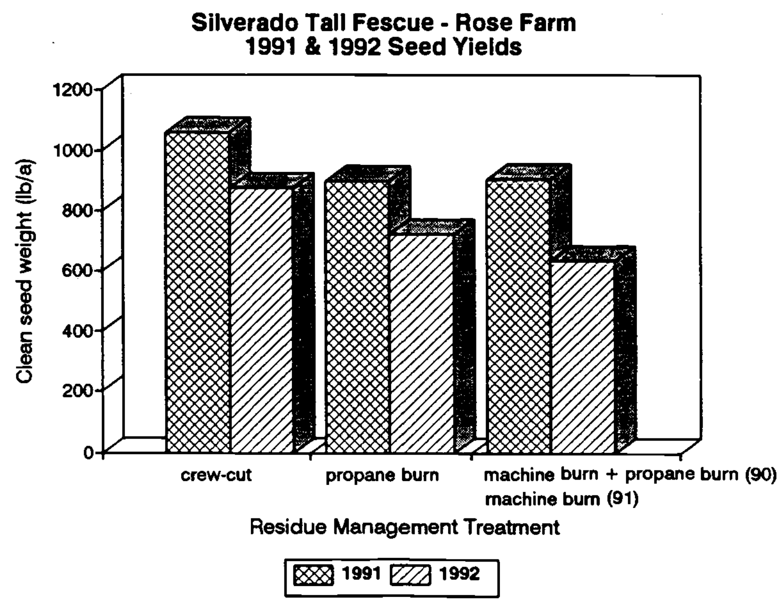


Figure 12

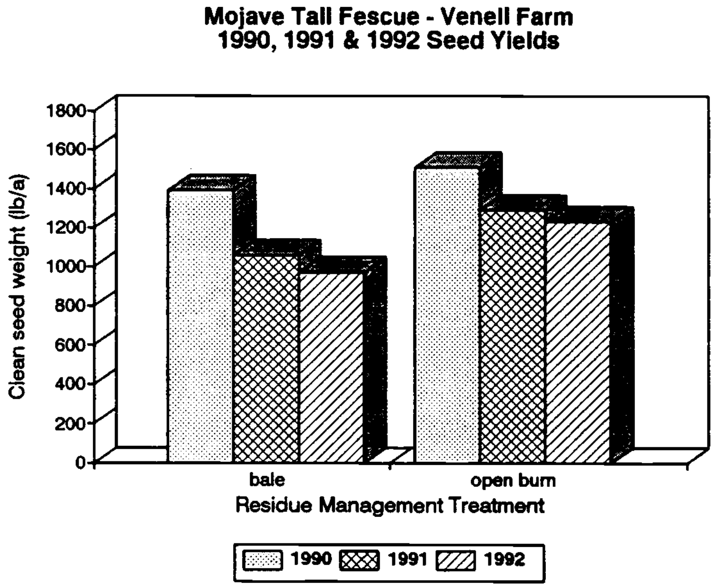

Mojave Tall Fescue - Venell Farm
1990, 1991 & 1992 Seed Yields
Clean seed weight (lb/a)
1800
1600
1400
1200
1000
800
600
400
200
0
bale
open burn
Residue Management Treatment
1990
1991
1992

Figure 13

Appendix Table 1. Long-term residue management field sites and treatments studied, 1990-92. Noted in parentheses is the treatment date for each residue management option used in the summer of 1991 (1991-92 crop year).

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)

(continued)

Appendix Table 1. (continued)

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. Residue management treatments studied in fields of older grass stands, 1990-92. Noted in parentheses is the treatment date for each residue management option used in the summer of 1991 (1991-92 crop year).

PERENNIAL RYEGRASS

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)

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)

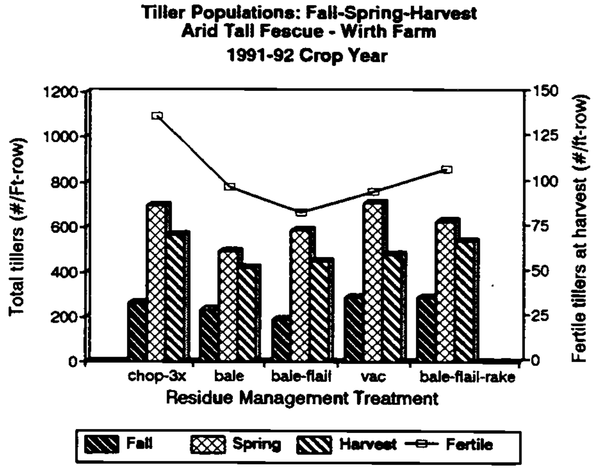
TALL FESCUE

Mojave tall fescue
- Clarence Venell
  - Bale only (July 28)
  - Open-field burn (August 28)

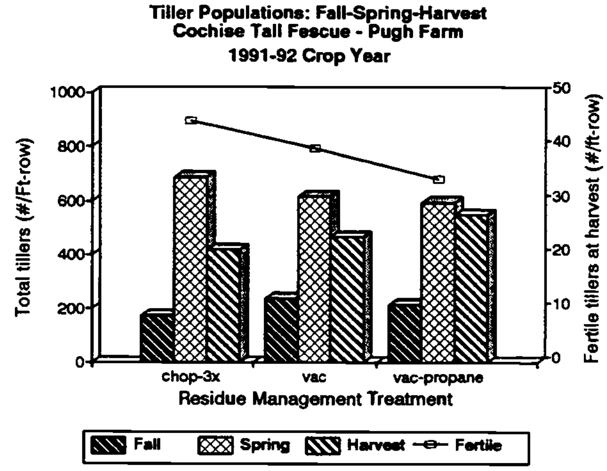
Silverado tall fescue
- Bill Rose
  - Bale and vacuum-sweep (August 22)
  - Bale and propane burn (September 20)
  - Bale and machine (improved mobile sanitizer) burn (September 20)

BLUEGRASS

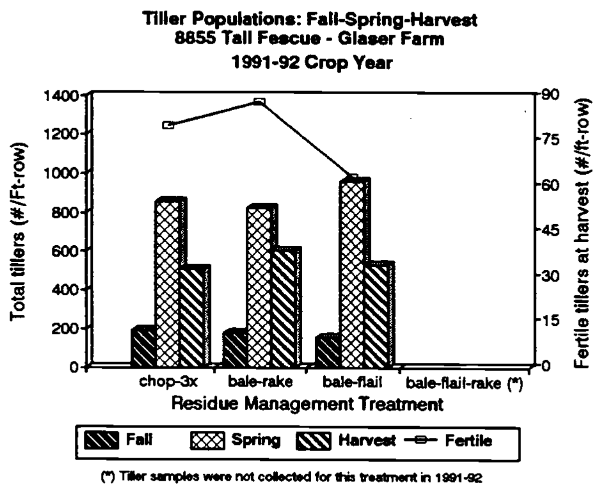
Challenger bluegrass (Treatments not applied in 1991)
- Bill Rose



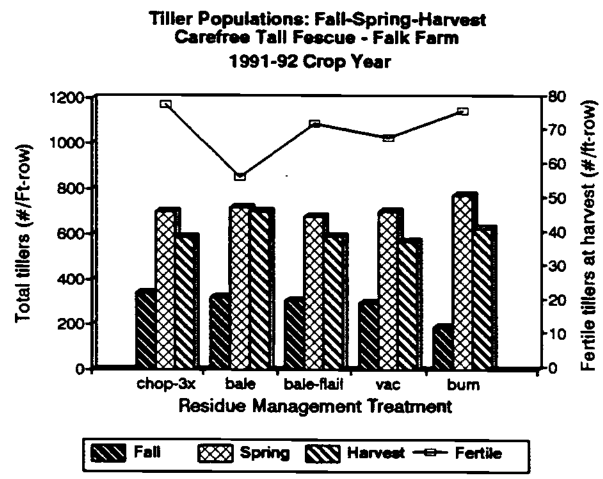
Appendix
Figure 1



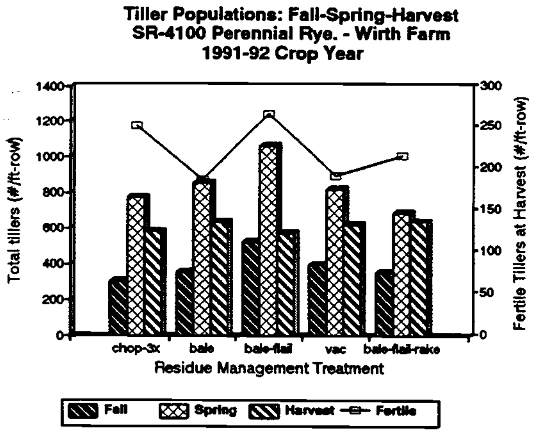
Appendix
Figure 2



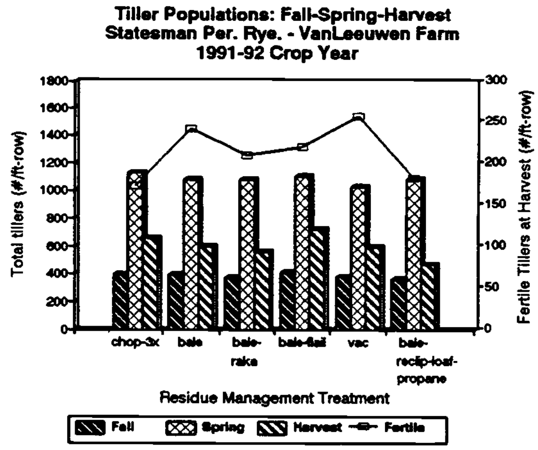
Appendix
Figure 3



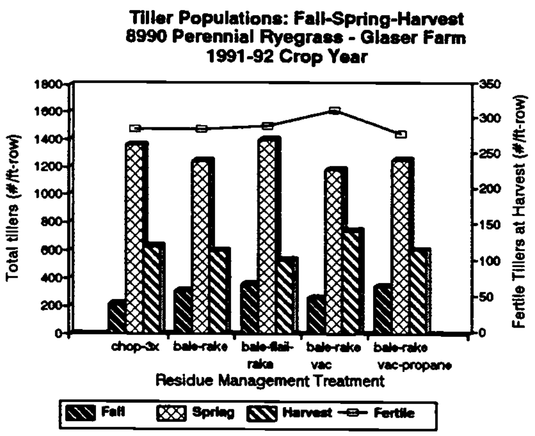
Appendix
Figure 4



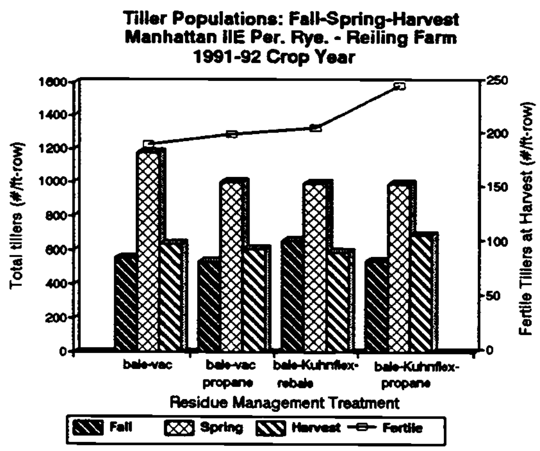
Appendix
Figure 5



Appendix
Figure 6



Appendix
Figure 7



Appendix
Figure 8

Appreciation is expressed to the following cooperators:

Aart Falk
31180 Green Valley Rd.
Shedd, OR 97377

Dennis Glaser
Mid Valley Farms, Inc.
32381 Seven Mile Lane
Tangent, OR 97389

Wendell Manning
29872 Manning Rd.
Brownsville, OR 97327

George & Paul Pugh
Pugh Seed Farm, Inc.
30405 Green Valley Rd.
Shedd, OR 97377

Bill Rose & Mark Fricker
Turf-Seed, Inc.
P.O. Box 250
Hubbard, OR 97032

Ken & Jack Sayer
37177 Hwy. 228
Brownsville, OR 97327

Clarence & Larry Venell
30742 Venell Pl.
Corvallis, OR 97333

Don Wirth
Cala Farms, Inc.
31144 Wirth Rd.
Tangent, OR 97389

James VanLeeuwen
27070 Irish Bend Loop
Halsey, OR 97348

Neal Reiling
Reiling Farms, Inc.
29611 SW Camelot St.
Wilsonville, OR 97070