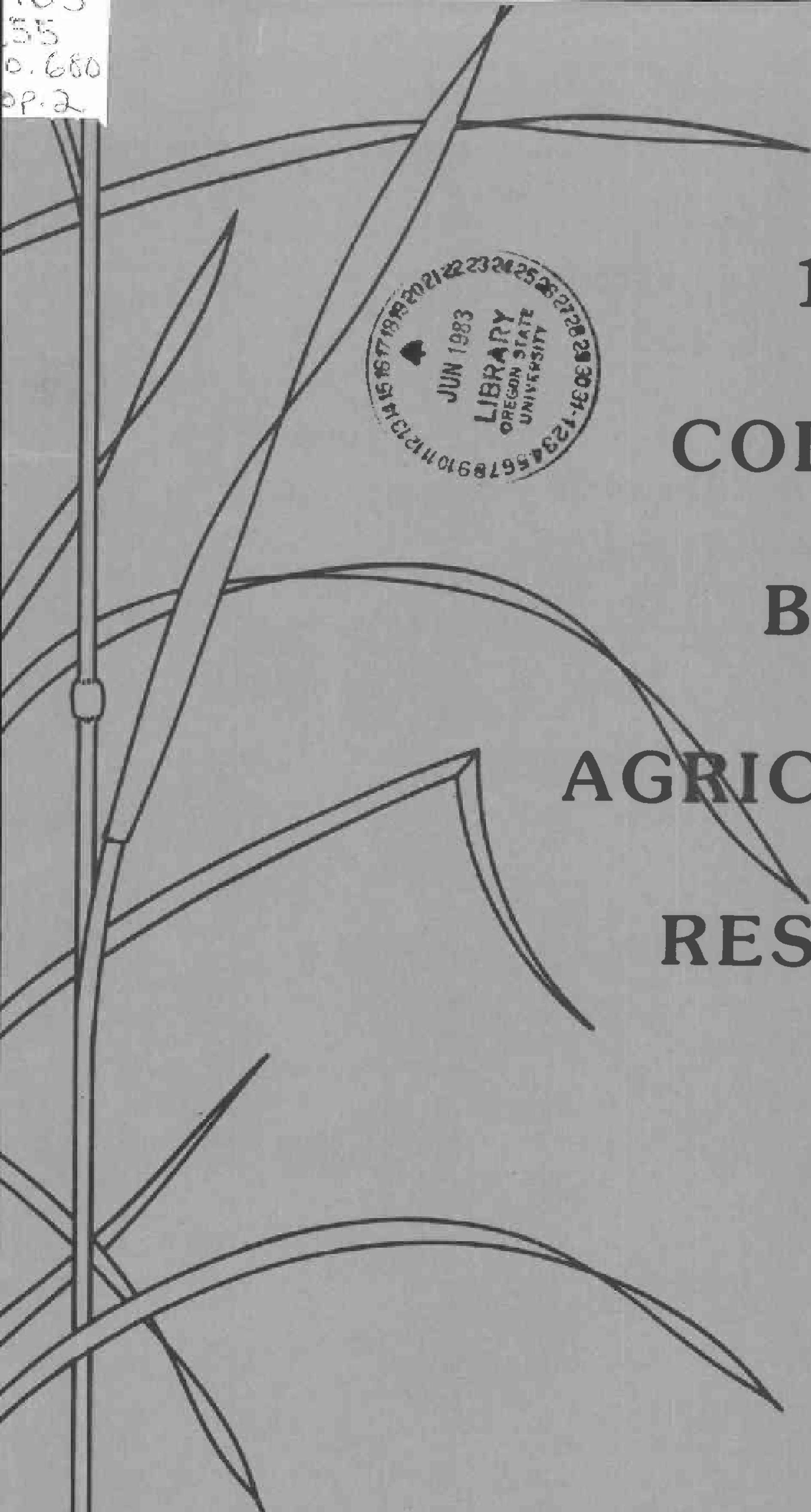

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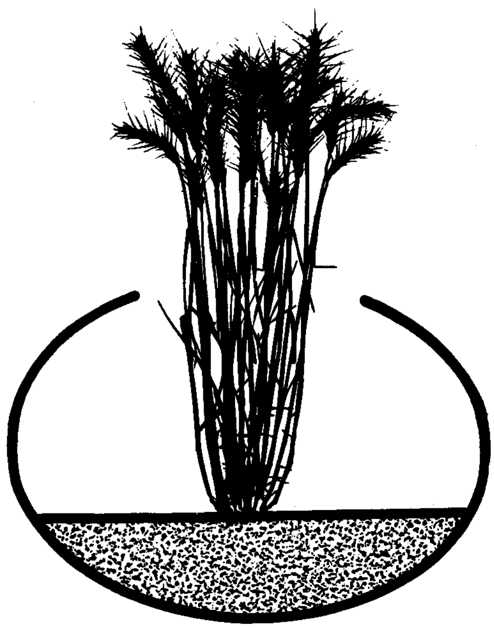

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DESCRIPTION OF NEW CEREAL VARIETIES

Charles R. Rohde[1]

WINTER WHEAT

Crew

Crew is a multiline variety of club wheat made up of a blend of 10 components which have resistant or intermediate resistant reactions to the prevalent races of stripe rust. It is heterogeneous for plant height, chaff color, and heading date because of inherent differences among its components. Crew equaled or exceeded Faro for stand establishment, cold hardiness, and lodging resistance. In tests at Moro and Pendleton, the yield and test weight of Crew have been about equal to the yield and test weight of Faro. Most of the components head about two days later than Faro. The milling and baking quality of Crew is similar to that of Faro. Crew was developed cooperatively by Agricultural Research Service, U.S. Department of Agriculture, the Washington Agricultural Research Center, and the Oregon Agricultural Experiment Station. Crew was released in 1981.

Hill 81

Hill 81 is a bearded, white-chaffed, semi-dwarf, white winter wheat released in 1982. Its grain test weight is about the same as that of Stephens. Hill 81 is more winterhardy than Stephens, and it is recommended for those areas where the winterhardiness of Stephens has not been adequate. This variety is usually one to two inches taller than Stephens. Hill 81 matures about four days later than Stephens. The milling and baking quality and resistance to lodging of Hill 81 are similar to these qualities of Stephens. Hill 81 is resistant to stripe rust, leaf rust, and most races of common bunt. This variety has yielded slightly less than Stephens in eastern Oregon except when winter injury occurs, then it yields higher than Stephens. Hill 81 was developed by the Oregon Agricultural Experiment Station.

Lewjain

Lewjain is a bearded, white-chaffed, semi-dwarf white winter wheat released in 1982. This variety is similar to Luke in maturity (somewhat late), straw strength, winterhardiness (moderate), and milling and baking quality (excellent). Lewjain is resistant to the local races of common and dwarf

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bunt. It is resistant to stripe rust, but susceptible to leaf rust and *Cercosporella* foot rot. Lewjain is moderately resistant to *Cephlasporium* stripe. This variety has yielded slightly higher than Luke, and it is recommended in areas where dwarf bunt is a problem. Lewjain was developed cooperatively by the Agricultural Research Service, U.S. Department of Agriculture, and the Washington Agricultural Research Center.

SPRING WHEAT

Owens

Owens is a bearded, white-chaffed, semi-dwarf, soft, white spring wheat released in 1981. The test weight of the grain is similar to that of Fieldwin. Owens matures about two days earlier, and its plant height is slightly taller than Fieldwin. This variety is resistant to stripe rust, and moderately resistant to leaf rust. Owens is slightly less resistant to lodging than Fieldwin, and has not yielded as high as Twin and Dirkwin in eastern Oregon. Owens has good milling and baking quality. It was developed cooperatively by the Agricultural Research Service, U.S. Department of Agriculture, and the Idaho Agricultural Experiment Station.

McKay

McKay is a bearded, white-chaffed, semi-dwarf, hard, red spring wheat released in 1981. The test weight of its grain is about one pound per bushel heavier than that of Fieldwin. McKay matures about the same time as Fieldwin, and its plant height is slightly taller. This variety is resistant to both stripe and leaf rust. McKay is very resistant to lodging. It has not yielded as high as Twin and Dirkwin in most areas of eastern Oregon. McKay has good milling and baking quality. This variety was developed cooperatively by the Agricultural Research Service, U.S. Department of Agriculture, and the Idaho Agricultural Experiment Station.

Waverly

Waverly is a bearded, white-chaffed, semi-dwarf, soft, white spring wheat released in 1982. The test weight of its grain is about equal to that of Fieldwin. Waverly matures slightly later than Fieldwin and its plant height is slightly shorter. This variety is resistant to the prevalent races of stripe and leaf rust found in the Pacific Northwest. Waverly has good milling and baking quality. It has not yielded as high as Twin and Dirkwin in most areas of eastern Oregon. This variety was developed by the Washington Agricultural Research Center.

WINTER BARLEY

Scio

Scio is a medium short, midseason, feed grain variety released in 1981. It is similar to Boyer in maturity, and about three inches shorter than Boyer. It is very stiff-strawed and well adapted to high rainfall areas and irrigated areas where severe winters do not occur. The spike of Scio is mid-dense and the kernels have a white aleurone. Scio was developed by the Oregon Agricultural Experiment Station.

SPRING BARLEY

Gus

Gus is a short, medium late maturing, six-row, feed grain, spring variety. The test weight of its grain is very high, averaging more than two pounds per bushel heavier than Steptoe. Gus is very resistant to lodging, and very well adapted for growing under irrigation. This variety has not yielded as high as Kombar in eastern Oregon.

CEREAL BREEDING AND TESTING PROJECT

Charles R. Rohde, Charles R. Crampton, and Kathleen Van Wagoner[1]

The cereal breeding program at Pendleton has the primary objective of developing high yielding, soft, white winter wheat varieties for the lower yielding areas of eastern Oregon. Varieties adapted for lower yielding areas must often be taller than semi-dwarf varieties such as Stephens and Daws and include club varieties such as Moro and Faro.

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Desired varietal characteristics for lower yielding areas are: (1) production of high yields of grain with excellent milling and baking quality; (2) resistance to smut, stripe rust, foot and root rots, and *Cephlasporium* stripe; (3) ability to establish quickly in a high residue seedbed; (4) ability to emerge when seeded deep or when soil moisture in the seeding zone is low; (5) resistance to shattering; (6) medium straw height; (7) resistance to lodging; and (8) moderate winterhardiness.

New varieties of spring and winter wheat, spring and winter barley, and spring oats, developed by public and private breeders are compared in the variety testing program at the Columbia Basin Agricultural Research Center. Plot sites at Pendleton, Moro, and Hermiston stations and on farmers' fields that are representative of cereal-growing areas of northeastern Oregon, provide data of yield, agronomic quality, and disease reaction characteristics for comparison to commonly grown varieties.

Climatic and soil conditions are diverse in northeastern Oregon; consequently, it is necessary to test cereal varieties at many locations and for at least three years to get reliable information as to their adaptability for various areas of northeastern Oregon. Tables 1 through 9 give yield data obtained from these trials for new and old varieties of wheat and barley. Detailed variety descriptions of newly released varieties are included in another article in this progress report.

Table 1. Yield data of winter wheat varieties tested in the lower yielding areas of eastern Oregon, 1978-1982

Variety	Moro	Pilot Rock	Echo	Lexington	Heppner	Arlington	Condon	Average
				(bushels per acre)				
Crew[2]	47.8	40.5	31.6	40.1	37.9	41.0	35.7	39.2
Jacmar[1]	48.0	36.1	30.9	37.1	33.0	41.7	41.4	38.3
Stephens	46.6	40.1	31.2	41.2	38.2	35.7	30.4	37.6
Faro	46.4	35.7	32.9	38.6	37.9	36.8	33.0	37.3
Tyee	44.8	39.6	28.7	36.3	39.1	33.9	37.9	37.2
Lewjain[2]	44.2	38.7	26.4	43.6	32.8	40.0	34.2	37.1
Nugaines	46.1	36.3	28.9	36.3	37.3	34.6	37.4	36.7
Hyslop	43.1	38.9	29.0	37.8	37.6	34.0	31.2	35.9
McDermid	42.5	41.3	28.1	37.5	36.8	31.3	34.0	35.9
Daws	40.4	38.2	29.0	34.6	36.6	32.0	34.8	35.1
Hill 81	41.0	37.8	31.4	36.1	37.8	31.1	29.7	35.0

[1]Tested in 1980, 1981, and 1982 only

[2]Tested in 1982 only

Table 2. Yield data of winter wheat varieties tested in the higher yielding areas of eastern Oregon, 1978-1982

Variety	Pendleton	Holdman	Weston	LaGrande	Flora	Baker	Average
			(bushels per acre)				
Stephens	77.5	50.9	72.4	76.9	54.8	40.1	62.1
Hyslop	73.1	46.8	67.3	76.3	53.6	47.8	60.8
McDermid	72.3	47.5	69.5	76.6	53.6	44.0	60.6
Nugaines	72.2	48.5	68.2	74.5	48.7	45.4	59.6
Hill 81	71.3	47.4	65.8	71.2	55.4	44.6	59.3
Daws	72.9	49.8	68.6	74.9	47.5	38.8	58.8
Tyee	75.1	53.7	64.8	71.0	43.0	42.3	58.3
Faro	71.5	48.3	62.3	69.8	44.0	38.2	55.7
Jacmar[1]	68.1	53.0	67.6	68.0	42.8	33.7	55.0
Crew[2]	76.9	60.9	72.3	76.7	64.8	----	----
Lewjain[2]	71.6	59.8	73.0	73.0	65.6	----	----

[1]Tested in 1980, 1981, and 1982 only

[2]Tested in 1982 only

Table 3. Yield data of winter wheat varieties tested under irrigation in eastern Oregon, 1978-1982

Variety	Pendleton	Hermiston	Summerville	Average
		(bushels per acre)		
Hill 81	75.7	76.6	71.8	74.7
Stephens	80.6	76.9	64.1	73.9
Hyslop	79.0	77.0	64.2	73.4
Lewjain[1]	82.0	75.2	55.6	70.9
Daws	72.8	77.2	59.7	69.9
McDermid	74.8	68.4	57.5	66.9
Crew[1]	74.8	74.5	42.9	64.1
Nugaines	65.8	63.2	62.6	63.9

[1]Tested in 1982 only

Table 4. Yield data of spring wheat varieties tested in lower yielding areas of eastern Oregon, 1978-1982

Variety	Moro	Echo	Lexington	Heppner	Arlington	Condon	Average
				(bushels per acre)			
Dirkwin	40.5	22.7	34.1	27.3	34.2	26.5	30.9
Twin	39.9	22.1	32.3	25.5	33.0	28.0	30.1
Wared	39.4	22.4	32.3	24.7	30.5	27.7	29.5
Borah	37.2	21.6	29.5	31.0	30.2	26.3	29.3
Shasta	36.7	18.4	32.3	28.2	27.3	26.8	28.3
Owens[1]	38.1	23.7	29.2	21.3	32.7	24.1	28.2
Urquie	36.4	21.0	29.3	25.0	29.5	25.0	27.7
McKay[1]	41.6	17.5	29.2	23.1	28.3	23.8	27.2
Fielder	33.1	20.1	29.1	25.3	28.0	27.1	27.1
Fieldwin	33.0	19.7	27.7	26.0	27.2	28.6	27.0
Wampum	33.4	20.6	29.0	26.9	27.0	27.5	27.4
Waverly[1]	35.2	18.1	29.5	22.6	26.9	25.2	26.2
Walladay	37.7	19.9	26.7	20.6	30.4	21.8	26.2
Fortuna	29.0	20.0	27.0	24.3	27.2	22.2	25.0

[1]Tested in 1982 only

Table 5. Yield data of spring wheat varieties tested in the higher yielding areas of eastern Oregon, 1978-1982

Variety	Pendleton	Weston	Hermiston	LaGrande	Joseph	Baker	Average
				(bushels per acre)			
Borah	51.4	42.6	55.2	52.9	47.8	34.6	47.4
Dirkwin	52.1	43.7	47.0	55.9	46.0	38.5	47.2
Twin	49.4	40.6	43.2	60.9	42.7	37.7	45.8
Waverly[2]	50.2	42.7	----	51.5	38.8	----	45.8
Owens[1]	45.2	41.4	----	56.0	39.6	----	45.6
Wampum	49.5	41.2	43.1	57.6	42.3	37.2	45.2
McKay	49.5	42.9	41.5	56.4	36.0	32.9	43.2
Wared	45.6	39.4	46.3	44.7	36.6	34.9	41.2
Urquie	46.1	39.5	38.1	50.5	35.2	37.6	41.2
Fielder	39.9	38.4	52.8	46.9	36.0	31.3	40.9
Fieldwin	42.7	36.8	46.8	48.3	34.8	31.7	40.2
Walladay	48.6	37.3	39.2	37.6	23.4	33.9	36.7

[1]Tested in 1981 and 1982 only

[2]Tested in 1982 only

Table 6. Yield data of winter barley varieties tested in the lower yielding areas of eastern Oregon, 1978-1982

Variety	Moro	Pilot Rock	Echo	Lexington	Heppner	Arlington	Condon	Average
				(pounds per acre)				
Mal	3194	3081	2493	2854	2628	2678	2969	2842
Hesk[1]	3216	3175	2729	2894	2557	2804	2370	2821
Scio[1]	3074	3223	2894	3063	3028	2285	2009	2797
Steptoe (fall seeded)	2348	2884	2703	2951	2284	2725	2907	2686
Kamiak	2775	2734	2881	2729	2092	2450	2153	2545
Wintermalt	2796	2588	2546	3030	2288	2374	1875	2500
Hudson	2606	2410	2752	2577	1878	2366	1926	2359

[1]Tested in 1981 and 1982 only

Table 7. Yield data of winter barley varieties tested in the higher yielding areas of eastern Oregon, 1978-1982

Variety	Pendleton	Holdman	Weston	Hermiston	LaGrande	Summerville	Baker	Flora	Average
					(pounds per acre)				
Scio[1]	6478	3282	4619	6003	5004	4866	2061	2266	4322
Hesk	5877	3268	4690	5792	5016	4803	1984	2514	4243
Mal	6009	3207	4884	5556	4759	4854	1485	2530	4160
Boyer	6058	3259	4630	5405	4935	4724	1715	2431	4145
Schuyler	5495	3528	4369	4638	4381	4539	1632	2550	3892
Luther	4804	3112	4364	4942	4057	4401	2037	2496	3777
Wintermalt	5617	2621	3319	4595	4197	3897	1917	2149	3539
Kamiak	4920	2844	3688	4208	3679	3956	1522	3046	3483
Steptoe (fall seeded)	4899	2554	3794	4264	3985	4024	1692	2373	3448

[1]Tested in 1981 and 1982 only

Table 8. Yield data of spring barley varieties tested in the lower yielding areas of eastern Oregon, 1978-1982

Variety	Moro	Echo	Lexington	Heppner	Arlington	Condon	Average
			(pounds per acre)				
Steptoe	2914	2002	2563	2507	2838	2593	2560
Hector	2986	1942	2418	2125	2660	2411	2424
Gem	2572	1571	2448	2371	2744	2510	2369
Summit	2936	1827	2404	2035	2492	2272	2328
Advance	2598	1593	2252	2477	2548	2487	2326
Lud	2826	1642	2386	2271	2572	2256	2326

Table 9. Yield data of spring barley varieties tested in the higher yielding areas of eastern Oregon, 1978-1982

Variety	Pendleton Dryland	Pendleton Irrigated	Weston	Hermiston	LaGrande	Jodeph	Baker	Average
	(pounds per acre)							
Steptoe	3342	3689	3355	4985	4441	4203	3550	4037
Kombar	----	3899	3356	4715	4465	3023	3223	3780
Lud	3158	3459	3284	4846	4012	3870	3202	3779
Summit	3021	3521	3233	4422	4143	3667	3082	3678
Advance	2712	3404	3099	4399	4039	3745	2714	3567
Kimberly	----	3229	3262	4101	3735	3444	3103	3479
Gus[1]	2567	3045	2376	----	4066	3811	3693	3398
Gem	2915	2927	2962	3863	3370	3774	2742	3273
Cayuse (oats)	----	2980	2712	4500	3174	3190	2821	3230
Klages	----	3014	2952	3728	3462	3219	2791	3194
Morex[2]	----	2819	2248	----	2641	3343	3474	2905

[1]Tested in 1982 only

[2]Tested in 1981 and 1982 only

WATER MOVEMENT THROUGH TILLAGE PANS AFTER 52 YEARS OF CROP RESIDUE MANAGEMENT

J. L. Pikul Jr., R. R. Allmaras, and C. R. Rohde[1]

INTRODUCTION

There is increasing concern that soil compaction may be reducing crop production on Pacific Northwest farmlands. The National Agricultural Lands Study (January 1981) estimated that annual U.S. crop-production losses from soil compaction may be as large as $3 billion. Poor crop growth often results from restricted root development in compacted layers. Compaction also reduces the rate at which water moves into the soil. A serious soil erosion hazard exists when reduced soil water intake perches water near the surface.

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The development of layers which restrict water flow in agricultural soils is a process not entirely understood. Mechanical compaction from tillage operations and soil chemical changes may jointly produce a layer of both high strength and low permeability to water. Tillage operations inevitably produce layers with bulk density higher than that of surrounding soil. These layers of high bulk density may in turn induce the collection of soil constituents, notably silica which has moved out of the plow layer (Douglas et al., 1983). Silica accumulation may further reduce soil drainage by plugging channels for water flow between soil particles.

The incorporation of crop residue into soil favors the formation of large stable soil aggregates. Well aggregated soils are porous (low bulk density) and have good internal drainage (high hydraulic conductivity). However, crop residues without microbial decomposition have little if any effect on the stability of soil aggregates. Organic decomposition products (polysaccharides) that remain in the soil produce stable soil aggregates (Baver, 1972). The building of stable aggregates or even the maintenance of existing stability is a long-term process dependent upon frequent additions of organic material and an active soil microbial population.

There is also evidence that the availability of soil incorporated crop residue greatly influences earthworm populations. Earthworms ingest and intermix soil and partially decomposed organic matter, excrete material as worm casts, and form a complex system of burrows that permeate the soil. Earthworm casts also improve the stability of soil aggregates. Networks of burrows through tillage pans can also provide large channels for saturated water flow into the profile. Manures and other crop residues applied to arable land increased earthworm populations much more than inorganic nitrogenous fertilizers (Edwards and Lofty, 1982).

Incorporated crop residues in long-term soil management experiments clearly improve water conducting properties of the soil. However, very few field measurements are available to demonstrate that residue incorporation affects hydraulic conductivity of the saturated soil. Saturated hydraulic conductivity is a direct measure of the soil's water-conducting ability. Such field measurements are difficult to obtain because tillage pans are often as thin as 5 centimeters (2 inches). The objective of this study was to measure and compare the saturated hydraulic conductivity in and below the tillage pan produced in plots which have received different treatments of crop residue management.

MATERIALS AND METHODS

After years of an uninterrupted scheme of crop residue management, the soil finally develops a structure that will not change unless the scheme of management changes. Residue management plots established at the Columbia Basin Agricultural Research Center in 1931 are ideal for measuring long-term management effects on soil structure, water-conducting properties of the soil profile, and crop production. Residue treatments include: (1) straw plowed under in the spring, (2) straw plus 2,000 kg/ha (1,800 pounds/acre) dry pea vines plowed under in the spring, (3) straw plus 10,800 kg/ha (9,600 pounds/acre), dry weight, strawy manure plowed under in the spring, (4) straw burned in the spring, (5) straw burned in the fall, and (6) straw plowed under in the spring with 90 kg/ha (80 pounds/acre) NH_4NO_3 broadcast before seeding. All treatments except (3) above have shown a decrease in organic matter in the top 30 centimeters (12 inches) of soil between 1931 and 1976.

Soil hydraulic conductivity at saturation was measured in the field using a double-tube method. This technique requires prior knowledge of the location of slowly- or highly-permeable layers in the soil profile. Dry bulk density measurements for soil depth increments as small as 2-centimeters (3/4 inch) were used to locate the tillage pan layers where compaction was greatest. These are the layers which would be expected to have the least permeability to water. Saturated hydraulic conductivities measured at depths of 20 and 35 centimeters (8 and 14 inches) are the average of at least three determinations.

RESULTS AND DISCUSSION

Changes in bulk density with depth for two treatment extremes are shown in Figure 1. In one case, the straw residue was burned (Treatment 5) and in the other, straw plus strawy manure was plowed under in the spring (Treatment 3). The increase in bulk density at approximately 23 centimeters (9 inches) defines the depth where maximum compaction occurs. Both plots exhibit a compacted layer. However, the severity of this compaction is 10 percent greater on the fall burned plot.

Bulk density measurements determine where zones of restricted water flow are likely to occur and, consequently, the depth at which to measure hydraulic conductivity. But, more importantly, the measurements indicate long-term changes in soil porosity in response to residue management. Although both plots have had the same tillage operations, soil incorporation of strawy manure every other year has maintained high porosity (low bulk density) compared to the fall burned plot.

Saturated hydraulic conductivities in the tillage pan and subsoil of the six test plots are shown in Table 1. Soil organic matter changes in the top 30 centimeters (1 foot) of soil since 1931 are also shown (Rasmussen et al., 1978). Hydraulic conductivity of the subsoil was the same for all six treatments. However, significant differences of saturated hydraulic conductivity occurred in the tillage pan. Most notable is the low hydraulic conductivity of the fall burned plot (2.5 centimeters/day) compared to the high hydraulic conductivity of the strawy manure plot (7.3 centimeters/day), where soil organic levels have not declined over the years. Even where 80 pounds N/acre was applied and straw (Treatment 6) was returned every other year, the soil hydraulic conductivity is low. Managements which "mine" soil organic matter

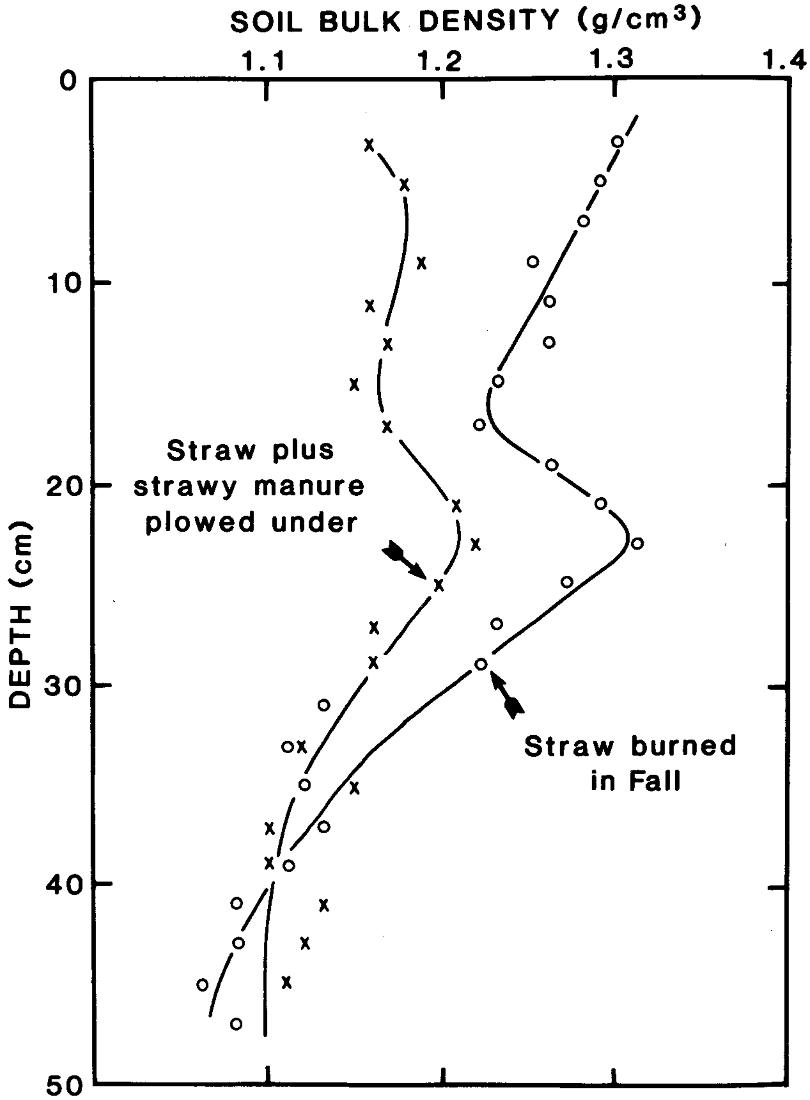

Figure 1. Bulk density of soil where the straw residue was burned in the fall (o) or straw plus 10,800 kg/ha strawy manure was plowed under in the spring (x). Each value represents 14 composited soil samples.

(Table 1) produced more compacted tillage pans which also had a restricted water flow. These layers limit water intake into the profile, aggravate erosion hazards, reduce the potential for crop yield (because less water is stored in the profile and root growth may be restricted), and create soil environments ideal for the *Pythium-Fusarium* root disease complex to survive and thrive (Allmaras et al., 1982).

Table 1. Field-measured saturated hydraulic conductivity and percent organic matter change since 1931 in long term residue management plots (1931 to 1983) of Walla Walla silt loam

Number	Treatment	Saturated hydraulic conductivity (cm/day) Tillage pan (20 cm)	Saturated hydraulic conductivity (cm/day) Below tillage pan (35 cm)	Percent organic matter change in top 30 cm of soil
1	Straw plowed under	3.0	15.0	- 21%
2	Straw plus pea vines plowed under	5.2	15.4	- 10%
3	Straw plus strawy manure plowed under	7.3	15.5	+ 1%
4	Straw burned in spring	3.6	12.8	- 20%
5	Straw burned in fall	2.5	15.1	- 23%
6	Straw plowed under plus 80 lbs N/acre	2.0	16.3	- 14%
	Standard error	1.8	5.0	

CONCLUSION

Saturated hydraulic conductivity in thin layers in and below the tillage pan was measured on Walla Walla silt loam field plots with 52 years of residue management history. Soil hydraulic conductivity was 35 percent lower on plots which had been fall burned as compared to plots into which strawy manure plus straw was incorporated. These results are consistent with the measured declines in soil organic matter and the development of denser tillage pans. Preliminary results indicate that the tillage pan poses a serious problem as the most restrictive soil layer governing water flow into the profile. Furthermore, once a tillage pan is created (no matter how slight) mechanical compaction, water flow, and soil chemical changes (silica migration) may interact to form a nucleus for subsequent accelerated pan formation.

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GRAIN DRILL MODIFICATIONS FOR IMPROVED OPERATION IN SURFACE RESIDUES

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Crop residues left on the soil surface increase overwinter storage of precipitation and reduce soil erosion. A major problem in reduced tillage systems is poor functioning of the seeding equipment in surface residue. Disk type openers tend to push residue down into the seed zone, and cause poor seed-soil contact or they may ride over the residue and lift out of the soil and thereby deposit seed on the soil surface. Hoe type openers tend to rake the residue and then plug the drill. Johnson (1979)[2] modified a deep furrow grain drill to accommodate larger amounts of residue by adding a power driven rake. This modification helped get through more residue but had the disadvantage of wrapping large weeds and tough straw around the rake.

Two types of free-floating power-driven wheels were developed as accessories for grain drills equipped with hoe-type openers. These power-driven wheels were field tested to evaluate their effectiveness to reduce the incidence of drill plugging with crop residue. One type was a rubber wheel 16 inches in diameter and 4 inches wide, which is a John Deere corn planter packer wheel. Another type of wheel was made by cutting a 16-inch diameter finger wheel from a piece of rubber one inch thick. This rubber had a durometer (instrument to measure hardness) reading of 70 (Figure 1).

These wheels were mounted on a CrustBuster[3] hoe-type drill. The mounting was designed so the wheels were free to float in a vertical plane and, therefore, followed the soil surface contour. The wheels were power driven 1.25 times faster than ground speed. Both types of wheels were positioned to allow a two-inch clearance between the wheel and opener shank. The plane of wheel rotation was parallel to the direction of implement travel and the point of ground contact was two inches ahead of the opener.

These wheels were tested in the fall in wet wheat residue ranging from 4 to 5 tons/acre. Both wheels were a hinderance and caused the drill to plug when not power driven. When power driven, the John Deere wheel reduced the incidence of plugging but the drill still plugged frequently in 4 to 5 tons/acre of residue. The power driven rubber finger wheel was more promising for negotiating tough wheat residue ranging up to 5 tons an acre. Plugging still occurred where the straw was not evenly distributed. Two principal

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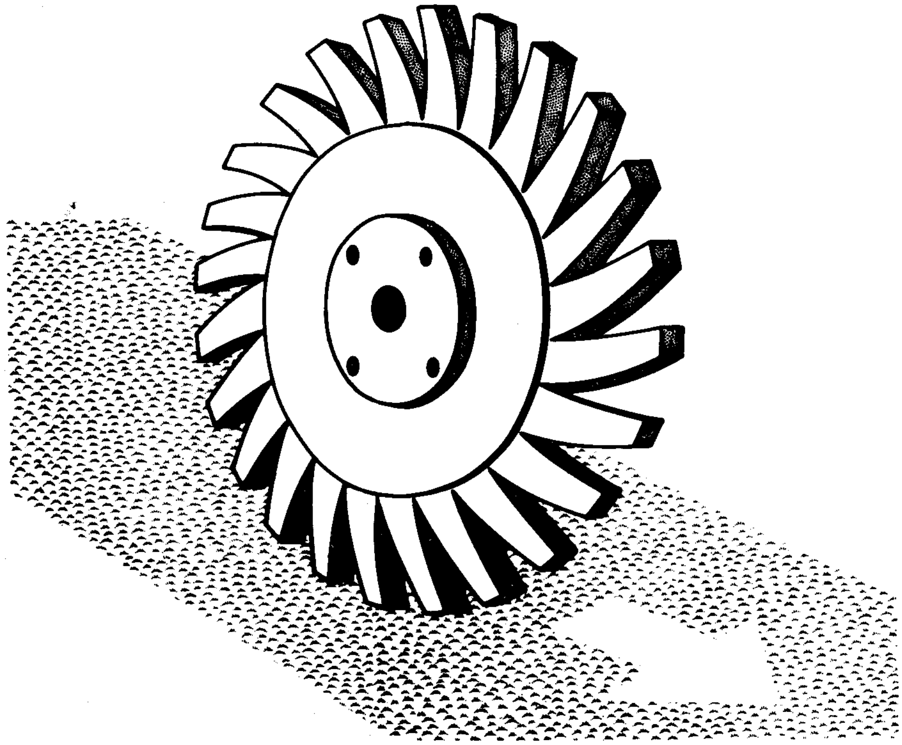

Figure 1. Rubber fingered trash wheel to aid in managing surface residue during grain drill operation.

disadvantages for using this technique to help a drill operate in heavy residue are too much residue left over the seed row for good early seedling development and the necessity that the trash wheel be power driven.

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[2]Johnson, C. E. 1979. A grain drill for operation in surface residues. pp 58-60. In Research Reports - Columbia Basin Agricultural Research, Special Report 547. Agricultural Experiment Station, Oregon State University in cooperation with USDA, Corvallis, OR.

[3]Acknowledgment is given to CrustBuster Inc., of Spearville, Kansas, for loaning a grain drill to USDA-ARS, Pendleton, Oregon, which was used in this research.

WINTER WHEAT RESPONSE TO NITROGEN FERTILIZER IN NO-TILL ANNUAL CROPPING AND CONVENTIONAL TILLAGE WHEAT-FALLOW ROTATION

Paul E. Rasmussen[1]

Winter wheat response to nitrogen was evaluated in two separate experiments at the Columbia Plateau Conservation Research Center. One comprised cropping in a fallow/wheat rotation with conventional tillage (mold board plowing and mechanical weed control). The other consisted of no-till annual cropping following spring wheat (weeds were controlled with herbicides). Both experiments were fertilized with 0, 40, and 80 pounds of nitrogen per acre, but the methods of application differed. Nitrogen was broadcast and incorporated immediately before seeding for conventional tillage, but banded 1.5 inches directly below the seed for no-till seeded wheat. Both experiments were seeded within five days of each other with 70 pounds per acre of Stephens winter wheat seed.

Grain yields without N fertilization were 38 and 20 bushels per acre for conventional tillage wheat/fallow and no-till annual cropping, respectively (Table 1). The higher yield in the wheat/fallow rotation was expected since it had the advantage of two years' mineralization of native soil nitrogen rather than one in annual cropping. Grain yield increased substantially when 40 pounds of nitrogen per acre was applied and further increased with the 80 pounds of nitrogen per acre application rate. Nearly identical increases of 37 and 38 bushels per acre were obtained for conventional wheat/fallow and no-till annual cropping, respectively, when 80 pounds of nitrogen per acre was applied. Grain yield increased nearly 0.5 bushels per acre for each pound of nitrogen applied, or conversely, 2.1 pounds of nitrogen per acre increased yield one bushel in both cropping systems. It is probable that nitrogen response might not have been the same had it been broadcast in the no-till seeding because of nitrogen immobilization by surface residue. These results indicate that winter wheat can use nitrogen just as efficiently in no-till as in conventional tillage if the fertilizer is properly placed to avoid "tie-up" by residue-decomposing microorganisms.

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At the 80 pound per acre nitrogen rate, grain yield under annual cropping was 58 bushels per acre compared to 75 bushels per acre in the wheat/fallow experiment (Table 1). The 23 percent lower yield in annual cropping was probably not caused by lower stored water because the soil profile in both systems was essentially full of water when spring growth started. It is more likely that 80 pounds of nitrogen per acre was not adequate for maximum yield under annual cropping or that recropped cereal grain was adversely affected by deleterious soil pathogens which are eliminated by fallowing. Long-term yields at Pendleton in annually-cropped winter wheat are about 75 percent of yields in a winter wheat/fallow rotation, where both receive 80 pounds of nitrogen per acre.

Winter wheat grown in no-till annual cropping produced substantially less straw than wheat grown with conventional tillage after fallow (Table 1). When 80 pounds of nitrogen per acre was applied, the straw-to-grain ratio was 1.16 for the no-till seeded annual crop compared to 1.64 for conventionally tilled, wheat after fallow. This difference in straw-to-grain ratio is consistent with previous research on no-till cropping; less straw is produced and the ratio is about 25 percent lower than that for conventionally tilled winter wheat.

Table 1. Stephens winter wheat responses to nitrogen fertilization in no-till annual cropping as compared to conventional tillage after fallow

Nitrogen[1] applied (lbs/A)	No-till; annual cropping			Conventional tillage; fallow/wheat		
	Grain yield (bu/A)	Straw yield (tons/A)	Straw/grain ratio	Grain yield (bu/A)	Straw yield (tons/A)	Straw/grain ratio
0	20	0.8	1.34	38	2.1	1.86
40	43	1.7	1.33	58	2.8	1.61
80	58	2.0	1.16	75	3.7	1.64

[1]Nitrogen was banded 1.5 inches below the seed for no-till wheat in annual cropping; nitrogen was broadcast and incorporated before seeding for conventionally tilled wheat following fallow.

JOINTED GOATGRASS - A NEW WEED INVADER

Don J. Rydrych[1]

Jointed goatgrass (Triticum cylindricum Ces., Pass.) is a new winter annual grass weed that is spreading in winter cereal areas in eastern Oregon and other areas of the Pacific Northwest. It is a close relative of wheat which makes chemical control very difficult. Control is limited to cultural methods such as spring cropping, double or triple fallow, crop rotations, and seed sanitation. There is no known chemical treatment that selectively removes goatgrass from winter wheat or winter barley.

Goatgrass, well adapted to our eastern Oregon environment, grows at elevations from 3,700 feet at Condon to 800 feet at Echo. It can adapt to areas that have either high rainfall (20 inches annually), or very dry habitat (10 inches annually). Goatgrass seeds have a long post-harvest dormancy and their germination six months to one year after maturity is often less than 50 percent.

Jointed goatgrass is found mostly in wheat fields, but it can spread from roadsides, waste areas, pasture or range sites, and often is introduced from one field to the other by combines and contaminated seed in the grain drill. The study, funded by the Oregon Wheat Commission and conducted in 1981 and 1982, is a continuing project and will be developed for several more seasons.

MATERIAL AND METHODS

Replicated plots were established in 1981 and 1982 at the Columbia Basin Agricultural Research Center, Pendleton, Oregon, to study the effect of goatgrass competition on winter wheat yield. The soil is classed as a Walla Walla silt loam (coarse-silty, mixed, mesic Typic Haploxeroll), pH 6.5, organic matter 1.9 percent, and a depth of five feet. Nitrogen fertilizer was broadcast at 60 pounds per acre. Annual precipitation averaged 20 inches a year during the two test seasons. A randomized block design with four replications was used in plots six feet wide and 20 feet long in areas that were dryland farmed in a winter wheat-fallow rotation. Stephens winter wheat was seeded with a deep furrow drill at 60 pounds an acre using 14-inch row spacings. Goatgrass populations were established at 5 plants/foot^2 in 1981 and 8 plants/foot^2 in 1982.

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Dry weights of grain were obtained from 20 feet of two center rows from each plot at maturity (July). Goatgrass was harvested two weeks before winter wheat maturity.

RESULTS AND CONCLUSIONS

The goatgrass competition trials were processed and evaluated at the Pendleton Station; further tests are being evaluated for the 1983 season. The results of winter wheat yield as influenced by goatgrass competition are listed in Table 1.

The results as recorded in Table 1 show that goatgrass is a serious competitor with winter wheat even at low populations. Goatgrass populations of 5 plants/foot^2 in 1981 reduced wheat yield by 24.6 percent and 8 plants/foot^2 reduced yield 29.4 percent in 1982. Goatgrass, a low profile competitor relatively unnoticed until heading, has a very vigorous root system that compensates for the lack of vigorous top growth. Once established, it competes with wheat for moisture and nutrients. Goatgrass consumed .40 inch extra moisture in 1981 and .90 inch in 1982 as compared with 1.00 inch for cheatgrass in 1981 and 1.80 inch in 1982. This is in addition to total moisture needs by the wheat plant. Goatgrass does not require as much moisture as cheatgrass but competes more vigorously through the root system.

These data show that goatgrass is a serious wheat competitor and that yield losses of at least 25 percent can be expected from low populations. In addition to the yield loss from competition, farmers can be docked 10 cents a bushel at the elevator. Goatgrass contaminated wheat cannot be used for seed certification. It is imperative that control measures using cultural or chemical control methods be developed to combat this grass weed. Such objectives and projects have been established in eastern Oregon by OSU in an attempt to develop an economical program for jointed goatgrass control in winter cereals.

Table 1. Goatgrass competition in Stephens winter wheat -- OSU Pendleton Station, 1981-82

Treatment[1/] year	Goatgrass plants	Winter wheat yield	Wheat yield loss
1981	-ft^2-	-bu/A-	-%-
Weeded control	0	110	0
Control	5	83	24.6
1982			
Weeded control	0	75	0
Control	8	53	29.3

[1/]Treatment values based on bushels/acre.

SOIL FROST PENETRATION UNDER CONVENTIONAL AND CONSERVATION TILLAGE

R. N. Greenwalt, J. L. Pikul Jr., and J. F. Zuzel[1]

Frozen soil is a major factor contributing to excessive soil erosion losses when combined with rain or rapid snowmelt and rain on snow in the Pacific Northwest (Zuzel et al., 1983).[2] Information concerning tillage influences on soil frost formation is lacking because of the difficulty of the research involved and the multitude of soil parameters affected. This research evaluates the effects of surface crop residues and tillage practices on overwinter soil temperatures and soil frost penetration.

MATERIALS AND METHODS

This study was conducted on a Walla Walla silt loam at the Columbia Plateau Conservation Research Center near Pendleton. Field plot measurements on six different tillage practices were taken during a two-month period beginning December 1, 1982. For illustrative purposes, this report will restrict its comparison to a fall-plow (conventional) and a no-till (conservation) treatment. The conventionally tilled system consisted of fall moldboard plowing and spring disking followed by two rod weeder operations before seeding in the fall. The conservation tillage system was chemically fallowed with Glyphosate and wheat was no-till seeded directly into standing stubble. Both plots were seeded the second week in October using a John Deere HZ deep furrow drill with 16-inch row spacing. Stephens winter wheat was seeded at 80 pounds per acre. Surface residue amounts after planting were 78 pounds per acre for the fall-plow treatment (conventional tillage) and 5,500 pounds per acre for the no-till treatment (conservation tillage).

Field instrumentation included shielded copper-constantan thermocouples at 1, 4, and 8-inch depths for measuring soil temperature. In each plot duplicate frost tubes were used to determine soil frost depth. These frost tube measurements were verified by hand sampling during soil freeze periods. Soil temperature and frost depth measurements were taken daily at 8 a.m.

RESULTS AND DISCUSSION

Three freeze-thaw cycles were observed during the two-month study. However, significant frost penetration occurred only during December 27

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through January 6. The average 8 a.m. air temperature during this time was 24°F. There was no snow cover.

Soil frost developed in the fall-plow treatment three days earlier and remained two days longer than in the no-till treatment (Figure 1). Maximum penetration of soil frost was three times as great on the fall-plow plot compared to the no-till plot. A comparison of soil temperatures for the two tillage treatments at each depth is shown in Figure 2.

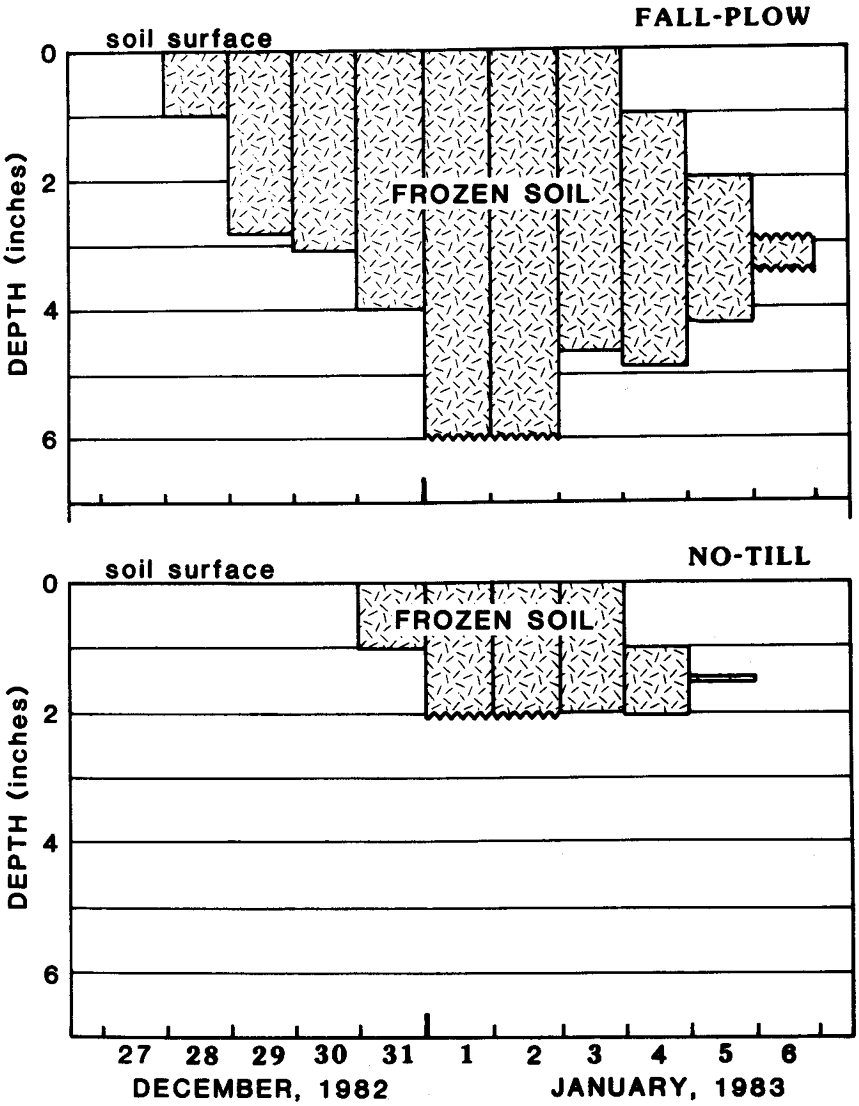

Figure 1. Depth of soil frost penetration in fall-plow and no-till plots from Dec. 27, 1982 to Jan. 6, 1983.

All values shown in Figure 2 below the solid horizontal line indicate frozen soil. Throughout the two-month period, soil temperatures in the fall-plow treatment were from 2 to 5°F lower than in the no-till treatment.

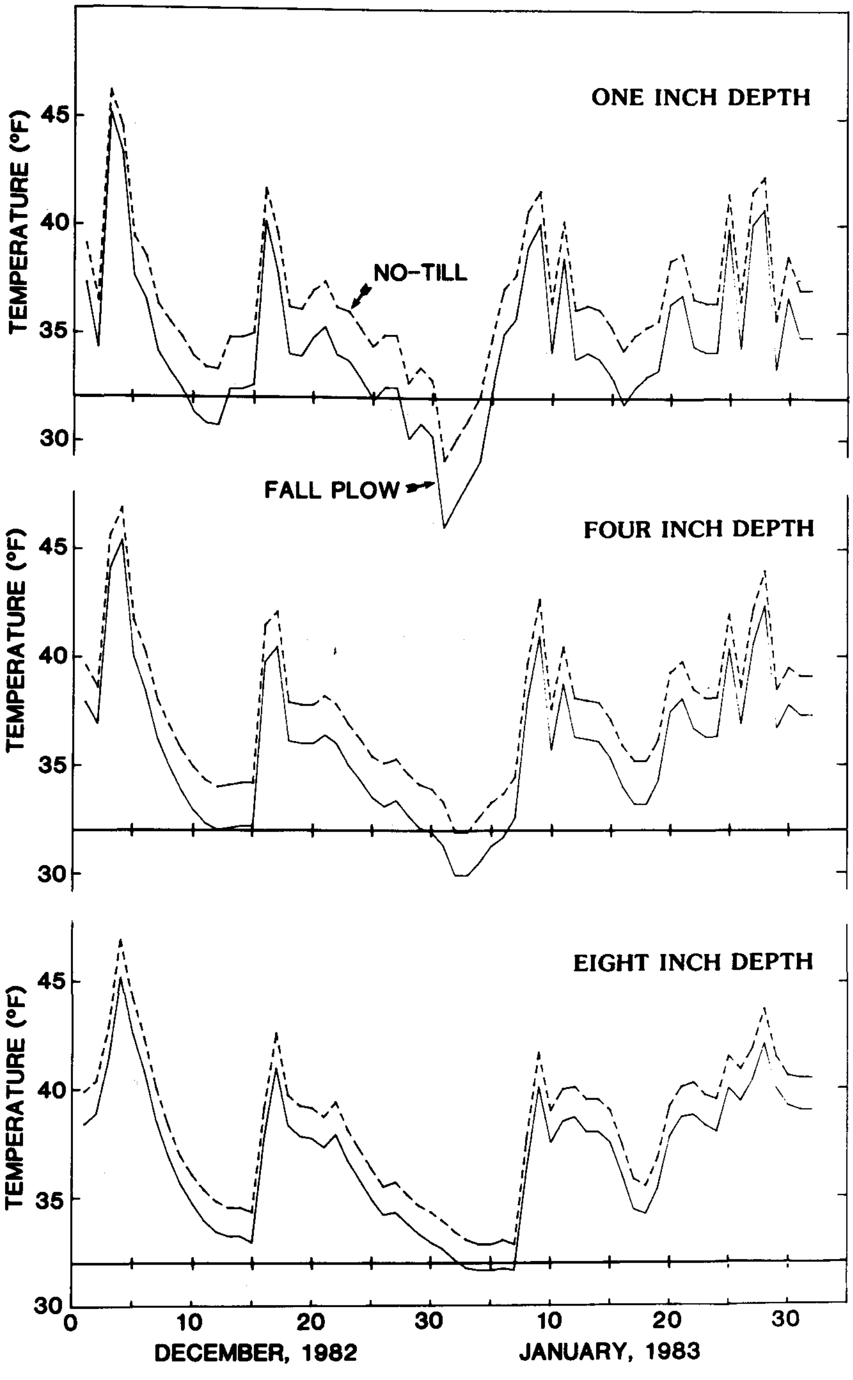

Figure 2. Comparison of soil temperatures between the fall-plow and no-till treatments at 1, 4, and 8-inch depths.

CONCLUSIONS

Soil frost penetration was significantly greater in the fall-plowed than in the no-tilled winter wheat plots because surface residues in the no-till treatment acted as a thermal insulator creating warmer soil temperatures when compared to the bare soil surface of the fall plow plot. Frost penetration was three times greater in depth and frozen soil layers were present twice as long in the conventional tillage system as compared to the conservation tillage system. Because infiltration rates can be greatly reduced when frozen soil layers are present, nearly all precipitation on frozen soil runs off or evaporates. Those tillage management techniques which leave adequate crop residues on the surface should be considered as a means to reduce or eliminate soil losses caused by soil erosion.

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[2] Zuzel, John F., R. R. Allmaras, and R. Greenwalt. 1983. Runoff and soil erosion on frozen soils in northeastern Oregon. Journal Soil and Water Conservation 37(6):351-354.

NO-TILL ANNUAL CROPPING

Robert E. Ramig and Les Ekin[1]

Summer fallow has been practiced in semiarid and subhumid regions for many years to control weeds, release nitrogen from soil organic matter, and store water to insure stable crop production. Now we can supply plant nutrients with commercial fertilizers and control weeds with new herbicides to eliminate tillage that causes water loss by evaporation. Crop residues can now remain on the soil surface to enhance water conservation and control soil erosion.

The objectives of this report are: (1) to discuss the feasibility of no-till annual cropping and, (2) present preliminary results using the system. No-till is defined as a procedure whereby a crop is planted directly into a seedbed not tilled since harvest of the previous crop.

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No-till cropping lowers the cost of production by saving fuel, time, labor, and wear on machinery, but there are additional costs for herbicides used in place of tillage. Production can be increased by growing a crop every year instead of in alternate years. Under irrigation, more than one crop a year is possible; double or triple cropping depends on the lengths of the crop-growing period and the growing season.

No-till annual cropping should be considered where soils are shallow (less than three feet in depth) and rainfall during the first winter after harvest is sufficient to fill the soil profile with water. Soils on about 60 percent of the cropland in the Columbia Plateau and Palouse and Nez Perce Prairies of eastern Oregon and Washington are less than three feet in depth.

Successful no-till annual cropping requires careful residue management, excellent weed control, proper seeding and fertilization, and crop rotation. Residues should be uniformly spread at harvest so they will not interfere with uniform herbicide application, fertilization, and clearance by no-till drills. It is easier to seed through anchored upright straw than through loose or flat straw. Well-designed drills with adequate vertical, lateral, and fore and aft clearance of the openers function satisfactorily in crop residues up to about 5,000 pounds per acre on the surface when soil moisture conditions are optimum for seeding. A yield of 50 bushels per acre will produce about 5,000 pounds of residue per acre. When the quantity of crop residues on the surface exceeds this level, some residue reduction or removal is suggested. The method of reduction should be chosen to avoid large quantities of loosened stubble on the surface.

Good weed control is essential for successful no-till annual cropping -- consult your county agent or ag consultant for proper herbicide usage. Proper seed and fertilizer placement are also important in no-till annual cropping. Seed should be in firm contact with moist soil at a depth that permits good germination and emergence. Seeding depth varies with crop variety, soil moisture and temperature, and season of the year, but typically ranges between one and three inches. Fertilizers should be placed in a band from one to two inches below the seed or below and to the side of the seed for best results. Some phosphorus-limited quantities of nitrogen and sulfur fertilizers can be placed with the seed without damage to germination and emergence. Amounts tolerated safely depend on soil moisture in the seed zone, crop variety, kind of fertilizer, and timing and quantity of rain after seeding. Generally, most crops will tolerate only about 20 pounds of phosphorus (45 pounds P_2O_5) and 15 to 20 pounds of nitrogen per acre placed with the seed in relatively dry soil.

Fertilizer placement near the seed is more advantageous to spring-seeded grains than fall-seeded grains because the seedbed is often cold and wet and the growing season short. Fertilizer placement near the seed results in early availability and efficient use of the nutrients by the crop, and not by weeds germinating near the soil surface or microorganisms decomposing crop residues on or near the soil surface.

Soil tests are not well calibrated for no-till annual cropping under non-irrigated agriculture. Preliminary recommendations when changing from the fallow-cereal system to no-till annual cropping are to apply 50 to 70 percent more nitrogen to each crop in the no-till system than the amount applied in the fallow system. Starter quantities of both phosphorus (10 to 20 pounds per acre) and sulfur (10 to 15 pounds per acre) should be applied with spring seedings of cereals.

In a low rainfall area, both winter and spring wheat produced similar yields following wheat, regardless of tillage before seeding (Table 1). To kill weeds and volunteer grain, all treatments were sprayed with glyphosate before seeding either fall or spring seeded cereals. Evaporation to water from the seed zone was reduced by not tilling before seeding. It was concluded that properly applied herbicides can replace seedbed tillage and, therefore, conserve water for crop production without decreasing yield.

Table 1. Tillage effects on yield of wheat following wheat or wheat following fallow, Echo, Ore., 1977-81, Ritzville silt loam

Year	Variety[1]	Crop year ppt.[2] inches	Grain yields for indicated tillage before seeding wheat after wheat			Wheat after fallow
			No-till	Fall disk	Fall chisel	
			- - - - - - - bu/A[3] - - - - - -			
1977	Hyslop	6.4	0	0	0	16
1978	Hyslop	13.9	35	27	27	56
1979	Fielder	11.3	24	20	26	24
1980	Stephens	11.6	36	31	38	48
1981	Stephens	11.3	47	47	49	77
Average		10.9	28	25	28	44

[1]Hyslop and Stephens are winter wheats and were seeded in late November or December. Fielder is a spring wheat seeded in March.

[2]Crop year precipitation is measured from September 1 through August 31.

[3]Average of 3 rates of nitrogen fertilizer (25, 50, and 75 lbs N/acre) broadcast on the surface before seeding. There were no differences in yield among nitrogen rates.

The 1977-81 average yield of no-till wheat after wheat was 64 percent of the yield of wheat after fallow on a Ritzville silt loam in a 10.9-inch annual precipitation zone (Table 1). The average two-year production of wheat after wheat was 127 percent of that for a wheat/fallow rotation. In very dry years, such as in 1977, wheat after wheat produced no harvestable grain. Alternate fallow-wheat cropping is still the recommended system for deep soils in a low rainfall area.

Similar data for McKay silt loam soil in a 19.4-inch annual precipitation zone are presented in Table 2. McKay silt loam is a shallow soil (20 to 40 inches) that is recharged with water every winter. Yields of wheat after wheat were again similar regardless of tillage before seeding. Winter wheat was not seeded in 1979 and 1981 because of a late dry autumn in 1978

Table 2. Tillage effects on the yield of wheat following wheat or wheat following fallow, Pilot Rock, Ore., 1978-81, McKay silt loam

Year	Variety[1]	Crop year ppt.[2] inches	Grain yields for indicated tillage before seeding wheat after wheat: No-till	Fall disk	Fall chisel	Wheat after fallow
			------ bu/A[3] ------			
1978	Hyslop	21.2	26	28	27	48
1979	Fielder	17.2	36	34	37	35[4]
1980	Stephens	19.7	58	58	58	64
1981	Dirkwin	19.3	29	32	31	60[4]
Average		19.4	37	38	38	52

[1]Hyslop and Stephens are winter wheats seeded in November. Fielder and Dirkwin are spring wheats seeded in late March.

[2]Crop year precipitation is measured from September 1 through August 31.

[3]Yields of wheat after wheat are the average of 3 rates of nitrogen fertilizer (25, 50, and 75 pounds N/acre) broadcast on the surface before seeding. There were no differences in yield among nitrogen rates. Wheat after fallow was fertilized with 50 pounds of nitrogen per acre injected in the fallow as ammonia.

[4]Stephens winter wheat on fallow.

and persistent rains in 1980 that prevented satisfactory seeding. Recropped spring wheat yielded as well as winter wheat after fallow in 1979 but only half as much in 1981. In the two years that winter wheat was seeded (1978, 1980), the yield of no-till winter wheat after wheat was 75 percent of the yield of winter wheat after fallow. In this rainfall zone, the total production of no-till winter wheat after wheat was 150 percent of the production of winter wheat after fallow. Annual no-till cropping on the shallow McKay soil in this rainfall zone is a viable option.

Grain yield progressively increased with increasing amounts of applied nitrogen when banded with phosphorus and sulfur below the seed (Table 3). Stephens winter wheat annually cropped after wheat and fertilized with 50 pounds of nitrogen (plus phosphorus and sulfur) banded below the seed yielded 43 bushels per acre. Stephens wheat grown after fallow and fertilized with 50 pounds of nitrogen (plus some sulfur) yielded 50 bushels per acre. No-till recrop winter wheat yielded 86 percent of wheat after fallow, and the two-year production for no-till recrop wheat was 172 percent of that for wheat after fallow. The superior yielding ability of winter varieties of wheat and barley compared to spring varieties is obvious in Table 3.

Table 3. Yields of no-till annual cropped wheat and barley band fertilized with different rates of nitrogen, Pilot Rock, Ore., 1982, McKay silt loam (crop year precipitation was 19.9 inches)

Crop type	Variety	Fertilizer - lbs N-P-S/acre[1] 50-10-10	75-10-10	100-10-10
			Bushels/A	
Winter wheat	Stephens	43[2]	50	54
Spring wheat	Dirkwin	30	38	41
			Pounds/A	
Winter barley	Kamiak	2366	3374	3730
Spring barley	Steptoe	1699	1944	2275

[1] Banded 1 inch below the seed.

[2] Yield of Stephens winter wheat after fallow was 50 bushels per acre. This wheat after fallow was fertilized with 50 pounds of nitrogen plus sulfur per acre.

Preliminary results suggest that no-till annual cropping of cereals is a viable option where soils are shallow and overwinter precipitation is sufficient to fill the soil profile. Banding nitrogen (at rates 50 to 70 percent larger than those usually used on wheat after fallow) plus 10 to 15 pounds each of phosphorus and sulfur one to two inches below the seed when seeding have given good response, especially for spring cereals. A complete no-till system or a no-till option when winter rainfall is non limiting is an otherwise conventional tillage system should both be considered. Either alternative encourages the use of residues on the surface to enhance water conservation and reduce soil erosion. On some of our shallow soils in Oregon erosion control now assures continued production.

USING AIR TEMPERATURE TO ANTICIPATE WHEAT CROP DEVELOPMENT

R. W. Rickman and B. L. Klepper[1]

INTRODUCTION

Many of the new herbicides must be applied at specific stages of development of a wheat crop to do maximum damage to weeds and minimum damage to the crop. Ongoing records of crop development during a season can be helpful for determining the onset and intensity of plant stress conditions in a field. The ability to anticipate the stage of development of a crop several weeks before that growth stage occurs would simplify scheduling field operations and evaluating management practices. Our objective is to explain what observations and weather information individuals may collect to anticipate plant development in their own fields. We also will explain how to calculate growing degree days and predict crop development stages for planning field work and recognizing plant stress situations. Although the development of a crop can be projected to the stage of heading in some situations, this article will concentrate only on the early development of the plant, from emergence through tillering to flag leaf appearance.

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MATERIALS AND METHODS

During the 1980-81, 1981-82, and 1982-83 crop years, Stephens winter wheat was planted in mid-October into a fallow seedbed with very little surface residues on a Walla Walla silt loam at the Columbia Plateau Conservation Research Center. Planting dates are provided in Table 1. Each seedbed was fertilized with approximately 70 pounds of nitrogen per acre. Plant growth stage was observed periodically each year as the number of leaves on the main stem of the plant (Klepper et al., 1982). Temperature records for growing degree day calculations were either collected daily at the field site or from the weather station on the research station.

Table 1. Expected and observed accumulated growing degree days with a 3 degree C base for particular growth stages

Planting date	Accumulated growing degree days		
	expected	observed	difference
	- - - - - - -Planting to emergence - - - - - - - -		
Oct. 7, 1980	100	88	-12
Oct. 16, 1981	100	105	+ 5
Oct. 22, 1982	100	86	-14
	- - - - - -Planting to 3 full leaves- - - - - -		
Oct. 7, 1980	265	235	-30
Oct. 16, 1981	265	263	- 2
Oct. 22, 1982	265	243	-22
	- - - - - -Emergence to 3 full leaves- - - - -		
Oct. 7, 1980	165	147	-18
Oct. 16, 1981	165	158	- 7
Oct. 22, 1982	165	158	- 7

RESULTS AND DISCUSSION

The temperature of a plant (with adequate water, light, and nutrients) controls both the rate of growth and rate of development. Development or stage of growth is measured by the appearance of successive leaves on the main stem of the plant. Growth, which is different from development, determines the size and weight of each leaf. Development of a plant is much more uniformly related to temperature than is growth. Because the temperature of a plant is determined by its environment, a measure of the temperature of that environment should be a useful predictor of plant development. For closest measurement and prediction, the temperature at the growing point of the plant is the temperature of interest. The growing point is in the meristem within the crown. Field measurements of actual crown temperatures and soil temperatures adjacent to the crown revealed no difference between the two. Soil temperature at crown depth is, therefore, a good predictor of plant development.

To utilize a predicting relationship over a large area, the required input or measured information must be easily available. Unfortunately, soil temperature at crown depth is not routinely available from any weather records. Average soil temperature and average air temperature, are, however, closely related. Since air temperature is easily observed and routinely collected at many locations, it can be used as a substitute temperature for estimating leaf development. Growing degree days, calculated using air temperatures, can indeed be related to wheat plant development (Klepper et al., 1982; Rickman et al., 1983).

Growing degree days can be computed for each day with Formulas 1, 2, and 3. First, convert Fahrenheit (F) temperature to Centigrade (C) with Formula 1.

1. $\text{Temperature (in degrees C)} = \frac{5}{9}\,[\text{Temperature (in degrees F)} - 32]$

Second, calculate average daily temperature with Formula 2.

2. Average temperature (in degrees C) = $\frac{\text{Maximum temperature} + \text{Minimum temperature}}{2}$ (both in degrees C)

Third, calculate growing degree days with Formula 3.

3. Growing degree days = Average temperature (in degrees C) - Base temperature.

4. Base temperature = 3 degrees C.

If the value from Formula 3 is negative (if average air temperature is lower than 3 degrees C), growing degree days are set equal to zero. Growing degree days are never subtracted from an accumulating total.

The base temperature can be different than 3 for different crops or different varieties. Corn, for example, has a higher base temperature than wheat and watermelons have an even higher one. For wheat, a range of base temperatures between 0 and 3 degrees C seems to include most commercial varieties. Unfortunately, a convenient tabulation of exact base temperature values for many varieties is not yet available. The base of 3 degrees C has worked satisfactorily for most varieties we have examined near Pendleton.

It is very important to note that when recomputing growing degree days to a new base, temperature each day must be recomputed and a new total found by adding up all of the recomputed daily values. Rule of thumb degree day totals for timing plant development will have different values if a different base temperature is used. For example, emergence is expected after accumulation of 100 degree days with a 3 degree C base. If a 0 degree base is used for degree day computation, emergence is expected after accumulation of about 190 base zero degree days.

Largest differences between average soil temperature and average air temperature occur in the spring and fall when daily air temperature changes rapidly. During such times, a careful observer may be able to detect more or less development than anticipated. Greater differences can be expected where soils contain heavy amounts of residue on the surface, which act as an insulator to slow both heating and cooling of the soil. However, on a month to month basis, development of a wheat crop should be very closely related to the total air growing degree days from planting. Patterns of growing degree days characteristic of some variety test sites in northeast Oregon are presented by Crampton[2] in this publication.

Table 2 illustrates a worksheet that can be used to record air temperature and compute growing degree days which can be plotted for specific fields as shown by Crampton[2]. A common time for recording temperature is early in the morning. For example, the weather observations at the Columbia Plateau Conservation Research Center are recorded at 8 a.m. each day. Readings from a max-min thermometer would be recorded in columns (a) and (b), respectively, of Table 2 for each date. Table 3 provides an example of a completed weather record sheet for February 1983 for the Research Station.

Figure 1 provides the relationship between growing degree days with base temperature 3 degrees C and the average number of leaves on the main stem of Stephens winter wheat. Table 1 provides a comparison of expected and observed development. The approximate 100 growing degree days accumulated from planting to emergence is only 7 percent higher than the average of the values for the three years shown. The time interval between the appearance of each leaf on the plant is approximately 55 growing degree days. The leaf development curve in Figure 1 shows one leaf appearing for every 54 growing degree days. If leaf development can be timed from 50 percent emergence rather than planting date, a slightly better estimate of growth stage can be obtained. The three-leaf stage is the beginning of tillering. Tillering will continue

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[2]See article on page 37 of this Research Report.

Table 2. Weather data collection sheet

(location) (month, year)

Air temperature and growing degree days

Date	Air temp. ( )* of past 24 hrs.** (a) max.	(b) min.	current	(c) ave.	Growing degree days (d) daily	(e) total	Rain inches	Plant development	Notes
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
Total									

Calculation instructions: [letters (a) through (e) represent the numbers of the columns on the weather record sheet]

For Fahrenheit temperatures in (a) and (b):

(c) = 1/2 [(a) + (b)]

(Centigrade temperature) = 5/9 [(c) - 32]

(d) = (Centigrade temperature) - 3

(d) = 0 if (Centigrade temperature) is below 3

For Centigrade temperatures in (a) and (b):

(c) = 1/2 [(a) + (b)]

(d) = (c) - 3

(d) = 0 if (c) is below 3

(e) is the total of the values in (d) for all days since planting

* temperature scale used (F for Fahrenheit, C for Centigrade)

** time of day when observations are normally recorded

Table 3. Weather data collection sheet completed for February 1983 at the Columbia Basin Research Center

Columbia Basin Research Center (location) February 1983 (month, year)

Air temperature and growing degree days

Date	Air temp. (_)* of past 24 hrs.** (a) max.	(b) min.	current	(c) ave.	Growing degree days (d) daily	(e) total	Rain inches	Plant development	Notes
1	44	30	32	37	0	222	.01		
2	41	29	29	35	0				
3	45	24	25	34.5	0				
4	43	19	21	31	0				
5	40	21	21	30.5	0				
6	42	22	40	32	0		.04		
7	46	31	35	38.5	0.6	223	.21	2.7 leaves	occasional TO
8	46	34	35	40	1.4	224	.04		⑥ ☆! Rabbit in plots
9	45	32	40	38.5	0.6	225	.61		
10	52	33	74	42.5	2.8	227	.03		
11	54	44	48	49	6.4	234	.05		
12	59	48	55	53.5	8.9	243			
13	61	38	41	49.5	6.7	249	.05		
14	53	32	36	42.5	2.6	252	.06		
15	54	33	37	43.5	3.4	255	.15		
16	53	36	38	44.5	3.9	259	.29		
17	55	38	46	46.5	5.1	264	.21		
18	57	44	44	50.5	7.3	271	.51	3.4	T1 out on most plants
19	45	35	36	40	1.4	272	.24		only 1/3 with TO
20	55	36	48	45.5	4.5	277	.04		several weeds 1/2" across
21	57	42	44	49.5	6.7	284			seems to be warming
22	59	44	49	51.5	7.8	292	.11		sooner than normal
23	64	48	55	56	10.3	302	.07		
24	64	38	38	51	7.6	310			
25	54	33	39	43.5	3.4	313	.02	4.4	T2 out on most
26	58	36	38	47	5.3	318	.04		same T3, only 1/3 or
27	56	33	47	44.5	3.9	323			less with TO
28	55	37	39	46	4.8	328	.19		some weeds 3" across
29									Get Spraying Out!!
30									
31									
Total					105.4		2.97		

Calculation instructions: [letters (a) through (e) represent the numbers of the columns on the weather record sheet]

For Fahrenheit temperatures in (a) and (b):

(c) = 1/2 [(a) + (b)]

(Centigrade temperature) = 5/9 [(c) - 32]

(d) = (Centigrade temperature) - 3

(d) = 0 if (Centigrade temperature) is below 3

For Centigrade temperatures in (a) and (b):

(c) = 1/2 [(a) + (b)]

(d) = (c) - 3

(d) = 0 if (c) is below 3

(e) is the total of the values in (d) for all days since planting

* temperature scale used (F for Fahrenheit, C for Centigrade)

** time of day when observations are normally recorded is 8:00 A.M.

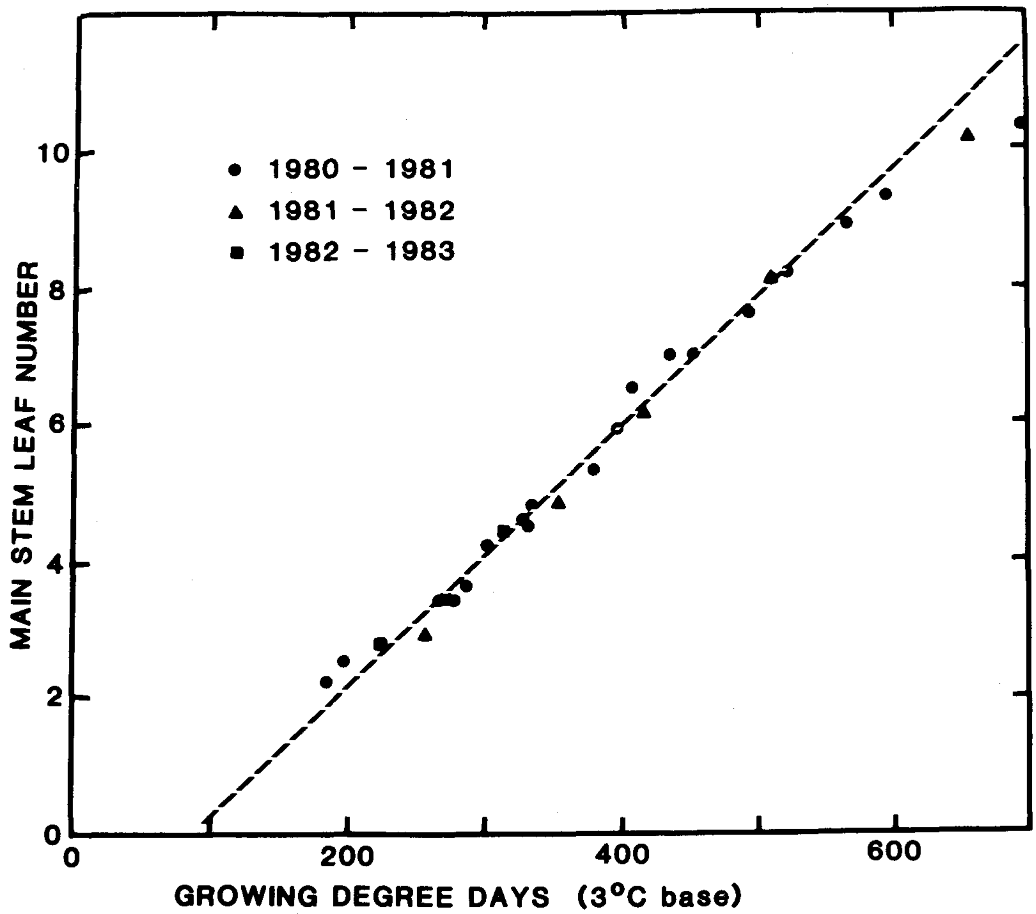

Figure 1. Leaf development in Stephens winter wheat during three different seasons.

according to the pattern described by Klepper et al. (1982) until the heading process is well underway or nutrient deficiency interferes. Head formation occurs between late February and late March in the Pendleton area.

To obtain an estimate of growing degree days expected at any time in the future, historic average temperatures can be used to provide the relationship shown in Figure 2. Figure 2 illustrates the pattern of accumulation of growing degree days with a 3 degree C base using five-year average air temperatures for the Columbia Basin Research Center. Crampton[2] provides historic growing degree day patterns for several other sites in northeast Oregon. Between March 1 and March 15, 50 degree days are expected. Between March 1 and April 1, 115 growing degree days are expected. Wheat plants growing under such conditions would be expected to develop one additional leaf on the main stem between March 1 and March 15 or two additional leaves between March 1 and April 1.

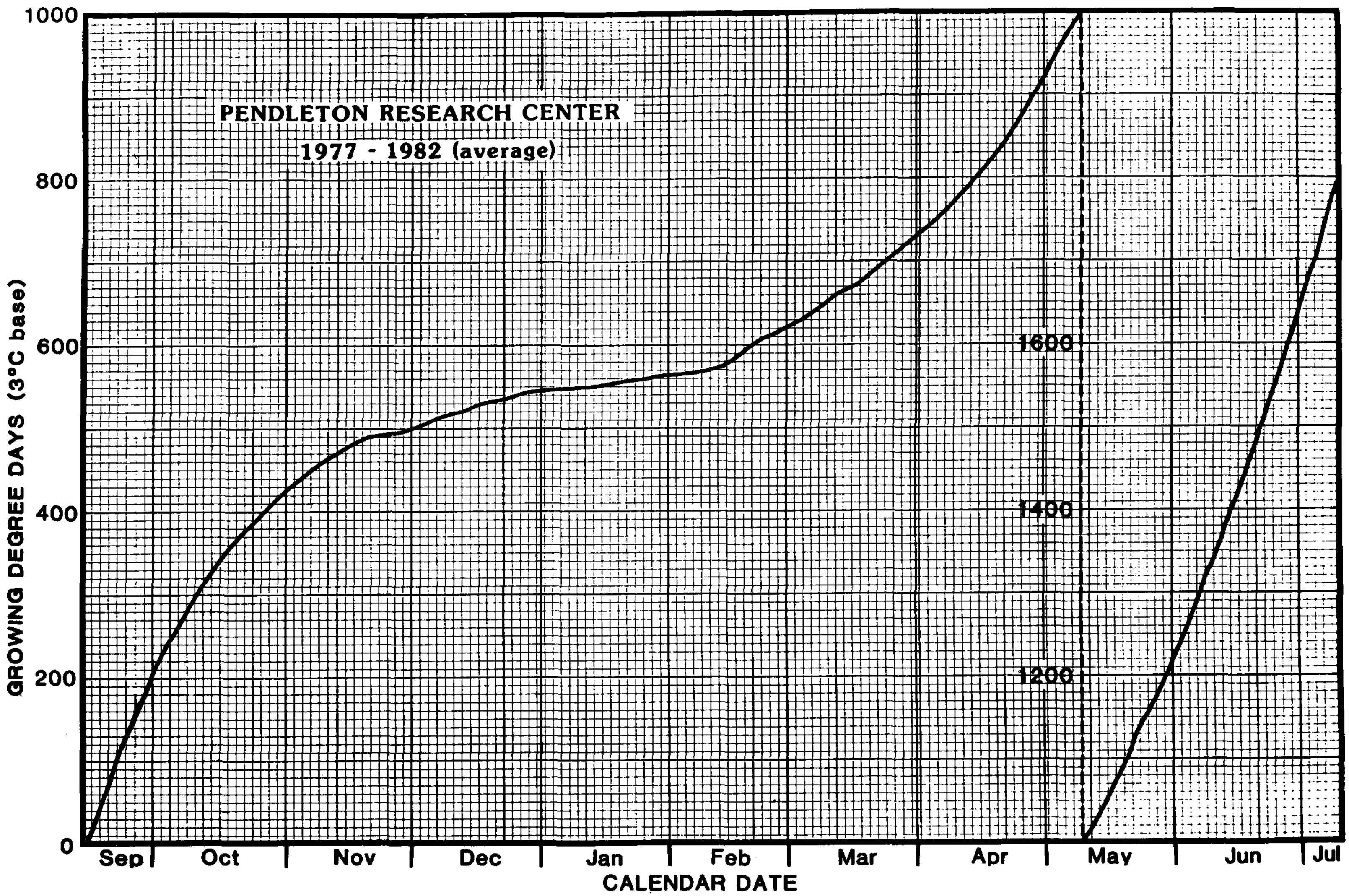

Figure 2. Growing degree days (3 C base) averaged for the 6 years 1977 to 1982 for the Columbia Basin Agricultural Research Center.

Crown or nodal roots will begin forming at the same time tillering begins and new roots will continue to form at regular intervals from nodes in the crown until dry surface soil prevents their elongation (Klepper et al., 1983). Nutrient or energy supply deficiencies brought about by crowding, insufficient fertilizer, poor seedlot, bad seedbed conditions, or any combination of these conditions can cause plants to skip the formation of any tiller (Peterson et al., 1982). By knowing how many mainstem leaves are present, the number of tillers and the number of leaves that should be present on each tiller can be easily found. Deviations from the expected number and development of tillers are a direct measure of the quality of the field environment as determined by the wheat plant itself.

SUMMARY

Records of maximum and minimum air temperature for each day of the growing season of a crop can be expressed as growing degree days. Growing degree days are used to illustrate the seasonal weather pattern, project crop development, aid in scheduling of field operations, and help in the evaluation of abnormal plant development brought about by plant stresses. Three years of plant and weather observations at the Columbia Plateau Conservation Research Center show that 50 percent emergence can be expected between 85 and 100 growing degree days (with a 3 degree C base) after planting. One leaf will develop on the main stem and on every tiller present for every 55 growing degree days after emergence. Growing degree day estimates based on historic temperature records provide a method to anticipate future plant development. The three-leaf stage of growth (fourth leaf just visible) marks the beginning of tillering and the beginning of crown root formation. A plant will naturally stop tillering as head formation proceeds but skipping tillers before that stage of development is a symptom of some stress affecting the plant which could be cutting yield.

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WINTER WHEAT TRIALS
A CASE STUDY USING DEGREE DAYS

C. R. Crampton, B. L. Klepper, and R. W. Rickman[1]

INTRODUCTION

Winter wheat variety trials are grown at approximately 17 locations in northcentral and northeastern Oregon and are reported each year in the Columbia Basin Agricultural Research Center field day reports. Some of these trials have been conducted for nearly 30 years and are planned to be continued for many years in the future. The information obtained from these trials is useful to growers in selecting the best adapted varieties for their farms and to plant breeders in evaluating their plant materials.

To make maximum use of the information, growers should know what the nursery site has in common with their farms and how the data might apply to their farms. Weather patterns, south- or north-facing slopes, deep or shallow soils, high or low organic matter, and field management techniques are used. To make the trials more valuable to growers who use these nurseries for selecting varieties, more information needs to be obtained for each nursery. The work described here is a preliminary study of one aspect of nursery site information - degree days.

This report will (1) compare degree days for five weather station locations and (2) use degree days as a model in predicting stage of growth with five varieties of winter wheat at three nursery locations.

MATERIALS AND METHOD

Weather information was obtained from U.S. Weather Service records of five weather stations in Gilliam and Umatilla counties. Table 1 gives the location of the stations and the distance to the nearest winter wheat outlying nursery.

Five years' daily maximum and minimum air temperatures from September 1 to July 31 for each year from 1978 to 1982 for all the locations listed in Table 1 were reduced to degree days using the formula:

$$\left(\frac{\text{maximum} + \text{minimum}}{2}\right) - 3^{o}C$$

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Table 1. Five weather station locations and relationship to the nearest nursery

Location	Elevation	Latitude	Longitude	Nearest nursery	Distance to nursery	Difference in elevation to nursery
	(feet)				(miles)	(feet)
Arlington	285	45° 43'	120° 12'	Shuttler Flat	14.2	+855
Condon	2830	45° 14'	120° 11'	Condon	4.6	-150
Hermiston	624	45° 49'	119° 17'	Hermiston	0.2	-10
Mikkalo	1550	45° 28'	120° 21'	Shuttler Flat	10.0	-410
Pendleton	1492	45° 41'	118° 51'	Holdman	11.0	+88

where maximum and minimum are the daily air temperatures and 3°C is the base temperature. An average sum of degree days was then obtained for each month for the five-year period. Figure 1 shows the continuously increasing sum of degree days for each of the five sites as a five-year average.

The three nursery locations and five varieties selected for plant evaluation are listed in Table 2 and 3, respectively. Included in Table 2 are the dates of planting and dates of observation.

Wheat plant development was described and evaluated by a method developed at the Columbia Plateau Conservation Research Center (2). The 1981, 1982, and 1983 Research Reports for the Columbia Basin Agricultural Research Center (1, 3, 4) cover different aspects and uses of this technique.

Briefly, each plant in at least two half-meter lengths of row was assigned a value representing its stage of growth which was measured by counting the number of leaves on the main stem. Each leaf was assigned a number in the order of its appearance. Tillers were assigned numbers according to which leaf axil they originated from. Stage of growth was measured at the three locations for the five varieties. Estimations of stage of growth were made for the different locations using weather data obtained for the 1982-1983 crop year.

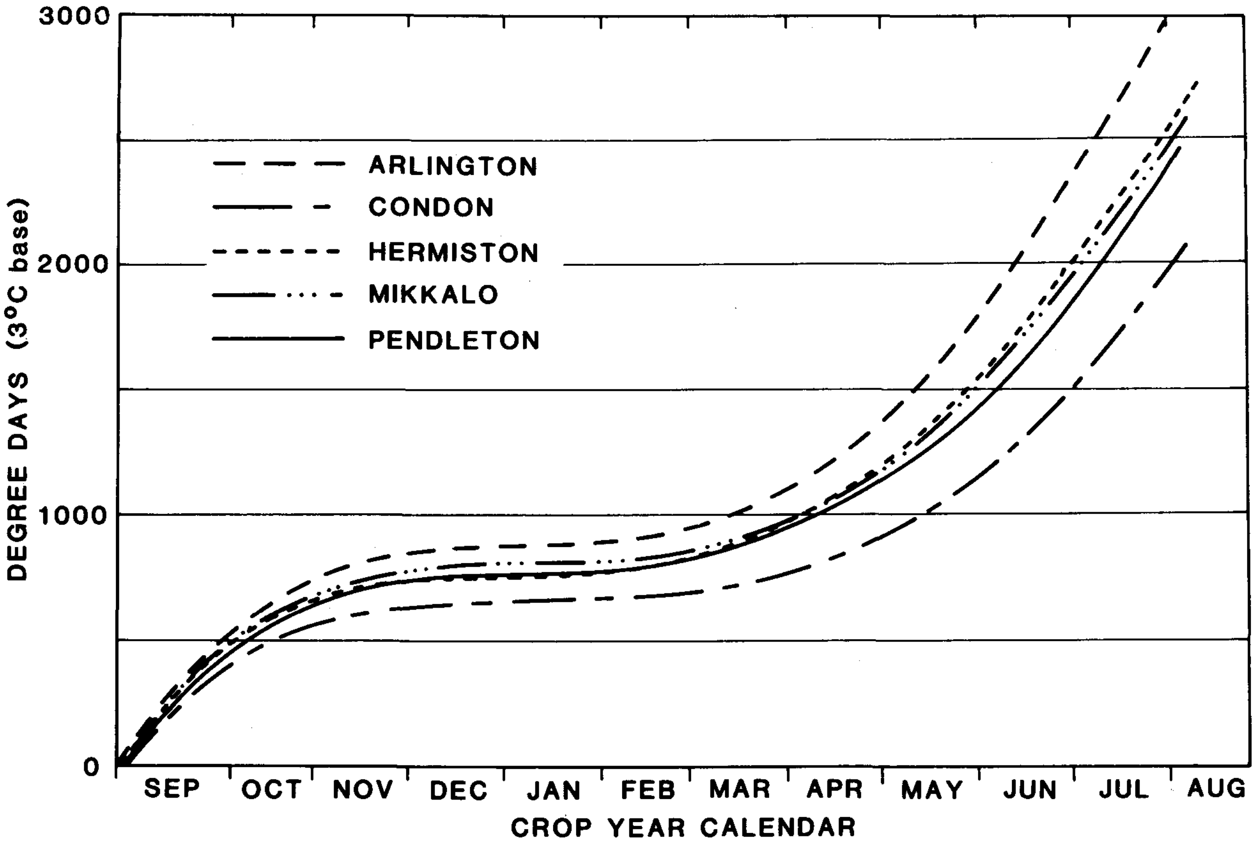

Figure 1. Five year average accumulative degree days.

Table 2. Nursery site descriptions and dates of planting and observation for three variety trials in northeastern Oregon

Location	Elevation	Latitude	Longitude	Planting date	Observation date
	(feet)			(1982)	(1983)
Marion Weatherford Farm (Shuttler Flat)	1140	45° 34'	120° 10'	Oct. 18	Jan. 5
Charles Dallas Farm (Near Holdman)	1580	45 48'	118° 47'	Oct. 5	Jan. 3
Hermiston Experiment Station	614	45° 47'	119° 17'	Oct. 14	Jan. 3

Table 3. Characteristics of five varieties of winter wheats grown in variety trials in northeastern Oregon

Variety	Head type	Kernel type
Stephens	Common	White
Hill 81	Common	White
Kharkof	Common	Red
TSN-B-2	Common	Red
Faro	Club	White

RESULTS AND DISCUSSION

Average accumulative degree days for five weather stations are plotted in Figure 1. All locations show little accumulation of degree days from the middle of November to the first of April. By the first of December there was already a spread of more than 100 degree days between these locations. Of the five shown, Condon is the lowest in cumulative degree days. Notice from Table 1 that Mikkalo is approximately in the middle latitude between Arlington and Condon. Also Mikkalo is 1,280 feet lower than Condon and 1,265 feet above Arlington. The cumulative degree days of Mikkalo are more like Arlington than Condon. Arlington, in the Columbia Gorge, is influenced by the more moderate coastal weather which blows up the gorge. Apparently Mikkalo is influenced more by this moderate weather than by its elevation.

Table 4 shows plant development as expressed by the number of main stem leaves and percent appearance of individual tillers. Assuming 100 degree days for emergence, and 60 degree days per leaf (see Rickman and Klepper, on page 28 of this research report), we would expect 3.2 leaves at Holdman which had accumulated 294 degree days from planting to observation date. We used weather data obtained at the Columbia Basin Agricultural Research Center. The average observed value was 2.9, or slightly less than predicted. However, the percent appearance of the T0 tiller at Holdman was low, possibly indicating a poor seedbed condition. At Shuttler Flat, the average observed value was 1.5 and the predicted value would be 1.4 using the Arlington weather station data of 185 degree days for this crop year. However, using data from the Mikkalo weather station, which is four miles closer, the predicted value would be only 0.4 leaves. For Hermiston, using this crop year weather data from the Hermiston weather station, 199 degree days would predict a value of 1.7 leaves while the observed average value was 2.8.

Table 4. Winter wheat plant development in three outlying nurseries

Variety	Main stem leaves	Percent appearance T_0	T_1
Holdman			
Kharkof	3.1	3	56
Hill 81	2.9	0	46
Faro	2.9	3	38
TSN-B-2	2.8	9	48
Stephens	2.7	0	37
Mean	2.9 ± 0.2	3	45
Shuttler Flat			
Kharkof	1.7	0	0
TSN-B-2	1.6	0	0
Stephens	1.5	0	0
Hill 81	1.4	0	0
Faro	1.2	0	0
Mean	1.5 ± 0.2	0	0
Hermiston			
Kharkof	2.9	37	42
Stephens	2.8	5	25
TSN-B-2	2.8	41	51
Hill 81	2.7	0	13
Faro	2.7	3	5
Mean	2.8 ± 0.1	17	27

CONCLUSION

There is a wide range of cumulative degree days between sites as indicated by the different weather station data. Degree days will be a useful tool in comparing nursery locations and variety performance at the different sites. However, data from existing weather stations will not be applicable to some nursery locations, and without better characterization of the soils and weather of the nursery sites such comparisons of degree days are not as useful as they might be. For example, why was there such a discrepancy between the observed and predicted value of plant growth stage at Hermiston? Since the emergence and development predictions are based on studies done at the Columbia Plateau Conservation Research Center, there possibly may be a need to modify the prediction model according to the different soils and climate conditions of Hermiston. Although there appears to be little difference in variety response to degree days at any nursery location, there was a response to an apparent stress period at Holdman. Possibly this stress was caused by a soil moisture condition. A critical requirement for improving our understanding of variety performance at these outlying nurseries would be the installation of equipment for collecting weather data on-site.

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EFFECT OF NITROGEN, PHOSPHORUS, AND PLANTING DATE ON PLANT GROWTH AND DEVELOPMENT, WATER UPTAKE, AND WATER STRESS IN DRYLAND WHEAT PRODUCTION

Raul Agamennoni and F. E. Bolton[1]

INTRODUCTION

Dryland winter wheat in eastern Oregon is usually subjected to water stress several times during the growing season. The level of fertility, stage of growth, availability of soil moisture, and climatic conditions all interact to determine the severity of the crop water stress. The level of nitrogen and phosphorous fertility in the growing wheat crop affects the plant growth and development, water uptake, and the incidence and severity of water stress. To gain a better understanding of the complex interactions leading to water stress in the wheat crop, a means of determining when and how long the stress occurs is needed. The experiment described below is one of a series of trials conducted to develop a Crop Water Stress Index (CWSI) model to help explain when, how, and why water stress occurs and how to avoid or minimize its effect on grain yield.

MATERIALS AND METHODS

A field trial, with different fertilizer treatments and planting dates, was conducted using a soft white winter wheat cultivar (Stephens) at the Sherman Experiment Station in eastern Oregon during the 1981-82 crop season. A split-plot design with 4 replications, and the main plot being date of planting was planted in with two dates: early (mid-September) and late (mid-November). The subplot source of variation was the fertility level, N (0, 80 kg/ha) and P (0, 100 kg/ha) factorially arranged within each date of planting. Plant samples and soil water measurements were taken every 15 days and canopy-air temperatures were recorded on a daily basis. Canopy-air temperature and relative humidity data were used to calculate CWSI for each day. This normalized index developed by Idso, S. B. et al. (1981), Agricultural Meteorology 24:45-55, was recorded on a scale of 0 (no water stress) to 1 (maximum water stress). A neutron probe and a portable infrared thermometer were used to obtain soil water and canopy-air temperature measurements, respectively.

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RESULTS

Based on the results from the data collected, application of nitrogen fertilizer significantly increased stem weight and number, head weight and number, leaf weight, and total dry matter production.

The effects of treatments on water uptake, CWSI and yield are summarized in Table 1 (average of both dates of planting). Using the $F_{(0.01)}$ test for analysis, nitrogen fertilization significantly increased the total water uptake in the tillering-heading period, but failed to reach significant differences in the heading-harvest period.

Table 1.

Treatments	Water uptake between tillering-heading mm (inches)	Water uptake between heading-harvest mm (inches)	Total CWSI tillering-heading period	Total CWSI heading-harvest period	Grain yield m T/A (Bu/A)
Control	95.4 (3.75)	103.1 (4.06)	4.9	15.4	3.07 (45.6)
P_2O_5	103.3 (4.07)	108.9 (4.29)	5.2	13.7	2.91 (43.3)
Urea N	132.2 (5.20)	108.5 (4.27)	2.8	12.9	3.58 (53.2)
P_2O_5+ Urea N	135.5 (5.33)	114.6 (4.51)	3.5	12.1	3.61 (53.7)

CWSI was significantly lower in both plant development periods and grain yield was significantly higher (0.05) because of nitrogen supply.

Phosphorous fertilization had little or no effect on these parameters.

Based on the data from the first year of study, an equation has been developed which relates grain yield and CWSI. The equation is:

$$Y = 9.5007\ e^{-0.0488(x)}$$

where Y : grain yield in metric tons/ha, and
x : CWSI (summation of all growing season)

Following this equation, a CWSI = 60.30 would result in a grain yield of 500 kg/ha (7.4 Bu/Acre), which is considered a crop failure. However, a CWSI 0 (e.g. fully irrigated wheat at Hermiston) could be projected to yield between 9,000-9,500 kg/ha (133.8-141.2 Bu/Acre).

STRIP TILLAGE PLANTING IN NO-TILL CHEMICAL FALLOW

Floyd E. Bolton[1]

INTRODUCTION

Additional field trials on a rotary strip-tillage-planting system in no-till chemical fallow were conducted during the 1981-82 season. As reported in 1979 to 1981, the strip-tillage-planting system has been successful in establishing vigorous stands and grain yields equal to or greater than the standard plow or stubble mulch fallow methods. The results presented in Table 1 continue to show that this planting method is equal in grain yield to the standard tillage and planting systems.

Table 1. Tillage system effects on grain yield in eastern Oregon

Tillage system	Grain yield metric tons/hectare (bushels)/Acre			
	1978	1979	1981	1982
Strip-tillage	3.12 (46.4)	2.92 (43.4)	3.33 (49.5)	4.02 (59.8)
Stubble mulch	3.02 (44.9)	3.05 (45.3)	3.33 (49.5)	4.00 (59.5)
Plow-based	3.34 (49.6)	3.07 (45.6)	3.52 (52.3)	

The very favorable growing season of 1979-80, which produced record grain yields in eastern Oregon, also resulted in high amounts of crop residues left in the fields after harvest. This presented an opportunity to test the strip-tillage-planting system under heavy crop residue conditions which occur on an irregular basis in the drier region of the Lower Columbia Basin.

CEREAL RESIDUE STUDY

Materials and Methods

No-till fallow plots were established in the fall of 1980 in residues of the previous harvest. The plots were kept weed-free during the fallow period using residual herbicides (Chemhoe-IPC and Roundup-glyphosate). The amount

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of residue present was determined by collecting several one-meter square samples over the trial area during the spring of 1981. Residue treatments were applied as follows: (1) all residue removed to create a bare treatment, (2) standing stubble and residue remaining on soil surface was left undisturbed, and (3) to the standing stubble and surface residue was added all the crop residue removed from the bare (No. 1) treatment. Thus, residue treatments of 0, normal, and 2 times normal were established.

All plots were planted using the rotary strip-tiller in rows 45 centimeters (18 inches) wide in early October. Sixty (60) kilograms (53.5 pounds) nitrogen was uniformly applied to all residue treatments. Stephens soft winter wheat was seeded at the rate of 65 seeds per meter (20 seeds per foot) in all treatments.

Results and Discussion

The data presented in Table 2 show that equal stands emerged in all residue treatments. Overall, the stands were uniform and equal throughout the growing season, indicating this method of seeding is capable of producing adequate stands in heavy crop residues. The rate of 7.8 tons per hectare (6,958 lbs/Acre) is considered quite high for this region and 15.6 tons per hectare (13,915 lbs/Acre) is well above any rate that would ever occur. The strip-tiller effectively removes the crop residues from the tilled seed zone so seedling emergence and growth are unaffected.

Table 2. The effect of cereal residue on seedling emergence and grain yield in a strip-tillage system, 1982 harvest

Residue level metric ton/ha (lbs/A)	Seedling emergence 21 days after planting (% of seeds planted)	Grain yield metric ton/ha (bushels/A)
0 - residue removed	73	4.28 (63.6)
7.8 (6959) - standing stubble	72	4.34 (64.5)
15.6 (13,915) - standing stubble + added residue	73	3.65 (54.3)

The grain yields for the three levels of crop residue were not significantly different when analyzed statistically even though the difference between standing stubble and the heaviest residue rate was 0.69 metric tons/ha (10.3 bu/Acre). The nitrogen fertilizer rate of 60 kg/ha (53.5 lbs/Acre) was probably not adequate for the heavy residue treatment. The conclusion drawn from these results is that the rotary strip tiller is capable of operating in very heavy crop residues and will produce adequate stands and grain yields.

TILLAGE SYSTEMS AND NITROGEN FERTILITY VS DISEASE LEVEL (Cercosporella Foot Rot)

Materials and Methods

Standard stubble-mulch and no-till chemical plots were established at the Sherman Experiment Station in Moro in the fall and spring of 1980-81. The no-till chemical fallow plots were kept weed-free using Chemhoe (IPC) during the fall 1980 and early spring 1981 period and Roundup (glyphosate) during the late spring-early summer of 1981. The stubble mulch plots received the standard tillage treatments during the spring and summer of 1981 to prepare a suitable seedbed for furrow planting.

Oat seeds were treated in a steam autoclave to destroy the viability and various organisms on the seedcoat so they could be infected with the Cercosporella foot rot inoculum. Enough inoculated oat seeds with the Cercosporella foot rot organisms present was produced to treat the field plots at a rate of 47 pounds of seeds per acre. The non-inoculated plots were sprayed with Benlate to prevent Cercosporella foot rot from natural field infections being present.

The field plots were seeded with either a standard furrow drill in the stubble mulch treatment or the rotary strip-tiller on the no-till plots. The fertilized plots received a uniform rate of 60 kg/ha (53.5 lbs/Acre) nitrogen in the form of ammonium sulphate. The trial was seeded in late September 1981 with Stephens soft white winter wheat at the rate of 65 seeds per meter of row (20 seeds/foot). Excellent stands were produced in all plots.

Results and Discussion

The data presented in Table 3 show that the greatest effect on grain yield was due to fertility level. Even though the inoculated plots had some

Table 3. Effect of tillage system and fertility level on grain yield loss because of dryland foot rot (Cercosporella), 1982 harvest

Disease level	Stubble-mulch N-level kg h/ha (lbs/Acre)		Strip-tillage N-level kg N/ha (lbs/Acre)	
	0 (0)	60 (53.5)	0 (0)	60 (53.5)
	- - - - -Yield - metric ton/ha (bu/Acre) - - - - -			
Inoculated[1]	2.50 (37.2)	3.39 (50.4)	2.61 (38.8)	3.78 (56.2)
Non-inoculated + Benlate[2]	3.04 (45.2)	4.00 (59.5)	2.42 (36.0)	4.02 (59.8)

[1]Plots inoculated with Cercosporella foot rot cultured on non-viable oat seeds.

[2]Non-inoculated plots treated with Benlate to insure disease-free conditions.

Cercosporella foot rot present it was not as severe as expected. In the non-inoculated plots and surrounding trials and adjacent production fields there was little or no Cercosporella foot rot. There was a significant effect (at the 10% level) between the tillage systems, stubble mulch vs strip-tillage, in the inoculated treatment with nitrogen. The loss in grain yield in the stubble mulch system with Cercosporella present as compared in disease-free was 0.61 ton/ha (9.1 bu/Acre), whereas, in the strip tillage system the difference was only 0.24 ton/ha (3.6 bu/Acre). This apparent difference may be caused by the tilling action of strip-tillage that spacially isolates the seed from the inoculum in the soil surface. The strip-tiller removes some soil from the tilled strip and deposits it between the rows, whereas, the furrow drill opens a furrow and pushes some soil aside. However, some of the surface layer containing the Cercosporella inoculum could move back into the seed furrow and be present to infect the seedlings as they emerge. This concept is only speculation at present and requires further investigation.

Summary and Conclusions

Grain yields produced by the strip-tillage system continue to compare favorably with the stubble mulch and plow-based systems after four seasons of investigations.

The strip-tillage system is capable of operating and producing adequate stands, seedling growth, and grain yields in heavy crop residues.

In plots inoculated with Cercosporella foot rot, the grain yield loss was greater for the stubble mulch system than for the strip-tillage system.

The results of trials during the last five seasons (1978-82) have shown that the concept of rotary strip-tillage works well in dryland cereal production areas and compares favorably with the current plow-based, stubble mulch, and other no-till systems. Plans are to develop equipment more suitable for commercial use and to demonstrate the strip-tillage system on a wider scale under farmer conditions.

PRECIPITATION SUMMARY

CBARC - Pendleton Station - Pendleton, Oregon

(Crop year basis, ie; September 1 through August 31 of following year.)

Crop Yr.	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
54 Year Average	.74	1.40	1.87	2.17	1.94	1.47	1.61	1.48	1.33	1.28	.33	.44	16.06
1964-65	.61	1.24	1.81	4.43	3.84	.47	.21	1.16	1.03	1.37	.75	1.33	18.25
1965-66	.20	.51	1.18	.45	2.35	.71	1.72	.51	.43	.99	1.14	.17	11.46
1966-67	.46	1.10	2.30	2.86	2.80	.32	1.51	1.60	.95	.55	.04	0	14.49
1967-68	.56	1.17	1.30	.76	.74	2.39	1.04	.21	.65	1.11	.34	.77	11.04
1968-69	.83	1.36	2.71	2.65	2.62	.78	.43	2.31	1.26	.75	.06	0	15.76
1969-70	.65	1.41	.44	2.39	5.23	1.50	1.87	1.05	.62	.85	.11	.05	16.17
1970-71	1.02	1.40	2.22	1.02	1.44	.77	1.28	1.65	1.66	3.14	.63	.33	16.56
1971-72	1.42	1.72	3.14	3.93	1.15	1.70	2.11	1.35	1.50	.91	.76	.35	20.04
1972-73	.49	.66	1.14	2.47	.89	.89	1.27	.58	1.03	.12	0	.09	9.63
1973-74	1.77	1.24	5.86	4.40	1.29	2.00	1.50	3.64	.38	.33	1.30	0	23.71
1974-75	.02	.35	1.56	1.76	3.73	1.68	.97	1.72	.68	.69	.05	1.38	14.59
1975-76	0	2.16	1.47	3.40	2.13	1.09	1.69	1.65	1.21	.58	.04	2.58	18.00
1976-77	.44	.53	.47	.59	.90	.57	1.72	.46	1.70	.31	.12	2.21	10.02
1977-78	1.54	.69	1.79	3.19	2.27	1.71	1.40	3.50	.81	1.27	.59	1.37	20.13
1978-79	1.61	0	1.68	2.28	1.31	1.54	1.74	1.82	1.15	.18	.12	2.08	15.51
1979-80	.17	2.56	2.31	1.05	2.85	1.55	2.12	1.20	2.45	1.42	.23	.18	18.09
1980-81	1.24	2.96	1.81	1.99	1.26	2.31	2.30	1.29	2.30	2.12	.40	.02	20.00
1981-82	1.51	1.62	2.41	3.27	2.56	1.86	1.99	1.54	.48	1.12	1.02	.50	19.88
*1982-83	1.68	2.68	1.46	2.69	1.63	2.97	3.90						
18 Year Average	.81	1.26	1.98	2.38	2.19	1.32	1.49	1.52	1.13	.99	.43	.75	16.30

*Not included in 18 year average figures.

PRECIPITATION SUMMARY

CBARC - Sherman Station - Moro, Oregon

(Crop year basis, ie; September 1 through August 31 of following year.)

Crop Yr.	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
72 Year Average	.59	.92	1.68	1.73	1.68	1.15	.93	.76	.79	.70	.20	.29	11.42
1963-64	1.63	.50	1.56	1.36	.60	.25	.60	.15	.08	1.30	.04	.18	8.25
1964-65	.16	.60	1.69	6.11	1.65	.16	.63	.72	.32	.59	.17	1.04	13.84
1965-66	.08	.36	2.07	.51	2.45	.54	.78	.06	.02	.13	1.31	0	8.31
1966-67	.47	.74	3.14	1.84	.91	.03	.55	1.47	.39	.32	0	0	9.86
1967-68	.26	.74	.84	.54	.97	1.04	.16	.10	.74	.10	.15	1.52	7.16
1968-69	.33	1.04	2.67	2.09	1.93	.44	.63	.84	.84	1.99	0	0	12.80
1969-70	.52	.76	.53	2.00	3.96	1.27	.88	.38	.33	.22	0	0	10.85
1970-71	.13	.68	2.36	1.21	1.63	.12	1.28	.84	.93	.81	.20	.09	10.28
1971-72	1.36	.45	1.50	1.03	2.25	.26	1.44	.40	.45	1.70	.07	.55	11.46
1972-73	.57	.43	.83	1.62	1.09	.34	.40	.21	.34	.25	0	.07	6.15
1973-74	.90	.85	3.70	3.99	1.29	.97	1.30	1.18	.38	.02	.41	0	14.99
1974-75	0	.37	1.02	1.39	2.01	1.47	1.25	.46	.53	.84	.40	1.26	11.00
1975-76	0	1.17	1.34	1.26	1.25	.93	.95	1.06	.14	.06	.79	1.17	10.12
1976-77	.04	.10	.43	.20	.18	.63	.50	.08	2.70	.28	.37	.90	6.41
1977-78	.88	.22	2.00	3.22	2.80	1.31	.74	1.42	.43	.44	.59	1.32	15.37
1978-79	.33	.01	.79	.69	1.59	1.54	.99	1.06	.28	.10	.07	1.05	8.50
1979-80	.53	2.59	2.23	.65	3.41	1.83	.94	.89	1.27	1.37	.16	.11	15.98
1980-81	.42	.79	1.73	2.95	1.52	1.22	.65	.41	1.06	1.15	.20	0	12.10
1981-82	.92	.82	1.99	4.73	1.10	.72	.55	1.45	.37	1.15	.21	.40	14.41
*1982-83	1.42	1.96	1.08	1.89	1.40	2.43	2.74						
19 Year Average	.50	.70	1.71	1.98	1.72	.79	.80	.69	.61	.67	.27	.51	10.94

*Not included in 19 year average figures.