Reprinted from *1998 Columbia Basin Agricultural Research Annual Report. Spec. Rpt. 989,* pp. 35-40, 1998
Oregon State University in cooperation with USDA-Agricultural Research Service, Pendleton, OR

# THIRTY-YEAR RAINFALL TRENDS AND IMPLICATIONS FOR CROP YIELD IN THE COLUMBIA PLATEAU

Paul E. Rasmussen, William A. Payne, and Roger H. Goller

## Introduction

The Columbia Basin Agricultural Research Center (CBARC) and the Columbia Plateau Conservation Research Center (CPCRC) maintain several long-term experiments as well as a Class-A weather station at Pendleton, Oregon (Rasmussen and Smiley, 1994, 1997; Payne et al., 1997). Other research centers in Oregon, Washington, and Idaho also have weather stations which record precipitation. We abstracted 30-year (1967–96) precipitation data from eight Pacific Northwest sites to detect trends in winter and spring rainfall. We also determined crop sensitivity to rainfall at Pendleton over this 30-yr period for wheat/fallow, wheat/legume, and wheat/wheat cropping systems.

With the demise of Federal farm programs in the next few years, more farmers will consider changing their present practices to more intensive cropping systems. Annual-crop yield is more variable than yield after summerfallow, which increases economic risk concurrent with the opportunity for increased profit. We present some implications for crop yield in intensive cropping systems based on precipitation trends and crop yields at CBARC.

## Materials And Methods

Precipitation data were collected for the 1967–96 period from weather stations at Moro, Pendleton (Pendleton Airport), CBARC (Pendleton 9NE) in Oregon, Lind (Lind 4NE), Walla Walla, Dayton, and Pullman (Pullman 2NW) in Washington, and Grangeville in Idaho. These stations span annual precipitation levels from 9 to 28 inches and represent practically all of the Pacific Northwest intermountain dryland agriculture region.

Crop yields in long-term experiments at Pendleton were determined over 30 yr for winter wheat/fallow, winter wheat/dry pea, winter wheat/winter wheat, spring wheat/spring wheat, and spring barley/spring barley rotations. Crop yield was related to precipitation using multiple linear regression. Precipitation was divided into winter (1 September to 31 March), April, May, and June amounts for regression analysis. Spring precipitation, where used in this report, represents total rainfall from 1 April to 30 June. July plus August rainfall were not included because the amount is very low (1.18 inches), and constitutes less than 6% of total precipitation. July and August rainfall does not affect cool season winter annuals (wheat, barley, canola, Austrian winter peas) or cool-season spring crops such as peas, spring wheat, spring canola, spring mustard, or chickpeas. The amount of July and August rainfall will likely affect the yield of warm-season annual crops such as corn, sorghum, millet, and sunflower.

## Results And Discussion

There has been a general trend towards decreasing winter precipitation and increasing spring precipitation over the past 30 years in the Columbia Plateau (Fig. 1 and 2). Winter-precipitation trends appear either

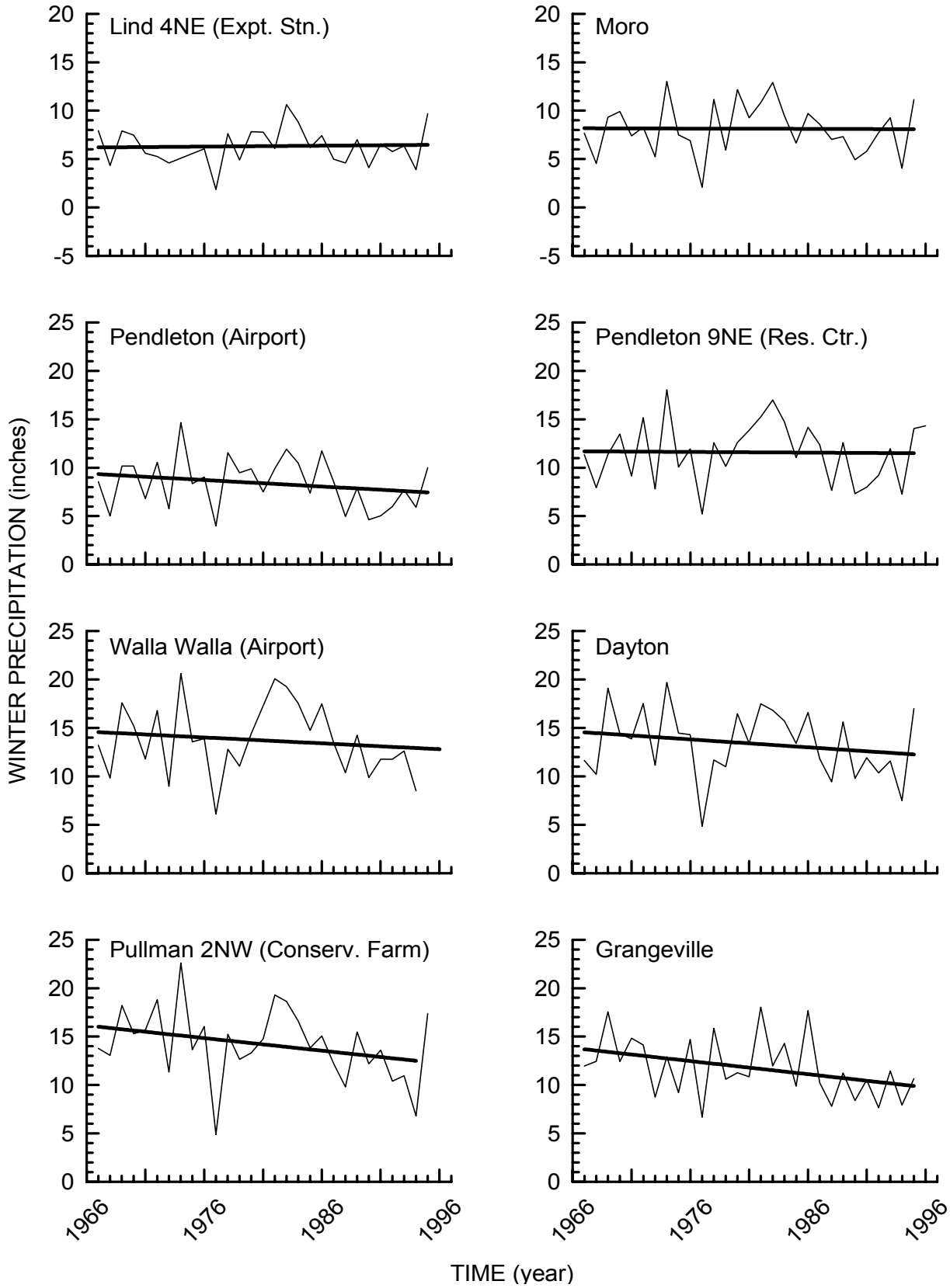


Figure 1. Winter (Sep.1–Mar.31) precipitation from eight Pacific Northwest sites 1967–96.

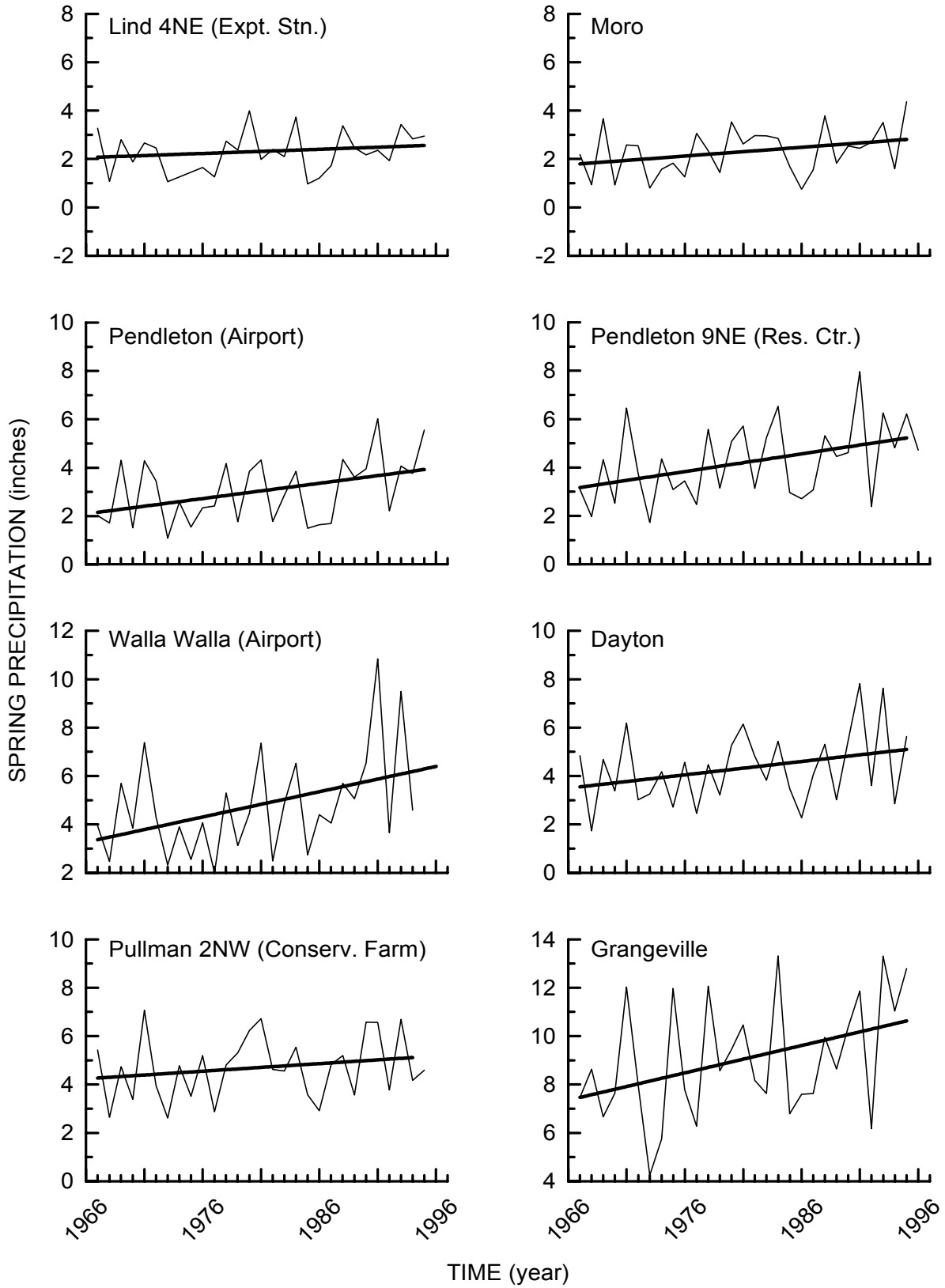


Figure 2. Spring (Apr.1–Jun.30) precipitation from eight Pacific Northwest sites 1967–96.

neutral (Lind 4NE, Moro, Pendleton airport, Pendleton 9NE), or negative (Walla Walla, Dayton, Pullman 2NW, Grangeville). But more importantly, the 30-yr trend in spring precipitation is positive at all eight sites. Because trends are evident at all sites, they likely result from a shift in weather patterns. This shift could be due to short-term weather cycles or related to longer-cycle weather patterns. In either case, crops that benefit most from spring rainfall should now yield relatively better than those highly dependent on stored winter precipitation.

All crops grown at Pendleton are affected by the level of precipitation, whether it be winter or spring (Table 1). Winter wheat following fallow shows limited response to current-crop winter precipitation because of the benefit of water storage in the previous year of fallow. The yield of crops grown without previous fallow are quite sensitive to amount of winter rainfall. The yield of all crops is even more dependent on the level of spring rainfall, especially that occurring in May. An additional inch of rain in May increased wheat yield about 7, 12, 8, and 8 bu/acre in winter wheat/fallow, winter wheat/pea, winter wheat/winter wheat, and spring wheat/spring wheat crop rotations, respectively. Crop yield was much less sensitive to higher rainfall in April and June.

Winter precipitation at CBARC has varied from less than 6 to over 18 inches. All crops show some sensitivity to level of winter precipitation; therefore it has great impact on yield and substantially increases the possibility of very low crop yield in low-rainfall years. Lows in annual-crop wheat yield are in the 15–25 bu/acre range, compared to 57 bu/acre for wheat following fallow. More risk is quite real when considering more intensive cropping in the dryland Pacific Northwest, a consideration that may not be so prevalent in central USA or Canada.

Winter crops have an advantage over spring crops in the Pacific Northwest. Winter cereals show yield response patterns that are more favorable than those for spring crops (Fig. 3). The histogram of winter cereal yield is skewed to the right (higher yielding years occur more frequently than low-yielding years). The reverse is true for spring crops (spring wheat or spring dry peas), where low yields occur more frequently than high yields. This pattern likely results because winter crops are able to complete more of their growth cycle before the onset of summer water stress unlike the case for spring crops.

Thirty-year crop-yield trends do indeed respond to shifts in precipitation (Table 2). Annual-crop yields have risen in proportion to winter wheat yield following fallow over the past 30 yr. Winter wheat grown following peas yielded 72, 84, and 99% of winter wheat following fallow for the 1967–76, 1977–86, and 1987–96 periods, respectively. Spring crops are especially favored, with spring wheat yielding 46, 57, and 76% of winter wheat following fallow during the same periods. Dry pea yields during these 10-yr periods also increased, from 1125 to 1430 to 1590 lb/acre. The sensitivity of green pea yield to spring rainfall was reported by Pumphrey et al. (1979). Annual-crop spring barley, a more-recent addition to long-term studies, yielded quite favorably, 4440 lb/acre, in the 1987–96 period.

Table 1. Correlation of precipitation with crop yield in differing rotations, using multiple linear regression. CBARC, Pendleton, OR. 1967–1996.

| Regression Predictor | Precipitation Average | Crop Rotation[1] | | | | |
|---|---|---|---|---|---|---|
| | | WW/F | WW/DP | WW/WW | SW/SW | DP/WW |
| | *inches* | *- - - - - - - - bushels/acre per inch of water - - - - - - - - - - - -* | | | | *lb/acre/inch* |
| Winter [2] | 11.60 | (4.6) | 2.0**[3] | 2.4** | 1.3 ns | 18 ** |
| April | 1.64 | 1.7 ns | 5.2[a] | 4.9[a] | 7.7* | 202 * |
| May | 1.55 | 7.3** | 12.4** | 7.9* | 7.8* | 461 ** |
| June | 1.05 | 3.4[a] | 9.3* | 2.4 ns | 2.2 ns | 108 ns |
| Average | 15.80 | 72 | 62 | 51 | 43 | 1375 |
| Range | 5.2-18.1 | 57-98 | 26-102 | 14-87 | 20-82 | 214-2415 |

[1] WW = Winter Wheat; F = Fallow; DP = Dry Peas; SW = Spring Wheat; All wheat is soft white; The crop being grown in each rotation is underlined.
[2] Winter Precipitation = 1 September to 31 March.
[3] Statistical probabilities : a = 0.20; b = 0.10; * = 0.05; ** = 0.01, ns = not significant.

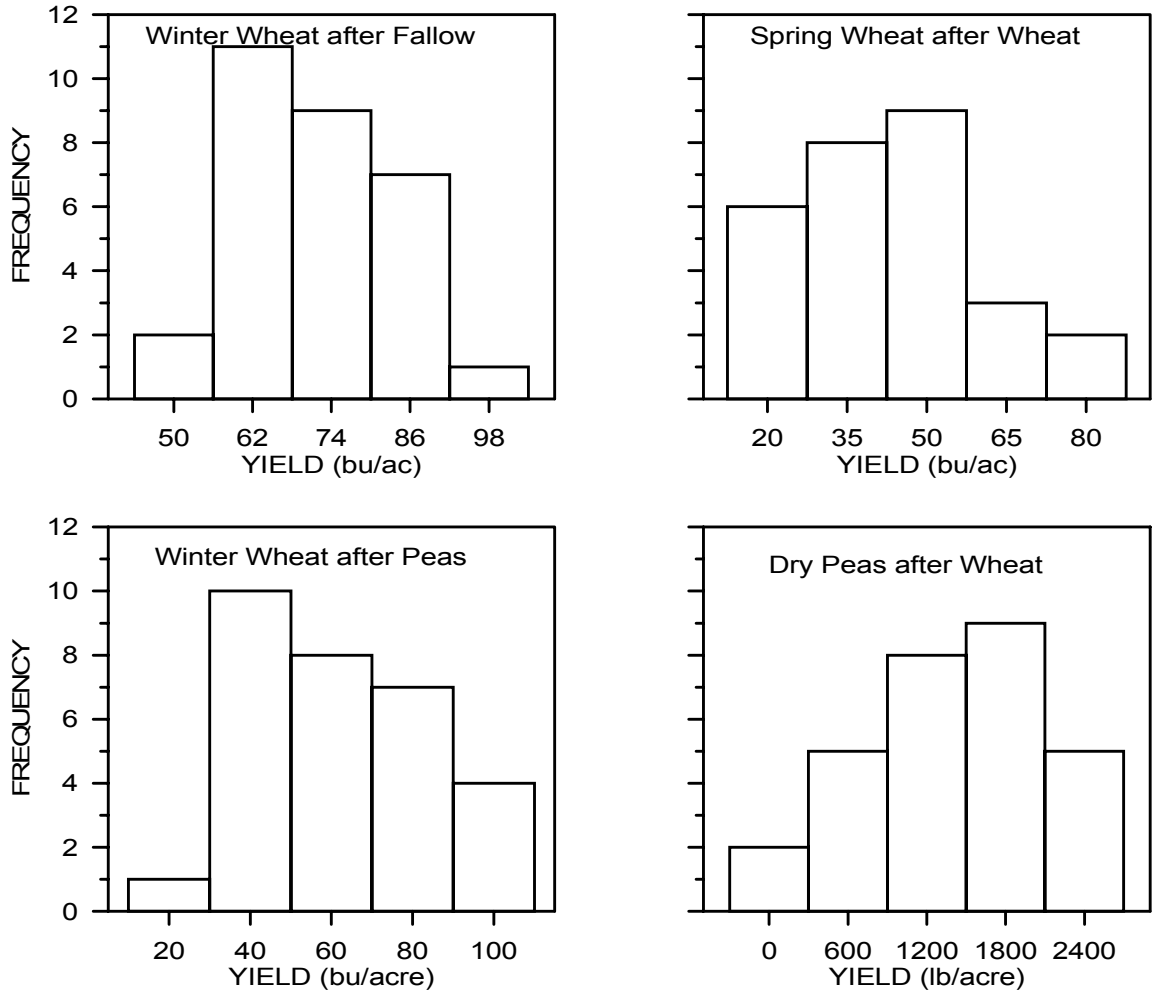


Figure 3. Histograms of crop yield CBARC, Pendleton, OR, 1967–96

Table 2. Precipitation levels and grain yield averages during three 10-yr periods between 1967 and 1996. CBARC, Pendleton, OR.

| Period | Precipitation | | Crop Rotation [1] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Winter [2] | Spring [3] | WW/F | WW/DP | WW/WW | SW/SW | SB/SB | DP/WW |
| | *- - - - inches - - - -* | | *- - - - - - - - - - - bushels/acre - - - - - - - - - - -* | | | | *- - - - lb/acre - - - -* | |
| 1967–76 | 11.6 | 3.5 | 68 | 49 | 37 | 31 | | 1125 |
| 1977–86 | 12.7 | 4.3 | 75 | 63 | 56 | 43 | 2937 | 1431 |
| 1987–96 | 10.5 | 5.0 | 72 | 71 | 60 | 55 | 4439 | 1590 |

[1] WW = Winter Wheat; F = Fallow; DP = Dry Peas; SW = Spring Wheat; All wheat is soft white; The crop being grown in each rotation is underlined.
[2] Winter precipitation = 1 September to 31 March.
[3] Spring precipitation = 1 April to 30 June.

## References


Payne, W.A., P.E. Rasmussen, and R.H. Goller. 1997. Major factors influencing wheat yield improvement during the past thirty years. p. 43–46. *In* J.D. Williams (ed.) 1997 Columbia Basin Agric. Research Annual Rept. Special Report 977. Agric. Exp. Stn., Oregon State Univ. and USDA-ARS, Pendleton OR.

Pumphrey, F.V., R.E. Ramig, and R.R. Allmaras. 1979. Field response of peas (*Pisum sativum*) to precipitation and excess heat. J. Am. Soc. Hort. Sci. 104(4): 548–550.

Rasmussen, P.E., and R.W. Smiley. 1994. Long-term experiments at the Pendleton Agricultural Research Center. p. 14–20. *In* D.A. Ball (ed.) 1994 Columbia Basin Agric. Research Annual Rept. Special Report 933. Agric. Exp. Stn., Oregon State Univ. and USDA-ARS, Pendleton OR.

Rasmussen, P.E., and R.W. Smiley. 1997. Soil carbon and nitrogen change in long-term agricultural experiments at Pendleton, Oregon. p. 353–360. *In* E.A. Paul, K. Paustian, E. T. Elliott, and C.V. Cole (ed.) Soil Organic Matter in Temperate Agroecosystems: Long-Term Experiments in North America. CRC Press, Boca Raton FL.