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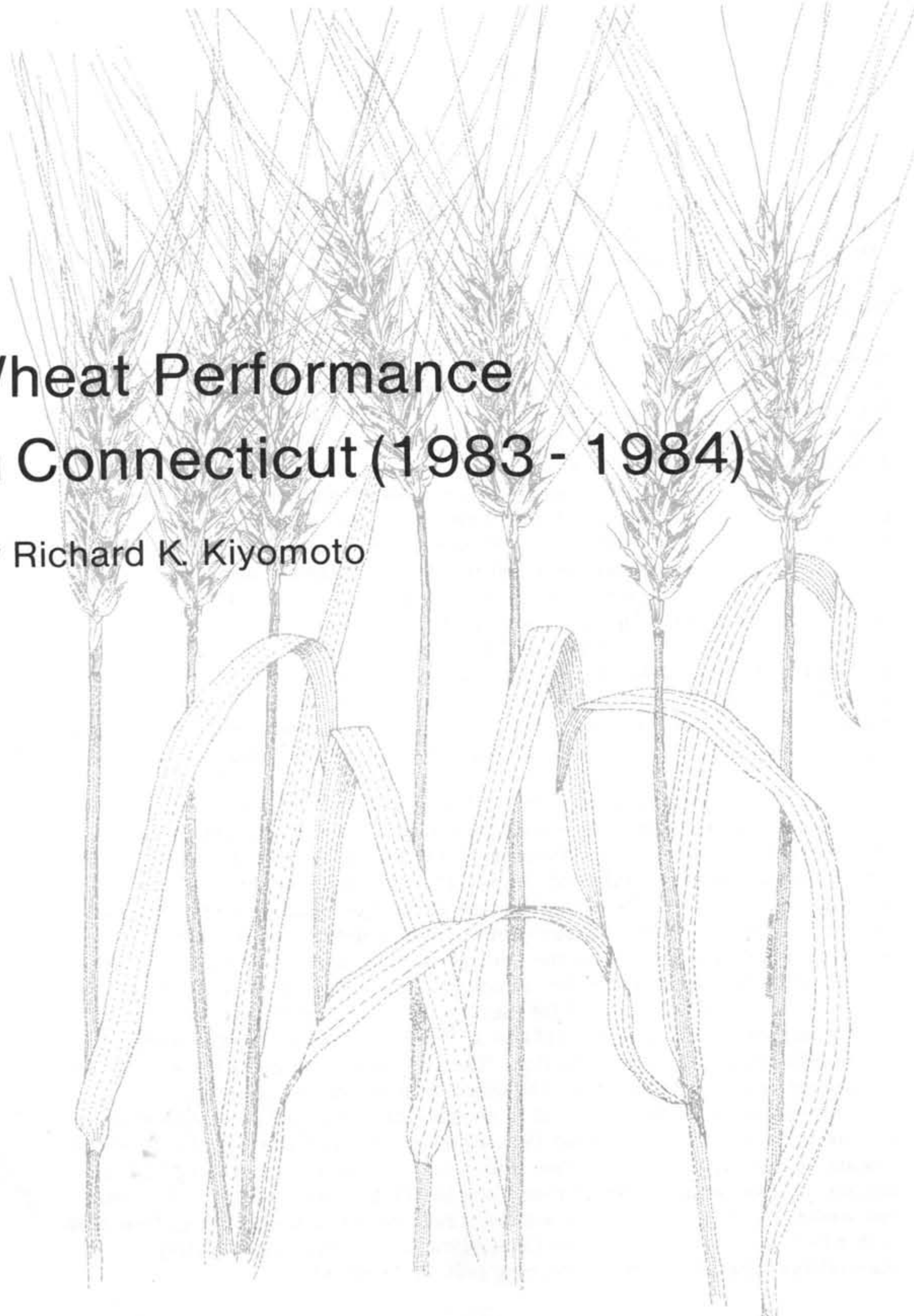
Wheat Performance in Connecticut (1983 - 1984)

By Richard K. Kiyomoto



THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION
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Abstract

In 1982 research on wheat was initiated at The Connecticut Agricultural Experiment Station to increase yield through breeding greater photosynthetic efficiency in a crop that accounts for a major share of mankind's calories. In Connecticut wheat is used as a cover crop, for straw, and for grain. Wheat trials were conducted to identify winter wheats that consistently yield well. The adapted, high yielding cultivars identified are being used to improve net photosynthesis and yield. In this Bulletin grain yield, total dry matter yield, and grain quality (i.e., % protein and 1000-seed weight) are presented. These results have practical value to farmers who wish to grow wheat in Connecticut. With few exceptions, this report is restricted to the performance of commercially available cultivars.

Two kinds of trials were conducted, replicated and unreplicated. In replicated trials each wheat entry was planted in four randomized plots of four rows each; whereas in unreplicated trials each entry was planted once as a single row. Replicated trials designed to compare a limited number of high yielding entries were planted in early October and November in 1982 and 1983 to test the effect of planting date upon yield. Unreplicated trials were conducted to screen many entries before placing the best in replicated trials. The replicated trials mainly compared soft white and soft red wheats. The unreplicated trials compared many hard red as well as the soft wheats. To reduce environmental limits on the expression of yield, trials were conducted at high soil fertility, at a soil pH of approximately 6.8, and with control of foliar diseases.

The highest yielding wheats in replicated trials planted in October, 1982 and 1983 included the soft white wheats Purcell and Ticonderoga from New York, Frankenmuth from Michigan, and the bread wheat Kavkaz from the USSR. Kavkaz was also highest in the production of straw. These results were similar to unreplicated trials of these cultivars in 1982, thus indicating stability of high yield. Although the average yield of the replicated trial planted in November, 1982 was as high as the trial planted a month earlier, higher yields were usually produced by October plantings. Overall, in 1983 the highest grain yield was 522 g m^{-2} (78 bu A^{-1}) for the New York cultivar Houser, and in 1984 the highest yield was 676 g m^{-2} (101 bu A^{-1}) for the powdery mildew-susceptible cultivar Blueboy from North Carolina. The protein content of soft wheats grown in Connecticut ranged from 9-12.7%, which is in the range expected.

Unreplicated trials were used to compare the yield and protein of hard red wheats with the soft white wheat Houser and the soft red wheat Hart. Hard red wheats as a group yielded less than Houser and Hart and had an average protein content of 10%, which is lower than the usual 11-15% protein reported for hard red wheat. Although the results with hard red wheat are disappointing, New York soft white winter wheats grown in Connecticut produce yield and quality competitive with other areas producing soft white wheat.

Wheat Performance in Connecticut (1983 - 1984)

By Richard K. Kiyomoto

For the past decade scientists in the Department of Biochemistry and Genetics of the Station have been attempting to increase crop yields by modifying the metabolism of leaves for more efficient photosynthesis (Zelitch, 1982). As part of this effort, attention has been directed toward wheat, a crop that accounts for more of mankind's calories than any other food (Evans, 1975). Yield depends on photosynthesis and an adequate storage capacity to accept the photosynthetic products. In the past 50-75 years of plant breeding, genetic improvements in wheat yield in the United States averaged 0.4-0.5% per year (Frey, 1981). This was achieved entirely by increasing the harvest index, the size of the storage organ relative to the size of the portion of the plant above ground (Austin et al., 1980; Gent and Kiyomoto, 1985). Although the harvest index in modern, high-yielding wheat cultivars approaches 50%, the total dry weight of the plant is no greater than in older varieties. Thus, net assimilation of CO_2 by photosynthesis has not been improved by development of modern cultivars. Because increasing yields further by increasing the harvest index above 50% may be difficult (Austin et al., 1980), large increases in yield may require a large harvest index plus increased net photosynthesis (Zelitch, 1982).

In an attempt to overcome the yield bottleneck due to unchanging photosynthesis, research was initiated in 1982 to breed wheats with superior net photosynthesis. To increase storage organ capacity to accommodate the products of greater photosynthesis, over 2000 different wheat varieties were indexed for bigger and more numerous seed, more spikelets, and more tillers. Such characteristics, which are used as indicators of greater ability to store photosynthate, were used in crosses with adapted high yield wheats and wheats having greater net photosynthesis.

Cultivars and advanced breeding lines from the United States and elsewhere were tested in the field to identify wheats that would produce high yields in Connecticut. Adapted wheats are required as parents if traits such as improved photosynthesis and large sinks are to be expressed in Connecticut's climate. Since yields of winter wheats in Connecticut were far greater than yields of spring wheats in 1982 and 1983, this Bulletin reports the performance of winter wheats.

Three classes of winter wheat were studied: hard red, soft red, and soft white (Table 1). The

Table 1. Region of production of different classes of winter wheat in the United States (Martin & Leonard, 1967).

Wheat Class	Production region	Some leading States
Hard Red	Central and Southern Great Plains with annual rainfall less than 88.9 cm (35 in).	Kansas, Oklahoma, Nebraska, Texas
Soft Red	States east of line of 76.2 cm (30 in) average annual precipitation.	Ohio, Illinois, Indiana, Missouri, Pennsylvania
Soft White	Far Western and Northeastern States	Washington, Oregon, Michigan, New York

hard red or bread wheats are generally higher in protein (about 11-15%) than the soft red or soft white wheats (about 9-10%). Soft red wheats are used in pastries, crackers, and biscuits. Soft white wheats are used in pastries and breakfast cereals. Grain from the performance trials was tested for protein to compare the quality of Connecticut-grown wheat with grain produced elsewhere.

In Connecticut, wheat is used as a cover crop, as a mulch in strawberries and other horticultural crops, and for grain. In northern New England, wheat was studied as an alternate crop at Presque Isle, Maine in 1984 (Murphy, Morrow, and Lloyd, 1985). The highest yield of 29 bushels per acre (bu A^{-1}) was obtained with Yorkstar, a New York soft white winter wheat. A higher yield of 48.6 bu A^{-1} was recorded with the same cultivar in 1976 (Murphy et al., 1977). The national average of winter wheat in 1983 was 42 bu A^{-1} (Agricultural Statistics, USDA, 1984).

In the present studies, winter wheats were evaluated in replicated and unreplicated trials. Unreplicated trials were used to screen a large number of wheats for yield and morphological components of yield, such as seed size or number or spike size or number. Replicated trials were used to compare more rigorously a limited number of promising cultivars or breeding lines. To test a representative sample for yield stability and to test the influence of planting date upon yield, wheats were planted in replicated trials on two dates near the extremes considered suitable for this region. To reduce environmental limits on yield the plants received a high rate of soil fertilization, the soil pH was adjusted to approximately 6.8, plants were watered occasionally, and foliar diseases were controlled. This report summarizes the dry matter production, grain yield, and protein content in the 1983 and 1984 wheat trials. With few exceptions, only the performance of commercially available cultivars is discussed.

Materials and Methods

Experimental Design. In the replicated trials, different wheats (entries) were planted in a randomized complete block design with four replications. Each plot of an entry consisted of four rows 4 m long. Unreplicated trials consisted of a single row 3 m long of each entry; the cultivars Houser and Hart were planted in every 10th and 11th row in 1983 and every 6th and 7th row in 1984 to provide standards.

Winter Wheats Tested. The different classes of winter wheat were represented by wheats adapted to the climates and soils of several regions (Table 1). The wheats in the 1983 and 1984 replicated trials are listed in Table 2. These included in the 1983 replicated trials soft white wheats from New York and soft red wheats mainly from the Midwest (Table 2) since they were developed and are grown in climates similar to Connecticut's (Table 1). In the 1984 replicated trials, soft white winter wheats developed and producing high yields in Washington and Oregon were compared with those developed in New York.

Unreplicated trials were used to screen 96 entries in 1983 and 60 in 1984. These included both cultivars and experimental lines. Only data on hard red cultivars are presented since few of this class were in replicated trials.

Cultural Procedures. Soil at Lockwood Farm, Hamden, Connecticut, was adjusted to pH 6.8 and fertilized at the rate of 84 kg ha^{-1} (75 lbs A^{-1}) each of N, P, and K before planting and once again at the end of April.

An early replicated trial of 18 entries was planted in the first week of October in 1982 and 1983. Later, in the first and second week of November in 1982 and 1983, seven or eight entries were planted in a second replicated trial. The seeding rate in 1982 (1983 harvest) was 2.5 g m^{-1} (110 lbs A^{-1}) in rows 20.3 cm (8 in) apart. In 1983 (1984 harvest) 62.5 seeds m^{-1} (99 lbs A^{-1}) were planted in rows 15.2 cm (6 in) apart. Seeding rates

Table 2. Winter wheats compared in replicated trials.

Winter Wheat	Origin	Year tested
Soft White Wheats		
Ticonderoga	New York	1983, 1984
Houser	New York	1983, 1984
Purcell	New York	1983, 1984
NY6708-18	New York	1983, 1984
NY6120-15	New York	1984
Frederick	Canada	1983, 1984
Frankenmuth	Michigan	1983, 1984
Nugaines	Washington	1984
Daws	Washington	1984
Stephens	Oregon	1984
Yamhil	Oregon	1984
Hill 81	Oregon	1984
Soft Red Wheats		
Hart	Pennsylvania & Missouri	1983, 1984
Roland	Illinois	1983
Redcoat	Indiana	1983
Benni	Indiana	1983, 1984
Caldwell	Indiana	1983, 1984
Arthur	Indiana	1983
Titan	Ohio	1983
Ruler	Ohio	1983
Logan	Ohio	1983, 1984
Blueboy	North Carolina	1984
Hard Red or Bread Wheats		
TAM 105	Texas	1983
Kavkaz	USSR	1983, 1984
Besostaya	USSR	1983, 1984

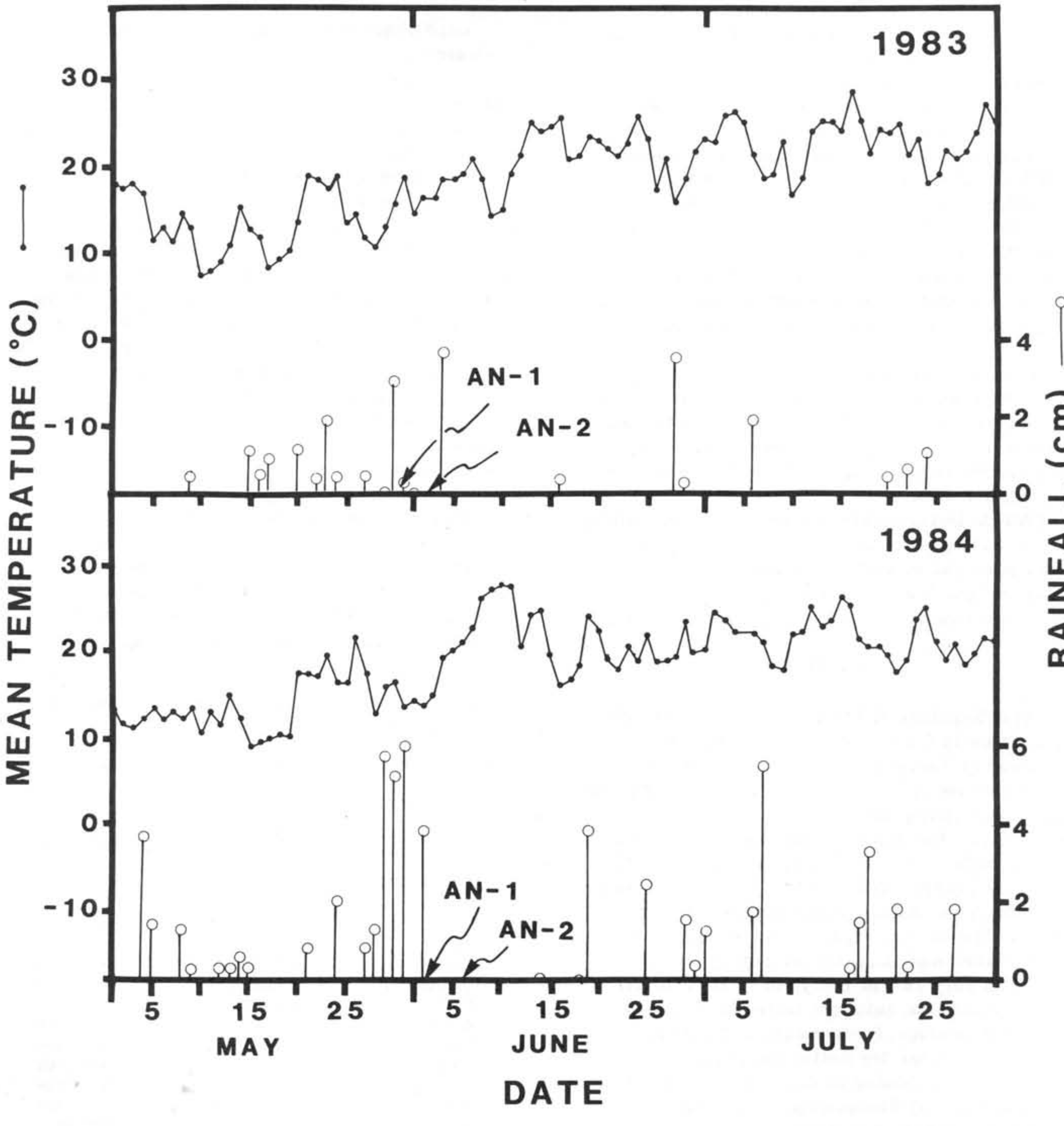

Figure 1. Daily rainfall and mean temperature from May through July in 1983 and 1984 at Mt. Carmel (Hamden), CT. AN-1 and AN-2 represent the date of anthesis for Benni, the earliest maturing wheat in the early and late-planted replicated trials, respectively.

and row spacings in unreplicated trials were the same as in the replicated trials.

Foliar disease was controlled with three applications of Bayleton 25 fungicide in early spring before anthesis. Because of subnormal rainfall during May-July 1983 (Fig. 1), the plants were visibly stressed on June 15 and were irrigated.

Harvest Procedures. Attempts were made to recover all leaves, stems, heads and grain. Plants were cut at soil level a few days after they became fully yellow, and they were dried under protective cover at least 2 weeks. The heads were threshed individually at 10-13% seed moisture. Harvest started on June 27, 1983 and July 10, 1984. Early harvest enabled us to minimize the loss of plant matter by retaining most of the leaf material; prevented the loss of seeds, which are more loosely enclosed in fully dry spikes; and avoided loss to birds.

In the replicated trials, 4 m of row from the middle two rows of each plot were harvested. In the unreplicated trials, 2 m of row were harvested, and yields are reported as percentages of the average values for the surrounding four rows, two rows each of Houser and Hart.

Protein Determinations. Protein was calculated from total nitrogen of flour made from 10 g of grain. The nitrogen values were multiplied 5.83 to obtain percent protein (Watt and Merrill, 1963). All protein values were adjusted for a grain moisture of 9.3%.

Results

Early Replicated Trials. The replicated trials planted in early October of 1982 and 1983 are summarized in Tables 4 and 5. Grain yields may be converted to lbs A^{-1} or approximate bu A^{-1} for grain yield by multiplying the g m^{-2} by 8.92 or 0.15, respectively. The top yielding cultivar in 1984, Blueboy, produced 676 g m^{-2} of grain (101 bu A^{-1}) and in 1983 Purcell produced the top yield of 489 g m^{-2} (73 bu A^{-1}). Although the average total dry matter, 1000-seed weight, and grain protein were similar in 1983 and 1984, the average grain yield in 1983 was only 78% of the yield in 1984 for all wheats. Among the cultivars tested in both years, Purcell, Ticonderoga, Frankenmuth, and Kavkaz produced more total dry matter and grain in both seasons, but they tended to have less protein in the grain. Purcell and Ticonderoga are cultivars developed at the Experiment Station at Cornell University in New York. Although 1000-seed weights were similar in 1983 and 1984, seed of cultivars such as Hart and Ticonderoga were reduced by approximately 10% in weight in 1983 when compared to the weights in 1984.

Straw yield, an important consideration in Connecticut, can be estimated by subtracting the grain from the total dry matter. For Purcell, Ticonderoga, and Frankenmuth, the range of straw yield was 882-935 g m^{-2} in 1983 and 890-923 g m^{-2} in 1984. In contrast, Kavkaz produced 1002 g m^{-2} straw in 1983 and 1047 g m^{-2} in 1984.

Late Replicated Trials. The results of replicated trials planted in November are presented in Tables 6 and 7. Seven cultivars were compared both years, and Frederick was included only in 1984. Hart and Houser yielded more than Ticonderoga in the late plantings. This contrasts with early plantings where Ticonderoga consistently yielded more grain. While Hart and Houser were high in grain yield in 1983 and 1984, Benni was erratic, producing a good yield in 1983 and a low yield in 1984. Although the average grain yield was almost identical in the two years, the straw yield in 1984 was only 54% of the straw yield in 1983. Wheats planted late in 1982 produced the heaviest seed (1000 seed weight), while wheats planted late in 1983 produced the lightest seed. Thus, yield potential of the late 1984 trial may have been limited by the amount of dry matter produced. Cultivar differences in grain protein were observed in both years with the lowest yielding cultivars generally having the highest protein.

Unreplicated Trials. Houser, a soft white wheat, and Hart, a soft red wheat, were used as standards for comparing the performance of hard red wheat cultivars in the unreplicated trials (Table 8). Although the hard red wheat Rita yielded well in 1983 and 1984, the hard red wheats as a group did not

Table 3. Winter wheats compared in 1983 and 1984 unreplicated trials.

Winter Wheats	Origin	Year Tested
Hard Red Wheats		
TAM W101	Texas	1983, 1984
TAM 105	Texas	1983, 1984
TAM 106	Texas	1983
Sturdy	Texas	1983, 1984
Tamex	Texas	1983, 1984
Mit	Texas	1983, 1984
Payne	Oklahoma	1983, 1984
Triumph 64	Oklahoma	1983, 1984
Centurk 78	Nebraska	1983, 1984
Bennett	Nebraska	1983, 1984
Newton	Kansas	1983, 1984
Vona	Colorado	1983, 1984
Manning	Utah	1983, 1984
Rita	South Dakota	1983, 1984
Dawn	South Dakota	1983, 1984
Arbon	Idaho	1983
Soft White Wheat		
Houser	New York	1983, 1984
Soft Red Wheat		
Hart	Pennsylvania	1983, 1984

Table 4. Replicated trial planted on October 7, 1982.

<table>
<tr><th colspan="2">Total Dry Matter[1]</th><th colspan="2">Grain Yield[1]</th><th colspan="2">Grain Protein[1]</th><th colspan="2">1000-Seed Wt.[1]</th></tr>
<tr><th>Winter Wheat</th><th>$g\ m^{-2}$</th><th>Winter Wheat</th><th>$g\ m^{-2}$</th><th>Winter Wheat</th><th>%</th><th>Winter Wheat</th><th>g</th></tr>
<tr><td>Frederick</td><td>1519|</td><td>Purcell</td><td>489|</td><td>Ruler</td><td>11.8|</td><td>Ruler</td><td>39.5|</td></tr>
<tr><td>Kavkaz</td><td>1447||</td><td>Ticonderoga</td><td>467||</td><td>Roland</td><td>11.4||</td><td>Houser</td><td>38.5||</td></tr>
<tr><td>Purcell</td><td>1424|||</td><td>Frederick</td><td>460|||</td><td>Redcoat</td><td>11.3 |</td><td>Besostaya</td><td>38.0 |</td></tr>
<tr><td>Logan</td><td>1406||||</td><td>Frankenmuth</td><td>454|||</td><td>Arthur</td><td>11.2 |</td><td>NY 6708-18</td><td>37.7 ||</td></tr>
<tr><td>Hart</td><td>1378||||</td><td>Kavkaz</td><td>445||||</td><td>Houser</td><td>10.7 |</td><td>Kavkaz</td><td>37.4 |||</td></tr>
<tr><td>TAM 105</td><td>1370||||</td><td>NY 6708-18</td><td>436|||||</td><td>Hart</td><td>10.7 |</td><td>Roland</td><td>37.0 ||||</td></tr>
<tr><td>Titan</td><td>1366||||</td><td>Houser</td><td>413 |||||</td><td>Benni</td><td>10.4 ||</td><td>Redcoat</td><td>36.3 ||||</td></tr>
<tr><td>NY 6708-18</td><td>1362||||</td><td>Logan</td><td>407 |||||</td><td>Besostaya</td><td>10.4 ||</td><td>Arthur</td><td>36.1 ||||</td></tr>
<tr><td>Ruler</td><td>1351|||||</td><td>Caldwell</td><td>399 ||||||</td><td>Caldwell</td><td>10.1 ||</td><td>Purcell</td><td>35.5 |||</td></tr>
<tr><td>Ticonderoga</td><td>1349|||||</td><td>TAM 105</td><td>384 |||||</td><td>Logan</td><td>10.1 ||</td><td>Hart</td><td>35.2 |||</td></tr>
<tr><td>Frankenmuth</td><td>1344|||||</td><td>Titan</td><td>375 ||||</td><td>Frederick</td><td>10.1 ||</td><td>Frankenmuth</td><td>35.1 |||</td></tr>
<tr><td>Arthur</td><td>1336|||||</td><td>Redcoat</td><td>373 ||||</td><td>Titan</td><td>9.9 |||</td><td>Frederick</td><td>34.9 ||||</td></tr>
<tr><td>Redcoat</td><td>1323|||||</td><td>Benni</td><td>363 |||</td><td>Ticonderoga</td><td>9.9 |||</td><td>TAM 105</td><td>34.7 ||||</td></tr>
<tr><td>Benni</td><td>1285|||||</td><td>Ruler</td><td>362 |||</td><td>NY 6708-18</td><td>9.7 |||</td><td>Ticonderoga</td><td>33.9 |||</td></tr>
<tr><td>Caldwell</td><td>1253 ||||</td><td>Arthur</td><td>353 |||</td><td>Frankenmuth</td><td>9.6 |||</td><td>Titan</td><td>33.5 ||</td></tr>
<tr><td>Houser</td><td>1194 |||</td><td>Roland</td><td>348 |||</td><td>Kavkaz</td><td>9.4 |||</td><td>Benni</td><td>33.3 |</td></tr>
<tr><td>Roland</td><td>1183 ||</td><td>Besostaya</td><td>344 ||</td><td>Purcell</td><td>9.4 ||</td><td>Logan</td><td>33.3 |</td></tr>
<tr><td>Besostaya</td><td>1125 |</td><td>Hart</td><td>335 |</td><td>TAM 105</td><td>9.1 |</td><td>Caldwell</td><td>29.5</td></tr>
<tr><td>MEAN</td><td>1134</td><td></td><td>400</td><td></td><td>10.3</td><td></td><td>35.5</td></tr>
<tr><td>CV (%)</td><td>8.4</td><td></td><td>8.3</td><td></td><td>4.2</td><td></td><td>2.8</td></tr>
</table>

1 Values connected by vertical lines are not different at the 5% level of significance by Duncan's Multiple Range Test.

Table 5. Replicated trial planted October 5, 1983.

<table>
<tr><th colspan="2">Total Dry Matter[1]</th><th colspan="2">Grain Yield[1]</th><th colspan="2">Grain Protein[1]</th><th colspan="2">1000-Seed Wt.[1]</th></tr>
<tr><th>Winter Wheat</th><th>$g\ m^{-2}$</th><th>Winter Wheat</th><th>$g\ m^{-2}$</th><th>Winter Wheat</th><th>%</th><th>Winter Wheat</th><th>g</th></tr>
<tr><td>Blueboy</td><td>1777|</td><td>Blueboy</td><td>676|</td><td>NY 6708-18</td><td>11.5|</td><td>Blueboy</td><td>39.8|</td></tr>
<tr><td>NY 6120-15</td><td>1618||</td><td>NY 6120-15</td><td>643||</td><td>Yamhil</td><td>11.2||</td><td>Besostaya</td><td>39.1|</td></tr>
<tr><td>Kavkaz</td><td>1594|||</td><td>Purcell</td><td>565 ||</td><td>Stephens</td><td>11.1||</td><td>Hart</td><td>38.7|</td></tr>
<tr><td>Purcell</td><td>1485 |||</td><td>Benni</td><td>555 |||</td><td>Nugaines</td><td>10.8|||</td><td>Houser</td><td>38.5|</td></tr>
<tr><td>Frankenmuth</td><td>1470 ||||</td><td>Ticonderoga</td><td>555 |||</td><td>Hill</td><td>10.8|||</td><td>NY 6708-18</td><td>38.4|</td></tr>
<tr><td>Yamhil</td><td>1445 ||||</td><td>Hart</td><td>548 |||</td><td>Besostaya</td><td>10.8|||</td><td>Ticonderoga</td><td>37.8||</td></tr>
<tr><td>Ticonderoga</td><td>1445 ||||</td><td>Kavkaz</td><td>547 |||</td><td>Daws</td><td>10.6|||</td><td>Kavkaz</td><td>37.7||</td></tr>
<tr><td>Houser</td><td>1444 ||||</td><td>Frankenmuth</td><td>547 |||</td><td>Frederick</td><td>10.6|||</td><td>Purcell</td><td>36.4 ||</td></tr>
<tr><td>NY 6708-18</td><td>1436 ||||</td><td>Houser</td><td>534 |||</td><td>Benni</td><td>10.5|||</td><td>Benni</td><td>36.1 ||</td></tr>
<tr><td>Benni</td><td>1431 ||||</td><td>Logan</td><td>513 ||||</td><td>Ticonderoga</td><td>10.4|||</td><td>Frankenmuth</td><td>35.9 ||</td></tr>
<tr><td>Hart</td><td>1418 ||||</td><td>Besostaya</td><td>504 ||||</td><td>NY 6120-15</td><td>10.3 ||</td><td>NY 6120-15</td><td>35.6 ||</td></tr>
<tr><td>Logan</td><td>1334 ||||</td><td>NY 6708-18</td><td>504 ||||</td><td>Houser</td><td>10.3 ||</td><td>Frederick</td><td>34.7 ||</td></tr>
<tr><td>Besostaya</td><td>1290 |||</td><td>Yamhil</td><td>475 ||||</td><td>Hart</td><td>10.0 ||</td><td>Logan</td><td>34.4 ||</td></tr>
<tr><td>Frederick</td><td>1274 |||</td><td>Frederick</td><td>459 ||||</td><td>Logan</td><td>9.9 ||</td><td>Stephens</td><td>33.8 ||</td></tr>
<tr><td>Hill</td><td>1261 |||</td><td>Daws</td><td>427 ||||</td><td>Kavkaz</td><td>9.9 ||</td><td>Daws</td><td>30.9 |</td></tr>
<tr><td>Daws</td><td>1227 |||</td><td>Hill</td><td>411 |||</td><td>Frankenmuth</td><td>9.8 ||</td><td>Yamhil</td><td>30.8 |</td></tr>
<tr><td>Stephens</td><td>1185 ||</td><td>Stephens</td><td>362 ||</td><td>Purcell</td><td>9.8 ||</td><td>Hill</td><td>30.3 |</td></tr>
<tr><td>Nugaines</td><td>1094 |</td><td>Nugaines</td><td>348 |</td><td>Blueboy</td><td>9.0 |</td><td>Nugaines</td><td>27.9</td></tr>
<tr><td>MEAN</td><td>1402</td><td></td><td>510</td><td></td><td>10.4</td><td></td><td>35.4</td></tr>
<tr><td>CV (%)</td><td>13.4</td><td></td><td>13.1</td><td></td><td>5.4</td><td></td><td>3.1</td></tr>
</table>

1 Values connected by vertical lines are not different at the 5% level of significance by Duncan's Multiple Range Test.

yield as well as the soft wheat standards. The hard reds also had a lower grain protein than the 11-15% expected. In contrast, the percentages of protein of soft wheats in all trials were comparable to published values (Watt and Merrill, 1963).

Discussion

My main objective in this Bulletin is to report wheat cultivars that consistently yield abundant grain and straw in Connecticut. Grain yield, total dry matter yield, and grain quality (i.e., protein and 1000-grain weight) are presented since this information is of practical value to farmers in selecting the best cultivars to grow in Connecticut.

In 1983 the average grain yield for all wheats in the early replicated planting (Tables 4 and 5) was only 78% of the yield in 1984. The great difference in yield between years was probably caused by the difference in temperature and rainfall between the summers of 1983 and 1984 (Fig. 1). Late May and early June are critical because flowering or anthesis usually occurs then and unfavorable weather can disrupt filling of grain, causing smaller or partially filled seed. Early June of 1983 and 1984 had periods of high temperature (Fig. 1), and the June average was 1.1 C (2 F) above normal in 1983 and 2 C (3.6 F) above in 1984. The most apparent difference between seasons, however, was the lower than normal and erratic distribution of rainfall in June 1983. Although water was applied, it was probably insufficient to reverse the senescence of cultivars maturing in the early replicated plots. Although 1000-seed weights were almost identical in 1983 and 1984 (Tables 4 and 5), some cultivars (e.g., Hart) were greatly reduced in yield and 1000-seed weight in 1983,

Table 6. Replicated trial planted November 18, 1982.

<table>
<tr><th colspan="2">Total Dry Matter[1]</th><th colspan="2">Grain Yield[1]</th><th colspan="2">Grain Protein[1]</th><th colspan="2">1000-Seed Wt.[1]</th></tr>
<tr><th>Winter Wheat</th><th>g m^{-2}</th><th>Winter Wheat</th><th>g m^{-2}</th><th>Winter Wheat</th><th>%</th><th>Winter Wheat</th><th>g</th></tr>
<tr><td>Houser</td><td>1729</td><td>Houser</td><td>522</td><td>Daws</td><td>10.9|</td><td>Houser</td><td>43.3</td></tr>
<tr><td>Hart</td><td>1605|</td><td>Hart</td><td>438|</td><td>Stephens</td><td>10.8|</td><td>Hart</td><td>41.7|</td></tr>
<tr><td>Benni</td><td>1534||</td><td>Benni</td><td>430|</td><td>Hart</td><td>10.6|</td><td>Stephens</td><td>40.7|</td></tr>
<tr><td>Ticonderoga</td><td>1494|||</td><td>Ticonderoga</td><td>417|</td><td>Nugaines</td><td>10.3|</td><td>Ticonderoga</td><td>38.8 |</td></tr>
<tr><td>Stephens</td><td>1416 |||</td><td>Stephens</td><td>370 |</td><td>Benni</td><td>10.3|</td><td>Benni</td><td>38.3 |</td></tr>
<tr><td>Daws</td><td>1363 ||</td><td>Daws</td><td>335 |</td><td>Houser</td><td>9.4 |</td><td>Daws</td><td>33.8</td></tr>
<tr><td>Nugaines</td><td>1337 |</td><td>Nugaines</td><td>314 |</td><td>Ticonderoga</td><td>9.4 |</td><td>Nugaines</td><td>31.9</td></tr>
<tr><td>MEAN</td><td>1497</td><td></td><td>404</td><td></td><td>10.2</td><td></td><td>38.4</td></tr>
<tr><td>CV (%)</td><td>8.6</td><td></td><td>8.3</td><td></td><td>4.5</td><td></td><td>3.3</td></tr>
</table>

[1] Values connected by vertical lines are not different at the 5% level of significance by Duncan's Multiple Range Test.

Table 7. Replicated trial planted November 2, 1983.

<table>
<tr><th colspan="2">Total Dry Matter[1]</th><th colspan="2">Grain Yield[1]</th><th colspan="2">Grain Protein[1]</th><th colspan="2">1000-Seed Wt.[1]</th></tr>
<tr><th>Winter Wheat</th><th>g m^{-2}</th><th>Winter Wheat</th><th>g m^{-2}</th><th>Winter Wheat</th><th>%</th><th>Winter Wheat</th><th>g</th></tr>
<tr><td>Hart</td><td>1129|</td><td>Hart</td><td>531</td><td>Daws</td><td>12.7|</td><td>Hart</td><td>35.9|</td></tr>
<tr><td>Frederick</td><td>1121|</td><td>Frederick</td><td>449|</td><td>Stephens</td><td>12.4||</td><td>Stephens</td><td>34.3||</td></tr>
<tr><td>Houser</td><td>1027||</td><td>Houser</td><td>427||</td><td>Benni</td><td>12.0|||</td><td>Houser</td><td>33.2 ||</td></tr>
<tr><td>Ticonderoga</td><td>968||</td><td>Ticonderoga</td><td>405|||</td><td>Houser</td><td>11.8 |||</td><td>Frederick</td><td>33.0 ||</td></tr>
<tr><td>Stephens</td><td>960||</td><td>Daws</td><td>370 ||</td><td>Nugaines</td><td>11.2 |||</td><td>Ticonderoga</td><td>31.9 ||</td></tr>
<tr><td>Daws</td><td>960||</td><td>Nugaines</td><td>365 ||</td><td>Ticonderoga</td><td>11.2 |||</td><td>Nugaines</td><td>31.7 |||</td></tr>
<tr><td>Nugaines</td><td>936 |</td><td>Stephens</td><td>363 ||</td><td>Frederick</td><td>11.0 ||</td><td>Daws</td><td>30.3 ||</td></tr>
<tr><td>Benni</td><td>885 |</td><td>Benni</td><td>332 |</td><td>Hart</td><td>10.5 |</td><td>Benni</td><td>29.9 |</td></tr>
<tr><td>MEAN</td><td>998</td><td></td><td>405</td><td></td><td>11.6</td><td></td><td>32.5</td></tr>
<tr><td>CV (%)</td><td>10.6</td><td></td><td>11.5</td><td></td><td>4.1</td><td></td><td>3.8</td></tr>
</table>

[1] Values connected by vertical lines are not different at the 5% level of significance by Duncan's Multiple Range Test.

Table 8. Relative yield of total dry matter and seed and the percent protein in in seed of hard red winter wheats harvested in 1983 and 1984 unreplicated trials.

Winter Wheat	1983 Total (% of Standards)[1]	1983 Seed (% of Standards)[1]	1983 Protein (%)	1984 Total (% of Standards)[1]	1984 Seed (% of Standards)[1]	1984 Protein (%)
Manning	137	125	10.6	68	56	8.8
Rita	124	111	--	119	108	10.1
Centurk 78	107	102	8.7	96	90	8.4
Tamex	99	96	9.9	81	77	8.6
Sturdy	99	93	10.6	67	56	9.9
Newton	98	92	9.7	81	77	9.2
Dawn	94	87	9.3	108	106	8.9
Payne	92	80	11.0	71	65	10.3
Vona	90	95	9.5	81	68	10.8
Mit	86	83	11.0	67	61	11.7
TAM 105	84	83	8.6	59	58	9.0
Arbon	81	76	9.3	--	--	--
Triumph 64	81	66	9.7	98	75	11.3
TAM W101	79	61	10.3	79	73	9.5
Bennett	73	61	11.3	81	77	9.9
TAM 106	69	63	11.0	--	--	--
MEAN	93	86	10.0	83	75	9.7

[1] Total and seed yield are given as a percentage of nearby standard cultivars Houser and Hart.

suggesting grain filling was impaired. Cultivars such as Ticonderoga were also greatly reduced in 1000-seed weight in 1983, but high yield was achieved by other mechanisms (e.g., high seed numbers, numerous tillers).

In the replicated trials planted in early October 11 cultivars were tested in both 1983 and 1984. Among these cultivars, Purcell, Ticonderoga, Frankenmuth, and Kavkaz produced more total dry matter and grain in both seasons. These results are largely in agreement with an unreplicated study of these cultivars in 1982, thus indicating stability for high yield. Although straw yields were high in cultivars with low grain yield, it is practical to focus only on cultivars with high grain and high straw yield. Kavkaz produced 1002 g m^{-2} (8938 lbs A^{-1}) straw and chaff in 1983 and 1047 g m^{-2} (9339 lbs A^{-1}) in 1984, making it the outstanding cultivar for straw production. Although these high yielding cultivars were generally lower than other cultivars in protein, the protein of the soft white wheats Ticonderoga, Purcell, and Frankenmuth were in the range of published values of this wheat class (Watt and Merrill, 1963). Kavkaz, a bread wheat from the USSR, was low in grain protein at 9.4-9.9%.

Differences in growth patterns were intentionally induced by planting some cultivars in early and late replicated trials (Tables 4, 5, 6, and 7). When compared to the early plantings, yield was much lower only in the late planting in 1983 (1984 crop). Thus, while planting between the first week of October and the first week of November may have little effect on yield, this is not always the case. The grain protein and 1000-seed weight of wheats in the late plantings were in the same range as wheats in the early plantings, indicating grain quality was not greatly influenced by planting date.

The best cultivars for early plantings may not be the best for late plantings. Among four standard cultivars included in early and late replicated trials in 1983 and 1984, Ticonderoga and Houser yielded well and maintained their ranking when compared to other cultivars in different years. In contrast, Benni and Hart fluctuated greatly in yield and rank among cultivars. While Houser and Hart had a lower yield relative to Ticonderoga in early replicated trials, they consistently ranked above Ticonderoga in the late trials in 1983 and 1984. Thus, Houser and Hart may be better cultivars for late plantings.

The early and late replicated trials show the soft white wheats (i.e., Houser, Purcell, Ticonderoga, Frankenmuth, and Frederick) developed in a climate similar to Connecticut's yielded more than soft white wheats (i.e., Daws, Nugaines, and Stephens) developed in the Pacific Northwest. Although the latter were high in grain protein for soft white wheats (Tables 5, 6, and 7), this may be due to poor grain filling, which caused low grain yields and low 1000-seed weights. Generally, wheats developed in New York were among the highest yielding in any year or trial. Although Blueboy, a soft red wheat from North Carolina, yielded well in both unreplicated and the 1984 early replicated trial, it is susceptible to powdery mildew, which was controlled with Bayleton 25. The highest grain yields in all trials were 522 g m^{-2} (78 bu A^{-1}) in 1983 and 676 g m^{-2} (101 bu A^{-1}) in 1984. The lowest grain yields were 314 g m^{-2} (47 bu A^{-1}) in 1983 and 332 g m^{-2} (50 bu A^{-1}) in 1984.

Results from unreplicated trials were presented to evaluate the potential of hard red wheats in Connecticut (Table 8). Although cultivars such as Rita, Centurk 78, and Dawn show promise for yield, the protein content of the hard red wheats was much lower than expected for this class of wheat (Martin and Leonard, 1967). Further testing will evaluate their potential in Connecticut. In contrast to the hard red wheats, several soft white wheats from New York produce excellent yields and protein content when grown in Connecticut.

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