Grain Protein Content and Its Relationship to Other Plant and Seed Characters in the Parents and Progeny of a Cross of *Triticum aestivum* L.  

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**RESULTS** of several studies concerning variability of grain protein content in segregating populations of wheat are reported in the literature. Some of the earlier studies indicated that phenotypic variability of protein in the *F₂* of a cross of two wheat varieties was no greater than that found in the parental populations although the parental varieties differed in protein content (1, 2, 3). While numerous investigations showed that high grain protein content is correlated with low yield, occasional exceptions were reported (5, 7, 8). Heritability of wheat grain protein has been considered to be low, but Haunold et al. (6) and Davis et al. (4) reported moderately high heritability estimates of 0.65 and 0.67, respectively.

The results of a study of a cross of a high protein with a low protein wheat variety are reported in this paper. Variability of grain protein content was studied in parental, *F₁*, *F₂*, and backcross populations. Correlations between protein content and several plant and seed characters were determined from *F₂* population data. Estimates of heritability were calculated for each of the characters studied.

**MATERIALS AND METHODS**

Parental stocks consisted of Wichita (C.I. 11952), a hard red winter wheat variety, and Atlas 66 (C.I. 12561), a soft red winter wheat variety. These varieties generally exhibit a wide difference in grain protein content. The populations were designated as follows:

- **P₁** = Wichita (Low protein parent)
- **P₂** = Atlas 66 (High protein parent)
- **F₁** = Wichita × Atlas 66 (First generation)
- **F₂** = Wichita × Atlas 66 (Second generation)
- **BC₁** = *F₁* × Wichita (First generation)
- **BC₂** = *F₁* × Atlas 66 (First generation)

Each of the parental stocks originated from a single plant on which the heads were bagged to insure self-pollination. The experimental populations were planted November 14, 1959, in a 12 × 34-foot greenhouse soil bed. A randomized complete block design with four replications was used. Each replication contained 1 row each of P₁, P₂, and *F₁*, 2 rows each of BC₁ and BC₂, and 7 rows of F₂. Rows were spaced one foot apart. Each row contained 22 or 23 plants spaced 3 inches apart.

During an 8-week vernalization period, a minimum night temperature of 20°F was maintained in the greenhouse. After vernalization, the temperature was raised to 70°F in small increments over a 4-week period. Natural light was supplemented during the entire growing season with eighteen 200-watt incandescent bulbs spaced evenly above the soil. Effective photoperiod was increased gradually to approximate normal field conditions. During the growing season, approximately 11 inches of water was applied by flood irrigation.

Soil analysis did not indicate need for application of any nutrient elements other than nitrogen. Nitrogen in the amount of 120 pounds per acre was applied in the form of ammonium nitrate. Applications of 40 pounds each were made at the beginning of the growing season, 2 weeks before flowering, and at flowering. A supporting wire network was provided from the time of jointing through maturity to prevent lodging and differential shading.

During flowering, individual plants were checked each day. When a head began to shed pollen, it was tagged to indicate its flowering date. At harvest, single plants were pulled and heads were threshed separately. Protein analyses were made with a Udy Analyzer in the Nebraska Experiment Station Wheat Quality Laboratory. Only heads that weighed more than 950 milligrams were used for protein analyses as suggested by Stuber et al. (10).

The following data were recorded for individual plants in all populations:

- **Grain protein content**—Amount of protein expressed as percent of the dry weight of the grain.
- **Grain yield per plant**—Weight of grain from each plant to the nearest 0.01 gram.
- **Grain yield per head**—Average weight of grain per head from each plant to the nearest 0.01 gram.
- **Plant height**—Height in centimeters from the soil surface to the top of the tallest tiller, excludingawns.
- **Flowering date**—Coded date when half the heads had shed pollen. Coded values are 1, April 21; 2, April 22; . . .; 20, May 10.
- **Number of tillers**—Number of culms bearing spikes in each plant.

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Table 1—Means and standard errors for plant height, tillers, yield per head and per plant, flowering date, and grain protein of individual plants of the parents and of the *F₁*, *F₂*, BC₁, and BC₂ of a Wichita × Atlas 66 cross.

<table>
<thead>
<tr>
<th>Variety or pedigree</th>
<th>Number of plants</th>
<th>Mean plant height, cm.</th>
<th>Mean number of tillers</th>
<th>Mean yield of grain per head, g.</th>
<th>Mean yield of grain per plant, g.</th>
<th>Mean flowering date</th>
<th>Grain protein content per plant, %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P₁</strong> (Wichita)</td>
<td>74</td>
<td>152.9 (4.01)</td>
<td>6.0 (0.34)</td>
<td>1.19 (0.0202)</td>
<td>1.40 (0.0202)</td>
<td>7.09 (0.3854)</td>
<td>6.5 (0.46)</td>
</tr>
<tr>
<td><strong>P₂</strong> (Atlas 66)</td>
<td>73</td>
<td>152.9 (4.03)</td>
<td>5.5 (0.34)</td>
<td>1.17 (0.0202)</td>
<td>1.41 (0.0202)</td>
<td>6.28 (0.3854)</td>
<td>10.7 (0.44)</td>
</tr>
<tr>
<td><strong>F₁</strong></td>
<td>73</td>
<td>165.9 (4.03)</td>
<td>6.4 (0.34)</td>
<td>1.23 (0.0202)</td>
<td>1.45 (0.0202)</td>
<td>7.53 (0.3854)</td>
<td>9.5 (0.48)</td>
</tr>
<tr>
<td><strong>F₂</strong></td>
<td>512</td>
<td>162.6 (4.92)</td>
<td>6.5 (0.35)</td>
<td>1.16 (0.0183)</td>
<td>1.40 (0.0119)</td>
<td>7.63 (0.3854)</td>
<td>9.4 (0.43)</td>
</tr>
<tr>
<td><strong>BC₁</strong></td>
<td>146</td>
<td>164.6 (4.43)</td>
<td>6.9 (0.29)</td>
<td>1.16 (0.0208)</td>
<td>1.40 (0.0119)</td>
<td>7.85 (0.2038)</td>
<td>8.3 (0.45)</td>
</tr>
<tr>
<td><strong>BC₂</strong></td>
<td>128</td>
<td>166.4 (2.97)</td>
<td>6.2 (0.18)</td>
<td>1.21 (0.0201)</td>
<td>1.42 (0.0220)</td>
<td>7.46 (0.2038)</td>
<td>10.6 (0.239)</td>
</tr>
</tbody>
</table>

* Mean yield per head of all heads of a plant.  ** Mean yield per head of only those heads weighing over 950 milligrams.

1 A mean yield of 7.00 grams per plant is approximately equivalent to 65 bushels per acre. 2 Flowering dates were coded. Coded values are 1, April 21; 2, April 22; . . .; 20, May 10.

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