Inheritance and Heritability of Seed Weight and Its Components in Oats

Charles F. Murphy and Kenneth J. Frey

A COMMON objective of small grain breeding programs is to improve grain yield. With oats, as with other crops, grain yield variation is due to an interaction of environmental and genetic effects. One method proposed to circumvent this problem is to select for characteristics associated with or composing yield, i.e., yield components. Primary components of grain yield are number of panicles per plant, number of seeds per panicle, and weight per seed. It is conceivable that if heritability percentages for and correlations among yield components were used to construct an optimum selection index, the efficiency of selection might be greater than when yield performance was used. Since seed weight can be subjected to component analysis and measured relatively precisely with small sample size, this character was selected to study the theory and application of character component analysis.

LITERATURE REVIEW

Grafius (6) interpreted yield as the multiplicative product of three components: number of panicles per plant, number of seeds per panicle, and weight per seed. By representing yield as the volume of a rectangular parallelepiped, with each component as one of its dimensions, he postulated that the components could be used to predict the crosses which would give maximum segregation for yield. Further subdivision of these components was also discussed, e.g., seed weight could be subdivided into diameter, length, and density.

The relationship between stand and panicles per plant was investigated by Grafius (7) and Wiggans and Frey (9). Most of the varieties tested adjusted for differences in stand by increasing or decreasing the number of panicles per plant.

Frey (1, 2, 4) has shown the effects of various nitrogen treatments and seeding dates upon yield and its components. All treatments had less effect upon weight per 100 seeds than upon number of panicles per plant or seeds per panicle. Furthermore, the variation due to variety X location interaction was smaller for yield components than for yield in 5 of 6 cases. This was explained as due to the multiplicative interaction of the components.

MATERIALS AND METHODS

F₁ and F₂ populations from 12 oat crosses were grown at Ames, Iowa. In 1958, F₁ seeds were space-planted at 12-inch intervals in 20-foot rows, spaced 1 foot apart. In 1959, F₂ progenies were grown, 1 line per 3-foot progeny row, with 1 foot spacing between rows. Each F₁ plant grown in 1958, was harvested and threshed separately. In 1959, each progeny row was harvested and threshed separately.

Weather conditions were favorable for oat growth in both 1958 and 1959, resulting in well-filled caryopses. The oat plants were sprayed with a fungicide (active ingredients Nabilam and zine sulphate) at weekly intervals from heading to maturity, to prevent rust infection which could confound the genetic expression of seed weight.

Measurements were taken on caryopses (groats) to eliminate the confounding effects of the hull (testa and palla), which adhere to the caryopsis in Avena sativa. Groat weight varies as a function of length, width, and density as follows:

\[ G.W. = I(W/2)^{2/D} \]

where G.W. = gross weight in grams per 100 groats, L = length in mm., W = width in mm., D = density, and K = a factor which corrects for the fact that groats are not cylindrical.

Ten primary seeds from each F₂ plant and F₁ line were dehulled and the groats singed to remove pubescence. Length and width of each groat was measured to 0.1 millimeter by projecting its shadow, at 10 times magnification, onto a sheet of "millimeter graph paper" with a Master Vu Graph.

Remnant oat seeds from each sample were dehulled with an impact dehuller and a 100-groat sample was taken from each and weighed to the nearest hundredth of a gram.

Density determinations were obtained by dividing the weight of 100 groats by the volume of acetone they displaced. Acetone was used because it had a low surface tension than water.

Length, width, and weight per 100 groats of oat strains used as parents for the crosses are given in Table 1.

In 1959, an experiment was conducted to determine the number of days required for length and width of the groats to develop. Twenty primary florets from tip spikelets were collected from each of 5 blocks of Clintland oats (six 8-foot rows per block) at 2, 4, 6, 8, 10, and 21 days after anthesis. Length and width measurements were made on 10 primary groats from each block immediately after harvest and on the other 10 after air drying for 48 hours.

EXPERIMENTAL RESULTS

Preliminary experiments showed that density of oat groats was influenced by storage conditions. This source of error was eliminated by storing groats in a dryer for 3 days prior to density determinations.

No significant variation in density was found among the means of the parental strains, in either 1958 or 1959. Mean density of all entries in this experiment was 1.3647.

In 1953, densities were determined, by water displacement, on oat groats from oat varieties in the North Central Uniform Nursery grown at Aberdeen, Idaho, under rust-free conditions, and at Kanawha, Iowa, under severe rust conditions.

MATERIALS AND METHODS

Strain | Wt. per 100 groats, g. | Groat length, mm. | Groat width, mm. |
--- | --- | --- | --- |
Clintland | 1.74 | 7.30 | 7.27 | 2.47 | 2.46 |
Bonnie | 1.98 | 7.08 | 6.79 | 2.19 | 2.16 |
Andrew | 1.39 | 7.03 | 6.79 | 2.19 | 2.16 |
Putum | 1.85 | 7.07 | 7.12 | 2.59 | 2.59 |
A 118-13-14 | 1.07 | 7.12 | 7.12 | 2.59 | 2.59 |
Burat | 2.13 | 7.05 | 7.55 | 2.14 | 2.14 |
A 72-165-81 | 1.17 | 7.05 | 7.15 | 2.14 | 2.14 |
Newton | 1.96 | 7.45 | 7.19 | 2.14 | 2.14 |
C.I. 6748 | 1.70 | 7.17 | 7.26 | 2.14 | 2.14 |
Bonda | 1.99 | 7.19 | 7.19 | 2.14 | 2.14 |
Eaton | 2.08 | 7.55 | 7.55 | 2.14 | 2.14 |
C. I. 2105 | 2.02 | 7.55 | 7.55 | 2.14 | 2.14 |
Bonda | 2.07 | 7.55 | 7.55 | 2.14 | 2.14 |


2 Formerly Graduate Assistant (now Assistant Professor of Field Crops, North Carolina State College) and Professor of Farm Crops, Iowa State University.