DIRECT AND INDIRECT SELECTION FOR GRAIN YIELD IN OATS (Avena sativa L.)

S. K. JOHNSON, D. B. HELSEL and K. J. FREY
Agronomy Department, Iowa State University, Ames, Iowa, USA

INDEX WORDS
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ABSTRACT
Direct and indirect selection for increased grain yield were carried out on a population of 678 F$_2$-derived lines of oats. A selection intensity of 10% was used with direct selection (selection for grain yield itself) and with indirect selection using three criteria, harvest index, vegetative growth rate, and the index of harvest index + vegetative growth rate. Expected gains from 1978 evaluations were compared to actual gains measured in 1980.

Actual grain yield increases were 4, 8, 7, and 6% from selection via harvest index, vegetative growth rate, grain yield, and harvest index + vegetative growth rate, respectively. Thus, indirect selection via vegetative growth rate gave a greater increase in grain yield than did direct selection.

Heritability values computed via components of variance ranged from 0.50 to 0.57 for the three traits, harvest index, vegetative growth rate, and grain yield, whereas regression heritabilities ranged from 0.41 to 0.55. Realized heritabilities were 0.33, 1.00 and 0.89 for the three traits, respectively.

Selection via all criteria caused significant changes in nearly all agronomic traits except weight per volume. Vegetative growth rate, which gave the greatest gain in grain yield, caused less drastic changes in days to anthesis, plant height, biological yield, and vegetative yield than did direct selection for grain yield.

INTRODUCTION
Direct selection for grain yield of crop plants is the most common procedure used by plant breeders for improving this trait. In some situations, however, indirect selection may be superior for choosing lines that possess high inherent grain-yielding capacity. For example, an index that includes the components of grain yield is expected to serve as an effective criterion for indirect selection if the index heritability is higher than that for grain yield and if a high genetic correlation exists between the index and grain yield. Selecting for component traits of grain yield to increase productivity of cereals was suggested by Takeda & Frey (1976). Eagles & Frey (1974) and Saad El Din (1979) showed that an index that included two or more traits was more efficient in selecting for grain yield of oats (Avena sativa L.) than was selection for grain yield itself. Helsel (1980) used the general concept that Grain yield = Growth rate × Growth duration × Harvest index in several direct and indirect selection schemes.
for increasing grain yield of oats and found that direct selection was more effective than indirect selection for improving expected grain yield.

Biological yield of cereals depends upon the size, duration, and photosynthetic activity of the vegetative plant parts (Frey et al., 1967), and grain yield is dependent on the portion of biological yield that is translocated into the caryopsis (Donald & Hamblyn, 1976). Growth rate measures net photosynthesis on a daily basis, and harvest index represents the efficiency of photosynthate deposition in the grain. Takeda et al. (1979) showed that, as hypothesized, growth rate and harvest index are highly and positively associated with grain yield of oats, but they were not correlated with each other.

Knowledge about the physiologic and genetic relationships of grain yield, growth rate, and harvest index was used in conducting a study to determine (a) the relative efficiencies of selection for grain yield directly or indirectly via growth rate, harvest index, or a combination of these traits, and (b) the effects that selection would have on the agronomic performance of selected lines.

MATERIALS AND METHODS

Our materials were 678 F2-derived lines tested in F4 and F5 from 12 oat matings. The number of lines within a mating ranged from 17 to 82. All parents were acceptable for agronomic traits.

Field experiments. All 678 F2-derived lines were tested in field experiments in 1978. The lines from a mating were tested in a randomized-block experiment with eight replicates. Thus, 12 experiments (one per mating) were conducted. For each experiment, four replicates were sown on a productive Clarion-Webster soil at Ames, Iowa, and four were sown on a Kenyon soil at Nashua, Iowa. In 1980, the selected oat lines, F2-derived lines in F5, were grown in a randomized-block experiment with six replicates. Three replicates were sown on a Clarion-Webster soil, and three were sown on a Copland soil, both locations being near Ames, Iowa. In both years, plots were hills spaced 30 cm apart in perpendicular directions and sown with 31 seeds each. N, P2O5, and K2O were applied preplanting at each experimental site as needed for high productivity of oats. The experiments were hand-weeded, and a fungicide, Dithane-45, was applied to the plants at weekly intervals from anthesis to maturity to preclude foliar-disease development.

Measurements on a plot basis were made in both years for four traits:
(a) Days to heading were recorded in days from planting when 50% of the panicles were completely emerged.
(b) Plant height (cm) was measured from the ground surface to the panicle tips 10 days post anthesis.
(c) Biological yield (q/ha) was the weight of the dried bundle of culms harvested when mature.
(d) Grain yield (q/ha) was the weight of the threshed caryopses.
From these measurements, values for three traits were computed:
(a) Vegetative yield (q/ha) was computed by subtracting grain yield from biological yield.
(b) Harvest index (%) was computed by dividing grain yield by biological yield.