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Yield Components in Oats. VI. Their Value in Selecting for Yield

K. J. Frey
Iowa State University

Yield Components in Oats. VI. Their Value in Selecting for Yield[1]

K. J. Frey[2]

Abstract. F_2 derived lines from 6 oat crosses were evaluated for production of the two yield components, spikelets per panicle and seed weight in 1958. From the yield component data the yielding ability of each line was predicted. All lines having a predicted yielding capacity of 110% or more were tested for actual yielding ability in 1959. The calculated-yield differential between the means of the selected lines and of the whole population was 16%, whereas the mean differential for actual yield in 1959 was only 5%.

In a companion study using 5 of the crosses, grain yield itself was the selection criterion. The differential between the mean yield of the crosses and the selected samples was 14% in 1958, whereas the mean yield of the selected sample was 7% higher than the cross means in 1959. Comparable values for these 5 crosses using the yield-component selection method were 17% and 6%, respectively. When costs and percentage of the selection differential retained were both considered, the use of grain yield as the selection criterion was most efficient.

When calculated yields were correlated with actual yields, either within the same year or between years, the mean correlation was approximately +0.40.

In a broad sense, plant breeding is composed of 2 phases: (a) discovering or inducing a variable population of plants, and (b) practicing selection on the variable population. A majority of studies on plant breeding methodology have been concerned with improving efficiency in the latter phase.

Considerable thought and study have been given to devising methods that would improve the efficiency of yield selection, especially. A recent study by Frey (2) suggested that the efficiency of selection for yield in oats might be improved if one selected on the basis of yield components instead of yield itself. Interlocation correlations for panicles per plant, seeds per panicle, and seed weight were highly significant in 8 of 9 cases whereas none of the 3 grain-yield correlations attained significance.

This study was conducted to determine the feasibility of predicting yielding capacity of oat strains from yield component data. The specific comparisons made were: (a) correlations between actual yields and those calculated from yield com-

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[2] Professor of Farm Crops, Department of Agronomy, Iowa State University.

ponent data, and (b) the relative progress from selection when calculated yield based on components and when actual yields were each used as selection criteria.

Materials and Methods

F_2 derived lines from 6 oat crosses (Table 1) were measured for 2 yield components (spikelets per panicle and seed weight) and grain yield in 1958 (F_4) and 1959 (F_5), respectively. In 1958 the lines from each cross were grown in a separate randomized block experiment with 3 replications, two in central Iowa (Ames) and one in southern Iowa (Seymour). A plot consisted of a hill planted with 25 seeds (4,6). The space between hills was 1 foot in perpendicular directions giving a plot area of 1 square foot. At a convenient time between anthesis and harvest the spikelets were counted on 5 randomly-chosen panicles from each plot. At maturity, the remaining panicles in each plot in the 2 replications at Ames were harvested, threshed, and used for seed-weight determinations. The line means for number of spikelets per panicle and seed weight were converted to percent of the cross mean and the 2 values were multiplied together for calculated yield. The distributions of calculated yields was approximately normal.

Table 1. Code numbers, parentages, and number of strains for oat crosses used in the selection experiments based on yield components

Cross No.	Parentage	No. of strains
C 220	Cherokee x Minland	228
C 221	Mo. 0-205 x Cherokee	183
C 257	Andrew x Cherokee	215
C 311	Andrew x P.I. 174544	98
C 368	Bonham x Clarion	132
C 370	Clintland x Garry	101

Within each cross, the F_2 derived lines with calculated yields of 110 or greater were retained as a "selected" sample (generally 15 and 20% of the lines tested). To provide a base with which to compare the mean yield of the progenies of lines in the selected sample, a stratified random sample composed of one-tenth of the lines in a cross was taken. Each stratum was composed of the lines within a relative yield interval of 10%, i.e., 81-90, 91-100, 101-110, etc.

In 1959, the F_2 derived lines representing the stratified random and selected samples from each cross were grown at Ames, Iowa in a separate randomized block experiment of hill plots with 8 replications. The parent varieties were included in both 1958 and 1959. Grain production of each plot was measured in grams. The mean grain weight of the stratified random sample in each cross was equated to 100% and the mean grain yield of the corresponding selected sample was calculated as a percent of this base. These values were directly comparable with the calculated yields from 1958.

In 1958 and 1959, a portion of the F_2 derived lines from 5 of the crosses (except C 370) were grown at Ames in hill-plot experiments where only grain yields were measured. The numbers of replications were 4 and 8 in 1958 and 1959, respectively. These data were used in 2 ways. First, simulated selection experiments based on grain yield were conducted to provide a comparison with selection based on yield components. Second, correlations were calculated between calculated and actual yields where the F_2 derived lines were grown in different experiments in the same year. Also, correlations were calculated between calculated yields in the stratified random sample from 1958 and actual yields in 1959.

Results

The calculated (1958) and actual (1959) yields for the material selected on the basis of yield calculated from components are given in Table 2. The mean advantage in relative yield for the selected sample was 16%, whereas the mean gain realized in the next generation was only 5%. Among crosses the gain from selection ranged from 0 to C 370 to 9% in C 257. A crude measure of heritability, obtained by dividing the predicted by the realized gain, was 31%.

Table 2. Mean predicted (1958) and actual (1959) relative yields of oat strains in the stratified random and selected samples chosen on the basis of yields calculated from components

Cross	Stratified sample		Selected sample	
	Predicted	Actual	Predicted	Actual
	(%)	(%)	(%)	(%)
C 220	100	100	119	106
C 221	99	100	117	106
C 257	98	100	115	109
C 311	99	100	117	106
C 368	100	100	115	104
C 370	99	100	115	100
Mean	99	100	116	105
Mean (Excluding C 370)	99	100	117	106

The mean relative yields for oat strains selected on the basis of grain yields in 1958 are presented in Table 3. The mean advantage predicted from selection was 14%, whereas the actual gain was 7%. For the 5 comparable crosses (excluding C 370) where yield components were used as the selection criteria, the mean expected and actual relative gains were 117% and 106%, respectively. Thus, for comparable materials the heritability of relative yield was 50% where grain yield was used as the selection criterion, and 35% where calculated yield from components was used. Either of these values is encouraging since yield is generally considered to be less heritable than found herein.

Table 3. Mean relative yields of oat strains in random and selected groups chosen on basis of actual yields

Cross	Random sample		Selected sample	
	1958	1959	1958	1959
	(%)	(%)	(%)	(%)
C 220	100	100	112	105
C 221	100	100	115	112
C 257	100	100	120	112
C 311	100	100	111	100
C 368	100	100	111	105
Mean	100	100	114	107

The F_2 derived lines tested had never been subjected to selection for yielding ability. Only lines that were exceptionally early or late were discarded prior to the experiments in 1958. Insofar as possible, no other selection was practiced during the F_2 and F_3 generations.

Table 4. Correlations between calculated and actual yields of oat lines grown in different experiments in 1958

Cross	d.f.	Correlations
C 220	87	0.41**
C 221	88	0.45**
C 257	88	0.17
C 311	37	0.35*
C 368	42	0.36*
Mean		0.38

When the actual and calculated yields from different experiments in 1958 were correlated 4 of 5 coefficients were significant (Table 4). Four of 6 correlations between calculated yields in 1958 and actual yields in 1959 were significant (Table 5). The mean correlation for both sets of comparisons was approximately 0.40. This is a standard unit heritability of 40%, which corresponds closely to the 35% and 50% calculated from selection gain. None of these data support the suggestion that selection for yield in oats would be more efficient if the plant breeder evaluated experimental lines for yield components in place of grain yield itself.

Table 5. Correlations between calculated yields of oat lines in 1958 and actual yields in 1959

Cross	d.f.	Correlations
C 220	23	0.28
C 221	18	0.51*
C 257	21	0.41*
C 311	19	0.55**
C 368	25	0.56**
C 370	18	-0.11
Mean		0.39

In general, visual selection for characters associated with yield in either replicated or non-replicated experiments has proven of limited value (1, 3, 5). The 35% retention of the yield selection differential found herein when yield components were used as selection criteria was encouraging in light of past experience. However, in the same crosses and experiments, using grain yield resulted in a 50% retention. Actually, the 50% and 35% retentoin of the selection differential by the 2 methods may not be completely comparable. In the year of selection grain yield was determined relatively more precisely than was the yield calculated from components. Grain yield was measured on 4 replications, where as spikelets-per-panicle was evaluated on 3, weight-per-100 seeds on 2, and panicles-per-plant was not assayed at all. Furthermore, the grain-yield experiments were grown at the same location in both 1958 and 1959, so the gain from selection contains an inseparable entry x location contribution. Two locations were used for assaying spikelets per panicle so a portion of the entry x location effect should be eliminated in the yield component method. If both factors, i.e., precision of measurement and entry x location contribution, were comparable for the 2 methods it would have the effect of bringing the values for percentage of selection differential retained closer together.

If the proportion of the selection differential retained was similar for both methods of selection, the cost factor would force one to use grain yield as the selection criterion.

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Inheritance of Seed Weight and its Relation to Grain Yield of Oats[1]

K. J. Frey[2]

Abstract. In 3 oat crosses seed weight appeared to be inherited as a quantitative character. Each of the crosses showed transgressive segregation. In 6 crosses, the correlations between yield and seed weight were all positive, but only 4 were significant.

In simulated selection experiments, the efficiency of selection for yield was compared when only yield or when yield plus seed weight were used as the selection criterion. In general, the addition of seed weight as a selection criterion decreased the gain in yield.

Introduction

Much research conducted by cereal breeders is directed toward developing greater efficiency in selection for seed yield. Since the heritability of yield is low, especially in early generations after hybridization, a common approach to improving selection efficiency is to search for attributes correlated with yield and also highly heritable. Seed weight may be such an attribute. It is a component of yield (1) and shows a relatively low genotype x environment interaction (4).

A partial summary of correlations between seed weight and grain yield in wheat and oats reported in the literature is given in Table 1. In general, the correlations for wheat appear to be somewhat larger than those for oats. The authors conclude that seed weight is of less value in explaining the variability of yield than is any other yield component. In each of these studies, except the one by Immer and Stevenson (5) the variability was measured either among variety means or single plants within varieties. Where variety means were used, the correlations would be related to the sample of varieties, and, where plants within

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[2] Professor of Agronomy, Iowa State University, Ames, Iowa