Adaptation Reaction of Oat Strains Selected Under Stress and Non-Stress Environmental Conditions

K. J. Frey

WHAT constitutes an optimum environment in which to practice selection for an attribute? Obviously, the optimum environment is one which will elicit the greatest differential genetic manifestation for the attribute in question (assuming, of course, that different genetic potentials exist within the population under test). In some cases defining the optimum environment is easy. For example, oat plants which possess the A gene for reaction to stem rust (giving a resistant reaction to races 7 and 7A) can be differentiated from those carrying the a gene by subjecting the plants to infection with spores of stem rust race 7. Other factors of the environment (temperature, soil moisture, etc.) can vary over rather wide ranges without seriously affecting the reaction conditioned by the A and a genes.

On the other hand, defining the optimum environment to differentiate the degree of adaptation characteristic of different small grain strains is difficult. Perhaps the reasons for the problem here are twofold: (a) adaptation reaction has different meanings under different situations, and (b) several different mechanisms may be responsible for adaptation reaction.

Generally, good adaptive capacity means somewhat superior productivity (relative to all strains being tested) of a genotype or population over several environments. It connotes a stability of superior productiveness relative to other lines being assayed. However, for the plant physiologist, the productivity may be measured by individual plant vigor; for the ecologist and evolutionist, productivity by propensity to produce numerous offspring; and for the agronomist, productivity by weight of grain produced per unit of land area.

It is conceivable that the mechanism responsible for adaptation reaction may also influence the optimum environment for differentiation of this attribute. The genetic, developmental, and polyploid mechanisms are basically genotype oriented, whereas the heterogeneity mechanism is population oriented. Thus the geneticists are interested in genetics while the agronomists are interested in the population.

As used in this paper, desirable or good adaptation reaction will connote the agronomists’ definition and will be identical to “wide adaptation”. This study gives data relative to the adaptation reaction of oat strains selected under “stress” and “nonstress” growing conditions at Ames, Iowa.

METHODS AND MATERIALS

The terms “stress” and “nonstress” used to describe the selection environments of this study are relative to one another, and neither was necessarily optimum. The 2 areas which supplied these conditions were located about 50 feet apart in a field on the Agronomy Farm at Ames. The “stress” area was an unfertile, gravelly outcrop resulting from many years of erosion of the topsoil from a knoll. The “nonstress” area was at the foot of the knoll where the eroded topsoil from the stress area was deposited. The stress area was both low in fertility and dryness, whereas the nonstress area had good moisture retention and high fertility. Since the 2 areas were only 50 feet apart, the macro-climatic factors, temperature, sunlight, rainfall frequency, etc., should have been similar for both. The mean oat grain yields of the stress and nonstress areas were 31 and 68 bushels per acre, respectively, for the period 1956-61.

The biological materials with which the selection experiment was initiated in each area consisted of 1200 F1 plants, 300 from each of 4 crosses. The crosses were: C311, Andrew X P.I. 174544; C349, Eaton X Alaska; C368, Clarion X Bonham; and C370, Clintland X Garry. The F1 plants were spaced at 1-foot intervals in rows 1 foot apart in each area in 1956. Selection methodology among F2 plants in each area was identical to that ordinarily used in the Iowa oat breeding program. Only vigorous plants with proper maturity and height and desirable appearance were retained. At maturity, 1 panicle was harvested from each surviving F1 plant, and, in 1957, the seeds from each panicle were planted in a separate progeny row in the same area (i.e., stress or nonstress from which the panicle was harvested. Each progeny row was 2 feet long, and the spacing between rows was 1 foot. In the F2 generation, selection was practiced among progeny rows only. The criteria for selection in the F2 generation were the same as those used in F1, and, at maturity the desirable rows were harvested and threshed separately.

The F2 progenies that survived the first 2 (F2 and F1) selection cycles were planted in a yield test with 4 replications in 1958. The plot size was a hill occupying 1 square foot and planted with 25 seeds. The numbers of F1 lines surviving after 2 selection cycles were 264 and 133 from the stress and nonstress conditions, respectively. Data upon heading date, plant height, test weight and yielding ability obtained from the 1958 yield tests were used for additional selection among F2 lines. In 1959 and 1960, additional hill plot yield trials were conducted with surviving F2 and F1 lines utilizing 8 and 15 replications, respectively. During the 5 years of selection there was no interchange of lines between the 2 areas.

In the F3 generation the best 18 lines from each of the selection areas and the 6 parent varieties, Andrew, Bonham, Clarion, Clintland, Garry, and P.I. 174544 were planted in a hill-plot experiment in 3 environments with 15 replications at each. The tests were planted at Beaconsfield in southern Iowa, and in the stress and nonstress areas at Ames.

The adaptation reaction of each group of strains, i.e., the group selected in the stress area and the group selected in the nonstress area, was tested by measuring the degree of significance of the mean square for the strains X environments interaction. A non-significant interaction mean square would indicate a similar reaction of the strains in a group relative to one another in all of the test environments, whereas a significant interaction mean square indicates a dissimilar relative performance of the strains in a group among different environments. In other words, the first denotes good or broad adaptation of strains, whereas the latter denotes narrow adaptation of strains.

During each of the years of selection and testing, the oat plants were sprayed with a fungicide at weekly intervals from heading until maturity to prevent foliar disease epiphytosis from confounding the agronomic performance of the oat strains.

EXPERIMENTAL RESULTS

Of the 8 oat varieties used as parents in the 4 crosses, Andrew, Bonham, Clarion, and Clintland, were well adapted to Iowa growing conditions and the other 4, Garry, Alaska, Eaton, and P.I. 174544, were more or less poorly adapted: thus, one cross, C368, had 2 well adapted parents; 2 crosses, C311 and C370, had 1 well and 1 poorly adapted parent, and 1 cross, C349, had 2 poorly adapted parents.

Lines which were early to midseason in maturity, were short to medium in height, produced high yields and test weights, and had good appearance.