THE EFFECTS OF MASS SELECTION FOR SEED SIZE IN HEXAPLOID TRITICALE

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by

Ian S. Ogilvie

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Mature Spike of Hexaploid Triticale

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ABSTRACT

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Three lines and two F3 segregating populations of hexaploid triticale (X *Triticosecale* Wittmack) were subjected to two cycles of ambidirectional mass selection for seed characteristics on the basis of size and density. No advance due to selection was observed in two contrasting environments. As neither seed size nor density were consistently correlated with plot yield, mass selection for these seed characteristics was ineffective in changing the yield of the populations studied. However, in seven crosses, plants resulting from large F2 seeds, selected on an individual F1 plant basis, outperformed those from small seeds. Similar selection in an advanced line yielded no significant differences. It is argued that the few genes which control seed size in these populations become fixed in the homozygous condition by the F3 generation, rendering further selection ineffective. This, coupled with a certain amount of outcrossing in triticale, suggests that mass selection techniques, suitable for wheat or other completely self-pollinated plants, would be ineffective in present early generations of hexaploid triticale, unless the techniques are modified, because of differences in the breeding system.

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INTRODUCTION

Selection for seed size and its effect on seed yield in triticale lines and segregating populations

Importance of selection from large populations

Large populations of the early segregating generations are required to recover all possible favourable recombinants, when working with characters controlled by a large number of genes, such as yield. Shebeski (1967) has calculated that in the F2 of a cross differing by 21 gene pairs (assuming only one gene difference on each chromosome of hexaploid wheat or triticale) only 0.237% of the plants would contain all the favourable alleles in either the homozygous or heterozygous condition. As environmental conditions would probably affect phenotypic expression of various genotypes, a much smaller proportion of the most favourable genotypes would exhibit superior phenotypes. This would necessitate using even larger F2 populations,than theoretically expected, to ensure a fair chance of selecting the desirable genotype.

Yield components and selection efficiency

To make selection for yield easier to manage, various characters associated with it have been used as its predictors. These characters, considered to be parts of yield, are known as its components and are thought to be under the control of a simpler genetic system. For crop plants in which the harvested seed is the economic product, the major components of seed yield are: (1) the number of plants harvested in a given unit area, (2) the average number of fertile or seed-bearing inflorescences per plant, (3) the average number of seeds per inflorescence and (4) the average weight of the individual seed (Langer, 1967).

All these yield components have been used in plant breeding programmes; however, some of them may be highly affected by environmental conditions and whether phenotypic selection actually indicates superior genotypes may, in many cases, be questionable.

To effectively deal with the large populations necessary for selection of the individuals with the largest possible number of genes for improved yield, a rapid method of handling must be used. The first three yield components depend on an extensive system of recording and labelling which would preclude the handling of a sufficiently large population to achieve significant improvement of the specific yield component.

Selection for seed size and yield improvement

Selection for seed size on a phenotypic basis could be achieved rather easily on a mass scale which would enable the use of mechanical methods and the rapid screening of reasonably large populations. A number of researchers have recorded evidence that seed size is positively correlated with seed yield in a number of cereal and other crops (see Literature Review). When different seed sizes of an inbred line are selected, the size differences should be due only to environmental differences or other factors such as the position of the seed in the inflorescence. When selecting from segregating populations, however, there will be both a genetic and an environmental component of seed size, and selection for a specific seed size should shift the mean seed size of the progeny towards the mean of the selected individuals with a corresponding shift in associated yield characters.

Problems in triticale breeding

The pedigree method and mass selection techniques for seed size selection, as a component of seed yield, have been widely used with positive results in hexaploid wheat and many other crop plants. However, for the object of this triticale investigation, some of the problems encountered are different from those associated with hexaploid wheat or any of the other more important cereal crops.

Hexaploid triticale has its origin from amphidiploids produced by colchicine or other chromosome doubling treatments of crosses between tetraploid wheats of various species (*Triticum* sp.), which are all naturally inbreeding, and diploid rye (*Secale cereale* L.) which is a naturally outcrossing species. The combination of an outcrossing species and a naturally inbreeding species in a new artificially synthesized hybrid appears to have created a number of problems which must be overcome before the new species can compete economically with established varieties of the traditional cereals. Many of the present triticale lines have very low fertility and produce varying amounts of shrivelled seed, especially in the early segregating generations. In this specific area, the problem of low fertility has been further complicated by the high susceptibility of most triticale lines to infection by ergot (*Claviceps purpurea* (Fr.) Tul.). Most florets which do not form seed are then infected by the fungal spores and produce a fungal body (sclerotium) in the place of the seed. Many seeds which do form are also infected by fungal spores at an early stage, with, in most cases, the embryo and much of the endosperm being destroyed by fungal growth.

These problems complicate the simple mechanical selection or separation of triticale lines on the basis of seed size as compared with hexaploid wheat or other cytologically stable crops. When there is a high degree of sterility on a given spike, only a few seeds may form. The possibility exists then that all the available nutrients could be translocated into these few seeds, resulting in much larger seeds than would be the case when the available nutrients are distributed to the much larger number of growing kernels in a highly fertile spike. Shrivelled, twisted seeds may be retained in the same class as large sound, plump seed when a bulk population is passed through a set of seed screens or sieves. These shrivelled seeds will have a much lower density than normal seeds, and will have a much lower weight and lower endosperm reserves for the nutrition of the developing embryo during germination and early development. Some method is therefore needed to compensate for this variation in seed density or weight in the mechanical separation on a size basis for most segregating triticale populations.

Because of these problems, mass selection screening techniques which have been used for increasing seed size and yield in other cereal crops may not be directly applicable to triticale breeding. Modifications therefore may have to be made to these methods to achieve any effective improvements.

Seed size selection in triticale

Some of the larger seeded lines of triticale have generally higher seed quality and indications of good yield combined with certain undesirable agronomic characters such as excessive plant height. An effective breeding programme should combine the reasonably good seed quality and large seed size of these lines with the short straw length of the semi-dwarf lines which have smaller seeds, a high degree of seed shrivelling and rather poor fertility.

When triticale lines of diverse origin and type are crossed there is some difficulty in obtaining sufficient amounts of seed from which to obtain, through mechanical separation, at least three different seed classes for a replicated yield trial. A preliminary experiment was first undertaken on F2 seed, using visiual selection for seed size and its effects on single plant and plot yields. Eventually two segregating populations of F2 plants were obtained from the winter nurseries growing at Ciudad Obregon, Sonora (Mexico), which gave sufficient F3 bulk seed for a replicated yield trial. Additionally, three advanced lines which differed widely in genetic origin and seed size were obtained. These five populations were subjected to two cycles of mass selection for seed size and were grown at two contrasting environments with a view to ascertaining: (1) the effectiveness of mechanical mass selection for seed size in segregating (F3 and F4) and pure triticale lines, (2) the correlated response, if any, of yield to selection for larger seed size and (3) the effect, in any, of the type of environment on the magnitude of the selection response.

This series of selection experiments, along with some growth studies of embryos cultured from seeds of various sizes from the lines and populations used in the F3 bulk selection experiments should give some definite information on the effectiveness of mass selection for seed size in increasing the yield of hexaploid triticale.

LITERATURE REVIEW

Genetic segregation in self-pollinated plants

When selecting for a quantitative character such as seed yield, in which a large number of genes may control its expression, large populations need to be evaluated. Shebeski (1967) has calculated that in a cross differing by 21 genes (one for each chromosome pair for hexaploid wheat or triticale) only 0.238% of all plants in the F2 generation would have all favourable genes in either the homozygous or heterozygous condition and that this would decrease to 0.0052% in the F3 and 0.00057% in the F4 generation. The difficulty of handling such large numbers of plants in order to obtain the most favourable possible genotype obviously makes it impossible to use the conventional pedigree system. This necessitates the use of certain screening techniques to eliminate obviously inferior genotypes and increase the possibility of selecting superior genotypes at the earliest possible generation.

Yield components as indicators of yield

Yield, in any crop where the seed is the desired economic product, may be resolved into four main components: (1) the number of plants per unit area, (2) the number of inflorescences or heads per plant, (3) the number of seeds per head and (4) the average weight per seed (Lander, 1967). All of these components can be used as a selection index in breeding for total seed yield, but it is necessary to choose one which can be used for populations consisting of many thousands of plants.