An Investigation of Modes of Reproduction in Grasses

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Objectives

1. To determine in some degree the prevalence of apomixis among species and biotypes (strains) of Poa (the bluegrasses) and Calamagrostis (the reedgrasses) in Jackson Hole--Teton Mountain area.

2. To investigate the embryological details of all agamospermic apomicts discovered, in an effort to determine the exact type of apomixis involved in each instance and the modes of origin of embryo and endosperm.

Status of the Problem

Many investigators have determined that certain grasses are able to reproduce sexually as well as apomictically. Many hybrid forms showing a wide range of chromosome variability are able to reproduce themselves agamospermically (by seeds formed without fertilization). Some of these local races would seem to have a very special advantage in their struggle for life.

Much remains to be done. As many as possible of the American species and biotypes of Poa and Calamagrostis - and other genera, in fact - should be examined for evidences of apomixis and their modes of reproduction accurately determined. Then it should be possible to evaluate the role of apomixis, facultative and otherwise, in the adaptation of biotypes to the particular environmental niches in which they are found, and in view of the fact that apomixis is being discovered in an ever-increasing number of species, we should eventually be able to incorporate the advantages of apomictic reproduction into many of our experimental grass improvement programs.

The possible advantages are obvious. It is well known that hybrids are often better adapted to "disturbed" or modified habitat than either of the parental species in the region involved, and it is also well known that hybrids may be more vigorous vegetatively and/or reproductively than either parent. Ordinarily, however, segregation occurs in the F_2 and succeeding generations and the advantages of hybridity are soon greatly diluted or lost. If, on the other hand, the crosses have occurred in such manner as to include genetic tendencies toward apomictic reproduction it is quite possible that the hybridity of the F_1 will be retained in succeeding generations of at least some of the "families". That this does happen in the wild and that it plays an important part in the adaptation of many biotypes to a multitude of micro-environmental conditions is, to say the least, quite probable. Since apomixis is already known to be rather common among species and biotypes of Poa and Calamagrostis further studies within these genera may be expected with confidence to yield

important basic information that may in turn prove to be of great practical value in the development of better forage grasses of many kinds for artificially improved pastures and range lands.

Procedures

So far, attempts have been made to determine:
(1) Whether any pollen at all is produced.
(2) The percentage of undeveloped or abnormal pollen grains among those that are produced.
(3) The range of variation in sizes of pollen grains. (Great variation in size may suggest meiotic irregularities.)
(4) Whether there are lagging chromosomes or other common irregularities in the meiotic behavior of pollen mother cells that may indicate apomictic reproduction.
(5) Whether there is variation in chromosome numbers among apparently closely related clones.
(6) Whether there is an unusual number of seeds having multiple embryos. (Multiple embryogeny suggests that there is at least some apomixis involved.)

And finally, through embryological studies it should be possible to determine:
(7) Whether the embryo sacs are developed aposporously or otherwise, whether facultative apomixis is at all likely to be occurring, and whether triple fusion is essential to endosperm development.

Ideally, these observations should be combined with genetic studies of nursery-grown material, as is being done in Sweeden, at Stanford, California, and perhaps in a few other places; but that is something that calls for funds in considerable amounts and the co-ordinated efforts of a team of workers.

Accomplishments during the Summer of 1955

(1) All collections of early-flowering biotypes of Poa nervosa examined before or during anthesis had abortive anthers, and the plants that were left undisturbed in the field did produce seeds, although usually in only a small proportion of the florets of each spikelet. Mature panicles were collected for further examination and for seed viability tests.

Ovaries in various stages of development prior to and following anthesis were preserved for future embryological examination.

(2) Many collections of Poa pratensis material, presumably representing several different biotypes, were made for cytological and embryological studies. All were found to produce pollen, but several collections showed considerable variation in percentages of good pollen (as determined by the application of iodine) and others showed variation in sizes of pollen grains and/or variation in number of chromosomes in PMCs. Seeds were also collected for viability tests and for seedlings from which to obtain root tips for chromosome counts.

(3) Several lots of cytological and embryological material of Poa palustris were preserved for future study. Whether there is likely to be any apomictic material in these collections was not determined.

(4) Some collections of Calamagrostis canadensis had abortive anthers that apparently never open, other collections had anthers which contained some pollen grains that appeared to be good and which did dehisce during anthesis, and still others seemed to have anthers well filled with good pollen.

(5) Collections of Poa fendleri obtained from around Lake Solitude and at Togwotee Pass on the Continental Divide had abortive anthers in all panicles examined, but the earlier critical stages of development were missed and no embryological material was preserved; so additional collections will have to be made before the reproductive details can be worked out.

(6) Miscellaneous lots of cytological and embryological material of species of Bromus, Agropyron, Elymus, and certain others, were preserved, primarily for use in graduate course work at the Agricultural and Mechanical College of Texas.

(7) Several hundred herbarium species of grasses and other angiosperms were collected during the summer for teaching use, and duplicate grass specimens were left to be used in expanding the herbarium of the Jackson Hole Research Laboratory.

Comment

From the limited observations thus far made, it would seem that the Jackson Hole area is rich in apomictic forms of grasses and should prove to be an ideal place for combining a study of the details of apomictic reproduction with observations on the special adaptive features of apomictic biotypes that seem to fit them peculiarly for their particular environmental niches. Much of fundamental and practical importance might be revealed by such investigations carried on there. I am not yet aware of a better place for a program of this kind.

(The literature pertaining to this problem is reviewed and a list of the most important references cited.)