concerned with such matters as relative costs of the materials and treatments which they recommend, this is not a consideration in the enforcement of the existing law as it gives no control over prices nor profits which a manufacturer may make.

THE PRACTICAL ASPECTS OF SEXUAL AND ASEXUAL REPRODUCTION IN TURF GRASSES

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Greenkeepers, nurserymen, and others interested in the propagation of grasses are often faced with difficult problems in the maintenance of pure stocks of selected turf grasses. Even in supposedly well managed grass nurseries it is not unusual to find numerous "off types" appearing from time to time. Unfortunately these are not usually recognized until they are placed in turf, where it is often too late to eliminate them. Greenkeepers often feel that such aberrant forms are the result of mixed stocks of stolons they have received. Errors of this sort are not impossible but, as will be shown here, most of such mixtures probably arise in the propagation nurseries and not at the source of the original stocks. If one is to know how and why such "off types" occur he must have some knowledge of the reproductive process in the grasses.

In the past much has been written on the breeding behavior and types of seed production among the grasses. In fact, the subject has been so widely discussed in recent years that it has

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been brought to the attention of those individuals who are primarily concerned with the purely practical aspects of grass work. Written reports on the subject, however, have appeared almost exclusively in technical journals and as a result are not available to those who are without specialized biological training. Nevertheless, the types of reproduction involved in the grasses play an important role in the development and maintenance of turf and some knowledge of the subject should be of special interest to those dealing with selected strains of the numerous turf species. Therefore, a discussion of the more common phenomena involved in reproduction in the grasses seems appropriate at this time.

In most plants, reproduction takes place by sexual means, that is through the union of egg and sperm. When both egg and sperm are involved the offspring naturally bears characteristics of both the male and female parents. In most of the grasses the male and female reproductive organs are borne on the same plant and in a great many grasses within the same flower. At maturity the anthers burst, shedding the pollen which bear the male cells. Some of the pollen grains are then distributed, usually by wind, to the pistils. When a pollen grain reaches the tip of a pistil it germinates, sending forth a tube which penetrates the tissue separating it from the ovary. After the pollen tube reaches the ovary the male cells are discharged into the embryo sac, where one of them unites with the egg forming an embryo or beginning of a new plant. The plant resulting from this union, therefore, contains a combination of materials from both the male and female parents from which it originated. It may then develop into a plant different from either of the two parents.

In certain of the grasses a type of reproduction is encoun-

tered very different from that just discussed. In a number of species it has been shown that reproduction may take place without the union of male and female cells. In such cases the non-fertilized egg cell or a cell of the ordinarily non-reproduc-

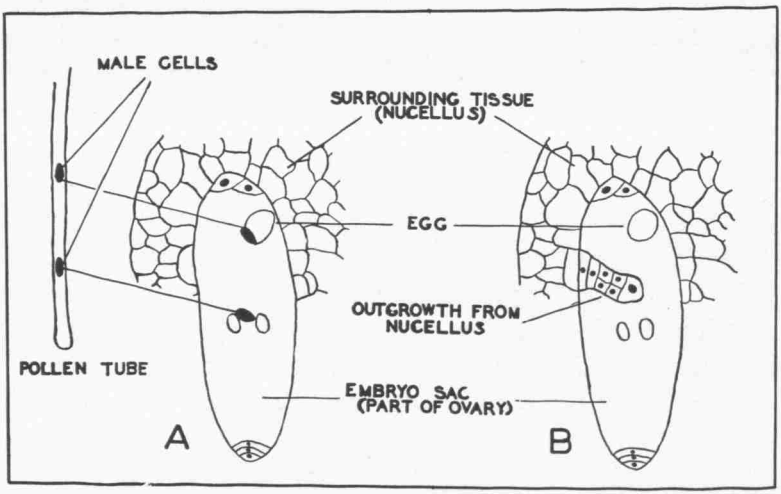


Diagram of sexual and apomictic reproduction as seen under the microscope.
A: Sexual reproduction. One of the male cells from the pollen tube unites with the egg to form an embryo, thereby bringing together in the offspring characters of both the male and female parents. The second male cell of the pollen tube unites with the polar bodies to form an endosperm (source of nourishment for the young seedlings).
B: A type of apomictic reproduction. In this case there is no sexual fusion of the male and female cells. Instead, an outgrowth of the nucellar tissue develops as an embryo within the embryo sac. Since the nucellus is purely maternal tissue the young seedling from this seed will be identical with the female parent from which it came.
For simplification not all structures are shown and both drawings are highly diagrammatic.

tive ovular tissue functions as an embryo, thereby eliminating any possibility of bringing into the offspring characters from the paternal parent. Actually, it is a case of vegetative reproduction through seeds. Many variations of this type of behavior have been encountered and a complicated terminology

Kentucky bluegrass strains in nursery at Arlington. Second row from right, progeny of an apomictic strain of bluegrass. Note the uniformity in these plants. Such strains may be reproduced from seed without contaminating the original stock.

describing them has evolved. Generally speaking, however, the process may be referred to as ***apomixis.***

It can readily be seen that the practical consequences of apomixis may be great and it is of immediate importance to those interested in turf grasses in so far as it relates to the propagation and maintenance of selected strains. In order to keep such strains pure it is necessary to limit propagation to vegetative methods. If the selected strains are sexual and are allowed to set seed, the plants resulting from that seed will in many instances differ widely from the parents and will

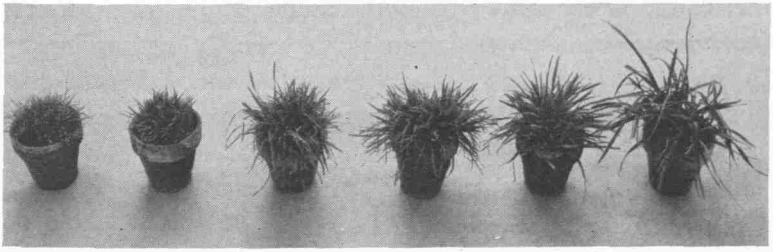
within a few generations develop into mixtures. Such procedures may soon result in a total loss of the selected types.

If the selected type is an apomictic one, reproducing it from seed will not result in the outcropping of new and different types. Rather, the seed will produce plants like the maternal parents only, since no sexual fusion occurs in the reproduction process, as illustrated in the accompanying diagram. The occurrence of a few sexually reproducing plants in a predominantly apomictic strain will not likely have a harmful effect on the strain as a whole. However, among the bluegrasses there are certain supposedly apomictic strains which produce approximately 20 percent of their offspring by the sexual method. Naturally a variety of forms would soon result if such a bluegrass selection were reproduced from seed. Also certain bluegrass strains and most of the bent grasses reproduce almost wholly by sexual reproduction. It is in these, of course, that the greatest variation occurs. Progenies of Kentucky bluegrass have been observed in which the varying types range from fine-leaved, low-growing plants closely resembling *Poa annua* to types which are almost as coarse as orchard grass. Also, plants have been observed among the progeny of fine-leaved creeping bents which are hardly distinguishable from mature plants of redtop.

Although apomixis has been demonstrated most often in the bluegrasses it has been known to occur in a number of other genera and species and is undoubtedly rather widely distributed throughout the grass family. Among the turf grasses, however, the majority of the species most widely used appear to reproduce sexually. These include redtop, creeping and Colonial bents, and the fescues.

A knowledge of reproduction in the grasses has an immedi-

ate application in the management of grass nurseries. For example, the creeping bents which have been selected and distributed by the Green Section are not genetically pure but will remain true to type as long as they are propagated by vegetative methods. If they are allowed to set seed in the nursery, the plants resulting from those seed undoubtedly in many cases will be very different from the original selection. It is of utmost importance, therefore, in the management of



Variation in progeny of a sexually reproducing selection of Kentucky bluegrass. Obviously this strain will produce many "off types" if allowed to set seed in the nursery.

nurseries in which selected strains are being grown to prevent seed setting. In large nurseries it is very easy to overlook a few scattered seed heads, yet if these are allowed to mature the entire stock may become contaminated. During the past few years the occurrence of "off types" in C-1 bent have been reported. Undoubtedly these types have arisen from seed which has been allowed to form in some nursery.

The same precautions should be taken in the management of fescue nurseries as have been described for the bents, as they too reproduce largely by sexual methods. Genetically pure lines may be developed eventually in this species but all those available at present are extremely variable.

Some bluegrass strains may be allowed to set seed without

fear of contaminating the stock. These, of course, are those strains which reproduce apomictically. Sexual bluegrass strains must be propagated solely by the vegetative method if they are to remain true to type, and this method is, of course impractical unless it is done on a small scale. Unfortunately, we have as yet no easy and quick method of distinguishing between sexual and apomictic bluegrass strains. Attempts are being made at present, however, to determine by progeny analyses and through cytological studies which of the Green Section bluegrass selections reproduce sexually and which are apomictic. Until that is done, the safest method is to treat all of those which are being propagated for turf as sexual plants.

SUBSTITUTE FOR MERCURY FUNGICIDES

Since war requirements have put a ban on the manufacture of mercury fungicides for turf purposes there has been considerable interest in substitutes. For some time the Green Section has been testing other fungicides and in *Science,* March 28, 1941, p. 311, reported that the most promising was tetramethyl thiuramdisulfide. It was found that this chemical controlled brownpatch and dollarspot as well as some other diseases, the causes of which were not definitely determined. Two ounces of the chemical to 1,000 square feet were not sufficient to give reliable control but partially checked the disease. Four ounces to 1,000 square feet gave complete control. In all the tests that have been made it has not caused injury to turf. Our recent tests have shown that this chemical also controls snowmold when applied at the same rates that are used for bichloride of mercury or calomel. Tetramethyl thiuramdisulfide is manufactured for use as a rubber activator. It does not provide a more economical control than mercury but since the latter is no longer available this new chemical may prove useful.