Holman M. Griffin, Northeastern Agronomist, USGA Green Section; Dr. C. Reed Funk, Rutgers University turf breeding specialist and Sang-Joo Han, graduate student in turf breeding at Rutgers; examine new bluegrass variety under test.

Turf Management Through Genetics

by HOLMAN M. GRIFFIN, Agronomist, USGA Green Section

Why not develop an all-purpose turfgrass which would grow well in wet or dry soils, hot or cold weather, sun or shade, and be wear-, disease-, and insect-resistant as well?

You might say, "Just what the doctor ordered." And why not? For years the doctors (geneticists) have been improving field crops by means of breeding programs, and have developed many strains which are highly superior to the parent materials.

While the development of such a turfgrass with all the attributes listed above is most unlikely, it is not impossible. We could certainly improve our present turf varieties a great deal.

Most of the turf varieties now available are the result of the selection of superior types of grasses from old turf areas where nature was the principal geneticist. Until recently, interested individuals selected, collected and tested these plants with little thought of any improvement by means of a breeding program. These gifts of nature, were sought as a finished product rather than as a source of superior characteristics which could be combined genetically to produce turf adapted to specialized requirements.

Merion Kentucky bluegrass is an excellent example of a **natural** hybrid which was selected, tested and accepted by the turf world as a superior variety. For years now Merion has been the standard by which bluegrasses are measured, but at the same time the inherent weaknesses of this grass have been realized.

Other superior plants might also be "found," as Merion was found growing in a natural state, but the possibility of such plants occurring in nature is quite low, and the probability of these plants being noticed and selected for testing further reduces the odds. Progress dependent upon such happenstance is extremely slow and unpredictable.

Surveys conducted in several states during the last four or five years indicate that the production and maintenance of turf is a multimillion dollar business ($4 billion according to the first edition of "Turf-Grass Times" in 1965). Nevertheless, the money being spent on turfgrass

Individual bluegrass plants being grown in greenhouse from seed in preparation for field trails.

research is insignificant when compared to the total expenditure on this crop. It amounts to something less than one per cent.

Although turf research programs are gaining in popularity and support faster now than ever before, we have a long way to go before the expenditures for turf research approach anything near the three to six per cent of gross income reportedly spent by progressive industries on product research.

Breeding Programs Neglected

The foregoing paragraph is a general picture of the meager allotments for general research on turf. You might well imagine that the portion allotted specifically for research on turf breeding is small, indeed. Until approximately five years ago, turfgrass breeding programs were either nonexistent or largely neglected in the general turf program. Fortunately, a number of universities, seed and sod growers and governmental agencies have begun to realize the value of turfgrass in our society and the possibilities of substantial improvement in turf through breeding programs.

Yes, interest in turfgrass breeding is increasing in the United States but we are still lagging behind Europe. Holland and Sweden in particular have developed and released a number of named varieties of bluegrass, fescue, ryegrass and bentgrass. Some of these grasses show promise for use in this country, but varieties better adapted to our own climate and needs could no doubt have been developed if we had had similar programs here.

Studies in genetics, botany, physiology, pathology, entomology, taxonomy, ecology, chemistry, turf management, and plant breeding are all essential to the development of a well-rounded and progressive turf breeding program. These programs must culminate in the development of breeding and evaluation procedures specifically adapted to the plant species involved and the particular requirements of the turfgrass industry. After the development of the appropriate breeding method, the greatest need is the development of faster and more efficient methods of evaluation and screening of new and potentially better turf varieties.

Obtaining Improved Varieties

Essentially improved varieties of turf are obtained through three methods. They are:

(1) Selection of superior plants occurring in nature.

(2) The use of radiation and other mutagenic agents to produce variants.

(3) Hybridization of promising selections.

Regardless of the method employed, it usually takes at least 10 to 15 years to develop properly a new turf variety to the point that it becomes commercially available. Much of this time is required for evaluation and testing: thus the need for more efficient methods of screening to separate the good from the bad.

We have already discussed the natural selec-

Flats of bluegrass seedlings ready for the field. This will constitute a portion of next year's nursery plants to be evaluated in the breeding program.

tion method by which most of our present turf varieties were obtained, and its obvious limitations. Next we should consider the use of radiation and mutagenic agents to create genetic variations. This method offers the plant breeder a chance to work with the most outstanding varieties, and alter their genetic composition in hopes of producing an even better plant, or of endowing the variant with a superior, transmittible characteristic. Also, it allows the breeder to produce his own source material rather inexpensively in the laboratory without depending on extensive travel or donations to obtain plants for evaluation.

Although this method of altering plant material has some distinct advantages, the breeder is still unable to control the genetic changes he brings about in the plants, and the probability of producing superior plants is again extremely low.

The third method for obtaining improved turf varieties is hybridization. Without doubt this is the most promising. The first two methods of deriving superior plants are normally used simply as a starting point for plant breeding.

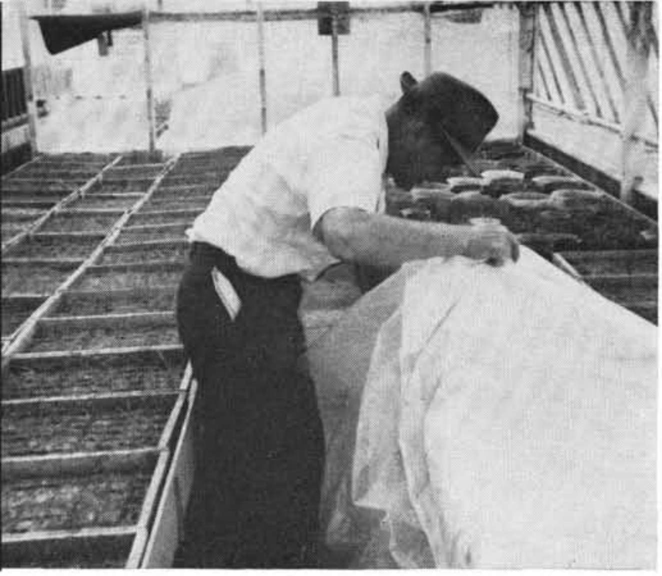
Reproduction is Complex

On the surface it would seem simple to collect different plants (source material), screen this material for the desired characteristics, and then cross the plants having these individual characteristics until a superior plant containing all the desirable features present in the source material is obtained.

However, it is much more complex than this. For one thing, the specific method of reproduction of different varieties of turfgrasses and the techniques of hybridization must be clearly understood for each variety. As an example, Kentucky bluegrass **(Poa pratensis)** reproduces both sexually and by apomixis. Apomixis is a process whereby seed is formed vegetatively without the union of the germ cells (egg and pollen). Seed produced apomictically is genetically identical to the parent plant and for this reason a high degree of apomixis is sought in new varieties.

Merion Kentucky bluegrass is extremely apomictic, producing only about 4% of its seed sexually, and can therefore be propagated from seed as a pure strain. A grass of this type in which each plant is genetically identical to the others leaves much to be desired, however, because every plant in the planting is subject to the adversities of disease and environment to the same degree as all the others. Figuratively speaking, we have all our eggs in one basket with a grass such as Merion, and some turf breeders now feel that the best bluegrass turf of the future will come from a mixture of highly apomictic and compatible strains.

Now that we have discussed some advantages of apomixis, we must also acknowledge that this process is a great handicap to the turf breeder. The reproductive process of apomixis is neither



Dr. C. Reed Funk checks new seed, placed under ice pack to break dormancy prior to planting in flats such as seedlings behind him.

clearly understood nor presently of use to the geneticists except as a means of maintaining the purity of a strain once the proper result has been achieved. All progress with cross breeding is totally dependent upon sexual reproduction.

The techniques and possible combinations for crossing plants are too complex and too numerous to cover in this article, except to say that the goal of such a program is a plant with superior qualities for turf which may be maintained true to type by its seed or by the less desirable means of vegetative propagation if the plant is not apomictic.

A Tedious Process

Dr. C. Reed Funk, associate research specialist in turfgrass breeding at Rutgers University, annually screens and evaluates some 50,000 individual plants of bluegrass, fescue, ryegrass and bent. Each year a large portion of these plants is discarded and replaced with new plants. Those with some superior characteristic will be retained for further evaluation.

Such large numbers of plants are necessary because of the difficulty of obtaining all desired characteristics in one plant. This is illustrated by the fact that if three independent, desirable characteristics were present in some of his crossbreedings in a frequency of one per 1,000 plants, the plant which he would be looking for, and which possessed all three characteristics would exist at a frequency of one in 1,000,000,000

To further illustrate the problems of genetics with an extremely simplified example, a cross between two plants which differ in only one gene (the unit of inheritance which controls the development of character in all life forms) would produce the desired plant which possessed both of the desired genes in a frequency of one in each four plants in the second, or F2 generation.

When you consider that bluegrasses may have from 38 to 150 chromosomes, each of which contains numerous genes independently assorted and capable of independent combination, the chance of the ideal plant being produced with only 20 different gene pairs concerned would be one in 1,099,511,627,776 plants.

To overcome such odds, the turf geneticist must be highly skilled in breeding techniques,

Ryegrass plants being evaluated both to determine characteristics of individual plants, and for seed production.

and must have a keen eye so that he can select and evaluate plants which show promise. In addition, he must be persistent, dedicated, and it would help if he were just plain lucky.

Generally, a progressive bluegrass breeding program might be outlined as follows:

First and Second Years

Collect source material and evaluate it. Produce seed from which vegetative or clonal nurseries are established of the more promising strains.

At this point I would like to make a particular point in the interest of better understanding between the researcher and the man in the field. The field men or turf managers are extremely valuable to the researcher when they provide source material which they have found to be outstanding. However, once the material has been donated, these individuals, being normally anxious about their discovery, quite often express concern that progress reports on their selection were either vague or nonexistent. The explanation for this seeming disinterest on the part of the researcher is that preliminary screening and evaluation takes anywhere from one to five years. Under these circumstances, when a geneticist is cornered at a conference or turf meeting he can hardly be expected to remember and recite a detailed evaluation of a particular plant which is only one of thousands.

If your selection has merit, I am sure you will be informed as soon as possible. However, this may take years rather than months, depending upon how your material is evaluated and how it is used in the program.

Third and Fourth Years

The promising selections must be screened for disease and superior characteristics. This may be done in a green house, growth chamber or in the field.

Fifth and Sixth Years

Determine the degree of apomixis and establish vegetative nurseries of individual plant selections.

Seventh Year

Cross superior plants in the greenhouse and replant their seed in the nursery.

Different types of plants produced by the same parent growing in nursery row for evaluation.

Progeny test. Bluegrass seedlings developed and evaluated as individual plants in spaced nursery.

Eighth Year

Screen superior progeny and establish mass seeded plots for evaluation.

Ninth and Tenth Years

Evaluate the solid seeded plots and vegetative nursery.

Continuation

After the 10th year the program would progress into the second and third cycle in which the superior plants from the 10-year program are further improved by repeating the procedures carried out in the seventh through the 10th years.

The program outlined above could most certainly produce some highly superior plants; however, it requires a considerable amount of time. In addition to the time required for the breeding program, commercial fields must be planted and brought into production. This process increases the time required for seed to become available to the consumer.

This article has dealt largely with bluegrass because this is one of the more complicated species. There is gross oversimplification of many genetic principals and breeding techniques, but this material is presented solely as a basic introduction into the field of turfgrass breeding, to provoke thought in this direction, to create a better understanding of the problems confronting the turf breeder, and to generate support for his efforts.

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