New Grasses

drought-resistant strains of perennials developed for dry range lands

This is the sixteenth and last article in a series of brief progress reports on the application of the science of genetics to commercial agriculture.

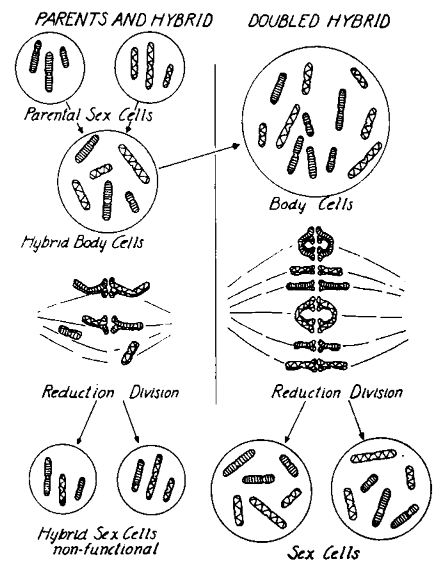
G. L. Stebbins, Jr.

New strains and species of drought-resistant perennial forage grasses—capable of competing with annual weeds more successfully than any species now existing—may be produced.

Grass breeders, through a knowledge of genetics plus an understanding of the growth requirements of California native grasses, have devised methods by which such forage plants can be developed.

The basic plan of development is to crossbreed existing strains or species which have desirable qualities of drouth resistance, aggressiveness, or palatability but which may differ widely from each other in their adaptive qualities.

Progeny of the second, third, and later generations from such crosses—which are very variable because of genetic segregation—are planted in natural, wild sites.



Specimens of two native species of grasses and their sterile F_1 hybrid. *Left to right:* Blue wild rye, blue wild rye x squirrel tail, squirrel tail.

On those sites, individual plants with poorly adapted genetic constitutions are eliminated by natural selection, and the most vigorous of the surviving plants can be taken back to the experimental garden for further hybridization and selection, or for increased seed production and range plot trials on a larger scale.

The principal difficulties involved in this method are: *1,* obtaining suitable strains to use as parents for the hybridizations and *2,* overcoming the sterility which is very often found in hybrids between widely different parents.

To obtain desirable parental strains, the breeder must be thoroughly acquainted with the grass flora of every region having a climate similar to his own.

The Division of Genetics has a collection of hundreds of different strains of native perennial grasses, and many more strains from all parts of the world which have a similar climate. These strains are tested for their ability to grow in various parts of the state, and to hybridize with each other. The more promising ones are then selected for crossing.

Sterility of Hybrids

The sterility of the hybrids can often be overcome by using methods based on a fundamental knowledge of the genetic nature of this sterility. If the hybrid is not completely sterile, a few seeds may be obtained by examining hundreds of flowering heads, spikes, or panicles.

Progeny from these seeds may again be highly sterile, but usually some plants are found which are more fertile, and these may yield fully fertile strains after two or three more generations of selection. Sometimes the first generation—F_1—hybrid is so sterile that it yields no seed when exposed to its own pollen or to pollen of other F_1 hybrids, but will produce a few seeds when exposed to large amounts of pollen belonging to one of its parents. To obtain these seeds, a large number of divisions of the sterile hybrid are produced by vegetative propagation, and these are planted alternately between plants of the more desirable of the parental species.

In one such experiment, a hybrid between blue wild rye and squirrel tail grass which previously had yielded no seed at all was interplanted with its wild rye parent. Out of 48,000 florets examined of this hybrid, one seed was obtained. The plant grown from this seed was vigorous, and resembled wild rye but contained some characteristics derived from the squirrel tail species. It yielded 10% of seed, and some of its offspring are both vigorous and highly fertile.

Another way of making sterile hybrids fertile is to double the chromosome number. This process of chromosome doubling occurs very rarely as a natural process, but it may be accomplished relatively quickly and efficiently through the use of a chemical.

This chemical—colchicine—is obtained from the roots of the autumn crocus or *Colchicum,* and has a very specific effect on living cells.

At the time when cell division normally takes place in the growing tissues, colchicine permits the chromosomes to divide in two, while preventing the division of the cells containing them. As a result, cells are produced which contain twice as many chromosomes as the original cell, and each of the chromosomes is present in duplicate.

If in a previously sterile hybrid, flowering heads are produced which consist

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Chart showing how doubling the chromosome number can convert a sterile hybrid into a fertile species. *Upper left,* the sex cells—pollen and egg—of two widely different parents contain chromosomes which differ widely from each other in their makeup. When such chromosomes are brought together in the body cells of the F_1 hybrid they may be able to work together during the growth of the individual. But when the time comes for maternal and paternal chromosomes to pair in preparation for the formation of new sex cells, this pairing is irregular, and the resulting sex cells have disharmonious combinations of chromosomes, which prevent them from functioning. Doubling the chromosome number makes each original chromosome present in duplicate in the body cells, and makes it possible for like chromosomes to pair prior to the formation of sex cells. The resulting sex cells have harmonious combinations of chromosomes which are the same as those present in the body cells of the undoubled hybrid.

of cells with the doubled chromosome number, these may yield functional pollen and viable seed. Many interspecific F_1 hybrids are sterile because of great differences in the chromosomes derived from their parental species. Any normal, fertile species of plant or animal contains two sets of chromosomes—one derived from its father and one from its mother. Each chromosome derived from the father has an exact counterpart as to genic content among those derived from the mother.

During the formation of pollen grains or egg cells these similar chromosomes pair—each pair consisting of a chromosome derived from the father and its counterpart derived from the mother. Later, the members of the chromosome pairs separate, and each member of a pair goes to a different pollen grain. The pollen grains—and egg cells—thus come to possess one half as many chromosomes as the number present in the body cells of the individual. These similar chromosomes must pair and separate in normal fashion if functional pollen grains and eggs are to be produced.

In a hybrid between two distantly related species, the chromosomes which have come in respectively from the father and the mother are not similar. They either do not pair at all during the formation of pollen and egg cells, or if they do pair, they separate to produce pollen and egg cells with abnormal, disharmonious combinations of chromosomes. Such cells cannot function, and the hybrid is sterile.

When the chromosome number is doubled, each individual chromosome becomes duplicated. During the formation of pollen and egg cells, each chromosome pairs with its exact duplicate. As a result, the pollen grains and egg cells come to possess exactly the same number and kinds of chromosomes which were present in the ordinary vegetative cells of the undoubled hybrid, and so are functional.

The effect of chromosome doubling in chromosome pairing is illustrated in the accompanying diagram.

The fertile, doubled hybrids have another characteristic not found in fertile strains which are derived from partly sterile hybrids without doubling of the chromosome number. In both appearance and adaptation, the doubled hybrids remain more or less constant for a condition intermediate between that of their parents, while the undoubled fertile derivatives come to resemble more or less closely one or the other of their original parents. When partly sterile hybrids have been produced, the breeder has two choices. If types intermediate between the parents are likely to be the most desirable, then the breeder can double the chromosome number and select from progeny of the doubled hybrid. But if types which resemble more or less closely one or the other parent are to be desired, then the breeder should select for fertility without doubling the chromosome number.

Experimental Hybridization

Development of valuable new strains of grasses by this method will be a long-time job but promising results have been obtained on a small scale.

In one experiment, a strain of California brome from Berkeley was hybridized with another from Mariposa, in the Sierra foothills. The second generation—F_2—hybrids were then planted on a dry, hot, south facing slope above the university campus at Berkeley, where the competition with wild oats is particularly intense.

Neither of the parental strains survived on this site but the hybrid derivatives have maintained themselves and have increased markedly through self seeding during the past five years.

In another experiment, a strain of mountain brome from eastern Alameda County was hybridized with one from the eastern crest of the Sierra Nevada in Plumas County. Seeds from the hybrids were planted on a particularly severe site in the upper Carmel Valley in Monterey County. They have survived and have shown good growth over a period of a year and a half, although their parents could not be established there.

Harding grass, tall fescue, rye grass, and other types of brome grass were complete failures in this particular site, and the stipas—although well established—are growing much more slowly than the hybrid brome.

In another series of experiments, various strains of blue wild rye have been hybridized with squirrel tail grass.

The former species—as shown by tests of the United States Soil Conservation Service in the Salinas Valley—is both drought resistant and able to withstand competition from annual grasses. However, the squirrel tail species is much more drought resistant, and provides a fair amount of palatable leafage during the late autumn and winter months. Its chief disadvantage is its fruiting head, which shatters very easily, and contains a large number of noxious beards or awns.

Hybrids between blue wild rye and squirrel tail are vigorous but sterile. When their chromosome number is doubled by means of colchicine treatment, they become fertile. These doubled hybrids possess the stiff, nonshattering heads found in wild rye, and their awns are short enough so that they are not dangerous to cattle or sheep. They possess more leafage in late spring than either of the parental species. Although they have not yet been tested for drought resistance, they should excel in this characteristic.

A third group of species which promises to yield valuable drought resistant strains is that of orchard grass.

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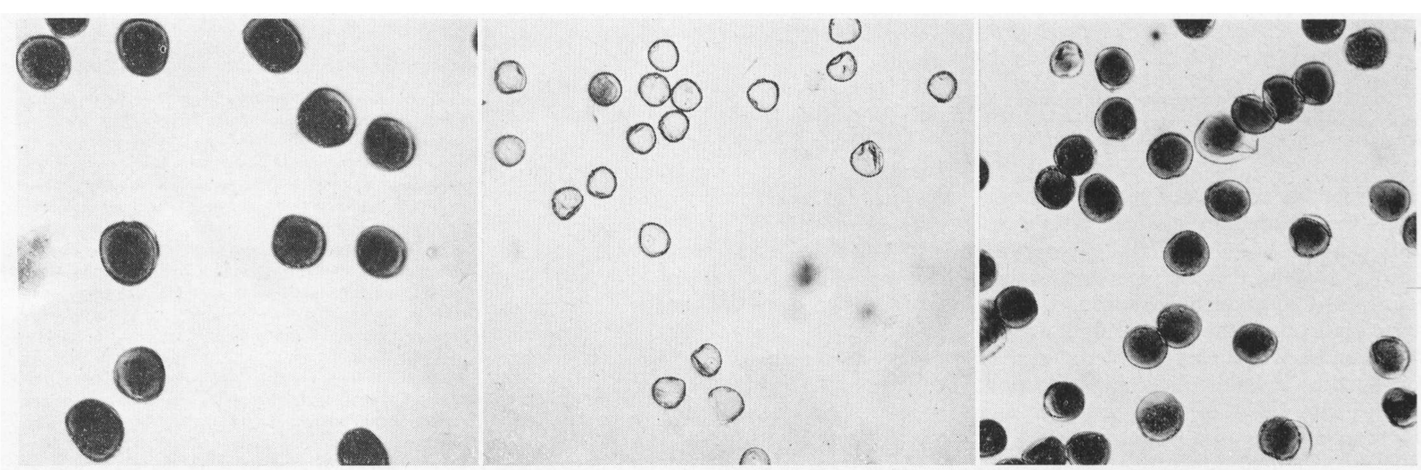

The pollen grains of blue wild rye *left* are plump and filled with living material, while those of the blue wild rye x squirrel tail hybrid *center* are empty and nonfunctional. However, when the chromosome number of this sterile hybrid is doubled, the resulting plant has essentially normal, functional pollen *right* so that the doubled hybrid is fertile.

PROTECTION

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the watersheds themselves. The damage which may then occur depends upon the precipitation pattern and on the magnitude of the downstream values affected.

An outstanding example of this is the Los Angeles County Pickens Canyon fire of 1933 which burned only 4,830 acres, yet a cloud-burst two months later resulted in a flood which caused 30 deaths and an aggregate loss of $5,000,000.

Such damage may not occur immediately. Only the experience of years can show the full damage resulting from a fire such as the 40,000-acre burn in 1948 which destroyed the cover on half of the Santiago Reservoir drainage, Orange County's major watershed.

The present level of fire damage, high though it may appear, is actually low relative to the values at stake and the degree of fire danger characteristic of California.

Maintaining the great differential between actual and potential damage is a major accomplishment of the protection agencies. The achieving of this degree of protection is an important element in the cost of wild fires in California.

During the last two fiscal years the cost of protection for the 31.1 million acres of timber, watershed, and range considered as state responsibility lands has been close to 8½ million dollars annually. The cost per acre of protection for the 13.7 million acres of state and private timber and primary watershed lands directly protected by the California Division of Forestry is estimated at 41.4¢, ranging from 20.2¢ in the North Coast District to 75¢ in southern California. Los Angeles County spends more than $10 per acre per year to protect some of its high value watershed lands. Cost estimates on federal lands are unavailable.

In addition to the realized costs of wild fires in California there is a potential cost which plays a major role in the economics of fire protection in the state. This is conflagration potential—the ever-present danger that a wild fire will become temporarily uncontrollable and sweep through occupied areas in a manner that will cause great destruction of property values and human life.

Under the extreme fire conditions in this state blow-up situations frequently occur. During such times wild fires must be controlled while still small. If not, they can attain a speed of travel and rate of combustion such that they appear practically to explode over large areas.

Such conflagration potential is also an important factor in the management of controlled fires. Confinement within the prescribed boundaries becomes absolutely essential. In some cases it may be necessary to defer control burns so that their smoke will not delay detection of wild fires.

In the face of these conditions of maximum fire danger, settlement in California is expanding rapidly into critical fuel areas. Housing developments are found in narrow, brush-filled canyons. Recreational development is heavy in areas of limited access where emergency exits might be cut off.

Almost every year several communities in the state narrowly escape being swept by a wild fire from the surrounding forest and brush lands. Moreover, the rapidly increasing capital investment and human use in highly exposed areas has greatly increased the magnitude of the protection problem. It is this danger of fire disaster which perhaps overshadows all other costs of fire in California.

Since the combination of wild land cover, climate, and topography result in California's high fire danger as well as its high productivity and desirability as a place to live, the cost of protecting the wild land from fire must be considered a part of the cost of living in the state.

John A. Zivnuska is Assistant Professor of Forestry, University of California College of Agriculture, Berkeley.

Keith Arnold is Assistant Professor of Forestry, University of California College of Agriculture, Berkeley.

LOSSES

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Use of the tables and maps before a fire—presuppression—is in planning the distribution of manpower and equipment within a protection unit to give the maximum protection available to the areas of highest value. This may mean concentrating fire fighting forces in areas where damages are high in order to provide fast attack on all fires in the high-value areas. The ability to get men and equipment on a fire within 15 minutes to a half hour after the fire is discovered may save a whole watershed from burning over.

Keeping fires small is especially important in areas of high potential damage. In southern California the vegetative cover is of primary importance for watershed protection with recreation values also of major importance in some areas. If these watersheds are burned, the usual result is accelerated erosion and runoff, and loss of water in flood flows. Damage to recreation values may also be high. In northern California timber and rangeland values, as well as recreation use and watershed protection, are important. Here, again, the areas with the highest value are being determined so that most men and equipment can be stationed in areas of high values.

On going fires the damage appraisal figures can be used to guide firefighting strategy. Probably the most important part of this task is deciding where to locate control lines to stop the spread of fire. When the potential damage on any portion of a watershed is known, the fire strategy can be planned to control a fire with the least amount of damage and suppression costs. Then the men and equipment needed to do the job within a given length of time are ordered.

It may be advantageous, for example, to allow a fire to burn a larger area in a low-damage watershed as in the case of a 500-acre fire, burning in steep, rugged country of low value. Putting a control line around this area would require considerable manpower and equipment at high cost, and there may be danger that the control line would not hold. By dropping back to terrain more favorable for construction of control lines, the fire may burn an additional 200 acres but be controlled with reasonable assurance; and less manpower and equipment can complete the job in shorter time under much safer conditions. The damage is still low, and fire fighting costs much less.

If the fire were in a watershed important to adjacent community values, the plan would be to hold it to the lowest acreage possible. Here the higher cost of suppression is justified by the greater values saved.

The use of fire damage appraisals in managing fire protection organizations is not the final goal of land managers. The ultimate goal is the reduction of all man-caused fires.

Charles Arment is Forester, California Forest and Range Experiment Station, maintained by the Forest Service, United States Department of Agriculture at Berkeley, California, in cooperation with the University of California.

GRASSES

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Commercial strains of orchard grass cannot be grown in California without irrigation except in the moister areas. A new strain imported from Palestine has proved highly successful under dry conditions on a ranch near Sacramento. The imported strain is a low producer but hybrids between it and a commercial strain are more vigorous than either parent, when grown in Berkeley, and have survived one long dry summer near Sacramento.

At present, drought resistant strains of orchard grass are being obtained from various parts of Southern Europe, North Africa, and Southwestern Asia, and these will be hybridized extensively in order to build up new drought resistant strains adapted to California conditions.

G. L. Stebbins, Jr., is Professor of Genetics, University of California College of Agriculture, Davis.