



QUALITY AND PERSISTENT VARIETIES OF FORAGE CROPS THROUGH
A BREEDING PROGRAM¹

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Pasturage for high producing dairy cows must be nutritious, succulent, and readily acceptable in sufficient quantity so that the animals can obtain their "fill" in a relatively short time. A similar statement might be made for beef and sheep in the production of meat and wool. It has been reasonably well established that correct management of forages can yield them more nutritious. This can be effected by increased fertility, regular applications of fertilizers, regular and adequate irrigations, as well as the method of grazing, and grazing intensity. Different species and species mixtures will behave in different patterns when subjected to different management practices. It is quite reasonable to expect that similar differences may exist in nutritive quality within the species. This is the job of the plant breeder to ascertain whether such differences do exist, and, if so, how can effective selection programs be set up to isolate the superior types.

Very spectacular achievements have been made in obtaining improved production of forage crops by selection for higher yield. In some cases, diseases and/or insects have been the limiting factors, and selection for resistance to such pests has prompted spectacular advances. The ultimate aim of the grassland

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specialist must be measured in the efficient output of animal products. Therefore, if the varieties developed by the plant breeder are not of high quality nutritionally, such efficiency cannot be obtained.

For purposes of our discussion in this morning, quality will be considered to be a composite of nutritional value, digestibility, and palatability. These are all factors contributing towards the efficient use of forage crops. They are intangible and difficult to measure. The pasture researcher has various methods whereby he can appraise various mixtures and management practices by the use of the grazing animal. The plant breeder is in a much more difficult position because of necessity, selection must be made on an individual plant basis. These individual plants, at the best, will not produce a large volume of forage, and hence the plant breeder is handicapped in being able to appraise or evaluate the breeding material with the animal. A good performing variety must also have persistence or longevity. It is extremely costly to establish a pasture having a high carrying capacity. A short-lived pasture is also costly. Again the plant breeder encounters difficulty in measuring this character of persistence.

Synthetics

It has been the practice to synthesize varieties containing many individual genotypes. In some cases, the number used in any one variety has numbered into the thousands and possibly no less

than a hundred. Crossing studies of recent years would indicate that serious thought should be given to reducing the number of lines used in any one synthetic. Our present-day knowledge of genetics would indicate that a maximum measure of hybrid vigor would more readily be obtained from a single cross or a limited number of lines going into a synthetic rather than a large number of lines. Theoretically, a large number of lines would tend to mask or reduce the benefits that might be attained from hybrid vigor.

If there are differences between individual plants in quality, then it would be possible that a cross embracing only two lines could well produce a synthetic of very poor quality and still be a high producer of forage. This would probably not be as noticeable if several lines had been used because some of these inferior characteristics would have been covered up. Plant breeding today is approached in a more refined manner, and it is necessary to have a better understanding of the breeding behavior of the species or crop with which work is being done. Thus, it is most important that consideration be given to the quality aspects. It is quite possible that two lines might be superior in seed production, forage production, disease resistance, and some other desirable agronomic characters and yet low in quality. In such a case, their progeny would not likely provide the most satisfactory type of forage. As a result, forage breeders are currently giving greater consideration to selection on the basis of quality and persistence when endeavoring to evolve new varieties of pasture and hay crops.

Nutritive Value

The problem of selecting for nutritive value has been a perplexing one. The end result is measured by the animal performance. Large animals require at least eight hundred to one thousand pounds as a minimum of green material to conduct a feeding trial. It is difficult to accumulate this amount of forage from an individual plant. It is not impossible, but it is extremely expensive and time consuming. As a result, the plant breeder must of necessity work out some laboratory method or micro-technique which will serve as an indicator of nutritive value.

Highly significant levels of protein and carotene content have been shown by Pickett (8) among unrelated first generation lines of smooth bromegrass. Heinrichs (6) found that protein content was negatively associated with yield in intermediate wheatgrass. Sullivan and Routley (11) determined that early and late plants of orchardgrass varied in percentage of protein, early types being favored. Cowan (4) has found wide differences existing in crude protein between lines of tall fescue. Some of these had a similar pattern; others varied as the season advanced. Considerable evidence has been accumulated on the nutritional importance of carbohydrates and lignin as forage plant constituents. Tsiang (12) has studied 36 clones of smooth bromegrass with reference to content of calcium, copper, iron, manganese, magnesium, and potassium, and found highly significant differences in content of magnesium and of potassium.

These nutritional differences would be of little value to the plant breeder if it is not possible to select for them. Frakes (5) has shown a high heritability for the characters of protein and dry matter in tall fescue. Tsiang (12) provided evidence of heritable variation in the carotene content of bromegrass selections. Clarke (3) obtained evidence of similar heritable variation in carotene and crude protein content of orchardgrass. Corkill³ working in New Zealand has found the following iodine values in different ryegrasses:

	<u>Iodine Value</u>
Perennial	146
Italian	87
H-1	17

For normal animal health a value of 17 is needed.

The fact that these differences have been established as being heritable provides the plant breeder with an opportunity to select and show improvement for such characters. Such a program for screening or eliminating inferior material on a nutritional basis is now being used in the tall fescue breeding program at Oregon State College.

Digestibility

It is quite possible to have forages that show a desirable chemical composition and yet are not being effectively used by the animal. Digestibility to some degree should be an indication of how well the material is being assimilated into the animal's body to be used in the form of energy and producing beef, milk, or wool.

³Unpublished. Personal communication.

In order to carry out a conventional digestibility trial, large quantities of forage must be available if such is to be done with large animals. As a result, this almost eliminates the possibility of the plant breeder's employing this particular characteristic as a means of screening or studying the behavior of forage crops. If it were possible to develop some indicators of digestibility that could provide a laboratory tool, then effective selection might be made on this basis.

Lignin has been studied and found to be not too satisfactory for this purpose. The results of lignin analysis to date have been rather unreliable. Low fiber would appear to be a more desirable indicator as far as digestibility is concerned.

Currently an extensive study is underway at Oregon State College in an attempt to devise a breeding technique for selecting on the basis of digestibility by use of the chromogen method. This is a method described by Reid et al. (9). The method was designed to aid in animal nutritional studies. It appeared to have some possibilities as a plant breeding tool. The procedure as initially described by Reid et al. (9) has been employed to ascertain whether differences exist between individual plants in their chromogen content. It has been found that the chromogen content in certain genotypes of tall fescue had a very wide range. Up to this point, it would appear to be rather academic unless there could be established a definite relationship between the chromogen content and the character digestibility. Three lines which showed a rather wide range in their chromogen content have been increased vegetatively three thousand times. This block is adequate to

provide anywhere from four hundred to one thousand pounds of green forage cut at the pasture stage (8 or 9 inches).

This forage is cut at a given stage of maturity and quick frozen. The quick frozen material is stored in a freezer. This will be fed to sheep in conventional digestibility stalls and digestibility coefficient calculated as well as determining the chromogen content of the forage and feces in order to predict a digestibility coefficient on the basis of the chromogen content. Should there be a good correlation between these two methods, then it is possible that the chromogen technique could be employed as a method of selection in grass breeding.

Palatability

It is quite possible that a forage might be analyzed and be shown to have a highly desirable chemical composition as well as highly digestible but not be readily accepted by the animal. The animal might be forced to graze certain forage having such highly nutritious content but low palatability and show positive gains. However, it would be much more desirable to have the characteristic of high palatability associated with good nutritive and digestibility values. The only way in which palatability can positively be established is by permitting the animal free choice of a number of lines. It is possible that some agronomic characteristic might be correlated with palatability, but, to date, no satisfactory correlation between a number of characters studied has been found.

If the plant breeder is going to make any headway in effecting improvement along this line, there must be differences existing between individual plants. An illustration of striking differences present in palatability of grass strains was reported by Burton (2), following studies of Bermudagrass strains. Nine strains were planted clonally in duplicate plots 30 x 60 feet in size and subsequently grazed by Jersey cattle. The differences in palatability were not associated with the several chemical characters studied or with observable morphological differences of the strains in question. Similar results have been obtained by Crampton⁴ and co-workers at MacDonald College where a study was being made between species. It was found that, although the nutritive value and digestibility of Lotus was quite low as compared to some other forage species, when animals were permitted to graze upon it with free choice, greater gains were made by the eating of Lotus. It would appear that the gains were due to a greater intake of this particular species. Buckner (1) and Peterson et al. (7) have found some definite differences in palatability between lines of tall fescue. In one study, 20 lines of tall fescue were set out in replicated vegetatively multiplied plots (7). These were grazed freely by sheep. The sheep showed a definite preference consistently at five different times over the growing season of 1956, for four lines. There were two lines which were refused consistently; the balance were of an intermediate nature. These intermediate lines

⁴Personal Communication.

were only grazed after the four more attractive ones were grazed down closely. The nutritive value, as measured by chemical analysis, of these four more acceptable ones varied considerably. One was extremely high in its production of crude protein, and one was of an intermediate nature. One was a good producer of forage while another was extremely poor in its total output. Thus, if improvement were expected in palatability, selection would have to be based on actual grazing.

Future

The relationship of palatability to nutritive value has not been fully established. Animals are capable of making good gains on some relatively unpalatable forage species. The possibility should not be overlooked that gains in palatability may be obtained at the expense of some other valuable characteristic such as persistence. The plant breeder must concern himself with palatability in as far as it complicates pasture management problems and influences the consumption of forage or herbage and the yield of animal products. If an otherwise valuable species is not accepted very well, the feasibility of using animals in screening selections and in evaluating experimental strains should be investigated.

There is some evidence that the conventional nutritive or chemical analysis of forage species and digestibility measures are not the tools which will best determine the efficient utilization of forage species. It may be that the total intake of the animal over a given period of time will be the best criterion. It is

impossible to graze a large number of lines and keep individual records of gains as would be necessary if the plant breeder were to use a procedure as a tool in his program. Therefore, some indicator or laboratory technique must be evolved. Factors affecting rumen activity could contribute to the effective utilization of the forage. Some of the minor elements may be associated with the high or low intake of the animal. More exhaustive studies of these minor elements and their association with acceptability and rapid gains by the animal should be more critically appraised.

There are some 125 forage species which hold a major place in the forage program throughout the country. Before much progress is made in breeding for quality and persistence of forages, more fundamental work must be done on all of these species to determine their breeding behavior of which quality and persistence are two important functions. This can only be accomplished by having an individual plant breeder or more working on a species. For too long there has been a situation existing where most forage crop breeders worked on any number of species from two to a half dozen. There should be alfalfa breeders, red clover breeders, orchardgrass breeders, tall fescue breeders, and bromegrass breeders, etc. These plant breeders must in turn work cooperatively with agricultural chemists and/or animal nutritionists to accumulate a fund of knowledge on the variability existing within the species. The facts derived from such studies with many species will assist in the establishment of concepts, principles, and techniques which will enable the plant breeder to select on a more sound basis for quality and persistence.

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