Getting New Range Plants Into Practice

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PERHAPS the easiest way to get people to reseed range land is to claim that you have discovered, produced, or introduced a plant that is the perfect panacea. It should have universal adaptation, no limitations, and require little more than casual broadcasting. It should, of course, be grazed the first season and stringently thereafter with very little management. None of us has yet realized this dream. Getting new range plants into practice still requires painstaking testing and a long siege of transmitting our findings to land owners and operators by education and demonstration. It is just hard work, unless one schools himself to enjoy increments of progress and the occasional reward of finding something just a little better or someone a little more willing to adopt something new but yet not sensational.

The discussion here will be from the viewpoint of an agronomist, but it has been necessary to devise methods that facilitate the introduction of new material and methods for a wide variety of farm and ranch lands. My job has been to provide the soil conservationist with good plants and good methods for conservation seedings out on the job. He can not use "cut and try" methods if he is to be successful in getting conservation on the land and gain the confidence of the people in the Soil Conservation District to which he is assigned. He can implement effective soil and water conservation when a large number of ranch people adopt his recommendation. Materials and methods that work facilitate his job.

There is nothing glamorous or sensational about what we have learned from our work, but we have employed some principles that have proved practical and have facilitated the adoption and use of new plants and new methods. If there are things here that might facilitate range reseeding, they will promote soil and water conservation in the West.

Experiences in testing plants may be portrayed by dividing the subject on the basis of answers to the questions why, what, how, and where. It is assumed that the areas we are discussing really merit reseeding. This qualification is made because experience indicates the wisdom of not trying to reseed range lands where some good method of grazing management will restore climax grasses and improve the condition class.

Why Do We Test?

Every test involves some kind of measurement. The very fact that we are testing implies that we are seeking something better than what we have. When grasses and legumes are tested, appraisal of their forage value is usually accepted as a primary consideration. More feed, better feed, feed at the right time, and consistent production are the objectives. These objectives are broader and more complicated than just yield and adaptation. They are complex because they require husbandry for both the crop and the stock. They are further complicated by the fact that the crop may modify the environment. So, we must test and measure all of these effects.

When forage crops are tested, it is implied that they will be planted and grown. Immediately this involves culture. The agronomist knows that success with growing the crop depends, in large measure, on good cultural techniques. He regards the study of cultural requirements as an important phase of testing. He has learned that improper cultural techniques have resulted in discarding a number of otherwise good plants. We often say that we use applied ecology in our tests but fail to include the item of culture that is an important factor in modifying the natural environment of the plant at some critical stage as, for example, during seedling development. Success with many plants depends on the skill with which this is done. Also, lack of attention to the minimum cultural requirements has been one of the reasons why so many large-scale seedings have failed.

Both the grazier and the agronomist are aware of the importance of good grazing management on sustained production by range and pasture crops. The tenets of good management are the same whether the forage is grown on farm land or on grazing land. A rather new concept is developing in the field of management that has a cumulative effect on production. I refer to designs for utilization that provide a liberal amount of organic residue. This has soil and water conservation value and also contributes to increased production. Therefore, in the quest for something better, the tests must be made with a particular kind of grazing management in mind along with its indirect effects.

The conservationist grows forages on cultivated land for the influence they have on soil structure. Improvement in structure that is brought about by the effect of grass roots on soil aggregates sets in motion a chain of events that result in increased infiltration rates, higher fertility levels, and greater resistance to erosion. Obviously, this leads to better and more consistent yields. It has prompted the study of root production as an objective of testing. Work in this field has resulted in giving a favored place to species and strains that otherwise might have been rejected. I am confident that the soils of range lands are subject to similar improvement and suggest that this be studied.

The objectives for testing grasses and legumes are similar for the agronomist and the grazier, but they differ in that the plants used on cropland must give optimum performance for a relatively shorter period than those planted on range land, and some adjustments must be made in testing range plants to compensate for this difference. The agronomist may fertilize or even irrigate the crop, and he can substitute a better variety each time the rotation cycle comes around. The grazier can hardly use these devices; so he must lay stress on finding material and systems of management that maintain yields for long periods. His reasons for testing are to bring plants, animals, and soil into adjustment to obtain sustained production at practical levels.

What Shall We Test?

The first inclination is to test everything; thus a huge assortment of material is gathered from every possible source and planted "to see what will happen." Further, each time a new employee comes to that location he repeats the process. Lists have been seen that include every possible species from the tall-grass prairie, the short-grass prairie, the Palouse bunchgrass prairie, and even from outside the grassland formation for a new nursery in a warm-temperate Mediterranean climate. I have been guilty of a certain degree of this indulgence myself. One hesitates to suggest that there are better ways, because it crosses the grain of human nature. However, the range ecologist has at his disposal some devices of considerable objectivity. He knows what the species of the climax vegetation should be. He should know the existing successional stage on the site and the probability of site improvement. He should know the limiting factors to plant growth where he will test his material. By using this information, he should be able to approach the *what* by choosing species that are similar to those that compose the climatic climax or the existing association. In fact, he must compare the new materials to these standards.

There are several well-known sources for plant material. They divide themselves into two categories: (1) species from commercial channels, foreign plant introduction, and the native vegetation; and (2) strains, ecotypes, and hybrids that have been selected or produced by professional plantsmen.

During the decade and a half that marks the beginning of grassland agriculture in America, a vast amount of material of all kinds has been assembled and produced. The tendency has been to refine and subdivide the material to narrower and narrower limits of inherent genetic constitution. For this the agronomist may have to assume the responsibility since he is dealing primarily with short-ley seedings on cultivated cropland. The range man must remember that his is a different problem that may suffer from too much over-specialization of plant material. Objectively, then, he will profit from reasonable generalization, regardless of source of the material. A nice example of over-specialization has been reported by Colonel W. H. Leonard. Japanese scientists developed strains of rice during the prewar period that were high in production when heavily fertilized. After the war when fertilizer was available in smaller quantity, these highly specialized strains broke down badly with a disproportionately low yield. We have had similar experiences with strains of native wheatgrass.

There has always been a mystic appeal to anything imported from foreign lands. I would be the last to contend that foreign plant introductions have not been beneficial in America, but after many years I am persuaded that an equal amount of work on native forage plants would have produced remarkable results, especially for non-cultivated areas, albeit such work is more prosaic. Introductions should not be overlooked, but the beginning tests should revolve around plants that resemble the climax or a closely related seral vegetation.

We have made good use of materials from the native vegetation in our work. A surprising array of strains within species have been discovered but we found that they could be grouped into a few "strain types." This terminology is artificial, but we have used it because we were not in a position to determine if the material merited such distinctions as ecotypes or varieties. We did learn that a good native type outyielded commercial species and varieties and new introductions when planted on low capability land, especially during years when climate was decidedly limiting.

All sources of material should be examined when making lists for testing, but the final selection should include species similar to those in the climax association and over-specialized strains should be avoided. This will reduce costs and allow for more attention to studies of culture and management. Culture and management are dominant influences on plant growth on low capability lands, and it is our conviction that the more remote the species are in relation to those in the climax, the more intensive the culture must be to get optimum performance.

How Shall We Test?

If one has fully developed the answer to *why* he is testing and has used good judgment in choosing *what* is likely to succeed, he can plan his methods for testing objectively. Methods may be general or precise like shooting at a target with a short-range shotgun or with a long-range rifle. Really, both general and precise methods are useful depending on the nature of the objective. However, they are frequently misapplied.

A beginning step for testing is usually the planting of the newly assembled material in a row nursery. Let us say that the commonly accepted broad objective is adaptation to climatic and edaphic conditions. It is almost patented that yield is the criterion for decisions, at least among agronomists. Where this is the case some erroneous conclusions can be reached. A few examples may serve to illustrate this point.

Some contend that a nursery for testing adaptation of range plants should not be cultivated. Accordingly, the material is planted and left to fight it out with the resident annual grasses and other volunteering vegetation right from the beginning. If any species should fail to yield well under such rugged competition, it is regarded as not being adapted. Nevertheless, some very useful grasses and legumes can easily be overlooked in this way. Some grasses that have good possibilities for range or pasture have weak seedlings, but after they are established they maintain their stands against competition. All they need is a little culture during the seedling stage. The kind of trial just cited therefore confuses two objectives—adaptation and minimum cultural requirements. It was found profitable to separate these objectives. Study of cultural requirements includes only material that is adapted to the soils and climate of the site. By this method it has been possible usually to find a satisfactory cultural procedure for good materials.

Many nurseries contain a heterogeneous mass of material, and, all too often, a single criterion such as total yield of dry matter at hay stage is used to sort it. Where this method is used, one ends up by finding that he has tried to compare dissimilar material with confusing results. It is not unlike trying to compare elephants, sheep, and chickens to determine the probable use for "animals." This is a crude example of incorrect method, but it is just as misleading to compare mountain brome (*Bromus marginatus*), intermediate wheatgrass (*Agropyron intermedium*), and Sandberg bluegrass (*Poa secunda*). To improve this situation we used the row nursery to divide the materials into "use groups" and compared only within groups. For example, vernal dominant bluegrasses were compared with each other but not with the summer-growing grasses. This suggests that for range reseeding the grasses that have promise for spring-fall use should not be compared with those that could provide summer grazing and so forth.

Each use group should contain a standard to which the others are compared. For example, commerical slender wheatgrass is the standard with which mountain brome, Canada wild-rye (*Elymus canadensis*), blue wild-rye (*Elymus glaucus*), bearded wheatgrass (*Agropyron subsecundum*), and Italian ryegrass (*Lolium multiflorum*) are compared. These grasses are a group wherein the members are more like one another than they are like other grasses when one considers their salient characteristics from the standpoint of their use and management in the field.

It would be disastrous to compare any of them with grasses in the groups exemplified, respectively, by Idaho fescue (*Festuca idahoensis*), orchard grass (*Dactylis glomerata*), purple needlegrass (*Stipa pulchra*), or western wheatgrass (*Agropyron smithii*). The group exemplified by slender wheatgrass (*Agropyron trachycaulum*) depends on reseeding for its longevity. High seed yields, rapid germination, and vigorous seedlings make this possible. If they are harvested before the seed matures they are relatively short-lived; and in a nursery where the method is to compare grasses on the basis of total production of dry matter at the hay stage, one would fail to discover the merits of these species.

Many other examples of objectivity in nursery and plot testing could be given. Those cited point out the need for using methods that have well-defined but simple objectives that are based on the use of the plants. This seems to be the best hope for finding something better than what we have in time to get a big and important job done.

Our testing work has been divided into the following steps: (1) An adaptation nursery in cultivated rows but not replicated. Here comparative notes are made at all the important growth stages. Species are tentatively placed into their use group and strain types are determined. (2) A replicated row nursery by use groups. Species within use groups or strain types within species may be compared by some pertinent measurement. The measure may be yield, response to treatment, or anything appropriate to the objective of further sorting the material for use. (3) Plot trials in solid-seeded pure stands with material from the replicated nursery. Plots are one step nearer the actual field conditions under which the plants will be used. Again, any measurement appropriate to the objective is applied, but usually within use groups. (4) Cultural trials in plots to determine the minimum requirements for management in keeping with specific uses. The objective may be establishment, competition in mixtures, response to fertilizers, response to clipping or grazing, et cetera, but seldom a combination of objectives. (5) Seed production trials under conditions similar to those that will be used on farms.

This system is a series of screens that gets finer and smaller with each step. The first contains the most material and the last contains the least. You will notice that use groups and single objectives dominate each step in the series. Cooperating research agencies extract materials anywhere along this line. Materials for plant breeding or disease resistance studies may come from the adaptation nursery or the replicated nursery. The products of plot trials may be used to test palatability or coefficients of digestibility. A promising combination of grasses and legumes from the mixture tests in the cultural trials may be used in a grazing study or in a study of erosion control. The objectives of each kind of trial are known to all agencies, and the results each one gets facilitate the supplemental work of others.

Another consideration in how to test is the design of the trial. Much has been written about design by agronomists and statisticians, but the truth is that little has been said about designs for perennials and even less has been said about designs suited to low capability lands. At the moment we have a tendency to make a fetish of this tool for investigation work. Elaborate designs are applied to adaptation nurseries on low capability land that were intended for use only where small differences among crop varieties are to be evaluated on good farm land. I have seen adaptation nurseries on low capability land that contain materials from several entirely different use groups. Usually, only one criterion of evaluation was applied, and the data were analyzed as a single trial. I would be the last to discount the value of statistical analysis of data, but wisdom must be used or regrettable and costly mistakes in procedure will be made. To illustrate: a nursery that is replicated and randomized according to some common design contains Sandberg's bluegrass, crested wheatgrass, mountain brome, Indian ricegrass, pubescent wheatgrass, and sheep fescue. Yields are taken at the hay stage for each of five years. One could easily conclude that mountain brome is valueless because it produced a good crop for only three years, with no opportunity to reseed. The Indian ricegrass failed to germinate because the technician did not know how to grow it. Sheep fescue was low in yield, yet it probably had produced several tons of roots that improved the soil and a good dense top growth that protected the surface from erosion. One might conclude that pubescent wheatgrass has no claim to further consideration because it yielded less than crested wheatgrass; yet it was well adapted and had a different season of use than crested wheatgrass that would make it very useful on that range area.

A good agronomist once concluded that something was wrong with his data because there were no differences in yield among several grasses in a use group at the 5 percent level. These tests were made where soil and climate were limiting to growth. However, there were differences that were important only if yield was the same, but he did not discover them. These illustrations make the point that refinement in designs of testing may lead us astray unless we are wise in applying them and comparing like things within the capabilities of the site and within well-defined objectives.

We have learned that interactions are very important when working with perennials and design our trials to evaluate them. A few of these should be mentioned. Some of the most significant are those where "seasons" are one of the interacting factors because fluctuations in climate are notoriously great in the range area. Our study of this interaction has resulted in a hypothesis that those species or strains that fluctuate least in production from year to year are best adapted to a site. This view has provided an *a priori* means for finding material with wide genetic constitution. The influence of season on some unit of performance must be segregated from that resulting from age of the perennials. Such relationships have an important bearing on use and management of established stands. For instance, we have found a considerable variation among species of the dryland bunchgrass group with respect to the years required to reach full production after seeding, and the differences became greater as the conditions of the site became more limiting.

Treatment is a factor in interactions. This is a broad term but includes factors we can control. It seems unwise to compare grass that is planted on abandoned tillable land with native pasture on untilled land. Yet this has been done, and the conclusion was that the native grasses were inferior to the commercial species. This is much like comparing a breed of domesticated sheep with its wild progenitor. Clipping versus harvest at the hay stage has produced several differential plant responses even among strains within a species that would not have been apparent had only one treatment been given. When designing such an appraisal, care is required so that each species or strain is treated at comparable growth stages. If this is not done the results may be misleading, as anyone conscious of season-of-use influences would surmise. A common illustration is the "calfeteria" method for testing relative palatability of a list of grass species from several use groups.

The compounding of mixture seedings results in interactions that can be important but are often overlooked. Here the use group concept is again helpful. In the area where the bunchgrass association is the climatic climax, interactions between bunch and sodgrasses are very noticeable, even among wheatgrasses, and analyses show that production per acre is determined by the bunchgrass. Another interaction, somewhat more complex, emerged from our mixture studies. It involved "place" and use group. An example is the mixture of crested wheatgrass and big bluegrass (*Poa ampla*), where the wheatgrass determined the yield at a semihumid location, but the bluegrass determined it at a semiarid station. These and other results have led us to believe that some theories about mixtures of perennials deserve careful examination. A common one is that the deliberate compounding of complex mixtures with species having widely different seasons of use will extend the probable grazing period. Our results show that this theorem is valid only when a skilled and well-trained operator manages the livestock. This does not happen very often in practice; so we believe that simple mixtures of species having similar seasons of use are to be desired. At least we know that production is as good or better than that from heterogeneous mixtures and that management is simplified. It does mean that adjacent but separate pastures are required to extend the grazing period.

Plant diseases sometimes influence the performance of a grass. Mountain bromegrass strains vary widely in vigor and in yield, but this rapid-developing grass depends on reseeding for its longevity. A strain susceptible to head smut, even if otherwise robust and vigorous, is destined to extinction, while a resistant one will be in production for a long time, although its annual increment of production is somewhat less.

Rodents are another biotic factor interacting with plant performance that must be reckoned with, especially in small plots. Any western range man knows what may happen to his trials with grass in the center of a sagebrush area if he forgets to control rodents.

Many other examples of interactions could be given, but I am sure that failure to recognize that they are especially important when working with perennials and failure to include them in the design of investigations has led to errors in interpretation of results. There are several that influence the performance of plants on the annual grass range, but they would support the theme that one must recognize interaction and exercise wisdom in design of trials.

Where Should We Test?

There are three things that have been valuable guides for deciding where to test grasses on agricultural lands. They should have counterparts on range lands. They can be illustrated by recounting how the system of outlying nurseries was devised and used in our work.

It is obvious that a single test under moderate conditions in large crop zones like the North Pacific coast or the Columbia Plateau would not serve the agriculture of these zones. Within them are smaller areas that differ significantly in the major factors that limit the growth of grasses and legumes. A system of outlying nurseries was devised into which were placed a limited number of type materials and type practices from the large central nurseries. They supplemented the findings in the large nurseries. The idea is not new, but it was revised to suit the needs of perennial plants.

The tendency for the grass man is to institute too many supplemental trials. He may be borrowing the idea from the cerealist, forgetting that his material is perennial, does not have the advantage of frequent cultivation, should not have a narrow genetic constitution, and will not be planted on high capability land. For these reasons his outlying tests can serve a large area with respect to edaphic and climatic factors. We have abundant proof of the wisdom of this viewpoint. It is unavoidable that it combines "what to test" with "where to test." It has been profitable for us to take a good strain or composite with rather wide genetic constitution and then select the location of outlying tests on the basis of agricultural enterprises or soil groups rather than on the narrower basis of crop variety areas or soil types. The range ecologist has devices he can use to divide his area, but only to the extent required for perennials with wide constitution.

When an outlying nursery is established, attention should be given to correct land use. It is all too common for people to suggest that land best suited to the growth of timber or brush be converted to grassland for grazing. It is also common for people to believe it is easy to plant grass on open range totally unsuited to any cultivation. They usually come to this idea after the land has been denuded and eroded by either improper use or management. In a few instances reclamation has been achieved, but time after time we labor for years on such sites despite continuous failure. It may be a long time before the end justifies the expensive means that are required to establish and maintain good perennials on these places. Strict compliance with the tenets of correct land use will avoid the selection of these sites for the initial outlying tests.

When an area is selected for testing we have learned to consider the major land capability classes represented in it. This broad classification expresses the plant producing potentials of the land and the limitations with respect to its use. It is very common to find several capability classes on one farm or ranch. When one is working in a new area it has been wise to begin on the better land and work toward that having the greatest limitation. I recall a circumstance where an outlying nursery was established in an area representing more than a million acres of land. The major part of the area was used for grazing. The vegetation was all annual with a very short season of use. Overgrazing, run-off, and soil erosion were common. The area contained three typical land capability classes. A considerable portion of it had been used for grain production but was abandoned. This part was tillable. Many attempts had been made in the area to establish perennials but usually on the poorer land on which no preparation was possible. They were failures. By confining the trials to the tillable land with higher capability and by using appropriate but simple cultural techniques, it was possible to establish several good perennials, extend the season of use by several weeks, and get higher yields per acre. When the value of this work is fully recognized and adopted by ranchers, it will then be time to devote attention to the land having lower capability. I am sure that every potential grazing area where trials are contemplated has these differentials and that it will be profitable to treat the better ones first; in fact, I have seen this done to good advantage.

We have used a fourth device for the *where* of testing that is related to getting things in common use by ranchers. It really supplements the central nursery and the system of outlying nurseries. We call it "field-scale trials." It is really a controlled demonstration planting on a limited number of typical farms in an enterprise area. In such a planting we use either a new species, variety, or strain or a new cultural or management practice that has been promising in the nursery trials. It is applied on an entire field adjacent to or near commonly used plants or methods and the two are compared. We usually supervise these plantings to make sure they are properly handled, because experience has taught us that just writing or talking about it, and then sending it out, doesn't usually get results. The people in that community are apprised of the comparison and can observe the differences, and we obtain comparative data while actually introducing the new things. This has shortened the time between investigation and application, and in these days that is important.

Summary

New range plants will get into practice if they provide more feed, better feed, and feed at the right time and if they give consistent production. There is no way to determine this except by testing them in comparison with what is on the range. It is especially important now that testing be facilitated and this can be done by a number of useful devices.

All tests should be objective with special emphasis on practical application. They should feature materials that resemble the climax grasses or a closely related association. The material should not be too specialized but should have broad adaptation.

A well-planned program for testing will have the larger number of plant accessions in simple comparative trials and fewer and fewer chosen accessions in a series of more complex tests that feature culture and management.

It will be helpful to sort the species into use groups and to test them within these groups. Strains within species can be classified into types and representative ones should be carried into advanced trials.

Designs for testing should be appropriate to the limitations of the site, to the objective of each trial, and to the plants in the test. Sight must not be lost of the fact that perennials are being tested and that several important interactions occur.

Tests that have featured an average location with respect to climatic and edaphic factors and a system of a few outlying supplemental tests have been more productive of results than a large number of small tests in areas that differ only slightly. The reasons are that long-lived perennials are under trial, that low capability lands impose limiting factors, and that culture and management are very important where animals, plants, and soil are integrated.

There is no substitute for judgment when conducting trials with range grasses. No system of methods succeeds well without it, but results are certain when the two are combined. If perchance there is also an urge to question dogma and to pioneer in unexplored areas of grassland agriculture, progress is assured. The real challenge comes when one is required to get good, sound findings into practical use on a large scale, but nothing is more urgent in these days when food is so badly needed and our range and soil resources are being de-

pleted faster than we seem able to replace them.

There is much to be gained from exchange of ideas and methods between agencies that work with range reseeding. An advantage from cooperative work is the greater rate at which we can accomplish this big and necessary but complex job. The final step in testing is getting a supply of good seed of authentic materials. Here the projection of probable needs by years in interagency meetings has been helpful. Those of us who work closely with the Crop Improvement Associations, Soil Conservation Districts, and other farm groups believe we can bring the better things into production within a reasonable time.