ALFALFA BREEDING FOR DESERT CONDITIONS

Melvin H. Schonhorst
Department of Agronomy & Plant Genetics
University of Arizona

Developing more productive and pest tolerant or resistant varieties are important objectives in most alfalfa breeding programs throughout the United States. However, under desert conditions, as found in Southwestern United States, the alfalfa plant must continue to grow and successfully combat a continuous series of obstacles twelve months of each year, and this is extended over a period of 3 to 5 years. For these reasons, alfalfa breeding for desert conditions may present a greater challenge than that encountered by alfalfa breeders in more northern regions where the growing season is considerably shorter. The low winter temperatures of the North not only halt active plant growth but also greatly restrict the activities of destructive pests.

It is not my intent to bemoan the many problems associated with alfalfa improvement in the Southwest, but rather to discuss briefly some of the accomplishments now being achieved through research which, hopefully, will minimize the risk and make the production of this our most important forage crop more economically competitive in our present-day system of agriculture.

With the sudden awareness of the spotted alfalfa aphid throughout the low desert valleys of the southwest in 1954, a new era in alfalfa improvement began to unfold. The problems on alfalfa caused by this plant pest were so great that they threatened the existance of alfalfa culture in this region. Fortunately, administrators in the several Southwestern Agricultural Experiment Stations, and the U.S. Department of Agriculture immediately created and filled positions in plant breeding and entomology which were established to cooperatively study and hopefully solve this problem. The major objective of these programs was to develop varieties of alfalfa which possessed natural resistance to this insect.

The success of these programs is history at this point, but I for one would like to express my gratitude that our first major alfalfa problem was very quickly and relatively easily solved. Alfalfa varieties developed from those early efforts include Moapa, Lahontan, Zia and Sonora. During their prime, 50% or more of the alfalfa acreage in the Southwest was planted with seed of these varieties. The tremendous aphid populations of the early 1950's have not been observed since that time. Beyond a doubt, the widespread acceptance and use of these resistant varieties by farmers and ranchers has had a major role in subduing this important pest.

Although populations of the spotted aphid were drastically decimated, they were never completely eliminated. After a period of three or four years, reports were received from growers and farm advisors indicating that considerable aphid damage was reoccurring primarily on the 'resistant' variety Moapa. An investigation into this problem indicated that a new aphid biotype had evolved. Apparently, a common biological phenomenon, called a mutation, had occurred which produced an aphid which now could feed and multiply on a formerly resistant alfalfa (host) plant. Since 1954, seven biotypes have been identified in southern Arizona and California. Fortunately, our knowledge of natural field populations and culture under greenhouse conditions of both aphid and host plants has increased to the point where we now can select plants which will produce progeny with seedling survival rates well above 90% (see photo No.1) with only one cycle of visual (phenotypic) selection.

Another alfalfa problem becoming increasingly more important in the Southwest is that of the stem nematode. Approximately twenty years ago small outbreaks of this pest were observed in alfalfa fields west of Phoenix, Arizona. Since that time, the stem nematode has been observed doing considerable damage to alfalfa in a number of other areas of the state. This pest thrives under high moisture conditions, cool temperatures, and a susceptible host. During late fall, winter and early spring, these conditions are easily met in southern Arizona. Approximately five years ago this nematode was found for the first time on the University of Arizona Mesa Experiment Station at Mesa, Arizona. This event soon proved fortunate for our breeding program. It provided an adequate testing and observation site over which we had control. Within a short time populations of the stem nematode were increased and uniformly distributed over several borders of land on this station. This site has been used very effectively in our screening and selection program for developing alfalfas with resistance to this problem. Two experimental non-dormant alfalfas have been developed and are being tested on farmers' fields in cooperation with our extension agents in Graham and Maricopa County.

Another severe alfalfa problem found in the Southwest is caused by a fungus called Phymatotrichum omnivorum. This fungus can attack and kill approximately 2000 different kinds of plants. Among its hosts are alfalfa and cotton, two major agronomic crops in the Southwest (see photo No.2). The disease caused by this fungus has several common names, such as 'cotton' root rot, or 'Texas' root rot. It has been found in much of southern Arizona, New Mexico, Texas, and the western edge of Sonora, Mexico. Fortunately, for Californians, this disease is seldom found in your State.

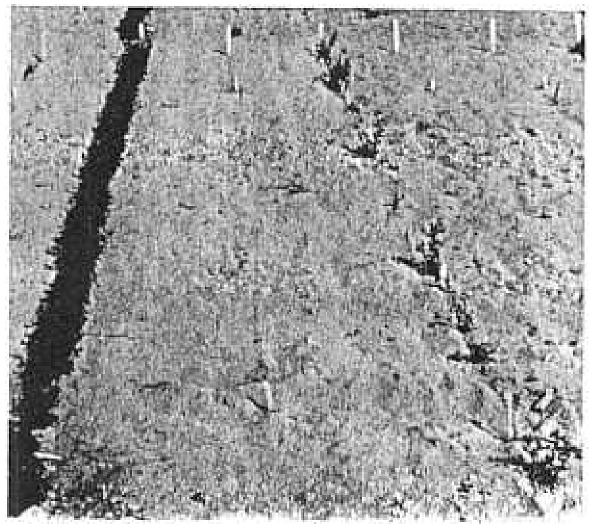
For the past 15 or 16 years, we in Arizona have attempted to find an alfalfa with resistance to this fungus. To date, we have not succeeded. However, we have made some interesting observations. For example, in the past we have dug up surviving plants and examined their roots and saved those with healthy tap roots. When seed from these plants was planted in a fungus-infested soil, the plants were killed just as readily as those from the original population. We have repeated this procedure a number of times and regret to admit that zero progress has been made. Apparently, the surviving plants with intact tap roots were merely those which had escaped infection. With the realization that this approach was futile, we took another look at the surviving plants and found a number of individuals which had young, healthy lateral roots which had formed just above the rotted area on the tap root (see photo No.3). In all cases, those plants which had been infected and killed during the first summer of exposure to the fungus lacked the new lateral root system.

Currently, we are testing the theory that some alfalfa plants in a population have the inherited (genetic) ability to rapidly develop a number of lateral roots which seems to be stimulated into development after the tap root has been infected and extensively destroyed. With the on-set of cool temperatures, the development of the fungus on the tap root is arrested and the new laterals develop quickly. Thus, these plants have an escape mechanism which permits them to survive for at least one more season.

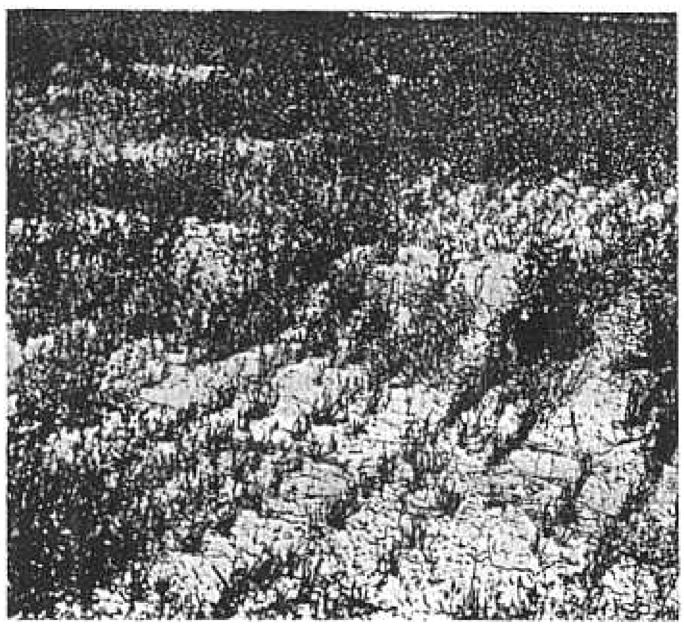
Another major objective of the alfalfa breeding program in Arizona has been that of increasing the total amount of high quality forage produced. This too is a very complex problem. Fortunately, we realized a number of years ago that a group of plants selected for a specific trait, such as resistance to the spotted alfalfa aphid, did not automatically result in a high-forage-producing variety. It is true that the resistant plants performed better than the original susceptible source when both plant populations were exposed to large populations of the pest. However, when the selection pressure was reduced, that is the population of the pest was low or absent, then frequently the resistant plant population no longer was superior, and in some cases no longer equal to the original or susceptible variety in forage production. This problem has been more pronounced when selection for resistance was based on young seedling performance. Apparently, when selection for resistance is based on the performance of more mature plants, we are selecting not only for reaction to the pest, but also for other desirable traits associated with adaptation and productivity. As a result of these findings, we in Arizona are convinced that selected plants must be progeny tested under field conditions so as to eliminate those entries which give low-forage-producing progeny. Unfortunately a thorough progeny test of a large group of alfalfa selections requires uch time and labor as well as a large area of fairly uniform soil. To illustrate these points, the variation in forage production of a large number of African and Sirsa #9 progeny is shown in Figure 1.

Varieties developed by using the progeny testing method include Sonora, El-Unico, Mesa-Sirsa, Sonora-70, and Hayden. Their ability to produce more forage in Arizona than the older check varieties, Hairy Peruvian and Moapa is well documented in the following three tables.

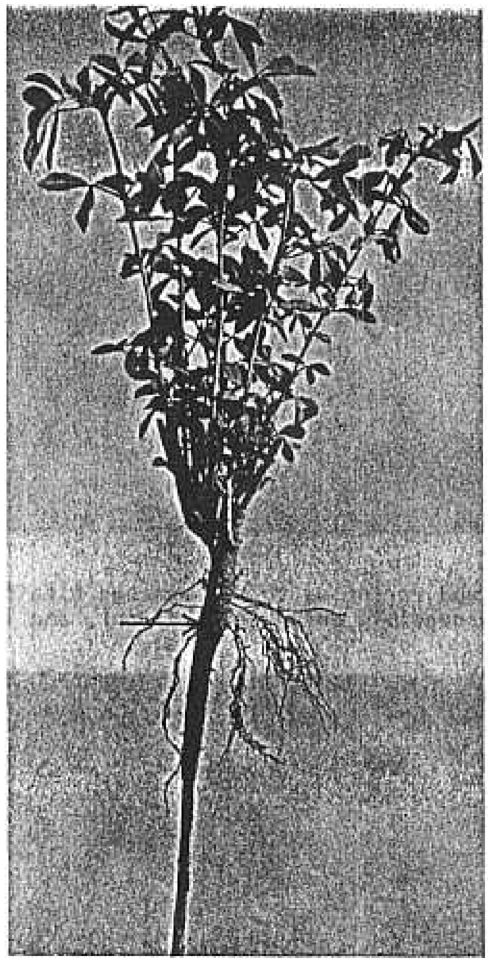
Time and space for this report permit only a brief discussion of a few examples of breeding efforts aimed at developing better alfalfas for desert conditions. We fully realize that with the current enthusiasm and interest in cooperative work among breeders, entomologists, physiologists, plant pathologists, nutritionists, animal and soil scientists, the future of alfalfa improvement looks most promising. Hopefully, the slow and tedious techniques of today will soon be replaced by more simplified and productive techniques.



Reaction of alfalfa strains and varieties to the spotted alfalfa aphid: highly resistant strain (left row), highly susceptible entry (center row), and low level of resistance (right).



Alfalfa plants being killed by the "cotton root rot" fungus, Phymatotricum omnivorum, in Arizona



A healthy-appearing alfalfa plant in a root-rot-infected area. The taproot may be killed to within 1 inch below the crown. Such plants are supported by lateral, adventitious roots. Photo by Dr. R. B. Streets, Plant Pathologist, University of Arizona.

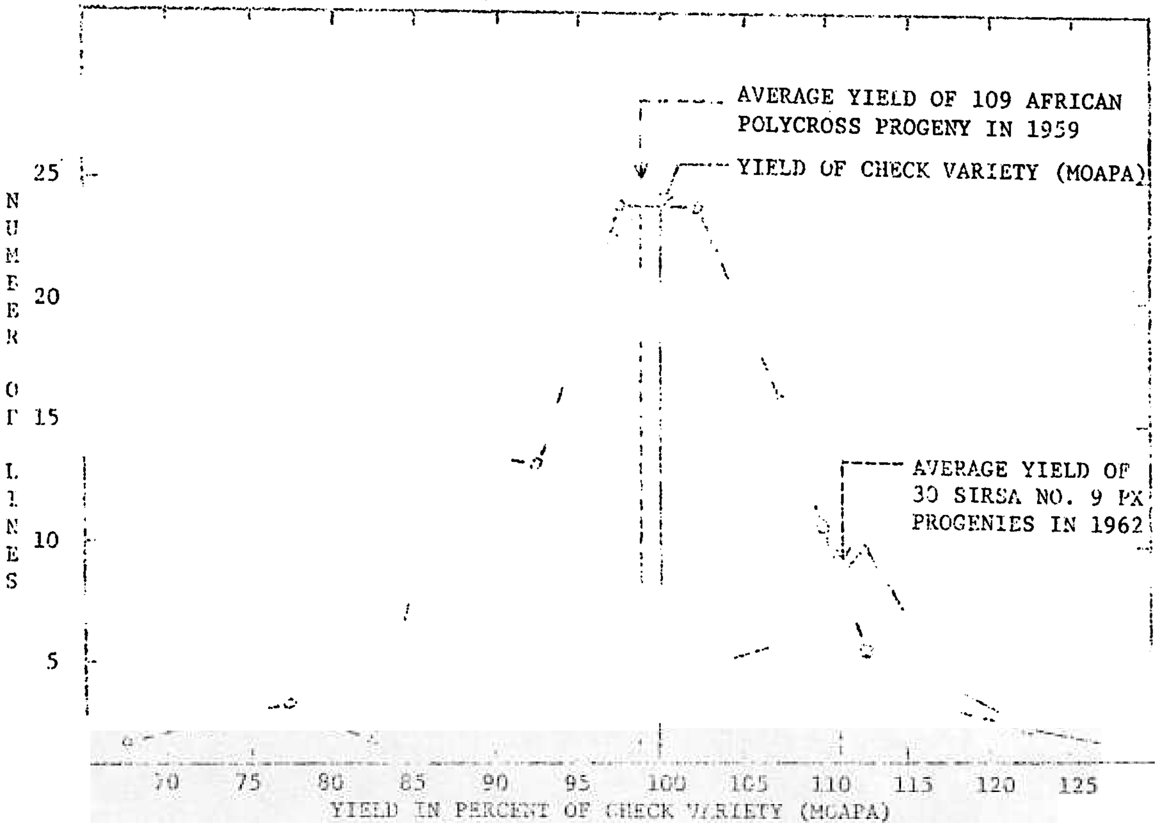


Figure 1 Mean and frequency distribution for forage yield (green weight) of 109 African and 30 Sirsa No. 9 polycross progeny grown at the University of Arizona Mesa Branch Station.

Table Three-year summary of forage production comparing Mesa-Sirsa with the check variety Moapa[a/].

Cultivar	Total annual green forage production (lbs.) 1966	1967	1968	3-year total yield[b/]	Yield in % of Moapa
Mesa-Sirsa	304.8	250.7	212.6	768.1	127.0
Moapa	231.3	210.1	163.6	605.0	100.0

a/ Test was planted 10-5-65 on the University of Arizona Mesa Farm Border A:89.

b/ Twenty-two harvests were obtained during the three years of harvest.

Table 2. Three-year summary of forage production comparing old vs new alfalfa cultivars grown in Arizona[a].

Cultivar	Total annual green forage production (lbs.) 1967	1968	1969	3-year total yield[b]	Yield in % of H. Peruvian
Sonora-70	245.9	286.0	223.4	755.3	152.4
Mesa-Sirsa	242.3	252.0	207.2	701.5	141.6
Moapa	213.2	222.4	206.8	642.4	129.6
Hairy Peruvian	186.5	182.7	126.3	495.5	100.0

a/ Test was planted 10-28-66 on the University of Arizona Mesa Farm Border E:17.

b/ Twenty-four harvests were obtained during the three years of harvest.

Table 3 Three-year forage production comparison of Hayden and Sonora-70 alfalfa with three check entries (El-Unico, Mesa-Sirsa and Sonora)[a]

Entry	Annual Forage Production in pounds of Green Weight 1968[b]	1969[c]	1970[d]	3-Year Total Yield	Yield in % of Mesa-Sirsa
Hayden	342.9	373.3	262.5	978.7	111
Sonora-70	328.1	353.0	236.0	917.1	104
Mesa-Sirsa (cert.)	326.3	313.5	238.9	878.7	100
El-Unico (syn-1)	313.9	309.9	212.1	844.9	96
Sonora (cert.)	283.6	262.9	167.9	714.4	81

a/ This test was planted November 11, 1967 on the University of Arizona's Mesa Branch Station Border E:24. Five Replications.

b/ Seven harvests were obtained in 1968 by 11-2-68.

c/ Eight harvests were obtained in 1969 by 10-28-69

d/ Seven harvests were obtained between 10-28-69 and the final harvest on 9-2-70.