BREAKING THE ALFALFA YIELD BARRIER

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Historical Background for U.S. Production

During the past one-hundred or so years, alfalfa production has spread and flourished in the United States. It has contributed to progress in many phases of the livestock industry.

The value of alfalfa, or lucerne as it is called in Europe, as a forage crop was recognized early in U.S. history. Colonists had attempted frequently to introduce alfalfa to the Atlantic states prior to the Revolutionary War (alfalfa was recorded in Georgia in 1736 and North Carolina in 1739). In general, these attempts failed for reasons not stated.

Between 1854 and 1873 alfalfa was brought from Chile to California where a sizable and successful production area was established in the San Joaquin Valley. From this "foot hold" in California, alfalfa production spread eastward. At the same time, Wendelin Grimm's "everlasting clover" contributed greatly to alfalfa expansion in the colder regions of the U.S. where a hardy type was needed. By the early part of this century, alfalfa was considered one of the best known forage plants.

In preparation for this paper, I reviewed some of our Experiment Station documents to learn something about when interest in alfalfa developed among North Carolina researchers. In the process, I found a bulletin from 1894 which reported evaluations made in 1891. I believe that the following quote from that bulletin typifies the early recognition by researchers of alfalfa's potential as a forage plant. "Lucerne grows best upon a deep, loose, dry limestone soil, but when lime or marl can be artificially supplied does excellently on sandy loam. Our plats were upon a stiff red-clay soil and upon a lowland plat rather too moist. The roots could not penetrate deeply, and upon such soil (lowland) the growth was necessarily slow and the plant was unable to withstand the intrusion of crab and bermuda grasses and weeds. Where it succeeds lucerne is the best of all meadow plants".

Many factors are responsible for making alfalfa one of the most widely grown forage crops in the U.S. Some of these factors include:

a. high yields and nutritive value of alfalfa relative to other forages.

b. perennial nature of the crop (stand persistence).
c. deep root system and drought tolerance, but also good adaptation to irrigated conditions.
d. development of regionally adapted cultivars and responsiveness of the crop to intensive cultural management.
e. availability of sound research data that positively influenced production.
f. development of a stable and active seed industry.

Alfalfa Yield Potential and Progress

If one examines the annual estimates of alfalfa yields in the United States over a period of several decades, the apparent increase in average yields over the years is dismally low. The 1899 estimated average alfalfa yield was 2.5 tons per acre; in 1979 the average estimated yield was 3.18, a 0.68 ton/A increase in 80 years.

I would like to use some data from North Carolina as a specific case in point. Average alfalfa yields are presented in Table 1 for the period of 1919-1981 with average yields for six decades as well as the individual years of 1919, 1930, 1940, 1950, 1960, 1970, 1980 and 1981.

Table 1. Average Yield Estimates for Alfalfa Grown in North Carolina 1919 - 1981.

Year(s)	Individual Year	Decade Avg.	% Change
	-------- Tons/A --------		
1919	1.80	1.73	--
1919-1929			
1930	1.60	1.85	+6.9
1930-1939			
1940	2.00	2.07	+11.8
1940-1949			
1950	2.15	1.98	-4.3
1950-1959			
1960	2.0	2.08	+5.0
1960-1969			
1970	2.40	2.54	+22.1
1970-1979		--	--
1980	2.25	--	--
1981	2.40	--	+33.3
1981 vs. 1919	--		
1919-1929 vs. 1970-1979	--	--	+46.8

The North Carolina data are similar to national averages in that the actual increases in yield varied from 0.60 tons/A for the

individual year comparisons 1919 vs. 1981, to 0.81 tons/A for the decades comparison 1919-1929 vs. 1970-1979. These changes represent an increase of 33-47% in 60-70 years in North Carolina versus a 27% increase in 80 years for the national average yields. When comparing alfalfa yield increases to increases of other crops such as corn or grain sorghum where over 100% increases have been achieved in a decade, alfalfa average yield increases appear to have been minimal.

Nevertheless, relying on average yields as an indication of production trends can be deceiving. It is well documented that top farmers have been able to consistently produce 100-150% more than state average yields. Also, in some areas of the U.S. where state yield averages have not shown a consistent trend toward increasing, individual growers have regularly recorded yield increases far superior to the state averages.

Breaking Yield Barriers

We have been breaking yield barriers for 60 years. Each new advance in cultural management or in breeding has tended to act in a barely perceptible, but additive way so that slowly but steadily, yield advances have been made. What is particularly disturbing is that during the past 50 or so years these advances have not been used to advantage by a sizable percentage of the growers. This is reflected to a large degree in the poor to mediocre increases in average yields mentioned previously.

It is believed by some that the progress in yield improvement made during the decade of the 70's was the greatest ever seen in the U.S. Notably, in the past five years numerous reports from many states have shown high yield responses. This is encouraging, but there is plenty of need for further improvement particularly in view of the tremendous acceleration in production costs.

High Yield Recipe

Reports of non-irrigated yields of 7 to 10 tons of hay equivalent per acre have been frequent during the past several years. Irrigated yields of 11-14 tons have also been reported. Numerous steps, keys, formulas, factors, etc. have been offered as recipes for attainment of high yields. Not surprisingly, most of the high yield programs have recommendations with much in common. Below is an attempt to collate some of these ideas that research and extension workers from many states feel are important to the high yield approach.

1. SOIL SELECTION - Choose a deep, well-drained, fertile soil.
2. LIME SOIL to pH 6.5 - 7.0.

3. SOIL FERTILITY - Establish stand to soil test.
   --Annual topdressing with P, K, B essential (sometimes S is needed)
   --K requirement usually 2-3 times that of P
   --Fertilize to yield-goal level
   --Split annual topdressing
   --Frequent soil testing
4. PLANT AN ADAPTED VARIETY WITH HIGH YIELD POTENTIAL.
5. GET AN EXCELLENT STAND
   --Prepare a good seedbed
   --Sow seeds on time
   --Sow enough seeds (8-25 lbs/A)
   --Always inoculate seed with proper strain of *Rhizobia* (use sticker)
   --Use herbicide to control weeds in seedling stands.
6. HARVEST PROPERLY
   --1st cut - late bud stage
   --2nd and later cuts - 10% to 25% bloom or about 30 to 35 day intervals.
   --Manage for as many cuts as possible in your area, 3, 4, 5, 6, etc.
7. CONTROL PESTS
   --Insects - alfalfa weevil, leaf hoppers, aphids, armyworms, etc.
   --Weeds - use recommended amounts of labeled herbicides
   --Disease - cultivar selection
8. FALL MANAGEMENT
   --Do not harvest within about 30 days of the average frost date. Allow 12-18" regrowth prior to frost.
   --Harvest surplus growth after killing frost of about 24°F.
   --Leave 3-5 inches of stubble for snow cover.

Maximum Economic Yields

To the farmer, high yield without regard to profitability is absurd. Profit is not only influenced by the yield per acre, but also by the costs associated with producing such yields. Clearly, simply maximizing yield per se is no guarantee of maximizing profit.

To the scientist, investigating the scientific principles relating to plant yield is very important. His treatments or his specific approach to a problem may not be economically feasible by present day standards. Nevertheless, he must continue to determine the hows and the whys, for it is this approach that will assure future success.

Just imagine what the skeptics were saying about Thomas Edison while he was spending years and innumerable tests on some "fool thing" called the electric light!

Although the grower must be concerned with total production costs as well as yield, nowadays profitable alfalfa production depends on high yields per acre. This is true because, within limits, extra costs associated with high yields increase at a lesser rate than the value of additional forage produced at high yield levels. In addition, some costs are similar regardless of yield.

Growers should find out the yield potential of their soils and climates and strive to reach this potential as economically as possible. As breakeven yield levels continue to increase during the 80's, maximum economic yields will become essential to profitable alfalfa production.

CHALLENGES FOR THE 80's, 90's AND THE 21st CENTURY

Growers Challenge

In the years ahead, the successful grower will be the one who is able to put numerous production components together in the proper fashion. Much like fitting pieces of a puzzle together, he must be able to select the important information from a variety of sources and form a smooth running production system. Flexibility will be very important. The ability to feed, store, sell or further process the alfalfa crop will be a great advantage to the grower. Alfalfa, in the final analysis, is marketed through animals. It is unlikely that this will change. The grower must be able to deal with interacting plant and animal factors. He must make better use of information available to him. His decisions must be based on scientific evidence not tradition or testimonial. Growers shouldn't be overly critical of researchers who appear to be studying things of little practical value. Technology is dynamic, what appears to be nonsense today may be salvation in the future; remember Thomas Edison.

Researchers Challenge

Much progress is still to be made with existing technology. We must strive to find the right combinations. Intensified soil fertility is as much a part of the high yield approach as cultivar improvement or any one thing. There is still much to be learned about nutrient interactions. Irrigation must be studied again in the humid areas of the U.S. because of the recent development of high yielding disease resistant cultivars. Establishment, harvest and utilization techniques that increase the odds of success and profits are continually needed. Can cultivars be developed that regrow quickly producing enough leaf area so that plants may be cut more frequently without depleting carbohydrate reserves or lowering yield per cutting? Should leaf angle be more upright allowing light penetration into the

canopy? Is it possible to retain the rapid growth characteristics of nondormant alfalfa types and at the same time increase their winter hardiness? Although basic research is a constant need, it must always be balanced with practical or applied research that maintains a continuing link to grower needs. Interdisciplinary, cooperative research will be necessary and should be demanded by university administrators. This is particularly important in bringing animal scientists, agronomists, agricultural engineers, and others together in cooperative work. Cooperative work on the practical extraction of alfalfa plant protein is an example of the kind of research that should be intensified in the future.

Plant Breeders Challenge

Much progress has been made in developing high yielding, regionally adaptive alfalfa strains. Nevertheless, there is probably more potential for future yield improvement by breeding than any single factor. One area that needs much emphasis is breeding from a "world collection". Too many times have we dug into the same old "bag of tricks". Much breeding has been done from similar germplasm lines. Perhaps new collections should be obtained. This approach is costly and time consuming, but has great potential for alfalfa improvement. Utilizing breeding techniques to produce high-yielding F1 hybrids has great potential. Interspecific crossing of Medicago species also may hold great potential. Breeding for N fixation potential, photosynthetic efficiency as well as multiple pest resistance by using some of the new "genetic engineering" techniques may allow great advances to be made in the future.

Extension Challenge

Extension must find means to streamline the transfer of research findings to the grower. I am confident that one way or another computers will play an important role in this transfer. Extension must be able to convert these findings into a relevant and meaningful form that can be easily used by growers. Extension staff working together with growers should have the flexibility to help validate alfalfa research findings over a wide range of soil and environmental conditions. Extension personnel must be deeply committed to helping farmers develop total management packages by assisting in assembling the proper components of high yield and high profit systems. Extension must act as a vital link between growers and researchers so that information can move in both directions. New research finds should be rapidly transfered to the growers, also growers and extension personnel should have some input in setting research priorities.

Extension should encourage farmers to strive for maximum economic yields. The competitive spirit of growers must be

stimulated, even though it may involve some additional risks due to increased inputs. One of the best examples of extension involvement in motivating growers toward attaining high yield levels is the competitive alfalfa growers program conducted in Pennsylvania for the past several years. This program and similar ones in other states can have a very important and favorable impact on production practices. This approach is capable of deeply involving growers and once the involved growers are convinced that certain production practices are worthwhile, they are extremely effective in influencing non-involved growers to accept desirable practices.

Seedsmans Challenge

Seedsmen must continue to increase seed yields per acre in order to maintain a reasonable margin of profit and to assure the lowest possible price to growers. Cultural techniques that influence seed yield should be studied completely. Concentrated work in the area of pollination and seed set could help to increase seed yields. Moreover, finding ways to produce F1 hybrids effectively and efficiently could advance forage yield levels significantly. Many times experimental lines with excellent yield potential are discarded because conventional seed production practices produce unacceptable amounts of seed. New seed production practices must be explored and made practical so these high potential experimental lines can be offered to the grower at a reasonable price.

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