# MINUTES
of the
JOINT SESSION
of
PUBLIC AND PRIVATE ALFALFA RESEARCH WORKERS

held at the

TENTH CENTRAL ALFALFA IMPROVEMENT CONFERENCE
CONRAD HILTON HOTEL
CHICAGO, ILLINOIS
JANUARY 26, 1967

Reported by

Kenneth L. Larson 1/, Secretary

1/ Associate Professor of Agronomy, North Dakota State University
Fargo, North Dakota

TABLE OF CONTENTS

General Program - Chairman Dale Smith

MINUTES OF THE JOINT SESSION OF PUBLIC AND PRIVATE
ALFALFA RESEARCH WORKERS HELD AT THE
TENTH CENTRAL ALFALFA IMPROVEMENT CONFERENCE

Chicago, Illinois
January 26, 1967

The meeting was convened at 8:30 a.m., January 26, 1967, in the Conrad Hilton Hotel, Chicago, Illinois, by Chairman Dale Smith. Chairman Smith welcomed representatives of the experiment stations and private industries to the third joint session of public and private alfalfa research workers in the Central Alfalfa Improvement Conference.

D. F. Beard served as moderator for the presentation of papers on stand establishment by J. M. Sund and G. C. Marten.

## METHODS AND DEPTH OF SEEDING FORAGE GRASSES AND LEGUMES

J. M. Sund[1], G. P. Barrington[2] and J. M. Scholl[3]

During a 24-year period, nearly all types of farm machines available for seeding forage grasses and legumes were included in forage establishment stuies on three Wisconsin soil types. Many of them were found very inefficient in getting the seed into the soil. The 5 best ones were further evaluated during the last 8 years of the study and form the basis for this report.

The objectives of the study were (1) to evaluate the effectiveness of various machines, (2) to improve the design of seed-placement mechanisms on farm machines and (3) to determine some of the reasons for poor stands generally obtained with machine seedings.

Machine seeded plots were established on well-prepared seedbeds in field plots one seeder-width wide and ranging in length from 40 to 120 feet in 4 replicates each year.

During the last 4 years of the study depths of seed placement of alfalfa, red clover, bromegrass, orchardgrass and timothy were evaluated in small hand-seeded plots on loam, clay and sandy soils at 3 locations. The procedure used is described in reference number 5 of the attached bibliography. Briefly, the surface soil was removed to the desired depths at 1/2-inch increments from the surface to 2 1/2 inches deep with a scraper bar pulled along iron rails installed at surface level. This procedure left the soil undisturbed and firm below the point of seed placement. The soil was then replaced over 100 seeds in each of 3-foot rows spaced 6 inches apart in 4 replicates. The soil was firmed over the seed with a flat piece of iron held at an angle to push the soil downward.

---

1/ Assoc. Prof. - Agronomy.
2/ Assoc. Prof. - Agric. Eng.
3/ Prof. - Agron., College of Agriculture, University of Wis., Madison.

## Results

Even the best farm machines (Nos. 2-6 described in Table 1), available to farmers for seeding forages, were found inefficient. Generally, only 26 to 32% of the seed would establish plants. A 62% establishment was obtained only once in a total of 140 seedings. This was obtained with the roller cultipacker seeder with ideal moisture conditions in the upper 1/2 inch of the seedbed. A summary of the results is presented in Table 2.

The poorest stands were obtained with machine No. 1 equipped with 4-inch wide expanded metal press wheels which were designed to regulate the depth of seeding rather than firming the soil.

Machines numbered 2, 3 and 4 were considered to perform the best of all. The corrugated roller seeder (No. 2), drops the seed in furrows made by the front roller and the back roller covers the seed and firms the soil over it. It generally scatters the seed at various depths in the upper 1/2 inch. It is most satisfactory on loam soils; it is generally unsatisfactory on sandy soils because (1) the seed is not placed deep enough to obtain moisture and the surface sand may become too hot and (2) it leaves the surface smooth and subject to wind erosion. With proper moisture conditions, it does a good job on clay soils but sometimes a crust may form if the soil is too wet. Single disc or shoe openers were used on machine number 3. A trailer wheel was attached to accurately operate the fluted seeding mechanism for exact rates of seeding on machines No. 2 and 3. The same seed box was used on both machines.

Among the grain drills, the best stands were obtained with those having a disc furrow opener for the grain and equipped with press wheels. The forage seed was dropped through a tube in front of the press wheel. The most effective press wheel was 1-inch wide and 8 or 9 inches in diameter. Press wheels should exert a pressure of 6 to 15 pounds per square inch. On well-prepared seedbeds the double disc furrow opener (Machine 4) was best while on trashy or poorly prepared seedbeds the single disc opener (on No. 3) was best. A specially designed shoe-type furrow opener should give the best performance but it created problems with trash dragging in front of the openers.

The major fault with most farm machines appears to be a lack of firming the soil below the seed. Press wheels effectively firm the soil above the seed but do not firm it deeper than 1 inch leaving the soil loose below the seed.

The importance of a firm soil below the seed is evident in the data from the small hand-seeded plots. Firmness below the seed was probably the major reason for 90%, or more, of the seed establishing plants at the 1/2 and 1-inch depths of planting in these plots. These depths were the best on all 3 soil types (Table 3).

The 1-inch depth appears only slightly better than the 1/2-inch on sandy soils in the hand-seeded plots but the 1-inch depth was always better than the 1/2-inch with the farm machines on sandy soils. On loam and clay soils satisfactory establishment was obtained at both the 1/2- and 1-inch depths of

planting. Even at 2 inches deep in hand-seeded plots an establishment of 40% was obtained. This is better than the 32% obtained at the better, shallower depths by farm machines.

Timeliness of seeding is important because of soil moisture and temperature conditions. Data in Table 4 show 46% establishment from the May 12 seeding but only 1% when seeded June 15, 1961, a dry year. Surface seedings in 1962, a year of good moisture conditions, gave a 68% establishment in the May 4 seeding but only 36% when seeded June 15. In the very dry year (1961), the soil was too dry even at 2 inches to obtain good germination. This is most likely to occur late in the season. In 1962 (good moisture) alfalfa established well even from 2 inches deep because of proper moisture at that depth -- and no crusting above. Generally 2" seemed too deep.

Alfalfa and bromegrass can generally be seeded 1/2 inch deeper than red clover and orchardgrass under similar conditions. Smaller-seeded species (ladino clover and timothy) can seldom be seeded deeper than 1/2 inch.

Based on all data available, the optimum depth of seeding varies with (1) time of seeding and (2) soil type affecting moisture and temperature conditions and possible crusting of the soil. Suggested depths of seeding alfalfa, bromegrass, red clover, and orchardgrass for early and late seeding dates on 3 soil types are given in Table 5.

The effect of row spacings compared with broadcast seeding is shown in Table 6. Adequate stands were obtained in 4-, 6- and 8-inch row spacings but 12 inches was too wide. More weeds appeared in the 12-inch spacing and yields were also lower at this width.

## Principal conclusions

1. Seed placement mechanisms on farm machines should be improved to place all the seed at approximately 3/4 inches deep for best results under most soil conditions and for the 4 species of forages listed in Table 3.

2. The seedbed should be well-prepared such that it is firm below the seed and loose only in the upper 1 inch. Such a seedbed is best obtained by fall plowing and light tillage in the spring. In areas where fall plowing is inadvisable because of wind erosion a plow-packer should be used with spring plowing.

3. Timeliness of seeding is important in relation to the machine on hand. If the machine cannot be adjusted to seed most, or all, of the seed at 3/4 to 1 inch deep, the seeding must be done early. Late seedings can be made if the machine available can be adjusted to seed deep enough to place seed in moist soil but no deeper than 1-3/4 inches.

4. Fertilizer should be well incorporated in the soil before seeding. Band seeding (fertilizer to the side of the seed) was effective in only 2 out of 12 years. These 2 years were very dry.

5. With good seedbed preparation and good machines, adequate seeding rates in pounds per acre are: alfalfa - 4, bromegrass - 6, red clover - 3 and

orchardgrass - 1 1/4. With farm machines available prior to 1962 (newer ones have not been evaluated) it is necessary to seed at heavier rates since only 32% establishment can be expected on well-prepared seedbeds and less on poorly prepared seedbeds.

Table 1. Machine descriptions.

| No. | Size* and type | Openers | Seed placement | Seed covered by |
|---|---|---|---|---|
| 1 | 17 x 7 grain drill Legume attachment | Double disk | Furrow | Expanded metal wheel |
| 2 | 8' corrugated roller | Ribbed roller | Broadcast surface | Ribbed roller |
| 3 | 20 x 4 alfalfa drill | Single disk and shoe | Furrow | Rubber wheel |
| 4 | 11 x 7 grain drill Legume attachment | Double disk | Surface over fertilizer | Ribbed wheel |
| 5 | 12 x 6 press wheel drill | Single disk | Surface over fertilizer | Rubber wheel |
| 6 | 13 x 7 grain drill Legume attachment | Single disk | Surface over fertilizer | Steel wheel |
| 7 | 8' Experimental | None | Surface ahead of wheel | Ribbed wheel |

*All machines used fluted wheel seed-meters.

Table 2. Percentage establishment of forage species from machine sowings. Wisconsin 1951-62.

| Machine | Entries | Alfalfa range | Avg. | Entries | Clovers range | Avg. | Entries | Grasses range | Avg. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 5.8-21.5 | 11.1 | 22 | 3.3-42.1 | 20.6 | | | |
| 2 | 38 | 9.1-62.4 | 32.0 | 8 | 16.2-47.5 | 30.6 | 1 | 32.0 | 32.0 |
| 3 | 18 | 9.8-49.1 | 30.3 | 13 | 19.0-49.7 | 31.4 | | | |
| 4 | 37 | 12.8-40.2 | 28.1 | | | | | | |
| 5 | 4 | 13.3-37.3 | 25.7 | | | | | | |
| 6 | 10 | 8.1-36.5 | 27.8 | | | | | | |
| 7 | 33 | 9.8-42.4 | 26.8 | | | | 4 | 8.0-12.5 | 11.0 |

Table 3. Number plants established from 100 seeds (4-year average) in hand-seeded plots.

| Alfalfa | | | | Red Clover | | | |
|---|---|---|---|---|---|---|---|
| Depth | Sand | Loam | Clay | Depth | Sand | Loam | Clay |
| 1/2 | 71 | 59 | 52 | 1/2 | 67 | 47 | 40 |
| 1 | 73 | 55 | 48 | 1 | 66 | 45 | 35 |
| 1- 1/2 | 55 | 32 | 28 | 1- 1/2 | 53 | 24 | 14 |
| 2 | 40 | 16 | 13 | 2 | 27 | 13 | 7 |
| **Bromegrass** | | | | **Orchardgrass** | | | |
| Depth | Sand | Loam | Clay | Depth | Sand | Loam | Clay |
| 1/2 | 71 | 68 | 56 | 1/2 | 61 | 56 | 60 |
| 1 | 64 | 50 | 37 | 1 | 56 | 39 | 26 |
| 1- 1/2 | 48 | 31 | 17 | 1- 1/2 | 30 | 28 | 6 |
| 2 | 29 | 19 | 6 | 2 | 13 | 16 | 1 |

Table 4. Early sowing is better than late sowing.

Number of Alfalfa Plants from 100 Seeds

| Inches depth | 1961 - Dry | | 1962 - Adequate | |
|---|---|---|---|---|
| | May 12 | June 16 | May 4 | June 15 |
| 0 | 46 | 1 | 68 | 36 |
| 1/2 | 80 | 64 | 68 | 78 |
| 1 | 74 | 47 | 68 | 32 |
| 1-1/2 | 48 | 19 | 54 | 10 |
| 2 | 16 | 12 | 61 | 1 |
| 2-1/2 | 4 | 0 | 21 | 0 |

On loamy soils - Madison

Table 5. Sow seed at proper depth.

| Soil Type | Alfalfa and Bromegrass | | Red Clover and Timothy | |
|---|---|---|---|---|
| | Early* | Late* | Early | Late |
| Sandy | 1 | 1-1/2 | 1/2 | 1 |
| Loamy | 1/2 | 1 | 1/2 | 3/4 |
| Clayey | 1/2 | 3/4 | 1/4 | 1/2 |

* Early spring - surface moist - warm.
* Late spring - surface dry - hot.

Table 6. Effect of row spacing on stands of alfalfa.

| Spacing | % Stand -4 entries * |
|---|---|
| Broadcast | 23.4 |
| 4-inch Row | 24.3 |
| 6-inch Row | 26.6 |
| 8-inch Row | 22.2 |
| 12-inch Row | 16.9 |

* Average 2 locations in each of 2 years.

## Bibliography

(For further information on factors affecting establishment)

1. Beveridge, J. L. and C. P. Wilsie. 1959. Agron. J. 51:731-34.

2. Garrison, C. S. 1960. Adv. in Agron. No. 12.

3. Lueck, A. G., V. G. Sprague and R. J. Garber. 1949. Agron. J. 41:137-40.

4. Sund, J. M., G. P. Barrington and J. M. Scholl. 1966. 10th Int. Grass. Cong. Proc. pp. 319-323. Paper No. 56.

5. Tesar, M. B., K. Lawton and B. Kawin. 1954. Agron. J. 46:189-94.

6. Triplett, G. B. Jr. and M. B. Tesar. 1960. Agron. J. 52:681-4.

7. Wagner, R. E. and W. C. Hulburt. 1954. Nat. Fert. Rev. Jan.-Mar. pp. 13-16.

## STAND AS RELATED TO YIELD OF ALFALFA

G. C. Marten
Crop Research Division, ARS, USDA
and
University of Minnesota

For purposes of this discussion, I will define a "stand" as a growth of plants with regard to number upon a given area or percentage of a given area covered.

According to Willard (16), "a general relation between stand and yield is obvious to the most casual observer...". Knodt (7) reported that "a good stand of alfalfa is 15 to 20 plants per square foot". He also concluded that 10 pounds of seed per acre will put down 55 seeds per square foot.

The majority of reports on this subject are presented in terms of alfalfa plants per unit area. Cowett and Sprague (1) reported that as stand density increased from one to 8 plants per square foot, the yield per acre increased, but the number of stems and dry weight per plant decreased. Rumbaugh (12) examined the relationships among yield components (crown width, length of longest stem, and stem number), determined in spaced nurseries, as affected by population densities. As plant spacings increased from 5.25 to 42 inches, yield per plant increased, as did crown width and stem numbers. Stem length showed a curvilinear response to spacings. Salmon et al. (13) concluded that stand counts of alfalfa may be misleading in that loss of plants may be offset by greater stem production per plant. Increased root and crown size were also reported in thinned stands by Garver (2).

Under greenhouse conditions, Hueg (4) found that 11 plants per square foot (two pounds of seed per acre) yielded more than four plants per square foot (one pound of seed per acre); however, increasing plant densities to greater than 11 per square foot did not increase yields. Wakefield and Skaland (15) reported that larger plant size did not compensate for reduced number of alfalfa plants per unit area between 10- and 5-pound seeding rates (19 and 7 plants per square foot, respectively), but larger plant size did compensate between 20- and 10-pound rates (31 and 19 plants per square foot, respectively). Yields of alfalfa hay also increased with seeding rates up to about 10 pounds per acre (about 5 plants per square foot after the first harvest year), but yields failed to increase beyond that point, even though plant numbers increased, in a New York study (MacDonald, 9).

Ronningen and Hess (11) reported that alfalfa stand counts at four locations in Maryland were not significantly correlated with yields when counts were made after the second year of harvests, but stand counts were correlated with yields after the third harvest year at three of the four locations; stands ranged from about two to five plants per square foot, and yields ranged from less than one ton to two tons per acre. Gerwig and Ahlgren (3) also found a positive relationship between plants per square foot (range of one to 10) and yields (two to over five tons per acre) when 15 fertility treatments were applied to alfalfa in New Jersey; a correlation of $r = +0.92$ existed between plant counts and yields when data from three years were combined (correlation analysis performed by Mrs. May Wright at the University of Minnesota, with data taken from the published article).

Similarly, when data from the Wisconsin report of Klebesadel and Smith (6) were tested at the Minnesota Station, correlations as high as $r = +0.95$ occurred between alfalfa plants per square foot and yields per acre; highest correlations appeared where alfalfa yield differences within companion crop spraying treatments and years were greatest. Plant counts ranged from three to 18 per square foot, and single-cutting yields ranged from 0.3 to 2.7 tons dry matter per acre.

Eight alfalfa populations (ranging from 0.11 to 144 plants per square foot) were space planted in an English study (5). Yield reductions did not occur until plant numbers dropped to four per square foot (compared to 144) or to about two per square foot (compared to 36); original plant populations were reduced by over 50 percent by the end of three years for the initially-very high population (144), but only by less than 10 percent for initially-low populations (four or fewer plants). Willard (16) also reported poor correlations between alfalfa yields and stands ($r = +0.28$).

With very fertile soils, Marten et al. (10) found no reduction in yields the year after seeding of an alfalfa-brome mixture until stands were thinned to four or fewer alfalfa plants per square foot (compared to more than 12 per square foot). The second year after seeding, when the range of alfalfa plant densities had decreased to include a maximum of seven per square foot and a minimum of 0.1, no yield differences appeared.

Kramer and Davis (8) planted 30 varieties and strains of alfalfa in 5-row plots (30-foot rows) with rows spaced seven inches apart. To estimate

stand, each row was considered to consist of 6-inch units, and the number of blank units per plot was expressed as a percentage of the 300 total units. They found an apparent linear relationship between these estimates of stand and yield, with correlation coefficients of +0.88 and +0.80 during successive years following the year of seeding. The greater influence of stand on yield during the first year after seeding was attributed to the ability of alfalfa to "adapt" to thin stands thereafter.

A similar approach for estimating stands of alfalfa in a fertility study in Indiana was used by Stivers and Ohlrogge (14). They employed a 30-inch-square metal frame with wires every 6 inches to provide 25 squares; if one or more alfalfa plants were found in each 6-inch square, a perfect (100%) stand was assumed. Percentage stand was obtained by multiplying the number of vacant squares per frame by four and subtracting the product from 100. Their results supported those of Kramer and Davis (8), as the correlations between stand counts and single-cutting yields of +0.90, +0.73, +0.87, and +0.66 indicated that a good estimate of relative yield could be obtained from alfalfa stand data, where stand varied widely.

It may be concluded that frequently alfalfa stands estimated either by plants per unit area or percentage of an area that is covered are positively related to dry matter yields. However, under some circumstances, such as very fertile conditions, alfalfa plants adapt quickly to fill vacant spaces by producing extra stems and bigger crowns. The use of a percentage stand estimate appears to be superior to plant counts per unit area, as plant numbers in excess of those needed for efficient land coverage do not necessarily contribute to greater yield (8).

## Literature Cited

1. Cowett, E. R., and M. A. Sprague. 1962. Factors affecting tillering in alfalfa. Agron. J. 54:294-297.

2. Garver, S. 1922. Alfalfa root studies. USDA Bul. 1087.

3. Gerwig, J. L., and G. H. Ahlgren. 1958. The effect of different fertility levels on yield, persistence, and chemical composition of alfalfa. Agron. J. 50:291-294.

4. Hueg, W. F., Jr. 1959. The influence of seeding rates on botanical composition and yield of forage mixtures under two different cutting treatments. Ph.D. Thesis, Mich. State Univ.

5. Jarvis, R. H. 1962. Studies on lucerne and lucerne-grass leys. V. Plant population studies with lucerne. J. Agric. Sci. 59:281-286.

6. Klebesadel, L. J., and Dale Smith. 1958. The influence of oat stubble and management on the establishment of alfalfa and red clover. Agron. J. 50:680-683.

7. Knodt, C. B. 1966. Economics of handling systems of forage. Proc. 12th Annual Farm Seed Conference, Kansas City, Mo. Public. No. 12, Amer. Seed Trade Assoc., pp. 41-45.

8. Kramer, H. H., and R. L. Davis. 1949. The effect of stand and moisture content on computed yields of alfalfa. Agron. J. 41:470-473.

9. MacDonald, H. A. 1955. Simple seed mixtures are best. N. Y. Agr. Exper. Sta. Farm Research 21(1):7.

10. Marten, G. C., W. F. Wedin, and W. F. Hueg, Jr. 1963. Density of alfalfa plants as a criterion for estimating productivity of an alfalfa-brome-grass mixture on fertile soil. Agron. J. 55:343-344.

11. Ronningen, T. A., and A. G. Hess. 1955. Relationship between stand and yield in alfalfa variety comparisons. Agron. J. 47:92-93.

12. Rumbaugh, M. D. 1963. Effects of population density on some components of yield of alfalfa. Crop Sci. 5:423-424.

13. Salmon, S. C., C. O. Swanson, and C. W. McCampbell. 1925. Experiments relating to the time of cutting alfalfa. Kansas Agr. Exp. Sta. Tech. Bul. 15.

14. Stivers, R. K., and A. J. Ohlrogge. 1952. Influence of phosphorus and potassium fertilization of two soil types on alfalfa yield, stand, and content of these elements. Agron. J. 44:618-621.

15. Wakefield, R. C., and N. Skaland. 1965. Effects of seeding rate and chemical weed control on establishment and subsequent growth of alfalfa and birdsfoot trefoil. Agron. J. 57:547-550.

16. Willard, C. J. 1931. The correlation between stand and yield of alfalfa and sweetclover. J. Agric. Res. 43:461-464.

C. N. Hittle served as moderator for the presentation of papers on soil fertility as related to persistence and yield by J. A. Jackobs and O. J. Attoe.

## ALFALFA FERTILIZATION METHODS AND TIME OF APPLICATION

J. A. Jackobs
University of Illinois

The fertilization of perennial forage crops is complicated by the fact that the stands last several years and there is a constant removal of nutrients. If the levels of available nutrients in the soil becomes limiting during the life of the stand, it is generally assumed that they can be corrected by top-dressings of the appropriate fertilizers.

The efficiency of topdressings of P and K on alfalfa were studied in a 4-year trial with alfalfa at the Northeastern Illinois Agronomy Research Center, Elwood, Illinois. The results of this trial indicate:

1. Fertilizer incorporated into the seedbed is more efficient than topdressed fertilizer early in the life of the stand.

2. Topdressed fertilizer is available to the plant even under quite dry conditions.

3. A full response to a topdressing may not occur in the first cutting following the application but in subsequent cuttings the response is as large as to incorporated fertilizer.

4. Alfalfa responds to applications of K after the soil test falls below 150 (Bray test).

5. Soil samples should not be taken in early spring if a K deficiency is suspected.

## EFFECT OF LIMING AND FLOODING ON MANGANESE TOXICITY OF ALFALFA

O. J. Attoe
University of Wisconsin

Incubation and greenhouse studies showed that regardless of soil pH, flooding increased the content of exchangeable Mn and the Mn content of alfalfa grown in a Kellner loamy sand. In the absence of a source of easily decomposable organic matter, Mn mobilization by flooding was considerably slower at a soil pH of 4.7 than at 7.3. Where alfalfa was grown in the soil or where finely milled oat straw was added, flooding mobilized more Mn in the acid than in the neutral soils. Liming promoted immobilization of Mn on the resumption of normal soil moisture relations after flooding. Seventy-two hours of flooding increased the Mn content of the alfalfa on the unlimed soil from 426 ppm to more than 6,000 ppm. Excess Mn tended to accumulate in the leaves and growing points of the plants. The results suggest that the well-known susceptibility of alfalfa to Mn toxicity may also account for its sensitivity to poorly aerated soils.

K. L. Larson served as moderator for the presentation of papers on harvest schedules for quality herbage by Dale Smith and W. F. Wedin.

## CALENDAR VERSUS MATURITY HARVESTING 1/

Dale Smith
University of Wisconsin

Alfalfa is the most important forage used in the North Lake States. Minnesota, Wisconsin, Michigan, and New York harvest 27% (1964) of the U.S.

---

1/ See "Alfalfa cutting practices for quality and longevity", U.S.D.A., A.R.S. 74-36, pp. 10-17, 1966, for additional data and discussion of the subject.

acreage used for hay. The growing season is short in these states and the winters are severe. These environmental factors limit to some degree the latitude that can be taken to increase forage quality by harvesting at early growth stages.

A decade ago, most alfalfa varieties used by farmers lacked a high level winterhardiness and/or wilt resistance. To maintain persistent and productive stands, alfalfa was cut twice at near full bloom, once in late June and again in late August. The result was fairly persistent stands, but poor quality hay.

With the advent of sufficient seed of winter hardy and wilt resistant varieties, such as Ranger and Vernal, greater latitude in management became possible. Research soon showed that these persistent varieties could be cut earlier and frequently (2,3,4,5,6,8,9). A 3-cutting schedule based on calendar dates soon evolved (June 1, July 15, August 30). The dates were established by dividing the growing season prior to September 1 into 3 equal periods and on not cutting during the critical fall period. Data, as in Table 1, accumulated to show that this schedule gave higher yields of hay and quality constituents than the old 2 cuttings system, and as high or higher yields than other combinations of possible cutting dates.

Table 1. Yields from Vernal alfalfa harvested with various cutting schedules over a 3-year period, 1954-56, at Madison, Wisconsin.

| Cutting schedules | Hay | | Protein | | TDN 2/ | |
|---|---|---|---|---|---|---|
| | Tons/acre | % 2 cuts | Tons/acre | % 2 cuts | Tons/acre | % 2 cuts |
| 2 cuts-Late June, late Aug. | 4.44 | 100 | 0.75 | 100 | 2.47 | 100 |
| 3 cuts-Late April, late June, late Aug. | 3.81 | 86 | 0.66 | 88 | 2.11 | 85 |
| 3 cuts-Late June, late Aug., early Oct. | 4.70 | 106 | 0.86 | 114 | 2.67 | 108 |
| 3 cuts-Early June, mid-July, late Aug. | 5.32 | 120 | 1.10 | 146 | 3.24 | 131 |
| 4 cuts-Early June, mid-July, late Aug., early Oct. | 5.46 | 123 | 1.19 | 158 | 3.36 | 136 |

Adapted from Wisconsin Ag. Exp. Sta. Res. Reports 10 and 11, 1962.

1/ Top dressed each year to maintain high soil fertility and insects controlled by spraying.
2/ Percent ETDN used from 1956 stage of growth studies.

The question soon was raised as to whether the persistent varieties, such as Ranger and Vernal, could be cut more than 3 times before September 1. Data, as in Table 2, soon showed that increasing frequencies of cutting would give reduced yields of hay and quality constituents, would not allow the development of a good root system, and increased the danger of winterkilling. The later point was well-documented on many farms in Wisconsin during the open winters of 1964-65 and 1965-66.

Table 2. Yields from Vernal alfalfa harvested 3,4,5 or 6 times before September 4 over a 2-year period, 1956-57, at Madison, Wisconsin.

| Number of cuts | Cutting interval, 1/ days | Hay | | Protein | | Final plant size, 2/ grams |
|---|---|---|---|---|---|---|
| | | Tons/ acre | % of 3 cuts | Tons/ acre | % of 3 cuts | |
| 3 | 48 | 3.60 | 100 | 0.76 | 100 | 2.44 |
| 4 | 34 | 2.96 | 82 | 0.72 | 95 | 1.65 |
| 5 | 28 | 2.22 | 62 | 0.54 | 71 | 1.20 |
| 6 | 22 | 1.58 | 44 | 0.44 | 58 | 1.01 |

Adapted from Crop Sci. 1:267, 1961.

1/ First harvest made May 16, May 16, May 24, and May 31 for 6,5,4, and 3 cuttings, respectively, and the final harvest for all schedules was taken on September 4.

2/ Four inches of root plus 1 inch of crown.

The 3-cutting schedule based on the calendar, although it does not take into consideration the physiological stage of growth of the plants, was very useful in changing the farmer from the old 2-cutting system to one that emphasized earlier cutting to improve hay quality. It also assured that the first cutting (June 1) was taken early enough to allow 2 more cuttings before September 1. This was not an easy transition since farmers had been using the 2-cutting system for 30 years or more.

The 3-cutting schedule by date has not been entirely successful throughout Wisconsin, especially in the northern areas of the state. Cutting on June 1 in southern Wisconsin closely approximates the appearance of the first flowers, and the remaining 2 harvests are also taken in early bloom. In northern Wisconsin, the season is progressively shorter and the first cutting is harvested at progressively younger stages. Stands are weakened, and hay yields from 3 cuttings by date are much reduced as compared with 2 cuttings. The appearance of first flowers on the Vernal variety occurs about June 2 at Madison and June 4 at Arlington in the south but it does not occur until some 18 to 20 days later (about June 22) at Ashland in the north. It has been necessary, therefore, to draw a line across the state above which only 2-cuttings should be harvested. Such a line is at best only arbitrary.

A cutting schedule based on plant maturity, instead of the calendar, would allow plants to indicate the proper time to cut, and would take into

account variations in maturity due to varieties, years, and locations. It would allow the plants to determine how many cuttings are possible during a season. The appearance of the first flowers has been used in Wisconsin as the guide to stage of growth cutting. This stage of growth was selected for 2 reasons, (a) first flower closely approximates the 1/10 bloom stage when research indicates a near maximum yield of quality constituents is reached (1,10) and when food reserves in the roots have been restored to a reasonably high level (6), and (b) the first flower stage is a much more easily recognizable stage of growth than is 1/10 bloom.

A management trial at 3 stations from north to south in Wisconsin has clearly indicated the practicability of cutting whenever first flowers occur (up to September 1) as compared with 3 cuttings by date (7). Yields from the two schedules were similar in southern Wisconsin, but yields were progressively in favor of first flower cutting as the schedules were used further north (Table 3). Thus, cutting at first flower has proved to be the most practical schedule over all conditions because it takes into consideration the progressively later maturity of the first crop from south to north. It also necessitates no line of demarcation below which 3 cuttings are suitable and above which they are not. The alfalfa itself is the indicator of the proper time to cut. Over varieties and years, 3 to 4 cuttings at first flower are possible before September 1 in southern Wisconsin, while only 2 to 3 are possible in the north.

Table 3. Yields in tons per acre from Vernal and DuPuits alfalfa cut by date 3 times and by first flower over a 2-year period, 1963-64, at 3 locations south to north in Wisconsin.

| Schedule[1] | Variety | Arlington | | Marshfield[2] | | Ashland[2] | |
|---|---|---|---|---|---|---|---|
| | | Hay | TDN | Hay | TDN | Hay | TDN |
| Date | Vernal | 4.69 | 2.85 | 3.63 | 2.40 | 2.44 | 1.57 |
| | DuPuits | 4.29 | 2.61 | 3.57 | 2.28 | 2.86 | 1.78 |
| | Avg. | 4.49 | 2.73 | 3.60 | 2.34 | 2.65 | 1.67 |
| Flower | Vernal | 4.31 | 2.71 | 4.09 | 2.68 | 3.02 | 1.78 |
| | DuPuits | 4.16 | 2.67 | 3.49 | 2.23 | 3.26 | 1.92 |
| | Avg. | 4.23 | 2.69 | 3.79 | 2.45 | 3.14 | 1.85 |
| LSD, 5% | | 0.15 | -- | 0.16 | -- | 0.11 | -- |

Adapted from Wisconsin Agr. Exp. Sta. Res. Report 23, 1966.

1/ Date schedule was June 1, July 15, August 30. Maturity schedule was cut whenever first flowers appeared to September 1 which gave 3 to 4 harvests at Arlington, 3 at Marshfield, and 2 to 3 at Ashland.

2/ Marshfield is about 100 miles north of Arlington, and Ashland is about 140 miles north of Marshfield.

## Literature Cited


1. Baumgardt, B. R., and Dale Smith. Changes in the estimated nutritive value of the herbage of alfalfa, medium red clover, ladino clover, and bromegrass due to stage of maturity and year. Wisconsin Agr. Exp. Sta. Res. Report 10. 1962.

2. Chance, C. M., W. L. Griffeth, C. W. Loomis, A. A. Johnson, and C. S. Winkelblech. Forages: production, harvesting, utilization. New York Agr. Exp. Sta., Cornell. Misc. Bul. 39, pp. 14-15. 1961.

3. Gross, H. D., C. P. Wilsie, and J. Pesek. Some responses of alfalfa to fertilization and cutting treatments. Agron. J. 50:161-164. 1958.

4. Kust, C. A., and Dale Smith. Influence of harvest management on the level of carbohydrate reserves, longevity of stands, and yields of hay and protein from Vernal alfalfa. Crop Sci. 1:267-269. 1961.

5. Smith, Dale. The establishment and management of alfalfa. Wisconsin Agr. Exp. Sta. Bul. 542. 1960.

6. Smith, Dale. Alfalfa cutting practices. I. Influence of cutting schedule, soil fertility, and insect control on yield and persistence of Vernal and Narragansett alfalfa. Wisconsin Agr. Exp. Sta. Res. Report 11:1-11. 1962.

7. Smith, Dale. The performance of Vernal and DuPuits alfalfa harvested at first flower or three times by date. Wisconsin Agr. Exp. Sta. Res. Report 23. 1966.

8. Smith, Dale, M. D. Groskopp, R. F. Johannes, D. R. Schmidt, A. M. Strommen, and G. H. Tenpas. Alfalfa cutting practices. II. Yields of Vernal with 2 and 3 cuttings at 6 locations in Wisconsin. Wisconsin Agr. Exp. Sta. Res. Report 11:12-16. 1962.

9. Twamley, B. E. Variety, fertilizer, management interactions in alfalfa. Can. J. Plant Sci. 40:130-138. 1960.

10. Van Riper, G. E., and Dale Smith. Changes in the chemical composition of alfalfa, medium red clover, ladino clover, and bromegrass with advance in maturity. Wisconsin Agr. Exp. Sta. Res. Report 4. 1959.


## INTERSTATE ALFALFA MANAGEMENT STUDY


W. F. Wedin
Iowa State University


A cooperative study was conducted in Wisconsin (Dale Smith), Missouri (A. G. Matches), Minnesota (G. C. Marten) and Iowa (W. F. Wedin) on alfalfa established in 1962, harvested in 1963 and 1964, with a residual harvest in 1965.

Early (DuPuits) and late-maturing (Vernal) alfalfas were harvested under three management systems (2, 3, 4 cuttings) by flower stage or calendar date as criteria for setting harvest dates. Thus, plots scheduled for harvesting by calendar date were handled similarly at all locations whereas the plots harvested by flowering stage varied with location.

Field and laboratory data were obtained in a uniform manner at each location. Plant samples were analyzed at Missouri for both inorganic and organic components, at Wisconsin for cellulose and in vitro digestible dry matter (DDM), while statistical computations were carried out at Iowa.

To date analysis on yields of dry matter, crude protein and DDM have been completed. These results indicate that distinct differences in yields as affected by experimental variables occur between stations, necessitating the local interpretation of data from studies conducted in the appropriate geographic area.

Data from the cooperative study will be published and will contribute to a clearer understanding of alfalfa managements and need for studies thereon in the four states. Benefits of cooperative studies are also evident from this venture and general guidelines for others using this approach are suggested.

M. D. Rumbaugh served as moderator for the presentation of papers on breeding for herbage quality by F. C. Elliott and C. P. Wilsie.

## BREEDING FOR QUALITY CONSTITUENTS

F. C. Elliott
Michigan State University

Our breeding for quality in alfalfa has been confined primarily to the development of bioassays applicable to single spaced plants. We have proceeded in an empirical way to assay single plants in populations, to cross selected individuals and to recycle these combinations screening off in a preliminary way only a relatively few plants with the most extreme responses in each cycle of selection. Since the crop may be used in different ways and by consuming entities with very different types of digestive systems we have tried to find bioassays that might be indicative of or correlative with responses in efficiency of utilization in widely differing systems. Our preliminary efforts have convinced us, too, that tetraploid alfalfas contain a number of antimetabolic systems which are present in varying levels and which interact in numerous ways. At the same time varying levels of positive responding elements are interacting with the negative components in eliciting a growth response in a bioassay. These complications have convinced us that a number of bioassays as unrelated as possible would be advantageous in the screening of single plants. To date we have employed chick tests, a vole weanling growth test, 6 hr. in vitro rumen fermentation tests of dry matter disappearance, and most recently a Trichoderma assay of crude saponins. The responses in the three latter assays appear to be unrelated or poorly correlated. The Trichoderma assay will be enlarged upon slightly later since our test is a major modification of that proposed by USDA workers at Utah.

Individually and collectively these preliminary bioassays are only screening tests to isolate unusually high or low responses in populations. This selection and recycling of high and low combinations may separate populations into groups with distinctly different heritable patterns for nutritional composition later. The preliminary bioassays are made on small amounts of material with little or no replication. The interactions between and among negative and positive components may be difficult to evaluate, and the conservative features of phenotypic buffering in a tetraploid cross-fertilizing genetic system contribute to restriction in the range of responses that any bioassay or group of bioassays can elicit. We regard as premature and unwarranted any attempts to consider these preliminary bioassays precise nutritional tests, or to correlate bioassay values with in vivo responses such as intake, digestibility, or preference in large animals until more differentiated populations of material are available and the bases for responses in the individual assays are better understood.

It would be desirable if biological values might be assigned forage materials similar to those employed in human nutrition. Although this would require extension and elaboration of more precise bioassays there is a definite need for this work as the science of human and animal nutrition come closer together. There may well be demand for processed forage leaf proteins for both human and animal diets in the near future should improvement in quality and palatability prove significant. We might, conceivably, be developing alfalfa varieties from which dehydrated leaf meals may be extracted for human consumption at the same time stem fractions of the same varieties may be utilized in ruminant diets along with other inexpensive protein and energy sources. For this reason bioassays indicative of ruminant animal response to whole plant meals may in the long run prove to be neither so discriminating nor important as bioassays reflecting limiting aspects of quality to monogastric systems. In our high DMD synthetics we are hoping for higher efficiency in ruminant utilization through faster release of nutrition and movement through the digestive tract. More rapid digestion may facilitate increased intake provided palatability is high.

Some changes in our techniques and materials involved in the individual bioassays may be worth listing here. In the vole weanling growth test we are anxious to know more about the nature of the caecal microflora inoculation of the weanlings, and the components of the flora itself. There is a need for information on vole nutritional requirements and limitations. This colony is now more uniform and domesticated than previously and litter size as well as weanling growth rates make them interesting animals for bioassays. There is a need for work on the development of tests for determining biological values of forage materials using young voles or similar animals adapted to low protein-high fiber diets. The facilities and care required to maintain a reproducing colony are considerable, however, and we could not under present arrangements attempt to screen large numbers of plants. Specific growth rates from preliminary screening tests are not well correlated with dry matter disappearance in 6 hr. in vitro rumen fermentation tests or with growth inhibition in the Trichoderma assay.

The 6 hr. in vitro fermentation test has proven suitable to larger numbers of assays than the vole weanling test and dry matter disappearance obtained in alfalfa clones has ranged from 26% to 56% with a relatively small

error term (S.D. 3.0%). Dr. Allinson's work with our spaced plants indicates that the lignin and fiber fractions are important in dry matter disappearance. The first opportunity to test large animal responses to high dry matter disappearing synthetics will come this season at least to the limit of the materials. A few clones assayed from different cuttings and seasons appear more stable than others in producing forage high or low in dry matter disappearance.

Recently we have been working on a modified assay for the levels of saponins in individual plants of alfalfa. The glycosides have deleterious effects physiologically in a number of systems. The strain of Trichoderma used in our assay was received from USDA workers in Utah and is sensitive to saponin levels.

Dr. Scardavi, a post-doctoral pharmaceutical botanist from the University of Pavia, Italy, has been responsible for the major modifications in the Trichoderma assay for us and the outstanding features of this modified assay are as follows:

1. Both mycelial growth and sporulation are considered while the original assay involved only mycelial growth and colony diameter.

2. Liquid PDA media in flask culture is utilized whereas surface phenomena on solid PDA media in Petri dishes was employed originally.

3. Inoculated cultures are grown 5 days and the mycelial growth and sporulation are scored over 5 concentrations of crude saponin extracted from single plants.

4. The crude saponin extracts are not autoclaved in our tests since autoclaving was shown to affect growth inhibition.

5. A commercial saponin source (NBC Reagent Saponin) is used as a standard in our assay in which the average % inhibition is 48% over the same concentrations used for the crude saponin extracts from the single plants. Average % inhibition for the crude saponins extracted from individual alfalfa plants ranged from 36% to 53% in the plants examined so far with only a small error term.

In summary we can say that we have found a few plants at the tetraploid level with reasonably good responses in all three bioassays. We have doubled some diploid falcatas with fair responses but we have not yet looked at diploid materials in sufficient numbers. It may well be that diploid sativa materials would be worthy of considerable concentration to determine if simpler genetic bases for quality factors might be found and put together into combinations at both the diploid and tetraploid levels through doubling.

Our main concern momentarily is the amount and nature of antibioses required for the alfalfa weevil and for the other insects and diseases common to our area. We expect to bioassay a number of weevil resistant materials for the Beltsville USDA group within the month and some helpful clues may be forthcoming from these tests. Unless and until the threat from the alfalfa weevil appears under control through breeding or management we are not optimistic for the future of our programs with alfalfa breeding for quality.

# BREEDING ALFALFA FOR MATURITY DIFFERENCES

C. P. Wilsie
Iowa State University

Differences in time of flowering of alfalfa, both within and among varieties, have been observed by most alfalfa workers, but little information is available on the genetics of flowering time or on the relationship between time of flowering and other agronomic characteristics.

Observations in Australia by Daday (4) have shown a range of 17 days in time of first flowers among 10 varieties grown at one location. In France, Demarly and Genier (5) observed a difference of 21 days in time of flowering among inbred lines ($S_4$ to $S_7$) and from 15 to 18 days among simple hybrids made from these inbreds. In Iowa (1), we have noted differences of 11 days in average date of first flowers among progenies of paired crosses of randomly selected clones from the Vernal variety. Miller and Schonhorst, in Arizona (7) found an extreme range of 60 days in time of first flowers in certain $S_2$ populations.

The wide range in time of flowering is conditioned by the genetic make-up of individuals and populations as determined by their evolutionary history in response to the environment, influenced especially by day length, light intensity, temperature, moisture and the various interactions involved.

Natural selection has resulted in a wide range of ecotypes (both wild and cultivated) differing in time of flowering as well as in other characteristics. Even within recent decades, evidence of natural selection has been observed by Daday (4). In South Australia, the common variety, Hunter River, has developed a local strain called Australian Dry Land which flowers 7 days earlier than the parent Hunter River variety.

Inbreeding, without any selection, may result in later flowering as shown by Aycock (1) in Table 1. Possibly this is simply a consequence of reduced vigor.

Table 1. Time of flowering of alfalfa of various levels of inbreeding (without selection).

| Generation | Origins of progeny | Days to flowering, after cutting | Inbreeding coefficient |
|---|---|---|---|
| $S_o$ | Non-inbred | 28.7 | 0.000 |
| $S_1$ | $S_o$ selfed | 32.6 | 0.167 |
| $S_2$ | $S_1$ selfed | 37.9 | 0.306 |
| $F_1$ | $S_o \times S_o$ | 28.3 | 0.000 |
| $FS_1$ | Full-sib cross | 32.2 | 0.083 |
| $F_2$ | $F_1$ selfed | 32.5 | 0.167 |

If selection is practiced during inbreeding a shift in time of flowering in either direction may occur (5). Table 2 shows data on time of flowering of 10 parent clones and their inbred progenies.

Table 2. Time of flowering of parent clones and derived inbred lines. (Data by Demarly and Genier).

| Parent Clone | | Inbred Line | |
|---|---|---|---|
| Identification | Flowering date 1/ | Generation | Precocity of inbred relative to parent (days) |
| 46 | May 19 | $I_6$ | -4 |
| 56 | May 19 | $I_6$ | -7 |
| 84 | May 17 | $I_5$ | -5 |
| 87 | May 19 | $I_4$ | +1 |
| 93 | May 19 | $I_4$ | -3 |
| 49 | May 7 | $I_7$ | +3 |
| 67 | May 7 | $I_5$ | -7 |
| 59 | May 7 | $I_6$ | +2 |
| 72 | May 6 | $I_5$ | -2 |
| 111 | May 5 | $I_4$ | +1 |

1/ Flowering date of DuPuits was May 10.

The time of flowering of alfalfa is heritable. Estimates of broad-sense heritability of 0.91 were obtained by Aycock (1) and of 0.85 were obtained by Daday (4).

Genetically, time of flowering appears to behave as a quantitative character. It is likely that several, or many, genes are involved. Unpublished data by Demarly and Genier (5) including crosses of Late X Late, Late X Early, and Early X Early, indicate that $F_1$ progenies tend to show mean dates of first flowers similar to or slightly earlier than midparent value. $F_2$ data are not available.

Daday (4) has provided data from a diallel cross analysis of 10 varieties differing in time of flowering. The $F_1$ generation showed considerable transgressive segregation in both directions. Average dates of flowering of parents and $F_1$ progenies are given in Table 3. $F_1$ progenies are classified relative to parental and midparent values.

Table 3. Frequency distribution of average first flowering dates of $F_1$ progenies from diallel crosses of 10 varieties. (Data by Daday)

| Parents | | Mean First Flowering Date of $F_1$ Progenies | | | | |
|---|---|---|---|---|---|---|
| Variety | Days to flower | Earlier than both parents | Compared with Midparent: Earlier | Same | Later | Later than both parents |
| Australian Dry Land | 19.1 | 1 | 4 | - | 3 | 1 |
| Afghan | 21.1 | 2 | 4 | 3 | - | - |
| Provence | 22.4 | 1 | 1 | 3 | 2 | 2 |
| Ladak | 23.8 | 1 | - | 2 | 2 | 4 |
| Old Franconian | 23.9 | 3 | 4 | 1 | - | 1 |
| Spanish | 25.0 | 1 | 6 | - | - | 2 |
| Hunter River | 26.4 | 2 | 4 | - | 3 | - |
| Rambler | 30.7 | 1 | 3 | 2 | 1 | 2 |
| Hairy Peruvian | 31.2 | 3 | 4 | - | 2 | - |
| *M. falcata* | 36.4 | 3 | 4 | 1 | 1 | - |

Of the 45 crosses studied, 26 produced $F_1$ progenies that were earlier than the midparent value, 6 approximately the same, and 13 that were later than the midparent value. Daday's analysis of general combining ability suggested that Afghan, Australian Dry Land, Spanish and Old Franconian contributed to earliness in their crosses while Ladak contributed to lateness in its crosses.

From data available it appears that selection for either earliness or lateness of flowering should prove effective. It is likely that among the genes conditioning flowering time some may show dominance for earliness and some for lateness.

In certain wild species, Layia platyglossa and Madia elegans, Clausen and Heisey (3) have shown that date of flowering is regulated by genes of opposing effects. In Layia, there may be three pairs of genes that promote earliness which are epistatic to one that promotes lateness. In Madia, one dominant gene for earliness is epistatic over a series of dominant genes for lateness. A similar situation may be present in alfalfa, with the overall greater likelihood of dominance for early flowering.

What range of maturity is desired?

Someone may advance the argument that early flowering is undesirable and that better quality of forage may be obtained if flowering were late, sparse or absent. However, there are arguments on the other side. Burton (2) noted in 1937 that in segregating progenies of late X late crosses high yielding plants tended to bloom early.

Data in Iowa (1) suggest that early flowering is associated with high yields of forage ($r = 0.59^{**}$), tall growth ($r = 0.72^{**}$), and seed production ($r = 0.67^{**}$). In Denmark, Nielsen and Mortensen (6) found that earliness was correlated with vigor and forage yield.

Common experience tells us that Flemish varieties tend to be earlier in flowering than most American varieties. However, seasonal variation in flowering date, caused by differences in temperature and possibly by moisture, may narrow the usual spread of 5 to 7 days difference between DuPuits and Vernal to 2 or 3 days or less.

Perhaps we need varieties that differ in time of flowering to a greater extent than are now available. If growers with large acreages are to take advantage of varieties of different maturities, in order to maintain a harvesting schedule that will give them high quality forage throughout the season, a spread in flowering dates of 7 to 10 days, or possibly 2 weeks, might be desirable. It appears to be within the control of the alfalfa breeder to provide such varieties in the future.

## References

1. Aycock, M. K., Jr. 1966. Inbreeding alfalfa, Medicago sativa L., by sibmating. Ph.D. Thesis, Library, Iowa State University, Ames, Iowa.

2. Burton, Glenn W. 1937. Alfalfa inheritance studies in New Jersey. Jour. Amer. Soc. Agron. 29:600-606.

3. Clausen, Jens and Wm. Heisey. 1958. Experimental studies on the nature of species. IV. Genetic structure of ecological races. Carnegie Inst. Wash. Publ. 615, Washington, D. C.

4. Daday, H. 1966. Personal communication.

5. Demarly, Y. and G. Genier. 1966. Personal communication.

6. Nielsen, H. M. and Gotfred Mortensen. 1963. Interrelations among various characters in lucerne (Medicago sativa L.). Royal Vet. and Agr. Col., Yearbook, pp. 97-118.

7. Schonhorst, M. H. Personal communication.

The session was adjourned at 12:05 p.m. and reconvened at 1:35 p.m.

E. L. Sorenson served as moderator for the presentation of papers on breeding for herbage quality by W. R. Kehr and F. Frosheiser.

## BREEDING ALFALFA WITH COMBINED RESISTANCE TO INSECTS AND DISEASES

W. R. Kehr, S. D. Kindler, J. M. Schalk, and R. L. Ogden.
Research Agronomist, Crops Research Division, ARS, USDA, and Professor, Agronomy Department; Entomologists, Entomology Research Division, ARS, USDA, and Instructors, Entomology Department; Assistant Professor, Department of Biochemistry and Nutrition; University of Nebraska.

Resistance to insects and diseases is a significant part of yield and quality, as shown in previous publications. Any insect or disease that causes defoliation potentially influences quality and yield. We have levels of resistance in many present alfalfa varieties that are taken for granted or not fully appreciated. The most practical control of diseases and insects is the development and use of resistant varieties. Insects and diseases may prevent or limit the establishment, persistence, and production of alfalfa. Both forage and seed production may be affected. Insects and diseases may influence forage quality including protein, carotene, vitamin, and mineral contents. Quality factors influence feed efficiency of animal rations. Resistance factors built into varieties insure yield, quality, persistence, and production. Everyone is insurance-conscious. Just talk with the man who lost production or quality due to insects or diseases. A seed trade advantage results from advertising a variety with insect and disease resistance. Obviously, in the absence of economic levels of injurious insects and diseases, varieties resistant to both insects and diseases may not show superiority over contrasting susceptible varieties. Insect- and disease-resistant varieties should at least equal susceptible varieties in yield, quality, persistence, and production in the absence of economic damage from insects and diseases.

Screening procedures are used which maximize damage in the shortest time interval at the most susceptible stage of growth. Potato leafhopper resistant populations are grown in greenhouse benches or boxes and infested with pea

aphids when the plants are in the dicot stage or have only the first true leaves. Plants with apparent pea aphid resistance are free of stunting. A plastic stake is placed next to the seedlings. The greenhouse is then fumigated, plants are cut back to about one inch high, and infested with spotted aphids when regrowth is about 2 inches high. Plants with apparent resistance to both species of aphids are potted in clay pots. When these plants are eight inches or more in height, caged stem tests are conducted. One stem from each plant is used for each aphid species. Tests for the two aphids are made at the same time. Only plants with the ability to cause death of both aphid species, or which prevent or reduce aphid reproduction, are held for leafhopper and other tests in the field. These plants are vegetatively propagated. Rooted cuttings are transplanted in two clonal nurseries: in one nursery hopper reaction is observed and in another seed is produced for progeny tests. Spotted aphid progeny tests are conducted in greenhouse benches or flats. Pea aphid progeny tests are also conducted in greenhouse benches or flats but final evaluation is in field cages. Leafhopper progeny tests are conducted in the field. The clonal nursery for seed production is also used to evaluate reaction to naturally occurring leaf and stem diseases, persistence, vegetative vigor, rate of recovery, etc. The forage yield potential of selected clones is evaluated in replicated progeny field tests using open-pollinated or polycross seed. Data also are obtained on persistence and reaction to naturally occurring disease epidemics and insect infestations. The bacterial wilt reaction of clones with combined resistance to three insects is determined by progeny tests in the greenhouse. The root-ball-soak method is used. Plants whose progeny showed resistance to spotted aphid, pea aphid, potato leafhopper, wilt and leaf spot diseases, and satisfactory forage yield, persistence, vigor, and rate of recovery are used to produce synthetic varieties. Experimental varieties are tested in as many locations as seed availability permits. Field tests are used to measure forage and seed yields, quality, persistence, reaction to insects and diseases, vigor, and rate of recovery. Experimentals are also tested for insect and disease reaction under controlled greenhouse and field conditions. New information from testing experimental varieties supports previously published information that resistance to insects and diseases contributes to increased carotene and protein contents.

## BREEDING FOR DISEASE RESISTANCE

F. I. Frosheiser
University of Minnesota

Reaction to diseases is directly or indirectly related to herbage quality in alfalfa (Medicago sativa L.).

Quantitative information on the reduction of nutritive value by disease is limited. Brigham (1) analyzed Cercospora-infected alfalfa leaflets and found that crude protein was reduced from 33% in healthy leaflets to 18% when half the leaf area was diseased. Ether extract was reduced from 4 to 2.5%, ash increased from 10 to 16%, crude fiber increased from 8.5 to nearly 10%, and nitrogen-free-extract increased from 45 to 53% when one-fourth of the leaf surface was diseased.

---

1. Brigham, R. D. 1959. Effect of Cercospora disease on forage quality of alfalfa. Agron. J. 51:365.

Coumestrol accumulated in alfalfa forage when infected with spring blackstem (Phoma herbarum West. var. medicaginis Fckl.), common leafspot (Pseudopeziza medicaginis (Lib.) Sacc.), Leptosphaerulina leafspot (Leptosphaerulina briosiana (Poll.) Graham and Luttrell) or Stemphylium leafspot (Stemphylium botryosum Wallr.) (2). Alfalfa mosaic virus infection also increased coumestrol content. Very little coumestrol was found in disease-free forage.

Foliar diseases cause considerable leaf drop, decreasing the leaf to stem ratio and thus reduce the palatability and nutritive value of the forage.

Much progress has been made in breeding for disease resistance, particularly to bacterial wilt. Resistance to foliar diseases has been improved, but a much higher degree of resistance is needed. I will briefly discuss the important diseases and methods for testing for resistance.

## Common leafspot (Pseudopeziza medicaginis (Lib.) Sacc.)

This is one of the destructive foliar diseases. It causes distinct necrotic lesions, which may be up to 1.5 mm in diameter, on leaflets. Margins of lesions are finely denticulate. A raised disc (apothecium) is usually present in the center of the lesion. Symptoms are usually found only on older leaves because it takes about two weeks for symptoms to develop.

Resistant plants may be symptomless or have relatively small, nonsporulating lesions. Leaflets tend to remain green. Susceptible plants have larger lesions with fruiting structures (apothecia). As the disease develops, the leaves become chlorotic and drop.

Reaction to the disease can best be evaluated in the field during the year of seeding or transplanting. When epiphytotics of common leafspot occur during the first year, the symptoms are usually free from symptoms of other diseases.

Results obtained from artificial inoculation and incubation in the greenhouse are comparable to natural infections. Cultures of the organism can be grown on oat agar and suspended over the plants in a moist chamber at about 21 C for 24 hours to produce the disease. Infected leaves with sporulating lesions can also be used, although there is danger of obtaining a mixture of diseases. When the plants are incubated at 21 - 24 C, the symptoms will appear in about two weeks.

## Spring blackstem (Phoma herbarum West. var. medicaginis Fckl.) (Ascoshyta imperfecta Pk.)

Resistance to spring blackstem is not clear cut as in common leaf spot. The more resistant plants appear to have fewer and smaller lesions and their

---

2. Hanson, C. H., G. M. Loper, G. O. Kohler, E. M. Bickhoff, K. W. Taylor, W. R. Kehr, E. H. Stanford, J. W. Dudley, M. W. Pederson, E. L. Sorensen, H. L. Carnahan, and C. P. Wilsie. 1965. Variation in coumestrol content of alfalfa as related to location, variety, cutting, year, stage of growth, and disease. Tech. Bul. 1333. Agr. Res. Ser. USDA.

leaves remain green longer. Clones that appear quite free of the disease in the field usually can be severely infected by artificial infection in the greenhouse.

Symptoms on leaves and stems are variable and may sometimes be confused with other diseases. Leaf lesions are usually irregular and dark. Stem lesions range from brown to black and may cover a considerable portion of the stems. Young shoots are killed under favorable disease conditions. Most of the damage results from defoliation. The disease is most severe in spring or fall.

Alfalfa plants are easily infected by artificial methods. Spore or mixed spore and mycelial suspensions are sprayed on the plants, which must be kept moist for 48 hours. Infected plants should be incubated at 20 - 24 C. Disease readings can be made in 8 - 10 days.

The spore concentration of the inoculum must be controlled to obtain reaction differences between resistant and susceptible plants. If the spore load is too heavy, "resistant" types which we have tested became as severely infected as susceptible types.

Leptosphaerulina leaf spot. (Leptosphaerulina briosiana (Poll.) Graham and Luttrell) (Pseudoplea briosiana)

This leaf spot has been very destructive on alfalfa. It attacks young tissue, and since only a few days are required for disease development, young growth is often severely damaged. Symptoms are distinct. Young leaf lesions have a tan center surrounded with a chlorotic halo. Older lesions have a brown border surrounding the tan center. Severely infected leaves die but remain attached to the stem for some time. Young growth following clipping is usually most severely affected.

Although the disease has been studied quite intensively, we do not know yet if artificial infections can be correlated with natural field infections.

Based on results of greenhouse studies, it appears that most, if not all plants, become readily infected, but in resistant plants the diseased spots remain small and the leaflets remain green much longer than in susceptible plants.

Infection may be accomplished by growing cultures in liquid media and spraying the suspension on the plants. In another and more natural method, the cultures are grown on solid media and when sporulating are suspended over the plants in a moist chamber. A 48-hour period in the moist chamber at 20 - 24 C is required for optimum infection.

After removal from the moist chamber, the plants must be exposed to sufficient light, probably a minimum of 1000 fc., for typical symptom development. The minimum light intensity or duration has not been established. Sixteen hours of high light per day has been adequate in our studies.

Cercospora leaf spot or summer blackstem. (Cercospora zebrina Pass.) (C. medicaginis Ell and Ev.)

Cercospora disease is usually more prevalent in warmer areas. In recent years, however, we have been seeing more and more diseases as far north as St. Paul.

Cercospora causes large brown to black leaf lesions of 3-4 mm diameter. During wet periods, they may have a grayish cast due to sporulation in the lesion. The spores can be seen with the aid of a hand lens. This is often an identifying characteristic. Stem blackening often accompanies leaf lesions.

Inoculation is accomplished by spraying alfalfa plants with spore or mycelial suspensions or suspending diseased plant material over the plants in a moist chamber. A 72-hour period in the moist chamber is recommended.

Producing sufficient spores in culture is often a problem. Flooding V-8 juice agar with 1 ml of spore or mycelial suspension and incubating at 25 C usually gives good results.

Bacterial leaf spot (Xanthomonas alfalfae (Ricker, Jones and Davis) Daws.)

The disease is very important in some areas, causing leaf and stem symptoms accompanied by defoliation. It may cause stand failure by post emergent damping off.

The bacteria may be grown in potato-dextrose broth and the diluted suspension sprayed on the plants for foliar infection. For seedling blight tests, the bacterial suspension is sprinkled on the soil at planting time and the flats kept in a moist atmosphere for 8 days. This may be a promising method of screening for resistance.

Bacterial Wilt (Corynebacterium insidiosum (McCull.) H. L. Jens.)

More progress has been made in breeding for resistance to bacterial wilt than any other alfalfa disease in U. S.

The most common method for testing for bacterial wilt reaction in alfalfa is the root-soak method. Eight-week-old seedlings or well developed cuttings are inoculated by soaking the roots in a bacterial suspension for 30 minutes, then transplanting them into the field.

The material is evaluated 3-5 months later by examining the roots for internal disease symptoms. Yellow to brown discoloration is present under the bark if the plants are infected. The degree of discoloration determines the severity of the disease. Some workers use the root-ball-soak method, described by Cormack, in the greenhouse.

In a cotyledon inoculation method described by Kreitlow, clipped cotyledons of 7-9 day-old seedlings are sprayed with a bacterial suspension. The plants are evaluated in the usual manner in 60-90 days. If selected plants are to be saved for transplanting, 90 days may be preferable. This method is not as accurate as the root-soak method, but may be desirable for preliminary screening of large populations to eliminate most of the susceptibles in situations where facilities for field testing are inadequate and greenhouse facilities are available. The period from planting the seed to final evaluation is only slightly longer than the time required to grow alfalfa seedlings preparatory to inoculation by the root-soak method. Inoculum prepared from frozen, infected roots has been superior to laboratory cultures.

## Alfalfa mosaic virus

Alfalfa mosaic virus (AMV) is prevalent in most of the alfalfa stands in our area. It may be transmitted by seed, and this undoubtedly accounts for most of the original infections in a field. The virus is easily transmitted by the conventional method of rubbing carborundum-dusted leaves of susceptible plants with infective plant juice.

AMV comprises a complex of many strains or isolates. Most strains do not produce visible symptoms in alfalfa plants except under favorable conditions. Symptoms are most apparent in the field in the spring or on lush growth in the fall.

The presence of AMV in alfalfa plants can be detected by rubbing the plant sap of the suspected plants on primary leaves of Bountiful bean (Phaseolus vulgaris L.) that have been dusted with carborundum. Some other bean varieties are also used as indicators. When the virus is present in the plant sap, necrotic spots appear on the inoculated leaves. The lesions vary in size from minute spots or rings to 4 mm in diameter. The very small spots or rings are often associated with systemic infection of the bean plant, while in the large spots the virus is usually localized in the lesion.

Reservoirs of AMV may build up in our alfalfa breeding and testing nurseries, especially when they remain in the same general area and aphids are not controlled. If a clone remains free of AMV after growing in such an area for several years, it most likely has some resistance to AMV.

## SELECTED REFERENCES CONTAINING INFORMATION ON INFECTING ALFALFA AND SELECTING FOR RESISTANCE TO CERTAIN DISEASES

### Spring Blackstem (Phoma herbarum var. medicaginis) (Ascochyta imperfecta)

Renfro, B. L. and R. D. Wilcoxson. 1963. Storage and production of inoculum of Phoma herbarum var. medicaginis. Pl. Dis. Reptr. 47:168-169. (Minnesota).

Renfro, B. L. and R. D. Wilcoxson. 1963. Spring blackstem of alfalfa in relation to temperature, moisture, wounding, and some observations on pathogen dissemination. Phytopathology 53:1340-1345. (Minnesota).

Edmunds, L. K. and E. W. Hanson. 1960. Host range pathogenicity and taxonomy of Ascochyta imperfecta. Phytopathology 50:105-108. (Wisconsin).

McDonald, W. C. 1961. Note on method of producing and storing inoculum of the alfalfa blackstem fungus, Ascochyta imperfecta Pk. Can. J. Pl. Sci. 41: 447-448. (Can. Dept. Agri. Winnipeg).

Ward, C. H. 1959. The detached leaf technique for testing alfalfa clones for resistance to blackstem. Phytopathology 49:690-696. (Cornell).

Banttari, E. E. and R. D. Wilcoxson. 1964. Relation of nutrients in inoculum and inoculum concentration to severity of Spring blackstem of alfalfa. Phytopathology 54:1048-1052. (Minnesota).

Cercospora Leaf Spot-Summer blackstem of alfalfa
(Cercospora zebrina)

Baxter, J. W. 1956. Cercospora blackstem of alfalfa. Phytopathology 46: 398-400. (Iowa).

Berger, R. D. and E. W. Hanson. 1963. Pathogenicity, host-parasite relationships, and morphology of some forage legume Cercospora and factors related to disease development. Phytopathology 53:500-508. (Wisconsin).

Berger, R. D. and E. W. Hanson. 1963. Relation of environmental factors to growth and sporulation of Cercospora zebrina. Phytopathology 53:286-294. (Wisconsin).

Common Leaf Spot (Pseudopeziza medicaginis)

Frosheiser, F. I. 1960. A method for screening alfalfa plants for resistance to Pseudopeziza medicaginis. Phytopathology 50:568. (Minnesota).

Davis, R. L. 1951. A study of the inheritance of resistance to common leafspot. Agron. J. 43:331-337. (Purdue).

Adams, M. W. and G. Semeniuk. 1958. The heritability of reaction in alfalfa to common leaf spot. Agron. J. 50:677-679. (South Dakota).

Carnahan, H. L., J. H. Graham, and R. C. Newton. 1962. Quantitative analysis of inheritance of resistance to common leafspot in alfalfa. Crop Sci. 2:237-240. (Pennsylvania, pasture Lab).

Leptosphaerulina leaf spot (Leptosphaerulina briosiana)
(Pseudoplea briosiana) (Pseudoplea trifolii)

Sundhein, Leif. 1965. Leptosphaerulina briosiana on alfalfa: Infection and disease development, host-parasite relationships, ascospore germination and dissemination. Phytopathology 55:546-553. (Minnesota).

Martinez, E. S. and E. W. Hanson. 1962. A rapid method for inoculating alfalfa with pseudoplea trifolii. Phytopathology 52:172-173. (Wisconsin).

Waddington, J. C., W. C. McDonald and A. Storgaard. 1964. A comparative study of methods of inoculating alfalfa with Leptosphaerulina briosiana. Can. J. Pl. Sci. 44:249-252. (Winnipeg).

Stemphylium leafspot (Stemphylium botryosum)

Graham, J. H. and K. E. Zeiders. 1960. Pathogenicity and morphology of some leguminicolous and related species of Stemphylium. Phytopathology 50:757-760. (Pennsylvania, pasture lab).

Phytophthora root rot (Phytophthora megasperma)

Erwin, D. C. 1954. Root rot of alfalfa caused by Phytophthora cryptogea. Phytopathology 44:700-704. (Riverside, California)

Erwin, D. C. 1965. Reclassification of the causal agent of root rot of alfalfa from Phytophthora cryptogea to P. megasperma. Phytopathology 55:1139-1143. (Riverside, California).

Bushong, J. W. and J. W. Gerdeman. 1959. Root rot of alfalfa caused Phytophthora cryptogea in Illinois. Pl. Dis. Reptr. 43:1178-1183. (Illinois).

Johnson, H. W. and F. L. Morgan. 1965. Phytophthora root and crown rot of alfalfa in the Yazoo -- Mississippi Delta Pl. Dis. Reptr. 49:753-755. (Stoneville, Mississippi).

Bacterial Wilt (Corynebacterium insidiosum)

Cormack, M. W., R. W. Peake and R. K. Downey. 1957. Studies on methods and materials for testing alfalfa for resistance to bacterial wilt. Can. J. Pl. Sci. 37:1-11. (Lethbridge, Alberta).

Elling, L. J. and F. I. Frosheiser. 1960. Reaction of twenty-two alfalfa varieties to bacterial wilt. Agron. J. 52:241-242. (Minnesota).

Kreitlow, K. W. 1963. Infecting seven-day-old alfalfa seedlings with wilt bacteria through wounded cotyledons. Phytopathology 53:800-803. (Beltsville).

Frosheiser, F. I. 1964. Alfalfa cotyledon innoculation with bacterial wilt inoculum prepared from infected host tissue. Phytopathology 56:566-567. (Minn.)

Graham, J. H. 1960. Rapid screening of alfalfa for resistance to Corynebacterium insidiosum by inoculating petioles (Abstr.) Phytopathology 50: 637. (Pennsylvania, pasture lab).

Bacterial leaf spot (Xanthamonas alfalfae)

Stutville, D. L. and E. L. Sorensen. 1966. Distribution of leafspot and damping off (Xanthamonas alfalfae) of alfalfa in Kansas, and new hosts. Pl. Dis. Reptr. 50:731-733. (Kansas).

E. L. Pinnell served as moderator for the presentation of papers on hybrids vs synthetics by W. H. Davis and D. Termunde.

## ALFALFA HYBRIDS

W. H. Davis
L. Teweles Seed Company
Milwaukee 1, Wisconsin

During the 1964 Central Alfalfa Conference meetings, we presented a new alfalfa breeding program for the development of hybrid alfalfa. The main points of this new program were and continue to be:

1. Random selection of clones from populations which have been subjected to several years of adaptation via ecological competition.

A. Selfing for extraction of inbreds for possible male sterile maintainers. Self sterile clones are handled as males only.

2. Top crossing by spatial isolation and pollen density of the randomly selected clones to a variety of a different genetic background, i.e., Flemish Clones x Vernal.
   A. Obtain seed set data (estimated in gms/plant)
   B. Obtain plot yield data (estimated in percentage of established/check)

3. Selection of the top performing clones in the variety top cross. Placing these in cages with male sterile lines (of different genetic background) for making partial diallels, i.e., each male crossed to four different females.

4. Commercial production of male sterile hybrids via seed lines following a pattern field planting.
   A. Top cross hybrids - save the pollinator
   B. Four way hybrids - save the pollinator
   C. Three way hybrids - discard the pollinator
   D. Single cross hybrid - discard the pollinator

Success in such a program depends upon overcoming three main problems:

1. Finding and utilizing cytoplasmic male sterility.
2. Through selection, obtaining male steriles that set sufficient seed to overcome the cost factors of research and production.
3. Will hybrids outproduce synthetics sufficiently to be worth the increased costs and efforts?

The following tables will present the progress of our program toward male sterile hybrids:

Table I shows a new source of cytoplasmic male sterility ($T_1$ms) in which the partial male sterile is converted to a full sterile and then this source is transmitted through two succeeding generations. Such transmission of this male sterility is only with selected "O" type maintainer lines.

Table II shows the results obtained (in percent of the 2 checks) (Vernal and Socheville) of a small 17 entry variety trial using male sterile top cross hybrids in comparison to commercial synthetics and caged two clone synthetics. All male sterile hybrids exceeded the commercial checks and the two clone synthetics. Highest predicted yield gain was 44% over the Flemish check Socheville. These data are only fragmentary, however, and we must wait for further information to substantiate such estimates.

Table III shows data obtained from field isolated clones (California Top Cross) is presented in percent of the two check varieties. The Flemish check, Socheville, did much better in comparison to the uncontrolled top cross hybrids as in contrast to the male sterile hybrids; the best exceeded the check by only 10 percent.

## Discussion and Summary

During the past two years we have completed all phases in the development of a workable cytoplasmically transmitted male sterility. Two key factors are essential in this form of sterility, i.e.,

1. A cytoplasm having male sterility present.
2. An "O" type or maintainer male to act in suppressing fertility restoration in the offspring.

The proposed Ecological Top Cross procedure gave a good separation of the randomly selected clones. The degree of selfing in such a method was not determined but may be a factor in yield prediction. The effectiveness of such a diverse top cross as compared to a polycross still remains unanswered.

Table I. Cytoplasmic Male Sterile Approach

$T_1$ ms (90% sterile = field selection)
$TO_1$ (partial "O" type = $S_3$ inbred line)

$T_1$ ms x $TO_1$

↓ (Segregation for Sterility)

($F_1$) $T_1$ - 22 ms x $TO_{31}$ ($S_4$ Inbred)

100% sterile ↓ Full "O" Type

$F_2$ ms 16 plants = all ms

↓

$T_1$ 500 ms x $TO_{31}$

↓

$F_1$ $BC_1$

22 Plants
21 ms
1 pms
0 pf
0 fert.

---

$T_1$ 497 ms x $TO_{61}$

↓

$F_1$ ms

26 plants
26 ms
0 pms
0 pf
0 fert.

Table II. Male Sterile Hybrid Test "C" - Richfield, Wisconsin - 1966

| Code | Description | % Vernal | % Socheville |
|---|---|---|---|
| 73 | Top Cross Hybrid - ms | 163 | 144 |
| 69 | " | 162 | 144 |
| 76 | " | 153 | 135 |
| 71 | " | 142 | 126 |
| 78 | " | 137 | 121 |
| 77 | " | 135 | 120 |
| 72 | " | 133 | 119 |
| 70 | " | 127 | 112 |
| 74 | " | 124 | 110 |
| 79 | Variety Cross - Field Poll. | 117 | 105 |
| 82 | Socheville (Flemish Check) | 113 | 100 |
| 81 | 2 Clone Synthetic (Caged) | 101 | 90 |
| 75 | Vernal (Hardy Check) | 100 | 89 |
| 80 | 3 Clone Synthetic (Caged) | 97 | 87 |
| 84 | 2 Clone Synthetic (Caged) | 96 | 85 |
| 83 | 2 Clone Synthetic (Caged) | 84 | 75 |
| 85 | 2 Clone Synthetic (Caged) | 84 | 75 |

Fall cutting - seedling year - cut twice previously - (Oct. 20, 1966)

Table III. California Top Cross Test "D" - Richfiedl, Wisconsin - 1966

| Code | Description | % Vernal | % Socheville |
|---|---|---|---|
| 206 | Clone x Variety | 135 | 110 |
| 209 | " | 135 | 110 |
| 208 | " | 131 | 106 |
| 210 | " | 124 | 101 |
| 199 | " | 123 | 100- |
| 200 | Socheville (Flemish Check) | 123 | -100°- |
| 204 | Clone x Variety | 120 | 98 |
| 202 | " | 115 | 94 |
| 198 | " | 112 | 91 |
| 194 | " | 104 | 85 |
| 195 | " | 102 | 83 |
| 207 | Vernal (Hardy Check) | -100- | 82 |
| 203 | Clone x Variety | 99 | 81 |
| 205 | " | 98 | 80 |
| 197 | " | 96 | 78 |
| 201 | " | 95 | 77 |
| 196 | " | 86 | 68 |

Fall cutting - seedling year - cut twice previously - (Oct. 20, 1966)

Evidence for yield advantages of the male sterile top cross hybrids over the present commercial synthetics looks promising. Additional harvest data are needed to further substantiate such early advantages.

When all phases of this hybrid program have been worked out, it is hoped that a thorough, predictive process of clonal selection of the components of the desired hybrids has been achieved.

Still unresolved is the seed set potential and patterns necessary to produce hybrids via the male sterile system proposed earlier. We are spending considerable efforts on screening male sterile clones for seed production in California. Data for this year's seed production are not complete. However, we are encouraged by partial results of the 1966 season.

Time and much effort will be expended over the next few years studying field patterns, bee preference, etc. of the male sterile hybrids. Much work still needs completion before commercial male sterile hybrids reach the seed markets and their full potential is utilized and realized by American farmers.

## SYNTHETIC APPROACH

Darrold Termunde, Research Associate
Pfister Assoc. Growers, Inc.
Cozad, Nebraska

Alfalfa breeders have explored the value of synthetics in order to exploit the possibilities of utilizing heterosis as a means of increasing the productivity of alfalfa. Until recently, synthetics of alfalfa and many other forage crops were developed by crossing noninbreds ($S_o$) plants without controlled pollination except for the restriction of parents and isolation. The anticipated gains in productivity using vigorous noninbred $S_o$ parents could not generally be shown. Yields in general were no better or below present varieties. Actual gains in yield of alfalfa, by breeding, over the past decade have been very small. It has only been recently that a great deal of work was begun using 2 clone combinations in trying to produce $F_1$ hybrids which would utilize heterosis and perform at a level superior to present varieties. In order to produce a true hybrid controlled pollination is necessary and generally something other than $S_o$ lines as parents are needed. Controlled pollination has not been attained on a commercial basis due to the lack of a good source of sterility. This problem still plagues the breeder with hybrid production, as well as others which are all limiting and important. I will mention some of these later.

Let us then examine what we already have and the knowledge we have accumulated on synthetics. First, let us take a closer look at how much crossing is needed to exhibit hybrid vigor. I am unable to find anything in the literature where true hybrids (95 to 100 percent known crossing) have been compared directly with standard varieties, planted by conventional methods and conventional rates. The data available are concerned with space planted tests and often do not include standard or present varieties; yield advantages for hybrids from such tests range from 10-40%.

I question whether these data would be the same when compared by regular testing procedures. Hanson, C. H., et al (2) reported from a diallel of 14 clones of quite diverse origin, that of the 91 two-clone combination made, none were significantly superior to the best variety; however, several had yields numerically equal or exceeding the average of the check varieties. These data are reported with an estimate of 60% plus selfing present. Tysdal, et al (6) reporting on the effect of self-pollination, stated that space plants of $S_1$ lines yielded 68% as much forage as noninbred plants. They concluded that considerable selfing is required to detract greatly from hybrid performance. In lieu of this, one can interpret the data of Hanson, et al (2) in two different ways. At first glance, one can say that two-clone combinations are of little value in increasing yield unless controlled pollination is applied. However, it may also be interpreted as an advantage for two-clone synthetics. The two-clone combinations reported, were roughly 60% self seed. If we were able to increase crossing by only 10-20% one could assume a significant increase in performance of these two-clone synthetics.

Furthermore, if this crossing percentage could be increased to 75 to 80 percent, I feel that it would approach or come near to equaling the performance levels of true hybrids. So I again ask the question, "Is complete crossing needed to achieve maximum yield levels?"

According to data reported by Kehr, W. R. and LaBerge (5) using a white flowered clone, as a marker grown in alternate rows with a purple under cages, a nucleus colony had an average of only 57% crossing during a two-year period; and 62% crossing when a hive and a connector were used during the same period. These data indicate that we are working within levels of 50 to 65 percent crossing, a lower percentage than many believe or report. This could mean we are working with as much as 45 percent selfed seed in our present synthetics. I, again, feel a great deal of synthetic improvement could be attained by increasing levels of crossing by an additional 10 to 20 percent. I have pointed out that we may not be getting the percentage of crossing we think we are; how then, can this be increased?

Literature supports the fact that inbreeding increases self-sterility of alfalfa. Actual percentages of crossing in these materials are not yet reported; however, some workers show in preliminary data a possibility of 10 to 15 percent increase in crossing for each self generation.

We have used this premise in our program and find that it looks very promising; however, data is not available at the present to support any statement. We hope to have this completed soon. $S_1$, $S_2$, and $S_3$ generations are presently being checked. It appears possible to attain levels of crossing of approximately 75 to 80 percent, by one or two generations of inbreeding with a great deal of selection pressure.

With this possibility, it would appear that synthetics of 2, 4, 6 or more clone could be produced economically and still exhibit hybrid vigor. The next question you will probably ask of me is, "What about yields of selfed populations? Are they lower than those of noninbred?" I would have to say that they are; however, seed yields of an $S_1$ or $S_2$ isolation would not need to be as great to still have economic production. I will elaborate on this a little later. I would like to look at seed production of hybrids first.

Beard, D. F. and Merserve, J. C. (1) reported that when selections of male sterile 20 DRC were compared with normals, seed yields were reduced by almost one-half. There is indication that bee selectivity would have an affect on the use of a male sterile line. This could be attributed to attractiveness or lack of viable pollen. I would also ask, "What information do we have on planting patterns to utilize maximum bee visitation and most efficient usage of an acre of land?" These problems I am certain are not insurmountable; however, they impose direct limitations to the economics of hybrids.

It would appear that by using the Syn-1 generation of synthetics many of these problems may be overcome and still have a synthetic which exhibits a very high performance level. Kehr, W. R. (3) reports that synthetics used in the first generation contain both hybrids and inbreds (unknown crossing percentage) gave a yield advantage of up to 13 percent over currently used varieties, as compared to a 10 percent increase for the use of advanced generations.

The optimum number of clones which a synthetic should consist of is still a question. The use of two clone combinations has recently received the greatest attention; however, there is still question if all our goals will be attained by the use of 2-clone synthetics. Several factors will determine the number of clones to be used, such as, area of adaptability, combining ability of the clones, disease and insect resistance required. Thus, one could say the optimum number of clones to include in a synthetic would be dependent on what the breeder wants in the variety. Kehr, et al (4) reported that the average Syn-1 yield of eight - 4-clone, five - 5-clone, one - 6-clone, and five - 2-clone synthetics were not significantly different, so optimum number of clones could not be defined. In some cases, 2-clone combinations were better able to capitalize on the heterotic affects; however, with further studies and tests those with a broader base are equal or superior to these two-clone combinations. Disease and insect resistance levels will also regulate how many clones will be used. Since it now appears that some resistance is more of the additive nature, it may be difficult to combine high levels of resistance to several insects and diseases in only two parents. The chances of attaining these levels of resistance in several clones would be much greater. I am sure that no one will argue that resistance to both are an important factor in a given variety. Yield increases may come through resistance in any given year or season, or it may only be a built-in insurance factor which is not always needed.

As I mentioned earlier, seed production may be less if $S_1$ or $S_2$ populations are used to utilize the Syn-1 generation. However, if production is based on this method this should not be an extreme limitation.

> $S_1$ or etc. selections grown in the greenhouse from which cuttings are made for isolation increases. The seed harvested from the isolations to be used as foundation seed for commerical production planted in alternate rows or blended or etc., the seed from this field would be sold to the consumer.

| | cuttings | increase | | | | |
|---|---|---|---|---|---|---|
| $S_1$ | → | isolations | → | production field | → | consumer |
| | | Breeders | | Foundation | | |
| | | Seed | | Seed | | |

In summary, I would like to again point out a few of the areas in which I think we can improve varieties via the synthetic approach.

(1) It would appear that we do not need complete pollination control to give an expression of hybrid vigor. 75-80 percent crossing may give us as much boost as complete crossing in a true hybrid.

(2) Increased cross fertility through one or two generations of selfing would enhance the opportunity of utilizing the expression of hybrid vigor.

(3) The fact that we may be overestimating the percent of crossing we are presently getting in synthetics would justify re-examination of much of our material. Improvement could be made through re-selection and inbreeding.

(4) Seed production of synthetics compared to hybrids would seem to offer an advantage for synthetics and should promote investigations in which Syn-1 generations could be utilized on a more economical basis than hybrids.

(5) Data support the theory that there may be little difference between 2-4-6 or more clone combinations, used in the Syn-1 generation.

(6) The combination of resistance to several diseases and insects, which could determine overall performance, are more easily attained by using several clones than being restricted to two-clone combinations.

(7) Adaptation over a larger area may be realized by the use of multi-clone synthetics as compared to two-clone combinations. However, this may not always be true.

## Literature Cited

1. Beard, D. F. and Merserve, J. C., Honey Bee Visitation to Male Sterile Clones. Nineteenth Alfalfa Improvement Conference, June 28. pp. 18, 1964.

2. Hanson, C. H., Graumann, H. O., Elling, L. J., Dudley, J. W., Carnalian, H. L., Kehr, W. R., Davis, R. L., Frosheiser, J. I., and Hovin, A. W., Performance of Two-Clone Crosses in Alfalfa and an Unanticipated Self-Pollination Problem: U.S.D.A. Tech. Bul. No. 1300, 42 pp. 1964.

3. Kehr, W. R., Alfalfa Variety Development, Alfalfa Research Day Program, pp. 11-12, May 1964.

4. _____, Graumann, H. O., Lowe, C. C., Gardner, C. O., The Performance of Alfalfa Synthetics in the First and Advanced Generations. Nebraska Agr. Exp. Sta., Bul. 200, 41 pp. October 1961.

5. _____, La Berge, Wallace E., Cross-Pollination of Alfalfa In Cages With Honey Bees, Crop Science, Vol. 6, pp. 91-93. Jan.-Feb., 1966.

6. Tysdal, H. M., and Kisselbach, T. A., Hybrid Alfalfa, 1944. Am. Soc. Agron. Jour. 36:649-667.

Chairman Smith earlier in development of the program extended an invitation to private and public alfalfa workers to suggest topics of interest for discussion. The following three papers were given in response to Chairman Smith's invitation.

## REGIONAL TESTING FOR SPECIAL CHARACTERS

I. J. Johnson
Caladino Farm Seeds

Alfalfa breeders must recognize that the consumer is becoming more sophisticated each year in the selection of alfalfa varieties or hybrids for his specialized needs. A part of this trend, whether good or bad, must be attributed to alfalfa breeders themselves in attempting to emphasize the unique characteristics of their products. But a part also is in keeping with the current trends for greater specificity in the total agricultural industry.

The demand for greater and greater refinements in alfalfas - if continued - will surely require greater refinements in evaluation. The old concept of yield of dry matter as the major criterion of performance (at least among specialized hay growers in the West Coast) is now giving way to a concept of TDN per ton and - if continued - may some day require analysis for specific amino acids to make it possible to more effectively blend the total feed intake to balance the nutritional requirements of the animal to which it is fed.

The current decade in which private alfalfa breeding has become "of age" has posed new problems - and perhaps new and greater opportunities - to both public and private plant breeders. To most effectively utilize manpower and resources in the best interests of our economy will require even greater levels of cooperation than have existed heretofore.

The ways in which industry and the universities can best join to increase the effectiveness of their respective efforts is not always clearly defined either by industry or the university. But a few basic concepts have become fairly well crystalized, including the following:

1. University efforts to serve industry by becoming the testers of private varieties is not fulfilling its maximum potentials in research.

2. New knowledge from basic research and new genetic stocks often resulting from such basic research fulfill their maximum potentials when many hands join to put them to use. Prompt publication and release of genetic materials are essential in keeping pace with fast-moving developments on the "farm front".

3. Industry has a responsibility to publicly acknowledge the use of genetic stocks when such stocks provide clones or genes incorporated into new varieties. The most effective way to increase emphasis on basic research is to give proper credit for it.

4. Industry has opportunities to provide its unique services to aid public research.

5. University research can accomplish more by developing and refining procedures for evaluation of special characteristics than by routinely testing breeding materials. Examples such as antibiosis resistance to spotted aphids and to bacterial wilt illustrate this principle. Present day breeding materials must have a combination of several attributes. Evaluation for only one criterion at a time can become a roadblock to progress.

6. There may be certain characteristics for which each industry or each university research program cannot undertake alone. Industry has found it to be advantageous to cooperate in such programs as breeding honey bees more effective as alfalfa pollinators. Experiment stations have been engaged in regional research projects for many years. Perhaps we also can envision jointly sponsored regional research on projects that involve costly and complex analysis techniques.

## A CODING SYSTEM FOR AN ALFALFA RESEARCH PROGRAM

Jonas W. Miller
Arnold-Thomas Seed Service

It is safe to assume that every plant breeder develops a pedigree and experiment numbering system to various degrees of perfection. Such identifications should be short, systematic, easily distinguished, and explicit.

Newell and Tysdal (1945) developed a numbering system applicable to perennial cross-pollinated crops. Major emphasis in their system was identification of different kinds of seed from selected clones or plants. Alfalfa was used as their example. The type of seed, such as selfed, crossed, advanced generation, polycross, close breeding, open pollinated, etc. was emphasized in their system.

The use of computers demands that clones, experiments, kinds of germ plasm, time of data collection and locations be assigned numbers for easy reference and clear identification. The clone numbering system Arnold-Thomas Seed Service and Pioneer Hi-Bred Corn Company have been using for 5 years on alfalfa consists of a letter and not more than 4 digits to accomodate 999 selections per year. The letters 'M' and 'C' designate two geographic areas of initial selection. 'C' identifies selections first made in California and 'M' defines selections first made in the Midwest. After 10 years, the letters 'C' and 'M' will be changed in order to avoid duplication of clone identity. 'C' could be changed to 'S' (seed) and 'M' to 'F' (forage) to represent the major initial basis for selection in the respective areas. The first number following the letter designates the year the plant was selected. The balance of the number consists of consecutive numbers for identifying individual plants selected in that year. In 1966 at Location 'C', all new selections start with C6. The C6 is followed by the number 1 for the first

selection. The second selection is C62; the 10th selection is C610, etc. Selections from area 'M' start with M6501 to avoid duplication of numbers which differ by only one letter. Once a number is assigned to a clone, it remains with that clone as long as the clone is in the breeding program.

Clone numbers are listed in a schedule giving source and field location along with pertinent information regarding the clone such as flower color, important performance data and reason for selection (Exhibit 1). In addition, a clonal history book is maintained wherein all summary data on clonal and progeny performance is recorded. Clonal sheets in the clonal history book are filed alphabetically and numerically within sources.

EXHIBIT 1 (A Coding System for an Alfalfa Research Program)

Headings from a page from the Master Schedule of Clones

| CLONE | SOURCE | FIELD LOCATION | FLOWER COLOR | FORAGE G.C.A | SEED SET SCORE | S.A.A. | BACT. WILT | SPECIAL COMMENTS | IN SYNTHS. |
|---|---|---|---|---|---|---|---|---|---|
| Clones C61-C678 are best seed setters from 6650149-09 | | | | | | | | | |
| C61 | | | | | | | | | |
| C62 | | | | | | | | | |
| C63 | | | | | | | | | |
| . | | | | | | | | | |
| . | | | | | | | | | |
| C678 | | | | | | | | | |
| Clones C679-C6100 are best seed setters from 6650143-09 | | | | | | | | | |
| C679 | | | | | | | | | |
| . | | | | | | | | | |
| C6100 | | | | | | | | | |

Since many experiments are planted at each location every year, a numbering system identifies the year the experiment is planted, the type of experiment (Exhibit 2-A) and the source of material (Exhibit 2-B).

EXHIBIT 2

Some codes for types of experiments and sources of materials

A. Types of Experiments

00 Clonal Holding Nursery
01 Spaced Plants
02 Clonal Test
03 4 Rep Progeny Row Forage Test
04 Variety & Synthetic Forage Yield Test
05 Winterhardiness Test
06 Bacterial Wilt Test
07 Transplanted Progeny Row Test
08 Insect Screening Test
09 2 Rep Preliminary Progeny Row Test
10 Test to evaluate plot sizes
14 Variety & Synthetic Seed Yield Test

B. Sources of Germ Plasm

00 Many Sources (Holding Nursery)
41 Arnim
42 Buffalo
43 Flemish Sources
44 Zia
45 Second Cycle Flemish
46 Root Spreaders
47 Plant Introduction
48 Flemish x Vernal and Backcrosses
49 Male Steriles
50 Restricted polycrosses from Synths.
51 Inheritance of Leafhopper Resistance
52 Handcrosses
53 Pea Aphid Resistant Selections
54 Germ Plasm Pool
55 Weevil Resistant Selections
56 Medicago Species
Etc.

Two digits are used to represent the source of material in an experiment. The code for source of material is on the right end of the experiment number. One experiment may contain selections from one variety. In such cases, a 'source' number identifies a variety. Other sources could be $S_1$'s, handcrosses, specific crosses, or specific type of resistance; i.e. selections from a pea aphid screening test. Constructing the experiment number from right to left, the next two digits refer to the type of experiment. Types of experiments may be clonal, spaced plants, progeny row, variety, bacterial wilt, winter-hardiness, insect screening, leaf disease resistance evaluation (specific insects and diseases may be assigned a number), etc.

The year the experiment is planted is the next digit to the left. We use the last digit of the year to characterize year of planting.

Since alfalfa is a perennial, data generally are obtained in more than one year from the same planting. Two digits on the left end of the experiment number designates the year of data collection. The data are identified by the last two digits of the year, which also specifies the year of planting in the rare instance an experiment is maintained ten or more years. Looking at the seven digit experiment number in units, as we have constructed it, the number is as long and easy to remember as your telephone number.

Locations are identified by two digit numbers. These numbers remain with the location permanently. The location number also differentiates the same experiment at more than one location.

The experiment designation 6760243-01 then indicates 1967 data (first two digits from left) from an experiment established in 1966 (3rd digit). The experiment is a clonal test (4th and 5th digits), and the clones represent selections from Flemish sources (6th and 7th digits). The last 2 digits identify the Johnston, Iowa location.

---

Newell, L. C. and H. M. Tysdal, 1945. J. Am. Soc. Agron. 37:736-749.

## COTTON PLANT PATENT SYSTEM IN RELATION TO ALFALFA

R. J. Buker
Farmers Forage Research Cooperative

The Cotton Industry submitted a 15 page report to The President's Commission On The Patent System recommending that the patent law be amended to read "whoever invents or discovers any distinct and new variety of cotton may obtain a patent therefore subject to the conditions and requirements of this title". Although the cotton group made no recommendations, they indicated that by striking out the word "asexually" from paragraph 161, title 35, chapter 15 of the U.S. Code all sexually reproduced crops could be brought under the patent act.

Those cotton breeding organizations working on this project were discouraged by the report of The President's Commission On The Patent System turning down their request. The Commission even went further to suggest that "All provision in the Patent Statute for plant patents shall be deleted and another form of protection provided".

## REPORT ON NC-83

W. R. Kehr reported on NC-83, "Seed Production of Breeding Lines of Insect-Pollinated Legumes." His report indicated good progress was being made toward fulfillment of the project's objectives. These objectives are as follows:

1. To determine (a) whether associations between seed production potential and morphological and/or physiological plant characteristics exist and (b) if such associations are of sufficient magnitude to be useful in identifying plants with both desirable forage and seed production potential.

2. To develop techniques for producing seed of experimental combinations under cages with special reference given to the genetic composition of the seed so produced.

3. To evaluate for seed production potential in the seed producing area, superior clones originating from the State breeding programs and selected by a regional committee.

4. To produce experimental combinations of selected clones and conduct subsequent performance testing of these combinations in the North Central Region.

The project budget for 1966-67 is $22,500.00.

## REPORT ON NCR-36

M. D. Rumbaugh reported that the last meeting of NCR-36 committee on forage breeding was held February 3 and 4, 1966. One day was devoted pri-

marily to the presentation of technical reports on various phases of breeding programs of several forage crop species.

The committee recommended the inclusion of three new varieties of grasses in the National Foundation Seed Project. These were:

(1) T-1 Timothy from Wisconsin,
(2) Nugget Kentucky Bluegrass, and
(3) Arctared Red Fescue from Alaska.

The next NCR-36 meeting will be September 19 and 20, at Kansas City, Missouri.

## REPORT ON NC-7

W. H. Skrdla reported on NC-7 and introduced Dr. James L. Jarvis and Dr. Ray Clark who are serving as Entomologist and Plant Pathologist, respectively, at the North Central Regional Plant Introduction Station. The following report was presented by Dr. Skrdla:

The purpose of this report is to present information on the activities of the Regional Station and our progress on alfalfa introductions since the last meeting of the Central Alfalfa Improvement Conference in 1965. Certain activities of the New Crops Research Branch and future plans will also be presented.

1. Entomology Program. In 1966, the Entomology Research Division placed an Entomologist at the North Central Regional Station. He is Dr. James. L. Jarvis and was previously with the USDA at Gulfport, Mississippi, where he has worked on a program concerning the white fringe beetle. His work will parallel that of the plant pathologist in that he will be concerned with screening plant introductions in search of natural resistance to insects. With the present interest in finding alfalfa weevil resistance, a follow-through on progress of finding possible resistance in alfalfa introductions will very likely become a part of his program. We anticipate that the entomology work, both at the regional station and possible cooperative work with entomologists in the region, will enhance the regional plant introduction program. Eventually, entomologists will be placed at each of the other three regional stations.

2. Plant Pathology Work. During the past year, Dr. Ray Clark started to screen alfalfa introductions for resistance to Pseudoplea. While only a portion of the total collection has been looked at, PI 170446 from Turkey has shown the most resistance. However, follow-up work on this line is still underway. We anticipate that screening for Pseudoplea will continue until the entire collection is screened.

Other information on 170446 indicates that at the end of seven years, in a planting at Columbia, Missouri, it had a stand percentage that was equal to the check varieties Lahontan and Buffalo. The stand for all three was between 65 and 70 percent. The average height of PI 170446, in the same planting, was 16 inches, compared to 17 inches for the checks.

3. Change in staff personnel at the Western Regional Plant Introduction Station. Dr. L. A. Mullen, formerly coordinator of W-6, retired on June 30,

1966. The new coordinator is Dr. Sam Dietz, who had been on the W-6 staff as Plant Pathologist. Dr. A. M. Davis is the new W-6 agronomist and will report for duty in the near future.

4. Inventory and Utilization of Alfalfa Introductions. Our inventory of active alfalfa introductions continues to grow. Since 1965, we received 135 new accessions, which increased the total inventory to 770 accessions. However, requests for alfalfa introductions decreased substantially during the past two years, 1965-66. In that time we distributed 1160 packets compared with over 3000 during the previous two years, 1963-64. Of course, several requests for large portions of our collection, in 1963-64, for alfalfa weevil tests contributed heavily toward the total of 3000 packets.

5. Foreign Exploration. There were four direct explorations completed in 1965, one of which concerned forage crops. This was the exploration made by Keller and Jones into the Soviet Union. Some 700 collections were obtained directly from remote regions of Central Asia and a similar number of requests were left with Soviet scientists. With regard to alfalfa, we received about 15 accessions from that collection among other legumes and grasses. Dr. Keller is increasing some other material which we hope to obtain at a later time.

If arrangements can be made, another exploration into the Soviet Union is planned during the summer and fall of 1967. Work would concentrate on collecting cereals for possible resistance to the cereal leaf beetle and on collecting additional forage crops. If this materializes, we will be in contact with NC-7 representatives to request specific material that plant breeders might want.

To assist in the procurement of desired material, Mr. Howard Hyland, New Crops Research Branch, would like to know when staff members from State Agricultural Experiment Stations plan trips abroad. This would give him an opportunity to ask them to collect certain material, if they have time. Anyone who plans such a trip and would like to assist Mr. Hyland should either contact me or Mr. Hyland direct.

6. National Seed Storage Laboratory. The New Crops Research Branch reports that the 1965 inventory of items in the National Seed Storage Laboratory is slightly over 43,000. Approximately 22,000 lots represent world collections. The North Central Regional Station submitted 3250 items, including 481 alfalfas, 415 corns and 2340 tomatoes. We are continuing to submit items as they become available.

The National Laboratory has made an effort during the past year to locate genetic collections for permanent storage. This has not been very successful, but during the next year additional emphasis will be directed toward obtaining such collections. At the present time the only genetic stocks in storage are those for barley (from Colorado) and a collection of tomato mutants (partly from the Regional Station).

I would like to solicit your assistance in helping Dr. James locate such stocks. If you know of any, regardless of which crop they are, please notify Dr. James or me. For alfalfa, I'm sure that he would like seed of genetic marker stocks or any other similar materials.

7. National Coordinating Committee. This committee met on October 19 and 20, 1965, at Louisiana State University. Plans for a National Clonal Repository were discussed after a recommendation by the Clonal Repository Committee was read. It recommended that several repositories for tree fruits and nuts, small fruits and vine crops be operated by the Federal Government either directly or on a long term contract or grant basis. To do this, State, Regional, and Federal funds would be required. Action by the National Committee was: (1) that the administrative advisers of the four Regional New Crops Programs convey the report of the Clonal Repository Committee to their respective Regional Association of Directors, (2) that the New Crops Research Branch prepare background information to support this need for each administrative advisor prior to the spring meeting of the Directors and (3) that the administrative advisors encourage the Regional Directors Association to send a resolution to the Administrator of ARS in support of the establishment of a federally administered program for clonally propagated stocks.

This report of progress is presented to this conference because, while the present emphasis is on fruits and nuts, the over-all effort encompasses the preservation of forage crops, including alfalfa.

8. Data Recording and Retrieval. Dr. H. L. Carnahan, former Chairman of the National Alfalfa Conference appointed a committee to develop a coordinated system of data recording and retrieval for alfalfa introductions and asked me to serve as chairman. I presented a report for the committee at the National Alfalfa Improvement Conference at State College, Pennsylvania, in July 1966.

The list of characters was divided into three categories: (1) Plant characterisitics; (2) Alfalfa diseases; and (3) Alfalfa insects. Suggested rating scales were provided for each category.

In order to adapt the system for use with punch cards, a proposed code was developed. On the basis of an 80 column card, the first 36 rows were devoted to documentation and card reference. The rest were devoted to the desired characteristics. For instance, there would be a separate card for each of the three categories listed above.

The report was accepted by the conference, except for scoring of flower color. In view of Dr. D. W. Barnes' work on this character, it was decided to wait until further consideration can be given to it. Copies of the report may be obtained from me upon request.

9. Alfalfa Evaluations. Presently, one of the most sought for characteristics in alfalfa is natural resistance to the alfalfa weevil. Seed samples of most of the alfalfa collection has been sent to Beltsville, North Carolina, and Tennessee for evaluation in areas where the insect now exists. Reports that certain introductions are showing resistance in preliminary tests have been received. However, more exhaustive testing is still underway. These introductions will be listed in Appendix C of the 1966 Annual Report from this station.

Various notes on other alfalfa introductions will also be reported in the 1966 Appendix C. This Appendix may be obtained upon request.

I wish to emphasize that when certain characters or traits are reported for a given introduction, we infer that they are usually in a segregating condition. Not often do we find an introduction that is completely homozygous for the less common traits. All plants may sometimes show good uniformity for vigor or plant height and size within an accession, but for disease and insect resistance, this uniformity may not be apparent. Therefore, it is necessary to look at individual plants rather than the accession as a whole.

When we report special traits in an introduction, we do not always know whether or not it is homozygous or dominant or recessive. It is, by calling your attention to that introduction for some reason, that we hope to be of assistance. I make this point because occasionally reports received by us suggest that a uniform, homozygous line was expected for a given trait which was listed in one of our reports.

## REPORT ON VARIETY REVIEW BOARD

C. H. Hanson reported that three alfalfa varieties, Bonanza, Dawson and Iroquois, received favorable reviews for certification on December 13, 1966 by the National Certified Alfalfa Variety Review Board. Delta and A-59 were considered initially at the 1965 meeting of the Board and subsequently reported favorably for certification. Copies of the report were mailed earlier in the week to alfalfa workers on the Conference's mailing list.

W. R. Kehr reported that seed of Dawson, previously identified as N.S. 27, is available to private and public alfalfa workers for testing.

The next meeting of the National Alfalfa Improvement Conference will be held at Reno, Nevada on July 9-11, 1968. Dr. Hanson stated that the conference would be held jointly with the Forage Insect Conference and the Technical Alfalfa Conference (Utilization). Suggestions for the Conference will be solicited by the Executive Committee of the Alfalfa Improvement Conference.

I. J. Johnson expressed appreciation in behalf of the private alfalfa workers for the fine cooperation existing between industry and the USDA and Experiment Stations in making genetic stock available to industry. He further expressed that industry and the stations can and are effectively working together, all of which represents good relationships in the improvement of alfalfa.

Chairman Smith announced that the Experiment Station Workers Session would be held the following morning, January 27 at 8:30 a.m. in Parlor 413. The Private Workers Session was cancelled.

H. L. Carnahan indicated that occasionally in the reporting of alfalfa performance data the numerical rating is in the reverse order of the recommended numerical scale.

Chairman Smith expressed appreciation to the program participants for their presentations, to C. N. Hittle for making arrangements for facilities, to private industry for the coffee breaks, and to H. L. Carnahan for his suitcase of California oranges.

The conference was adjourned at 4:53 p.m.

Joint Session
Central Alfalfa Improvement Conference
January 26, 1967

REGISTER

| | | |
|---|---|---|
| L. E. Arnold | Arnold-Thomas Seed Service | Fresno, California |
| O. J. Attoe | University of Wisconsin | Madison, Wisconsin |
| D. F. Beard | Waterman-Loomis Co. | Adelphi, Maryland |
| E. H. Beyer | Farm Seed Research Corporation | San Juan Bautista, California |
| Ted Bingham | University of Wisconsin | Madison, Wisconsin |
| D. E. Brown | W. R. Grace R. P. Division | Caldwell, Idaho |
| R. J. Buker | Farmers Forage Research | Lafayette, Indiana |
| H. L. Carnahan | Arnold-Thomas Seed Service | Fresno, California |
| Ray Clark | Regional Plant Introd. Station | Ames, Iowa |
| D. N. Clary | Waterman-Loomis Co. | Granger, Iowa |
| W. H. Davis | Teweles Seed Co. | Richfield, Wisconsin |
| F. E. Elliott | Michigan State University | East Lansing, Michigan |
| F. I. Frosheiser | University of Minnesota, A.R.S. | St. Paul, Minnesota |
| D. W. Graffis | University of Illinois | Urbana, Illinois |
| C. H. Hanson | Crops Res. Div., A.R.S., U.S.D.A. | Beltsville, Maryland |
| C. N. Hittle | University of Illinois | Urbana, Illinois |
| J. A. Jackobs | University of Illinois | Urbana, Illinois |
| J. L. Jarvis | Regional Plant Introd. Station | Ames, Iowa |
| I. J. Johnson | Caladino Farm Seeds | Woodland, California |
| Howard E. Kaerwer | Northrup, King & Co. | Minneapolis, Minnesota |
| W. R. Kehr | University of Nebraska, A.R.S. | Lincoln, Nebraska |
| L. J. Klebesadel | University of Alaska, U.S.D.A. | Palmer, Alaska |
| H. L. Kohls | Michigan State University | East Lansing, Michigan |
| K. L. Larson | North Dakota State University | Fargo, North Dakota |

| | | |
|---|---|---|
| G. M. Loper | South Dakota State University, A.R.S. | Brookings, South Dakota |
| G. C. Marten | University of Minnesota, A.R.S. | St. Paul, Minnesota |
| J. W. Miller | Arnold-Thomas Seed Service | Johnston, Iowa |
| J. L. Mings | Northrup, King and Co. | Washington, Iowa |
| Mark Mueller | Pioneer Corn Co., Inc. | Tipton, Indiana |
| A. A. Nevala | Jacques Seed Co. | Prescott, Wisconsin |
| R. L. Ogden | University of Nebraska | Lincoln, Nebraska |
| G. A. Page | Northrup, King & Co. | Minneapolis, Minnesota |
| W. D. Pardee | Cornell University | Ithaca, New York |
| F. G. Parsons | University of California | Davis, California |
| E. L. Pinnell | University of Missouri | Columbia, Missouri |
| J. M. Poehlman | University of Missouri | Columbia, Missouri |
| G. A. Rogler | A.R.S., C.R.D., U.S.D.A. | Mandan, North Dakota |
| M. D. Rumbaugh | South Dakota State University | Brookings, South Dakota |
| J. P. Silva | University of Wisconsin | Madison, Wisconsin |
| F. J. Simental | North Dakota State University | Fargo, North Dakota |
| W. H. Skrdla | Regional Plant Introd. Station | Ames, Iowa |
| Dale Smith | University of Wisconsin | Madison, Wisconsin |
| E. L. Sorensen | Kansas State University, A.R.S. | Manhattan, Kansas |
| R. E. Stucker | University of Minnesota, A.R.S. | St. Paul, Minnesota |
| J. M. Sund | University of Wisconsin | Madison, Wisconsin |
| D. E. Termunde | Pfister Associated Growers, Inc. | Cozad, Nebraska |
| J. R. Thomas | Farmers Forage Research | Lafayette, Indiana |
| R. W. VanKeuren | Ohio Agr. Res. & Dev. Center | Wooster, Ohio |
| G. E. VanRiper | Deere & Co. | Moline, Illinois |
| W. F. Wedin | Iowa State University | Ames, Iowa |
| R. D. Wilcoxson | University of Minnesota | St. Paul, Minnesota |
| C. P. Wilsie | Iowa State University | Ames, Iowa |