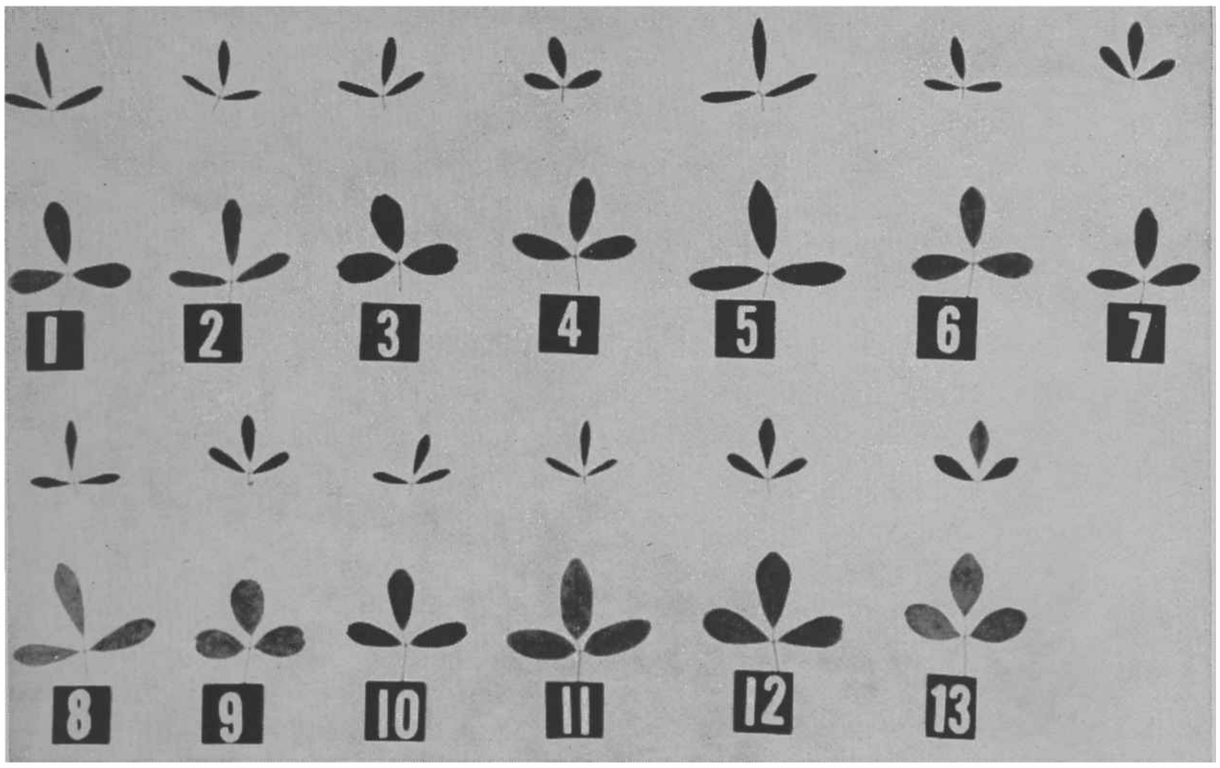

Figure 1. Fully expanded and young leaflets collected from 13 alfalfa clones showing variation in size and shape.

Productivity Indicators in Alfalfa

*by R. H. Delaney and A. K. Dobrenz**

Introduction

What does the ideal alfalfa plant look like? Will it have wide, heart shaped leaflets with short petioles and stems with long internodes or should it have narrow, linear leaflets with long petioles and numerous internodes on each stem? Such questions are currently being considered by University of Arizona Scientists working to improve alfalfa productivity.

Table 1. Several factors measured on alfalfa clones and used to determine relationship with yield.

Clone	*Average rate of CO_2 incorporation mg CO^2 dm^{-2} hr^{-1}*	*Leaflet width (mm)*	*SLW mg/cm^{-2}*	*Average yield (g/plant)*
1	26.1	10.0	4.14	23.3
2	27.0	8.2	4.47	34.1
3	21.9	12.5	3.48	33.8
4	19.7	12.2	3.65	31.7
5	23.0	9.7	3.53	27.7
6	21.0	12.9	3.86	28.8
7	19.4	13.5	3.52	20.9
8	24.1	9.3	4.14	30.0
9	22.7	10.7	4.07	38.0
10	20.9	11.0	3.72	25.6
11	22.8	11.1	3.78	25.2
12	21.7	12.8	4.25	18.0
13	18.6	17.7	3.86	61.6

Scientists are beginning to realize that future progress made by plant breeders on improving the yield of crops such as alfalfa may depend on the selection of morphological and physiological plant characteristics. To date, tremendous increases in yield have been due largely to insect and disease resistance. Researchers at the University of Arizona are looking at plant characteristics such as leaflet size, shape, area, and thickness. They are also determining the relàtionship between these morphological features and the rate which a plant incorporates carbon dioxide. These characteristics are relatively easy to measure, and if they are related to yield, could serve as valuable guides for plant breeders to isolate superior germplasm to include in new cultivars (varieties). This does not mean there will be reduced emphasis on disease and insect resistance. For example, only those alfalfa plants which display the ability to tolerate biotypes of the spotted alfalfa aphid will be used to isolate clones which vary in leaflet size, shape and thickness and these will be used to determine the relationship between such characteristics and yield.

Experiments in Progress

Thirteen plants were selected from an established field of Mesa-Sirsa alfalfa and used to evaluate the range in leaflet width, specific leaf weight (SLW) carbon dioxide incorporation rate (photosynthesis) and yield. Numerous cuttings were made from each of the individual plants which displayed a wide range in leaflet size and shape (Figure 1 and 2). These cuttings were space planted 60 cm apart in the field and after establishment all measurements were made on these field grown plants. At each harvest, stems were cut from the plants and photosynthetic rates (mg CO_2 dm^{-2} hr^{-1}) were measured in the laboratory with an infrared gas analyzer. This instrument can detect a change as small as 0.5 ppm CO_2 in the atmosphere surrounding the plant. Light intensity during measurements in the laboratory was similar to that in the field. Harvests were made six

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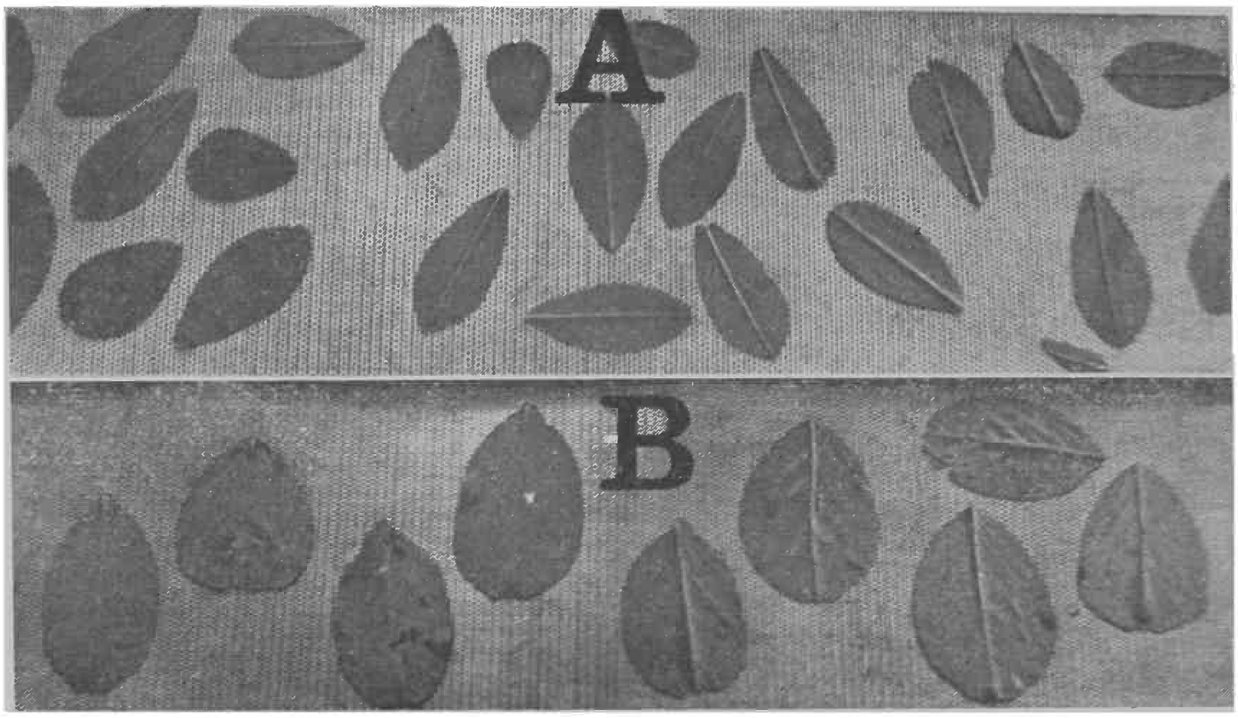

Figure 2. Variation in leaflet size among clones is illustrated by the number of leaflets required to make 60 cm² from clone 2 (A) and clone 13 (B).

times during the growing season and the data presented in Table 1 are averages of all harvests.

Yield and Photosynthetic Rates

Clone 13 produced the largest amount (61.6 g/plant) of dry forage per harvest when averaged over the entire growing season. This clone averaged over three times as much forage per harvest as clone 12 and yielded nearly 40 per cent better than any of the other clones.

Average yield and apparent photosynthetic rate (incorporation of CO_2 of the thirteen clones are compared in Table 1. There was no relationship between the photosynthetic rate (mg CO_2 dm^{-2} hr^{-1}) and yield of alfalfa over the growing season. Yield was high in the spring, dropped 60 per cent by the fourth harvest and remained low for the remainder of the growing season. Photosynthetic rates were highest at the June and September harvests. Correlation coefficients were used to evaluate the relationship between yield and photosynthetic rates of the individual clones. This correlation coefficient was $r = +.05$ which indicated that photosynthetic rate per unit leaf area could not be used to isolate higher producing plants. However, when photosynthetic rate per unit area was multiplied by total leaf area per plant a good relationship was found. Higher yielding clones incorporated more total CO_2. The correlation between CO_2 incorporated per plant per hour and yield was $r = +.93$.

Leaf Width

Clone 13 which had the highest yield also had the widest leaflets. The leaflets averaged 17.7 mm in width compared to clone 2 which averaged 8.2 mm (Table 1). We found a tremendous range in leaflet width which was the selection tool that was used to isolate these clones for this study. Even though leaflet width changed with environment and season we found that the clones maintained their respective rankings regardless of the temperature. Even though our highest yielding clone did have the widest leaflets the low yielding clones did not necessarily have the narrowest leaflets. We did find that leaflet width was useful in predicting the photosynthetic rate of the clones. Those clones which had the widest leaflets incorporated CO_2 at lower rates per unit leaflet area (Table 1 and Figure 3).

Specific Leaf Weight and Yield

Those clones which had the greatest dry weight per unit area of leaf did not yield the best. Specific leaf weight (SLW) Table 1, ranged from 3.52 to 4.47 for clones seven and two, respectively. Clones which had small leaves had a greater SLW which was also expressed as thicker leaves with more cell layers. These thicker leaves usually had much higher photosynthetic rates.

Conclusion

The plant breeder must know what combination of plant characteristics go together to make the ideal alfalfa plant so these factors can be incorporated along with disease and insect resistance into new higher yielding cultivars. We have found a wide range in alfalfa clones for such traits as leaflet size and shape, total leaf area production, and the rate of CO_2 incorporation. Plants which yield more definitely incorporate more total CO_2. It will be difficult and may be impossible to isolate one single plant characteristic which is simple enough to screen thousands of plants and yet give a good indication of yielding ability. However, by building germplasm banks for heritable characteristics such as leaf size, photosynthetic rates and leaf area the breeder can use these to structure the ideal plant.

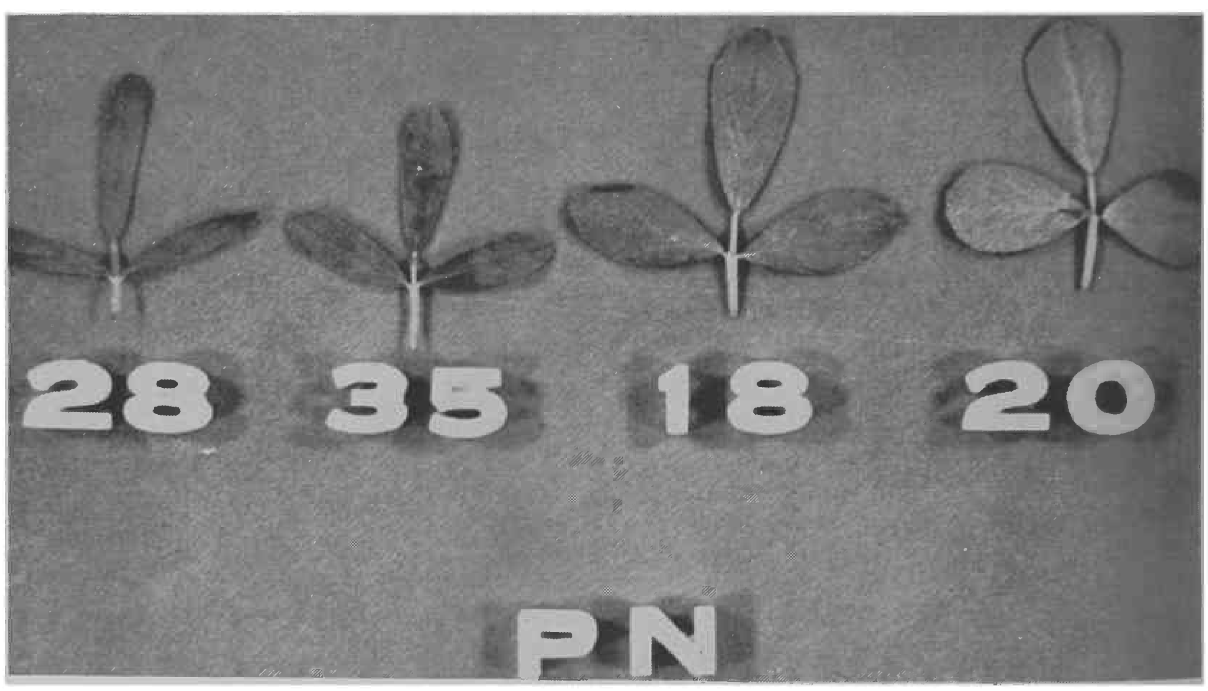

Figure 3. Photosynthetic rates (PN) were much lower for clones that had the largest leaflets.