# Relation of Selected Measurements to Weight Of Crested Wheatgrass Plants[1]

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One of the most useful criteria for judging the condition of grassland is herbage production. A common way of determining production is by clipping herbage on sample plots. Though this method is considered the most accurate, it has two serious disadvantages: (1) It is time consuming, and (2) it affects the vigor, growth, and physiological processes of the plant.

Clipping often causes long-lasting damage to perennial bunchgrasses growing under arid or semiarid conditions (Parker and Sampson, 1931; Lang, Barnes and Rauzi, 1956). Consequently, different plots should be clipped each year. This procedure introduces a great deal of variation and requires a large sample.

An ideal method from the standpoint of both range and watershed management, would provide for a continuous measurement of changes in herbage weight during periods of rapid and slow growth as well as dormancy. Such measurements would not cause changes in soil or vegetation. The herbage capacitance meter developed by Fletcher and Robinson (1956) solves this particular problem. Unfortunately, the capacitance meter does not separate production by species. It measures only the plant mass (grass, weeds, and brush combined) on a given area. Moreover, moisture content of plants and soil may affect the measurements. A more promising approach, one that is less subject to these outside variables, is the measurement of individual plants.

Many range technicians have considered using height as an index of gross volume or weight. The widely used height-weight and height-volume tables are based on this assumption. Several investigators (Caird, 1945; Clark, 1945) have shown that the weight of an individual grass plant is not strictly a function of height but rather a function of several variables, depending on

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growth form. Growth form of individual crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult.) plants has been shown by the author[3] to vary widely according to site conditions.

Studies were conducted on crested wheatgrass at three areas in New Mexico in 1957 to seek relationships that would permit a range manager to determine herbage production from measurements of individual plants. Since weight of individual plants is correlated with volume, linear measurements related to volume can be correlated with individual plant weight. This will indicate the relative merit of each measurement individually and in association with others as it affects plant weight.

## Description of Study Areas

Laguna Seca experimental pastures were about 40 miles northwest of Cuba, New Mexico, at an elevation of 7,400 feet. The long-time average precipitation approximates 16.5 inches but in 1957, the year of this study, the total annual precipitation was 22.7 inches. Before 1957, cattle grazed the area to an average of 20 percent utilization by weight, an amount considered to be light grazing.

Experimental pastures at the No Agua site were located 5 miles north of Tres Piedras, New Mexico, at an elevation of 8,300 feet. No Agua has an average annual precipitation of 13.3 inches; in 1957 it was 18.7 inches. Before the study, the pastures had been grazed by cattle in the spring at average utilization rates of 0 (none), 34 (light), 67 (medium), and 80 (heavy) percent.

The Cebolla Mesa experimental pastures were 20 miles north of Taos, New Mexico, at an elevation of 7,450 feet, with an average annual precipitation of 12.5 inches. In 1957 annual precipitation was 18.3 inches. Spring grazing by cattle before the study averaged 0 (none), 40 (light), 54 (medium) and 70 (heavy) percent utilization.

## Methods

Data were collected in each pasture at all three study locations during the growing season (June and July) of 1957. Linear measurements, accurate to the nearest .2 inch, were made on 923 ungrazed crested wheatgrass plants as follows:

1. Basal diameter
2. Crown diameter
3. Leaf height
4. Culm height
5. Compressed crown diameter
6. Compressed leaf length
7. Compressed culm length

The first four measurements were taken on undisturbed plants in their natural field condition. Basal diameter measurements of the plants were taken near ground level (Figure 1). Crown diameter, leaf height, and culm height were measured on undisturbed plants in their natural field position. Other measurements were taken after foliage and culms were compressed and raised to the maximum vertical position and grasped together by hand at average leaf height (Figures 2 and 3). After measurements were taken, each plant was clipped at ground level, oven dried and weighed to the nearest hundredth of a gram.

FIGURE 1. *Basal Diameter.* Diameter of the base of the plant was taken near ground level.

FIGURE 2. *Compressed Crown Diameter.* Diameter of the compressed crown was measured midway between tallest and shortest leaf collars.

Correlations (Goulden, 1956) of weight with all seven variables were computed by individual study areas or sites, individual pastures within sites, four intensities of use and overall or combined sites. Multiple correlations involving the best independent variables were then computed.

## Results

Intensity of past use had no apparent effect on the ranking of the correlation coefficients of plant measurements with weight of individual plants. When intensities of use were combined for all locations, there was less variation in the correlation coefficients than between different uses within a site.

Site also had no apparent effect on the ranking of correlation coefficients between plant measurements. There was some variation between values for pastures within an area, but when all pastures were combined variations balanced out. This was

[3] *Unpublished master's thesis, Uni. of California, 1958.*

**Table 1. Plant measurements ranked according to the sequence of their correlation with oven-dry plant weight by pasture, intensity of use, individual and combined location.**

| Location | Grazing use | Relative rank | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
| Laguna Seca | Light | CCD* | BD | CD | CLL | LH | CCL | CH |
| No Agua | None | CCD | BD | CD | CLL | LH | CCL | CH |
| | Light | BD | CCD | CLL | LH | CCL | CD | CH |
| | Medium | CCD | BD | CD | LH | CLL | CH | CCL |
| | Heavy | BD | CCD | CD | LH | CLL | CH | CCL |
| Cebolla Mesa | None | CCD | BD | CD | CLL | LH | CCL | CH |
| | Light | CCD | BD | CD | CLL | LH | CCL | CH |
| | Medium | BD | CCD | CD | CLL | CCL | CH | LH |
| | Heavy | CD | CCD | BD | CH | CCL | CLL | LH |
| No Agua | All Uses | CCD | BD | CD | CLL | LH | CCL | CH |
| Cebolla Mesa | All Uses | CCD | BD | CD | CLL | LH | CCL | CH |
| Combined locations | All Uses | CCD | BD | CD | CLL | LH | CCL | CH |

* Plant measurements were basal diameter (BD), crown diameter (CD), compressed crown diameter (CCD), leaf height (LH), compressed leaf length (CLL), culm height (CH), and compressed culm length (CCL).

also true when all three study locations were combined.

Values of individual measurements were ranked according to the numerical sequence of simple correlation coefficients with ovendried plant weight (Table 1). There were slight differences in the ratings of measurements between pastures and intensities of use. When either pastures or sites were combined, the relative rank of plant measurements in their contribution to weight was always in the order of: (1) Compressed crown diameter, (2) basal diameter, (3) crown diameter, (4) compressed leaf length, (5) leaf height, (6) compressed culm length, and (7) culm height.

Simple correlation coefficients between measurements of compressed and uncompressed plants were extremely high because of the close relation between the two values. Compressed measurements always gave higher correlation coefficients with plant weight than uncompressed measurements.

When all the independent variables were combined, a multiple correlation coefficient of 0.924 was obtained. Thus, 85.4 percent of the variation in individual plant weight was accounted for by these seven measurements.

Culm measurements, which had the lowest correlations, were eliminated. Crown diameter and leaf height were eliminated because: (1) Their dependence with the compressed measurements, and (2) their lower correlation values. This left basal diameter (which remains unchanged with compression), compressed crown diameter and compressed leaf length. Multiple correlations between these measurements and plant weight were computed for combinations of any two and for all three with the following results:

| Plant Measurements | Correlation Coefficient (R) | Portion of variation in weight accounted for ($R^2$) Percent |
|---|---|---|
| CCD & CLL | 0.918 | 84.3 |
| BD & CLL | 0.882 | 77.8 |
| BD & CCD | 0.874 | 76.4 |
| BD, CCD & CLL | 0.922 | 85.0 |
| All 7 variables | 0.924 | 85.4 |

On the basis of these relationships, the three measurements; basal diameter, compressed crown diameter, and compressed leaf length, provide an estimate of plant weight nearly equal to all seven combined measurements. Compressed crown diameter and compressed leaf length in combination were almost as good in this study, but might be expected to have less reliability under different conditions.

The following regression equation best represented the data: $Y = -26.240 + 2.148 X_1 + 22.872 X_2 + 1.900 X_3$ where Y = oven-dry weight of plant material

$X_1$ = basal diameter

$X_2$ = compressed crown diameter

$X_3$ = compressed leaf length

Evans and Jones (1958) accounted for 28.9 to 97.6 percent of the variability in yield on mixed annual ranges, using the product of plant height and ground cover. Hurd (1959), working with Idaho fescue and using leaf height, basal area, and number of flower stalks, accounted for 86 to 94 percent of the variability in plant weight.

## Summary

During the 1957 growing season, 923 crested wheatgrass plants were measured, clipped at ground level, oven dried, and

FIGURE 3. *Compressed Leaf Length.* Length to the tallest leaf collar after the foliage and culms are raised to the maximum vertical position and grasped together at average leaf height.

weighed. Linear measurements taken were basal diameter, crown diameter, leaf height, culm height, compressed crown diameter, compressed leaf length, and compressed culm length. Simple and multiple correlations were then calculated to determine the relative contribution of each measurement individually and in combination with others as it affects plant weight. Conclusions are as follows:

1. Intensity of past grazing use had no effect on the ranking of correlation coefficients between yields and each of the linear measurements.

2. Area or site conditions had no effect on the ranking of correlation coefficients.

3. Measurements of compressed plants were much more closely correlated with plant weight than those of uncompressed plants.

4. The combined seven measurements accounted for 85.4 percent of the variability in plant weight.

5. Measurement of basal diameter, compressed crown diameter, and compressed leaf length provides an estimate of plant weight nearly equal to that obtained from all seven measurements. Also, compressed crown diameter with compressed leaf length accounted for 84.3 percent of the variability in plant weight.

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