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Residue Characteristics for Wind and Water Erosion Control

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Résumé
Les résidus sur pied fournissent un moyen efficace de lutter contre l'érosion et de prévenir le soulèvement de la poussière dans les zones sujettes à l'érosion éolienne. Dans les climats nordiques, le chaume sur pied retient la neige et prévient la perte d'humidité causée par le vent, et dans les régions touchées par l'érosion hydrique, la couverture végétale résiduelle assure efficacement la protection du sol. La tige est la partie aérienne de la plante la plus efficace et la plus durable dans la lutte contre l'érosion. Il existe des différences considérables en ce qui a trait à la quantité et au diamètre des tiges, ainsi qu'à la surface projetée par unité de masse, entre les diverses cultures et entre les variétés d'une même culture. Nous avons mené une étude visant à établir la relation qui existe entre la masse de couverture résiduelle par hectare et chacun des facteurs suivants : rendement des cultures, quantité de tiges et de la couverture résiduelle, et surface des tiges par unité de masse, dans le cas de produits céréaliers communément cultivés sur les terres non irriguées de la côte nord-ouest des États-Unis. Le présent article fournit des données relatives à des cultures particulières et traite de l'impact de celles-ci dans la lutte contre l'érosion.

Abstract
Standing residue is an effective means of controlling erosion and preventing dust emission in areas prone to wind erosion. In northern climates, standing stubble retains snow deposits and prevents loss of moisture from removal by wind, and in areas affected by water erosion, surface residue is an effective means of protecting the soil. The most effective and durable aerial portion of the plant for preventing erosion is the stem. Considerable difference in stem quantity, diameter, and projected area per unit mass exists among different crops and different varieties of a particular crop. We conducted a study to obtain relationships between mass of surface residue per ha as a function of crop yield, portion of stem and surface residue, and stem area per unit mass for cereal crops commonly grown on the Pacific Northwest US dry-farmed cropland. Data for specific crops and implications for erosion control are presented.

Introduction

Wind and water erosion are both problematic on dry-farmed cropland of the Pacific Northwest US, a major cereal producing area. Surface residue is a major factor in preventing and controlling both wind and water erosion. Surface residue after seeding fall cereals is especially important in areas dominated by winter hydrology.

Standing and upright or anchored residue is important in preventing wind erosion. Following cereal harvest, the most important component for erosion prevention is the plant stem. It is the largest and most durable component of the residue, making up from 40 to 80% of the residue of small grains. Leaves and chaff are less durable and more prone to loss and relocation by wind.

We need to know the mass of stems, and their mass and area characteristics in order to plan conservation systems that will adequately control erosion. The purpose of this paper is to report a project in which we collected samples and developed a set of properties and characteristics of typical small grain residue, particularly stems, which can be used in water and wind erosion models such as RUSLE2, WEPP, and WEPS.

Background

Data separating above ground crop biomass into residue and grain portions has been collected for some time. In 1963, Vogel et al. presented data on residue to grain ratio (R/G) for semi-dwarf and tall winter wheat grown in eastern Washington. Semi-dwarf varieties were up to 89 cm tall, with R/G from 1.5 to 1.7, and a mean of 1.6. Tall varieties were up to 132 cm tall with R/G from 1.9 to 3.0, and a mean of 2.4. Yields ranged from 3.77 to 5.31 Mg ha^{-1} for the semi-dwarf and 2.82 Mg ha^{-1} for the tall varieties. Engle et al. (1984), in an extension bulletin, indicated the following typical values for R/G ratios: short straw wheat - 1.7, long straw wheat - 2.0, and barley - 1.4. McClellan et al. (1987) collected a large data set that indicated R/G ratio to be related to yield; R/G decreased as yield increased.

Residue partitioning data are more limited than R/G data. McClellan et al. (1987) presented residue partitioning data. In a three-year study, winter wheat residue was found to be about 33% chaff and awn and 67% straw. Spring wheat residue was 38% chaff and awn and 62% straw. Spring barley was about 28% chaff and awn and 72% straw. Winter barley was about 22% chaff and awn and 78% straw. Collins et al. (1990) partitioned Daws winter wheat samples collected in 1984 and 1985. Residue was found to consist of 37% stems, 30% leaf sheath, 20% chaff and 13% leaf blades. Andersen et al. (1983) partitioned barley plants at maturity in a one-year experiment. The barley was 52% seed, 38% straw, and 10% glume.

A relationship between fraction of ground cover of randomly distributed residue, the ratio of projected area to the mass of individual pieces of residue, and the mass per unit area of residue was developed by Gregory (1982).

$$F_c = 1 - e^{-A_m M}$$

Where F_c = fraction of soil covered
A_m = Area covered by one average straw per mass of one average straw (ha kg^{-1})
M = Mass per unit area of ground surface (kg ha^{-1})

Gregory quoted values of A_m for complete samples of wheat residue of 0.00054 and 0.00045 ha kg^{-1}. The latter value was from baled wheat straw. Greb (1967) measured only plant stems and found values of A_m for winter wheat and spring barley of 0.00027 and 0.00043 ha kg^{-1}, respectively.

Experimental Procedure and Results

Data for this paper were obtained from three different projects. The first was an extensive field collection that yielded the data reported by McClellan et al. (1987) dealing primarily with residue versus yield. A linear relation of residue versus crop yield was tested and then used in this analysis. The units for residue and yield are both in weight per unit area. The general form of the linear regression equation is:

Residue Yield = S x Grain Yield + I
(Where S is the slope of the line and I is the intercept)

When grain and residue yield are in kg ha^{-1} we found values of S and I to be 1.1232 and 1044 for winter wheat, 0.7826 and 1671 for winter barley, and 0.6799 and 1180 for spring barley.

Small grain partitioning data were developed from samples collected in the field at crop maturity in 1990 and 1992. All samples were harvested at crop maturity by standard sampling techniques. The dried samples were hand-separated into stem, leaf, and chaff components. The percent mass of stem, leave, and chaff were 57, 20, and 23% for winter wheat, 64, 20 and 16% for winter barley, and 56, 24, and 20% for spring barley.

Small grain samples for the area/mass analysis were also collected in 1990 and 1992 in conjunction with the partitioning project. Stem samples were stripped of leaves, separated by lengths, and cut into 15.24 cm segments, starting from the base of the plant. The segment samples were kept separate and analyzed by height from the ground. The samples were laid separately (no overlap) on trays and stem area was obtained using an image analyzer. Values of A_m were 0.00024 for winter wheat, 0.00032 for winter barley, and 0.00031 ha kg^{-1} for spring barley. These values are quite similar to those reported by Greb (1967) for small grain stems.

Discussion and Conclusion

The data presented in this paper enable one to estimate stem area per unit land area based on crop type and yield. For example, if winter wheat yield were 6725 kg ha^{-1}, total residue would be 8598 kg ha^{-1} (1.1232 x 6725 + 1044), and stem mass would be 4901 kg ha^{-1} (.57 x 8598). Using the equation of Gregory (1982), presented previously, a ground cover of stems of 69% is calculated.

The results provide a means to estimate stem mass, area to mass parameter, A_m, and finally total stem area per unit land area as a function of crop yield for cereal crops grown on Pacific Northwest US dry-farmed cropland. Use of stem mass and stem cover or projected area would provide more consistent results in wind and water prediction of estimation methods, but would require recalibration of surface effect relationships.

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