

Foliar Silica Application and Lodging Resistance of Oats¹

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Zusammenfassung

Die biologisch-dynamische Landwirtschaft braucht unter den von ihr verwendeten speziell behandelten Substanzen pflanzlicher und tierischer Herkunft, den Präparaten, die Substanz Hornkiesel «501», die auf wachsende Pflanzen ausgebracht wird.

Eine experimentell erfassbare Wirkung des Hornkiesels wird in der vorliegenden Arbeit beschrieben. Zu diesem Zwecke wurde während des Wachstums von Haferpflanzen wiederholt Hornkiesel in einer Konzentration von 40 bis 50 g/ha aufs Blatt gesprüht. Neben direkter Beobachtung wurde einerseits ein Faktor cL_r gemessen, der ein Mass für den Widerstand des einzelnen Getreidehalms gegen Lagern darstellt. Solches Lagern kann zum dauernden Umfallen der Halme führen und beeinflusst damit Erträge von Korn und Stroh weitgehend. Andererseits wurde der Kieselgehalt der Halme bestimmt.

Verglichen wurde der Einfluss von Hornkiesel bei zwei in der Gesamtgestalt ähnlichen Hafersorten, «Rodney» und «Au Sable». Bei der mehr zum Lagern neigenden Sorte «Rodney» wurde durch Hornkiesel der Widerstand gegen Lagern sowohl unter Freilandbedingungen als auch beim Wachsen der Pflanzen in einer Klimakammer signifikant angehoben. Die Sorte «Au Sable» zeigte diese Beeinflussung unter Freilandbedingungen nicht.

Der absolute Gehalt der Halme an Kiesel scheint unter Freilandbedingungen sowohl wie unter kontrollierten Wachstumsbedingungen nicht angehoben durch Anwendung des Hornkiesels. Ein hoher cL_r Faktor geht aber parallel mit höherem Kiesekgehalt unter Freilandbedingungen. Entsprechende Erniedrigung des Kieselgehalts und des cL_r Faktors werden unter Klimakammerbedingungen beobachtet.

Diese Ergebnisse werden diskutiert von dem Gesichtspunkt aus, dass Kiesel in den Pflanzen vorkommt als ein Strukturelement einerseits und andererseits in mehr dynamischer Form dergestalt, dass die Differenzierungsvorgänge der Strukturen im wachsenden Halm beeinflusst werden können.

Abstract

Lodging resistance determined by the lodging resistance factor cL_r of two oat (*Avena sativa*) cultivars "Rodney" and "Au Sable" correlated with the silica content of the plants grown under different conditions. Foliar applications of silica (biodynamic preparation 501) during growth at a rate of 40 to 50 g per ha enhanced the lodging resistance factor cL_r of the more lodging prone cultivar „Rodney“ under field as well under controlled environmental conditions.

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Small grain lodging, which results in permanent displacement of cereal plants from the upright position, is a serious problem in many parts of the world. Lodging affects further growth of plants and grain yields by lowering the availability of light for photosynthesis and by increasing humidity close to the soil surface, which fosters plant pathogens. Losses often amount to 30% of grain yields (*Pinthus, 1973*).

Often a genetic approach to reduce lodging has been taken. Grain yields have risen with the reduction in stem height and with higher amounts of nitrogen supplied, but under some conditions, lodging is still a limiting factor. Lodging resistance remains an exceedingly complex phenomenon involving the interactions of the environment and of plant height, ear size and weight, stem diameter, stem structure, cell wall structure, etc.

An alternative approach to diminish the degree of lodging takes advantage of the plasticity of the plant phenotype. Thus by modifying the mechanical properties of the cereal stem it is possible to diminish stem lodging. The phenotype of cereals can be changed by shortening the internode length of culms by anti-gibberellins, such as CCC, 2-chloro-ethyl-trimethyl-ammoniumchloride (*Wittwer and Tolbert, 1950*). This compound is extensively used in Western Europe, but has not been released for use on grains in the United States. When applied to growing plants, it is reported to be incorporated into seeds thereby inducing responses in the following generation(s) (*Pinthus, 1967*).

Nutritional factors, such as silicon (Si) uptake from the soil-solution can also influence lodging resistance (*Jones and Handreck, 1967*). The physiological importance of the presence of silicon in higher plants is far from clear. It is likely to play structural roles. In one study lodged oats are reported to contain 0.19% silica (SiO_2) and erect oats 0.71% based on dry weight (*van der Paauw, 1967*). It appears that increased uptake of orthosilicic acid (monosilicic acid) ($\text{Si}(\text{OH})_4$) and increased mechanical strength of oat internodes, which results in increased resistance to lodging, can be achieved by increasing the amount of soluble silicon in the form of sodium metasilicate in culture vessels (*Jones and Handreck, 1967*). For certain members of the grass family, use of silicon as a soil amendment is of economic importance. In Japan one million tons of slag, which is a source of silicon, are applied each year to rice paddies (*Silva, 1973*). Reported benefits include resistance to lodging, openness of the leaves (affecting photosynthesis in dense stands), water use (reduction in transpiration up to 30%), reduced susceptibility to pests and diseases and improved phosphorus and nitrogen use (*Yoshida, 1975*). In Hawaii, sugarcane yields on silicon-deficient soils are enhanced after calcium silicate applications, presumably due to the reduction of phosphate sorption by these soils (*Silva, 1971*), or to alleviation of iron, aluminium or manganese toxicities (*Clements et al., 1974; Plucknett, 1972; Roy et al., 1971*). Similar increases in yields have been reported from cane fields in Florida (*Gascho, 1976, 1977*). However these rates, in the range of tons per ha, of silicon application are rather high. Recently a remarkable observation of the effects of foliar application of silica (biodynamic preparation 501) has been reported (*Abele, 1973*). Silica applied to the tops of growing spring wheat, brought about an increase in the mechanical strength (breaking strength) of the first internode of mature culms. This finding may be of considerable economic interest as only 30 g of silica per ha were used. This is a reduction by a factor of about 10^6 compared to the above mentioned paddy and sugarcane applications.

Silicon has some attractive features as an "agrochemical", as it has been present in substantial amounts throughout evolution so most biological systems are probably well adapted to it. Silicon is the second most abundant element on earth and its compounds