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The Degree of Maturity Determines the Cutting Length

For the first time, maize plant maturity can be measured during harvest with a photo-optical sensor which determines the colour of the harvested crop as it is fed into the chopping unit. Based on this a control electronics system calculates ideal crop cutting length. The speed of the hydraulically driven pre-compression rollers is automatically adjusted to the crop maturity level. This completely new feature makes it possible for Krone Auto-Scan to improve basic fodder quality.

Until now it has not been possible to adjust the cutting length automatically to the degree of maturity under changeable conditions. Dry (brown) maize should be cut short to allow for better compaction in silo storage. Moist (green) maize should be cut longer so that the forage is not „mashed“ and thus retains the appropriate structure. The effect of cutting length on maize silage is also the subject of numerous current research projects (for example [1, 2]).

The experience of the authors using opto-electronic components in agricultural technology [3, 4] has led to the development of the „AutoScan“ system [5, 6]) for online measurement of the degree of maturity. In this way, the cutting length can also be optimally adjusted to large surfaces with different soils. That in turn ensures fodder quality will be maintained.

Measurement principle

The measurement principle is based on the known spectral reflective behaviour of plants. *Figure 1* shows a measured spectrum of a „green“ and a „brown“ blade of maize. The increase above 700 nm, characteristic for green plants, decreases as the level of maturity increases. With „brown“ maize plants on the other hand, similar values are spread over a very wide spectral range from approximately 650 nm to 900 nm. As in the definition of NDVI (Normalised Difference Vegetation Index) as a measure of physiological activity of plants, two selective wavelengths can be selected to determine the level of maturity. Thus the ratio of the wavelengths marked λ_1 to λ_2 in *Figure 1*, for example, is ideal for this purpose.

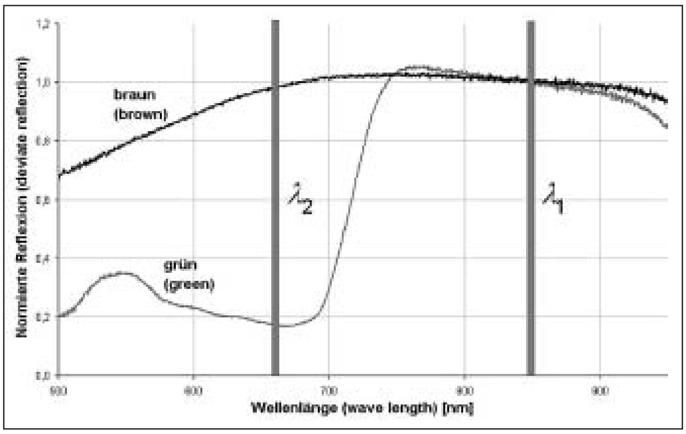

Fig. 1: Typical spectral response of a „green“ and a „brown“ maize plant. The measurement of selective wavelengths - e.g. λ1 and λ2 - makes it possible to measure degrees of maturity.

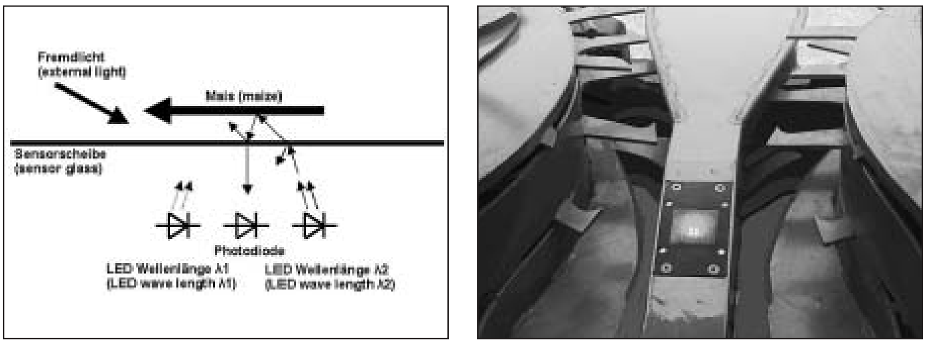

Fig. 2: Principle of measurement for determining the degree of maturity for maize (left) and integration of the sensor system into the maize header of the BiG X forage harvester (right)

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Keywords

Photo-optical sensor, degree of maturity, cutting length

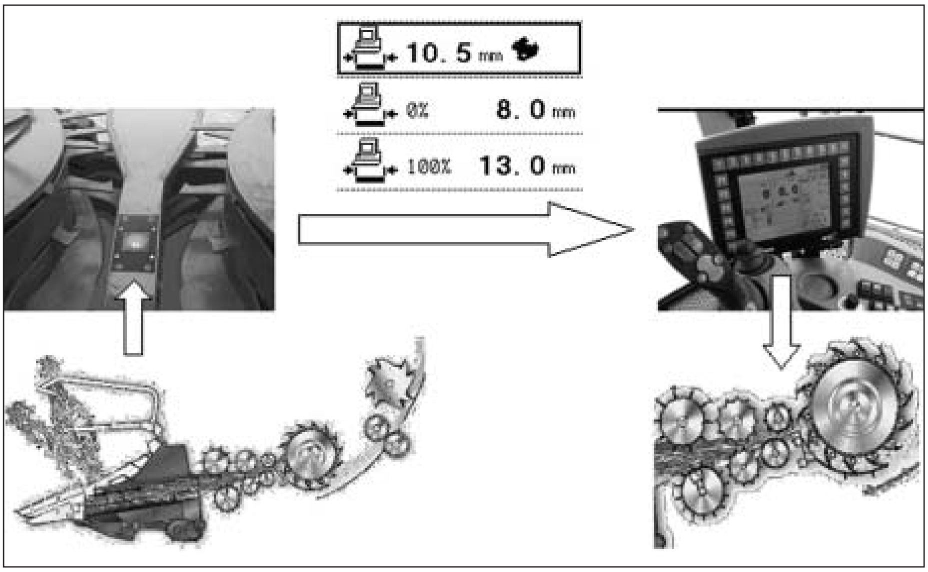

Fig. 3: System integration of the AutoScan sensor

Practical requirements for implementing the measurement principle are:
- Measurement position in the maize header
- Contact behaviour of the maize plants
- Feasibility of optical measurements in the maize header (interfering factors such as sunlight)
- Dynamic punctual measurement for two (or more) wavelengths
- Filtering interference signals (examples: no plants, sunlight)
- Averaging procedures

AutoScan

Figure 2 shows a diagram of the „AutoScan“ sensor system as implemented. The maize is guided by an optically transparent sensor glass. The „self-cleaning“ effect of the surface by the maize plants is utilised. Light sources (LEDs) are operated by pulse, which makes it possible to eliminate interfering factors. Relative measurements of selected wavelengths are performed. Since the absolute values are independent, deviations in signals are not particularly noticeable.

System integration

The sensor (see Fig. 2, right) on the maize header automatically determines the current maturity states of the maize plants by colour comparison:
- Dark green: moist plant
- Brown: dry plant

The sensor is able to distinguish any different levels of maturity (and thus dry weight contents) between these two colours by means of an electronic algorithm. A corresponding dry matter content of the plant is assigned to each colour state. Corresponding cutting length gradations are in turn stored for each dry matter content between two selectable minimum or maximum lengths.

Figure 3 shows the closed effective chain of the AutoScan sensor. By assigning minimum and maximum cutting lengths, the AutoScan control electronics system calculates the optimal chop length for the corresponding maize plants within the „corridor“ specified by the driver. The speed of the hydraulically driven pre-compression rollers can be adjusted accordingly. This in turn automatically changes the cutting length.

Field trials

The measurements demonstrate (see the example in *Fig. 4*) that based on the self-cleaning effect and signal filtering processes, a quantitative optoelectronic measurement of the degree of maturity can be performed in the maize header.

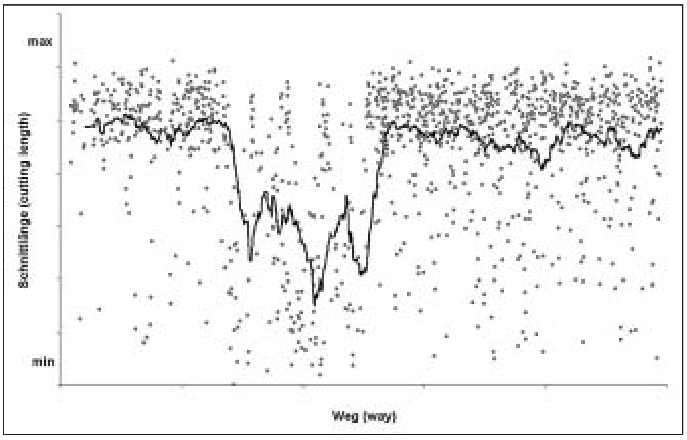

Fig. 4: Measurement results in a primed heterogeneous crop

Summary

AutoScan has been tested successfully in initial field trials. Optimising cutting lengths means ultimately reducing financial risk through better silage fermentation quality and optimised structure of the basic fodder. The quality of the basic fodder is considerably improved, which in turn has beneficial results on animal performance.

The advantages of AutoScan are:
- Automatic online detection of maturity states in maize
- Automated sequence and optimal adjustment of cutting length
- More „stable“ silage
- Automatic optimisation of fodder structure
- Electronic documentation (combined with GPS)
- Less work for the driver

Literature

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