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Plant Discrimination with Optical Sensors

It is possible to save further quantities of chemical pesticides in weed control by using sensors operating on an optical basis to distinguish between plants and soil. Field sprayers equipped with such sensors only apply spray ingredients selectively in places where weeds are to be found. However, their use has so far been restricted to areas on which there are not yet any useful crops. However, if such systems can distinguish between two different types of plants, they can also be used after field emergence. A further-developed system for site-specific weed control which can discriminate between plants is presented.

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Even at the threshold of the third millennium, agriculture cannot do without chemical weed control. However, spray ingredients should now only be applied in places where there are weeds which exceed certain damage thresholds. This calls for plant recognition, which is possible with the aid of opto-electronic sensors on-line. Such a system available on the market (Deflect spray® [1]) has been further developed at the Institut für Betriebstechnik (Institute for Farm Technology) for safe and easy use [2]. However, since such a system can only discriminate between soil and green plants, it has so far only been possible to use it on black fallow land, zero-tillage areas before crop emergence, or between rows of field crops sown in broad rows. Before each application, such a system is set to weed-free soil (zero point setting) and a threshold value is then adjusted (in accordance with the green component of the weeds within the field of vision of the sensor considered to be critical). It is also possible to compensate, for example, via a maize row or a weed-free crop. If additional green appears in the field of vision, a spray impulse is then triggered. The possibility of gaps in the row of maize being occupied by weeds is not recognised here, however. Safe use under such conditions or use in crops which have already emerged necessitates the ability to discriminate between plants.

Background

Reflection measurements on various plants have been the subject of research with a variety of objectives for decades now. A corresponding number of publications is available, only some of which are mentioned here. They consider, for example, changes in the reflection properties over the growth period [3, 4, 5, 6], or with different degrees of water supply [7, 8]. Some studies compare the reflection of different useful plants and weeds [9, 10, 11]. All the publications, including those not mentioned here, show in some cases clear differences in the reflection curves of different species and the growth period, which indicates that these can be used for plant discrimination [9, 12, 13, 14].

If one considers, for instance, the reflection curves of a sugar beet and four different weeds (fig. 1), it is possible to see that depending on the wavelength of the ambient

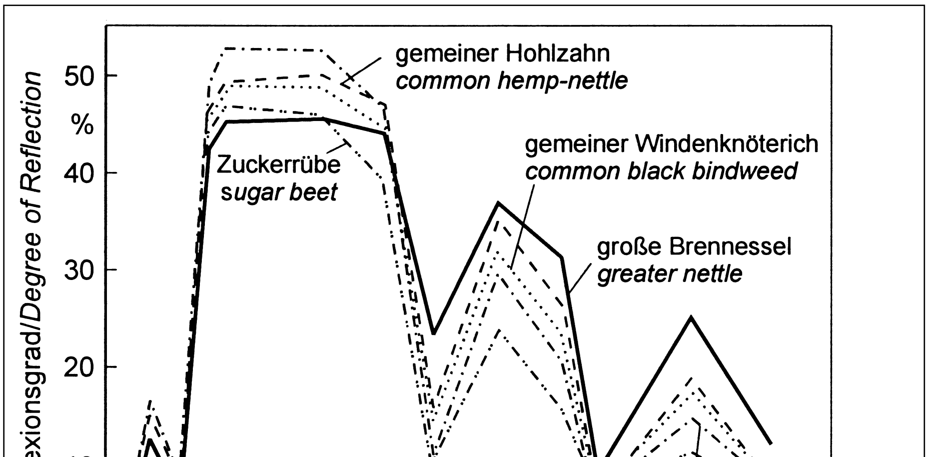

Fig. 1: Reflection of one useful plant and of four weeds

light, the sequence of intensity of the reflection is reversed in some cases, for instance in a comparison between nettles and black bindweed, before and after the water absorption bandwidth at 1.45 µm. This facilitates the discrimination of these plants on the basis of their reflection properties.

Plant discrimination with optical sensors

Making use of this fact, in 1997 a sensor was built up at the Institut für Betriebstechnik which measures the reflection of the ambient light of initially five selected wavelengths between 400 and 2500 nm. This sensor was used to measure the reflection of initially six different weeds and four crop plants. The results for winter grain and four weeds are set out in figure 2.

At the same time a programme was developed with which the various plants can be identified and displayed after certain boundary values or ranges have been entered. Figure 2 shows these limits (wavelengths λ_A = 85% and λ_E = 50%) as an example for two weeds. If the reflection value for wavelength λ_A is above the boundary value selected for it, then in this example the weed speedwell is in the field of vision of the sensor and, by analogy with this, the weed creeping thistle if λ_E is lower than 50%. In all other cases the sensor sees the crop plant or another weed, for which a condition can also be stated. If there are clear differences in the reflection in more than one measuring area, this five-eye sensor can also discriminate between more than four weeds by linking information from the five wavelength areas. Thus under ideal conditions (only one plant species under the sensor), three useful crops (sugar beet, maize and winter barley) as well as the weeds creeping thistle, speedwell, camomile, chickweed and darnel can be discriminated on-line. Sandy soil and wheat straw can also be distinguished.

Summary and prospects

At the Institut für Betriebstechnik und Bauforschung (Institute for Farm Technology and Construction Research) a sensor which measures the reflection of the ambient light from plants in five wavelength ranges is used. Laboratory tests show that under ideal conditions this allows on-line discrimination of various crop plants and weeds, if they show significant differences in at least one wavelength range. The advantage of such a method lies in the simple programming of the discrimination algorithm, since only boundary values need to be compared with current measurements. Work is currently in progress on converting this to practically oriented conditions. Thus, for example, the sensitivity of the original system has been improved by a factor of 30. Once this has been completed, an instrument will be available which permits target-oriented weed control even after field emergence. This would expand the use of opto-electronic systems in chemical plant protection and enhance the degree of acceptance among farmers.

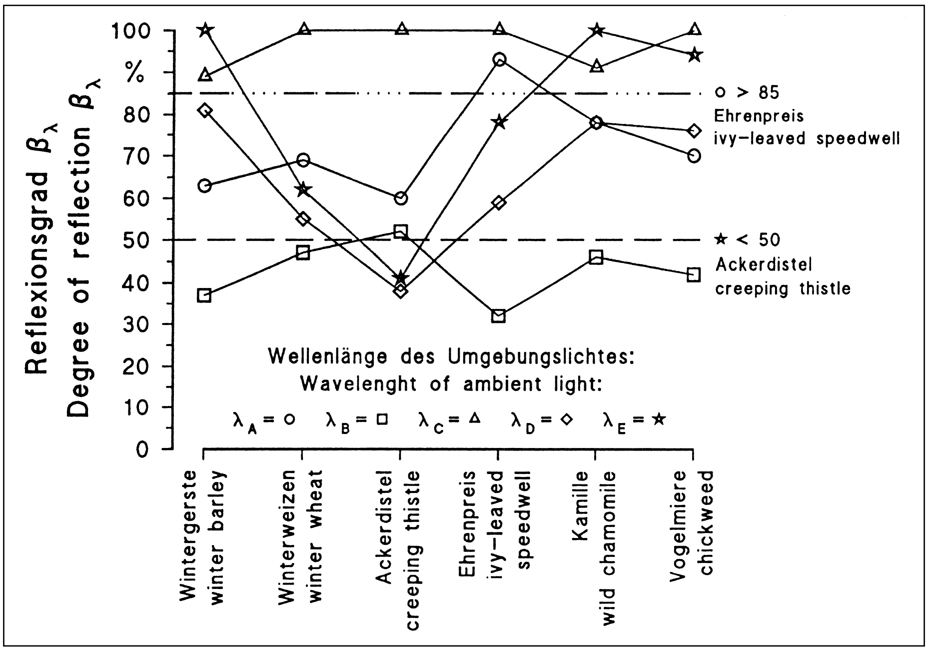

Fig. 2: Reflection of winter grain and of four weeds in five selected wavelenghts of the ambient light

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