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Mechanical Weed Control Measures

Technical Options for Improving Effectiveness

Economic and ecological constraints motivate the search for alternatives in conventional chemical weed control. Mechanical weeding has positive and negative effects. One major disadvantage is the large proportion of non-weeded space close to the cultivated plants. Possibilities for improving this are discussed.

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Keywords

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Mechanical weed control is both an alternative and a supplement to chemical weed control. From the point of view of plant cultivation, weed plants are serious competitors for sugar beets. First, the juvenile development of sugar beets is slow; second, crop density is rather low at 7-10 plants per m^2, which means that the canopy is late to become dense and that weed growth is promoted. This circumstance is also responsible for the high share of herbicide costs in variable costs (up to 40%).

Compared with chemical measures, mechanical weed control is characterised by a number of positive as well as negative effects, the assessment of which depends on subjective preferences.

- The saving of herbicides is to be welcomed from an economical and environmental point of view.
- the breaking of crusts, water capillaries are severed so that the evaporation of water is reduced.
- Soil loosening or aeration lead to a mobilisation of nutrients in the soil.
- On the one hand, hoeing is less weather dependent (no plant damage due to sunshine, etc). On the other hand, to prevent structural damage the soil must be dry.
- Subsequent weather conditions exert a decisive influence on the success of the measure: in the case of rainfall, weeds plants tend to take root again, and the number of weed plants may actually increase by vegetative propagation. Moreover, light stimuli may cause weed seeds to germinate.
- Poor process quality can impair beet growth.

Difficulties

In principle, the acceptance of mechanical weed control depends on its preventing the cultivated plant from damage and on the reliability with which it eradicates weeds on as large a proportion of the soil as possible. These two demands exert a negative influence on each other: the closer the ground-engaging equipment is brought to the cultivated plant, the greater the risk of plant damage is (pulling out, cutting, covering). Thus, pro-

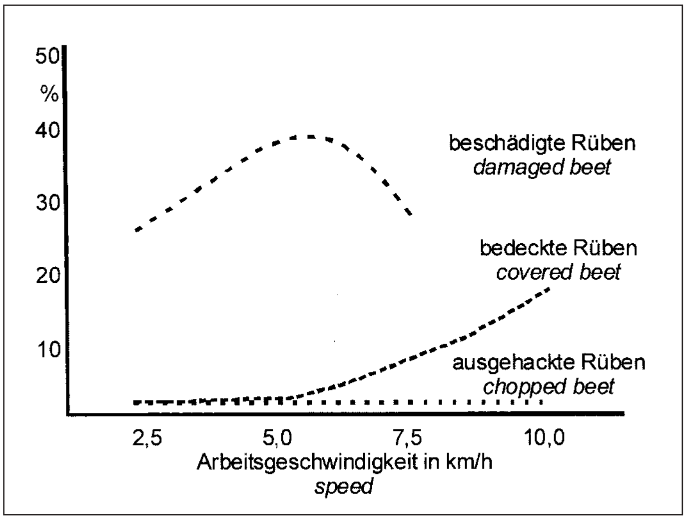

Fig. 1: Effect of driving speed on work quality of hoes ([2] modificated)

Table 1: Traditional methods for hoe set-up

adjustment to the soil	—> parallelogramm suspension with a depth wheel
flat tillage	—> rigid tines
tillage with mulch	—> spring tines
	—> vibro tines
protection of big plants	—> cutting blade
protection of small plants	—> concave protection discs

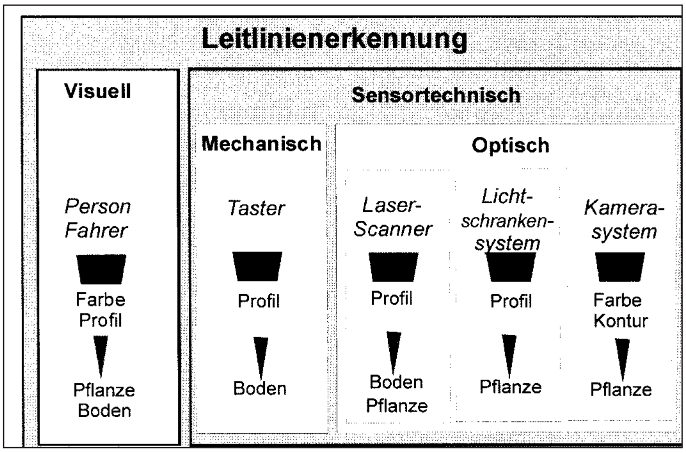

Fig. 2: Methods for recognising follow lines

cess quality is dependent on travelling speed (*Fig. 1*), tool selection and the precision with which hoeing units are controlled and steered.

At present, even assuming an optimum use of the hoeing machine, only about two thirds or three fourths of a sugar beet field can be hoed because the row space between the beets remains untilled. The use of chemicals cannot be discontinued completely just yet!

Technical possibilities of improving work quality

Selection and adjustment of chopping tools
The proper selection and arrangement of suitable tools is the prerequisite of hoeing as large an area - as close to the cultivated plant - as possible. Some principles (*Table 1*) have to be considered to ascertain optimal cutting. Otherwise, the cultivated plants may be affected detrimentally as the soil is torn up or moved.

Automatic row width adjustment
The use of sensor technology that recognises guiding lines makes it possible to increase the covered acreage per hour and to till closer to the plant row. Suitable control systems in combination with precise actuators for tool steering can be developed for this purpose.

Row recognition
One prerequisite of exact steering of the hoe along the row is the rapid and reliable recognition of rows or cultivated plants. This can be achieved by techniques that vary in suitability according to their respective plant-specificity and purpose - ranging from systems requiring manual correction to complex image analysis systems.

During seeding, it is possible to cut furrows as guiding lines which can be detected by means of a mechanical paddle or visually (laser scanner) (*Fig. 2*). The plant row can be recognised by two different principles: Picture analytical methods, which do not need to recognise every single plant, allow row recognition with sufficient precision and rapidity. Other methods, such as light barrier systems, scan individual plants.

Tool control
The exact fine control of the cultivation tools is achieved by the lateral adjustment of the complete hoeing implement by means of a hydraulical cylinder (*Table 2*). This can take place either at the draft links, the quick coupling, the toolbar, or at a guiding disc. At present, an independent adjustment of the individual unit is not available.

The described systems are available, but while contributing to an increase in work quality and field capacity per hour, they leave the weeds in the gap between the cultivated plants untouched.

In the following, two approaches to solving the problem of large proportions of soil remaining untilled shall be presented:

Transversal hoe
A transversal hoe which, due to individual plant recognition and mechanical cross-cuts, can work between plants within rows could be considered an optimal solution. That would require a reliable and rapid system of individual plant recognition and an exact real-time steering of the corresponding hoeing tools.

Individual plant recognition
The recognition of individual plants and the identification of their species can be realised only by means of special camera systems (e.g. bispectral cameras) and complex digital image processing [1]. Sensor systems with sensors installed parallel to the soil (light barrier system) or vertical to the plant row (electronic feelers) represent a compromise that is technically less demanding. They require plants taller than the roughness of the soil surface, and they do not allow the differentiation between species.

Weed control within rows
Weed control in the spaces between cultivated plants within rows requires that hoeing tools be introduced rhythmically into the rows. The frequency of the cross-cuts is dependent on the respective travelling speed and the theoretical plant distance. Technical difficulties arise from stand inaccuracies (e.g. inaccurate drilling, plant accumulation). Thus, a fast control system must be developed which recognises such inaccuracies and translates them into the corresponding measures. A second problem arises from the inertia of the actuators that must carry out these fast corrections without delay and with great precision.

Square patterns
Planted in square patterns, plants are equidistant in travelling direction and transversal to travelling direction so that hoeing is possible in two directions. A drilling of 30 • 30 cm is suitable for the sowing of the desired 100,000 seeds per hectare (normal 45 • 20 cm drilling). The adjustment of the hoe does not pose a technical problem. The distance between plants is too small for tractor tyres, so tramlines are required both crossways and lengthways. A prerequisite of square patterns is the exact drilling of each seed and the exact recording of its position because offset during drilling or arising from slippage is unacceptable.

If the crop is harvested in several rows, the lifting unit must be adjusted correspondingly.

Literature

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Technique	Place	Remark
manual	driver	
	operator	
hydraulic	draft link adjustment	hydraulic stabiliser
	quick coupling	lateral movement
	toolbar	lateral movement
	parallelogram	horizontal shifting
	guiding disc	in front or behind

Table 2: Possibilities for side adjustment of hoes