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Development of a precise actuator for sowing machines due to geo-referenced deposition of seeds

Coordinate related deposition of seeds can be an application for built up cross-compounds of plants in order to support mechanical weeding in length and additional in cross direction. Therefore up to 95 % of the field area can be hoed without damages of the cultivated plants. The technical requirements for cross-compounds are the online determination of position, the precise seed deposition and the development of a steering algorithm. First trials have shown, that an accuracy of ± 2 cm in regard of seed and its target position can be achieved.

Keywords

Mechanical weeding, cropping systems, row crops, cross compound

Abstract

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IWeed regulation in row crops mainly achieved with herbicides. Nearly no compromises of cultivation in regard of beet yield, quality and quality of the harvesting process can be allowed [1]. Totalherbicides before plant appearance and specialised herbicides are the first choice. But the development of new active ingredients is expensive and the chemical industry has to check the expected sales volume and benefit. Ecological aspects, like contamination of water, or special marketing strategies are arguments to look for alternatives to chemical crop protection.

Mechanical hoeing has lost importance because weed control by herbicides has been much more effective. Weak points of mechanical weed control are the higher costs low capacity (less operation width and lower velocity) and low effectiveness, because hoeing can be applied only between the rows and not within the rows. For sugar beets with a row distance of 45 cm this means, by consideration of a necessary protection area, only 2/3 of the field can be held free of weed. Therefore the advantages of hoeing play a subordinated role. To enhance machine hoeing it is proposed to create cross compounds, allowing hoe operation in two directions: in machine travelling direction and also in cross direction, which consequently raises the weed free area up to 90 %. The technical challenge is to sow the seeds parallel to each other in a way that makes possible to use a conventional hoeing machine.

Requirements

To achieve plant densities of 100 000 plants per ha distances of 45 cm × 20 cm are established. For parallel compounds distances higher than 30 × 30 cm are necessary. On the on hand a high plant density is necessary for yield, on the other hand tractor wheel and hoeing tools may not damage crops.

The accuracy of plant appearance is set to 2 cm. This is influenced by the quality of positioning, accuracy of deposition, variation of dropping curves, rolling effects and the vertical growth of the plant.

The sowing disc has to be accelerated or decelerated immediatly due to the variation of the tractor speed. This should be possible in a range of 1 to 3 $m \cdot s^{-1}$.

The implementation of the equipment in conventional seeders should be easy and should work under field conditions.

To realize different distances of deposition (20 to 35 cm), different compound types (f.e. quadratic or triangle compound) or different patter the target plant position has to be calculated (f.e. in office with GIS) and the real deposition points during sowing process hast o be stored.

Conception

An electronic precise steering mechanism was integrated in a conventional precise seeding machine for single seeding. Each seeding unit (sow disc) was adjustable independently.

Besides, the theoretical position of the next seed deposition (the angle of the sow disc) and the desired position in dependence of the neighbouring row had to be determined. With the difference of both positions the relevant angular speed depending on the driving speed was calculated.

To create crops in cross-compound different Steps are necessary:

At first, one row has to be seeded in one straight line and each plant/seed position has to be connected with its coordinates.

After that a kind of application map including each desired plant position has to be calculated.

The following step is the turn process. The machine turns over and set down parallel to the last lane and the first seed deposition should be parallel to the seed position of the last lane. For this purpose the sowing disc has to be steered in the right position.

Test performance

The sowing and deposition of the seeds begins (**figure 1**). During sowing the desired and the real deposition has to be compared continuously. In the case of differences, the position of the sowing disc has to be adjusted.

The described concept assumes optimal terms with right angled and flat fields. In other cases tracks end acute angled. The sowing discs must be stopped individual or the seeds which are out of the track should be eliminated by hoeing. The fact that the first track is in the middle of the field caused that four border tracks exists.

On uneven fields the neighbouring tracks only seems to have the equal length, but the transverse tracks for hoeing are sinuous. This case should be considered in the application map. Depending on the hoeing machine width each 6th, 12th or 18th row a distance correction has to be done.

Technical realisation

The technical realisation contains two parts: The development of a precise gearing system including steering unit and software and the development of a system for determination of position in real-time.

Development of a precise gearing system. For this project an Accord Monopill S precise seeder with a new developed actuator is in use. Instead of the mechanical actuator a stepping motor (behind seed box) and a tooth belt (transmission ratio 4:1) was installed (**figure 2**).

A defined number of steps are necessary to rotate the disc from one cell to the next one respectively from one point of deposition to the next. Also the number of steps corresponds to the desired deposition distance – one step corresponds to a defined driving distance.

Concerning to this relation, it is possible to vary the deposition distance by generating steering impulses for the stepping motor. Additionally, in the case of differences between desired and real deposition position it is possible to adjust the sowing disc by adding or blocking steps.

Beside of the steering function of impulses, they have an interface function between the technical (actuator) and the geodetic detection of position.

The task of the geodetic system is to generate distance equivalent signal and an information of each desired deposition.

The real deposition is detected with a light barrier next to the sowing disc.

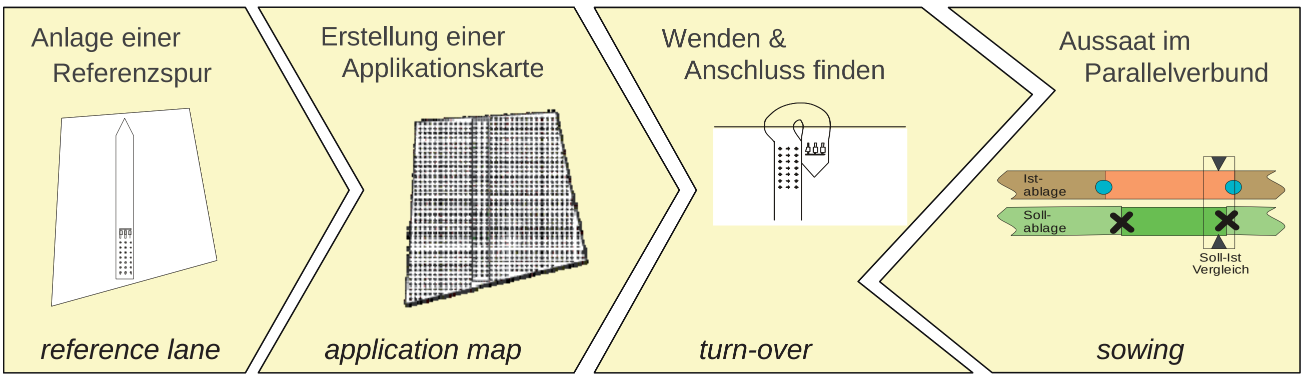
Determination of position in real-time. If high accuracy of position is requested, a sensor system containing DGPS assisted by other sensors is necessary. A RTK-DGPS on the seeding machine with a reference station next to the field on a well known geodetic position and an additional optical distance sensor was in used (**figure 3**). The measured values were integrated in a Kalman filter to calculate the precise coordinates in real-time. The turning procedure on headland caused problems. The distance sensor did not work on low speed and – in the other cases – the direction was lost. Stand alone of DGPS did not comply with the desired accuracy and the signals were influenced by shadowing effects when connection to satellites was missing.

Evaluation of the precise gearing system

To evaluate the working quality of a precise seeder the information of the accuracy of deposition is important. At the institute of agricultural engineering Bonn a standard measuremt device is developed to determine different parameters under defined conditions [3]:

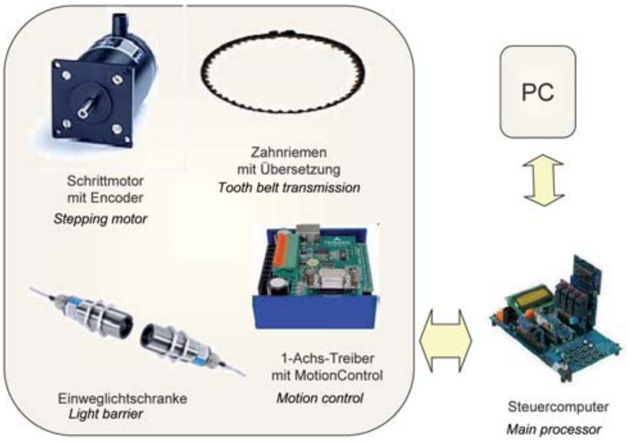
- Real distance of deposition (ISO-Norm 7256/1)
- Relative and absolute rate of exact, double and missing

Fig. 1



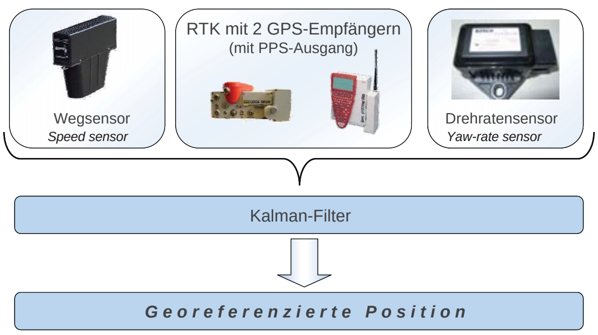
Conception of creating cross-compounds

Fig. 2



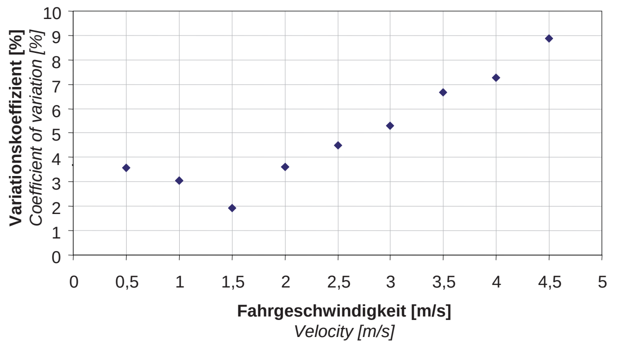
Components for actuator steering

Fig. 3



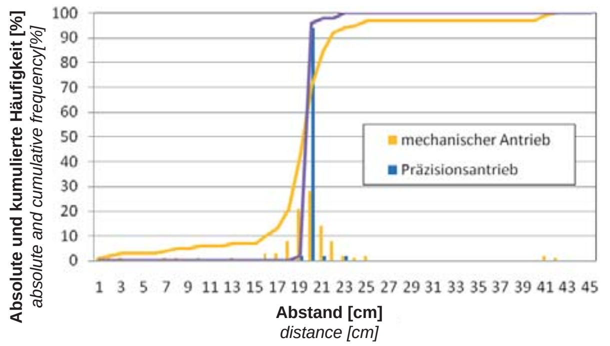
Positioning in real-time

Fig. 4



Driving speed and precision of deposition

Fig. 5



Comparison of mechanical and electronical actuation

depositions

- Standard deviation and coefficient of variation

The new precise gearing system is compared with the conventional.

In one trial the influence of driving speed in regard to the accuracy of devosition is tested (**figure 4**). The plant distance is 20 cm. The speed varies between 0.5 and 4.5 ms-1. The lowest (best) coefficient of variation was 1.9 by 1.5 ms-1. Reduced speed caused more double depositions. Higher speeds (more than 1.5 ms-1) caused a higher coefficient of variation (8.9 by 4.5 ms-1). Even the seed was sieved, the higher coefficient of variation is caused by a higher variation of the deposition curves.

The comparison of the new and the old gear (**figure 5**) shows, that the variation of the deposition distances is reduced by the new precise gearing system. 99% of the depositions are in a range of 1 cm.

Conclusions

The technical requirements for sowing parallel compounds are the precise determination of position in real-time and the precise deposition including a steering system.

The aim was a precise deposition of 2 cm. First trials prefigures, that the accuracy of positioning of the developed system is less than 2 cm.

For creating parallel compounds locating of the first target deposition point has to be solved.

Literature

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