Kam, Hing; Peveling-Oberhag, Christian and Schulze Lammers, Peter

Quantification of impact-factors on seeding accuracy of sugar beets

The creation of precisely positioned plant compounds requires precision drills with high accuracy of seed-placement at a pre-defined position. However, technical and environmental conditions have a significant influence on the precision of seed-placement which leads to a deviation of actual seed-position to the target seed-position under certain conditions. In order to determine impact and dimensions of these conditions on deviation of seed-placement several experiments were conducted, which are presented in this paper.

Keywords
Precision drill, seeding technology, precision farming, sugar beet, plant compound, optimized plant spacing

Abstract
Landtechnik 65 (2010), no. 5, pp. 357-359, 2 figures, 9 references

Seeding of sugar-beets, as well as seeding of other row-crops too, claims specific demands on seeding accuracy in order to achieve adequate distribution of the plants within the field. Adequate distribution means uniform plant development on the one hand and easier heritage and harvest on the other [1]. Monogerm sugar beet seeds opened the possibility to use precision drills, to get a constant spacing of the plants. In order to achieve this constant spacing there are several demands on precision drills. Besides exact seed-placement in cross-direction of the field and correct planting depth exact plant spacing of the seeds in the row (length-direction of the field) is one of the most important demands on precision drills [2].

The quality of operation can be determined by using a mobile or a stationary testing-equipment which detects the distance in length by means of a light bar directly at the seeder [3]. Other tests aim at measuring the distance in length of the emerged plants in the field with the help of measuring tapes or specific instruments [4].

One of the main problems of these measurements is the fact, that effects like rolling or jumping of seeds on the soil surface as well as the specific drop-parabola of the seeder are not recognized as a source of errors. For further applications in precision farming like optimized plant spacing in triangular compounds or machine hoeing of weeds in length- and cross-direction [5; 6; 7], which requires quadratic compounds with equal spacing in length and cross direction, it is necessary to place the seeds as precisely as possible at their specified positions [8]. For application of length- and cross-machine hoeing an accuracy of ±10 mm is required [8].

Sources of imprecise seed-placement

When a seed is transported by the cell-wheel of a seeder, the seed takes the same velocity then the cell wheel (v_{zr}). When the seeder is under forward motion with a specific velocity (v_f) and both velocities are the same there is no effect because both velocity-vectors are in opposition and therefore eliminate each other out (zero-speed-effect). If the seed leaves the cell wheel, acceleration by gravity (g) impacts the seed. This movement creates kinetic energy because of the drop-height of the seed (E_{kin}) which has to be relieved when hitting the soil-surface. Depending on several soil properties this relieve of energy can end up in a movement of the seed on the soil as rolling or jumping and therefore in a deviation from the specified position. However, the specific form of the drop-parabola and deviations from this form have an influence on the deviation from the target-position too [8].

Experimental site for measurement of seeding-accuracy

For quantification of the deviation of seed-placements an experimental site with three different types of soil (sandy loam, silt loam, silty clay) was used. Length of this site was 9 m while width was 2 m. Special properties of the experimental site can be found at [9] as well as specific properties of the soils. The precision seeder was attached to a portal-slide which was driven by a 0.45 kW electrical motor with variable transmission. Two additional rolls on the left side and on the right side of the system arranged a precisely guidance of the portal-slide. Further details can be found in [9].

As test seeder the „Unicorn Synchrodrive“ mechanical seeder from Franz Kleine GmbH (Salzkotten, Germany) was used for these experiments. In order to get a better control of the cell-wheel velocity the mechanical drive was replaced by an electrical one with variable transmission. Control of seeding-depth was guaranteed by a separate roll. The axis of the cell-wheel-drive was extended and a pin-wheel was attached which marked the position of each cell when the seed left the cell-wheel (**figure 1**). Coverers and press wheels were detached.

Soil preparation was done before each repetition of the experiment: the soil was grubbed and then leveled with a board. Subsequently the soil was recompacted by a roller and visually controlled for any irregularities.

For seeding sugar-beet the breed „Pauletta“ (KWS, Einbeck, Germany) was used. Diameter of these seeds varied between 3.5 and 4.75 mm while single seed weight varied between 0.02 and 0.036 g.

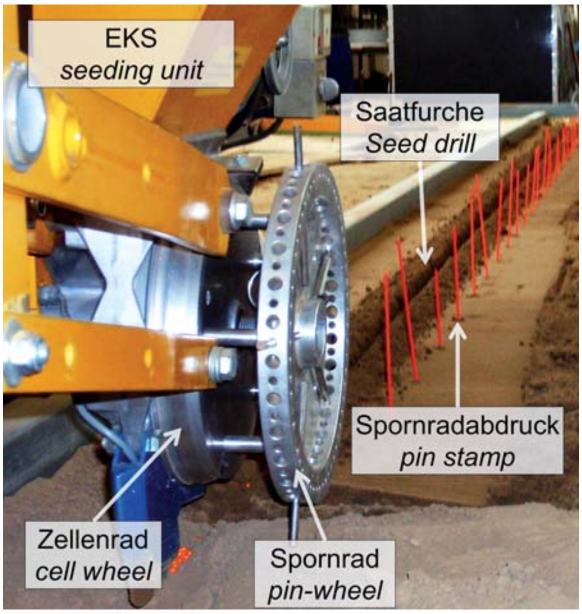
In order to quantify deviation of seed placement the pin stamps were marked with small poles and the distance from pole to seed position was measured. For a precise measurement a 90° angle was placed orthogonal to the steel bar, which was the runway for depth-control roll of the seeder. The long side of the angle was moved to the pole until it was in an upright position. The distance was measured with a set square and pole diameter was subtracted. For statistical proceedings of the raw-data the software SPSS (version 17) was used.

Experimental procedure and data acquisition

In the experiments the limit of seed-placement deviation of 10 mm [8] was met for velocities under 0.92 m • s^{-1} at 9 cm drop-height and for velocities up to 0.77 m • s^{-1} for 11 cm drop height only. For higher velocities the deviation of seed placement increased and was significantly higher than the limit. However, deviation of seed placement increased disproportionally with increasing velocity and drop height (**figure 2**).

The different soil types used in the experiments had no significant influence on deviation of seed-placement for all velocities and drop heights.

Fig. 1



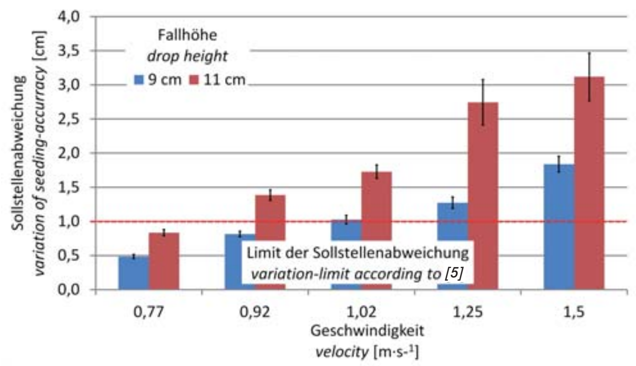
Experimental site for measurement of seed-placement deviation

Discussion

The measurement of deviation of seed placements was easy to handle with the configuration presented in our article and delivered constant results for several repetitions of the same scenario. The maximum velocity of 1.5 m • s^{-1} was limited by the dimension of the experimental site. For further experiments with higher velocities an acceleration-track and a breaking-track have to be provided in order to get an adequate number of samples for all soil-types. Because of the mechanical principle of pin stamps for the placement marks, the system can only run with the same cell-wheel and driving-velocity at the moment.

The results of the experiments show, that higher velocities and drop heights lead, as expected, to higher variations of seed placement. The reason for this might be the increasing kinetic energy (E_{kin}) because of increasing potential energy (E_{pot}) due to the drop height and increasing kinetic energy because of increasing velocity. This energy has to be absorbed when the seed hits the soil. The absorption can lead to a movement of the seed in form of rolling or jumping which increases with increasing energy of course. The intensity of jumping and rolling is strictly depending on soil properties which might lead to a deforming (ductile collision) or movement (elastic collision).

Fig. 2



Deviation of seed-placement in relation to cell-wheel velocity and drop-height; error-bars indicate single-value of standard-error

The problem about this result is that the deviation of seed placement cannot be referred to one single factor, because the position of the seed was measured after its halt. According to [6] and [8] the drop parabola has a significant influence on deviation of seed placement as well as movement of the seeds on the soil. Therefore the results have to be interpreted as the sum of the factors „properties of drop-parabola" and „movement of the seed on the soil" and can't be separated from each other with the current systems' configuration.

Conclusions

The results of the experiments show that cell-wheel velocity and drop-height of the seed have a significant influence on the quality of seed placement. Reduction of velocity, in order to achieve adequate results, is not an option for farmers, because of decrease in acreage. The only option is a reduction of drop height, which is depending on properties of the precision seeder and its specific design.

Further experiments have to figure out the influence of the single factors „drop parabola" and „movement of the seed on the soil", because it is not possible to separate them from each other at the moment. In addition the influence of coverers has to be tested as well as the influence of press wheels on the position of the seed after placement. Appropriate results require the test of several different seeders of course, in order to get general results.

Sugar beet seeds are formed to spheres by coating so the results of these experiments cannot be transferred to other seeds (e.g. maize). A general conclusion on all seeds would require more experiments with seeds of different surfaces, geometrical forms, size and mass.

Literature

[1] Diepenbrock, W.; Fischbeck, G.; Heyland, K.-U.; Knauer, N. (1999): Spezieller Pflanzenbau. Stuttgart, Ulmer Verlag, 3. Auflage, S. 185–208
[2] Kromer, K.-H. (1986): Zuckerrübenbau. In: Landtechnik Bauwesen. Hg. Wenner, H.-L., München, BLV Verlagsgesellschaft, 8. Auflage, S. 220–233
[3] Heier, L. (2001): Das Bonner Abstands-Aufzeichnungs-System – Ein System zur Prüfung von Einzelkornsägeräten, auch für die Praxis. Landtechnik 56 (Sonderheft 1), S. 192–194
[4] Heier, L. (1996): Das Bonner Abstands-Aufzeichnungs-System – System zur Bestimmung der Arbeitsqualität von Einzelkornsägeräten und Drillmaschinen. Landtechnik 51 (4), S. 204f
[5] Schmittmann, O.; Kam, H.; Schulze Lammers, P.; Siemes, M.; Schölderle, F.; Kuhlmann, H. (2008): Position Steered Sowing of Row Crops – Parallel Sowing of Sugar Beet. International Conference on Agricultural Engineering (EurAgEng 2008), 23–25 June 2008, Hersonissos, Greece
[6] Schmittmann, O.; Kam, H.; Schulze Lammers, P. (2010): Position Steered Sowing of Sugar Beet – Technology and Precision. 2nd International Conference on Machine Control & Guidance, Bonn, March 9–11, 2010
[7] Götz, S.; Bernhardt, H. (2010): Produktionsvergleich von Gleichstandsaat und Normalsaat bei Silomais. Landtechnik 65 (2), S.107–110
[8] Schmittmann, O.; Kam, H.; Schulze Lammers, P. (2010): Entwicklung eines Präzisionssägeräteantriebes zur koordinatengesteuerten Ablage von Saatgut. Landtechnik 65 (4), S. 286–289
[9] Konstantinovic, M. (2007): In-Soil Site-Specific Measuring of Sugar Beet Yield Using UWB Radar Sensor System. Dissertation, Universität Bonn

Authors

Dipl.-Ing. agr. Hing Kam and **Dipl.-Ing. agr. Christian Peveling-Oberhag** are scientists at Institute of agricultural engineering, University of Bonn, E-Mail: hing.kam@uni-bonn.de

Prof. Dr. Peter Schulze Lammers is head of the group technology of crop farming at Institute of agricultural engineering, University of Bonn.