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Accuracy of Path-dependent Seed Quantity

Evaluation of the Velocity Signal

Exactly determining the path travelled or the speed is important during drilling, if the seed rate within a field needs to be varied. In order to achieve high accuracy, different systems for speed measurement were compared to each other. Also the slip of different tail wheels, as well as the dispersion of the velocity signals, were examined. As an alternative the velocity values of the slip-free radar sensors and GPS receivers were compared. In addition to the speed, the soil conditions, as well as the position of the sensors, were varied.

In drilling the theoretical amount of seed is set by a turning attachment on the still standing machine. In most cases the real seed quantity in the field is lower than the theoretical due to the slip of the tail wheel. Slip can vary suddenly in a more or less wide range, sometimes even up to 56 %, depending on soil and machine specific parameters [1, 2]. These disturbances, often caused by chance, cannot be classified, so a continuing adjustment is impossible. The manufactures of drill seeders take slip into account as a constant, mostly between 2.5 % and 8 % depending on the different types, but the mentioned variations cannot be into account.

Slip on the tail wheel

To get information about the range in which the slip varies, studies with different tail wheels were made in the soil bin at Hohenheim University. The three tail wheels where chosen, differing in diameter and spur form. Than the parameters soil as well as breaking torque were varied. The different break torque can be caused by factors like the amount of seed inside the tank, different kinds of seeds, the style of construction as well as the load of the tail wheel itself and they can change all the time. E.g. during drilling of peas, which may cause, at very low rpm of the dosing wheel, the stop of the dosage for short moments in which the breaking torque rises up to 45 Nm. But experiences in the field show numbers of 30 and below. In the realised experiments, it was possible to keep the pre-set breaking torque constant by using a so-called magnetic particle break. The soil was, in addition to a loosened part, compacted with two different intensities. To examine the influence of changing soil conditions, the whole distance was inspected, not the single segments. A Peiseler wheel was taken as a reference system, the covered path of it and of the tail wheels were determined by an angular momentum transmitter.

For being able to give an assertion on the quality of the received signals the coefficient of variation (CV) is calculated as the quotient of standard variation and mean of the velocity-values. *Figure 1* shows the CV's of the velocity-values of the three examined tail wheels and a radar sensor. The two tail wheels with a medium diameter, which differ only different in their spur form, have shown a high dispersion of the velocity-values. This is due to the unstable scrolling pattern of the tail wheels at the applied braking torque of 30 Nm. The signal of the tail wheel with a high diameter varies slightly less than the values of the radar sensor whereby it has to be considered that with slip values between 4 and 12%, the CV is above 100%.

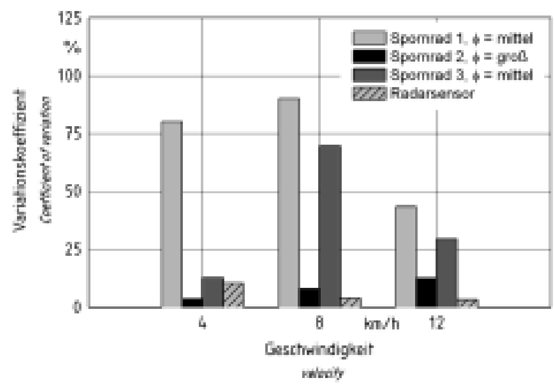

Fig. 1: Coefficient of variation of the velocity-values at different drive wheels and a radar sensor in relation to the velocity (braking moment 30 Nm)

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Keywords

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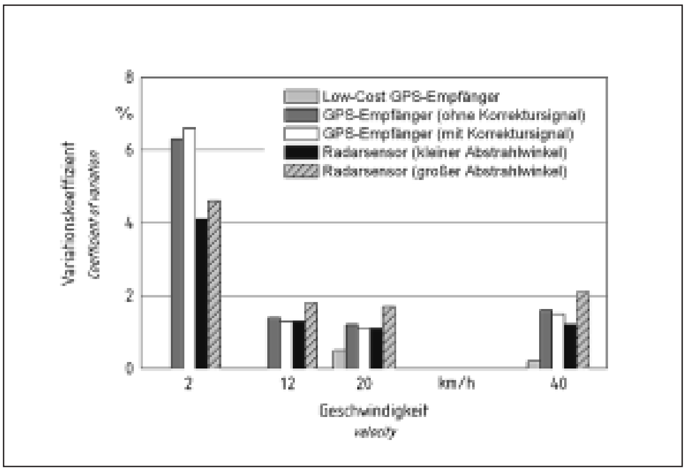

Fig. 2: Coefficient of variation of the velocity--values of two radar sensors and three GPS-receivers in relation to the velocity

Thus tail wheels highly vary with the different interferences of the velocity signals, resulting in an irregular dosage of the seed quantity.

Alternative measurement systems

By the use of an electrical actuation at the seeding shaft and electrical adoption mechanisms of the cell size or gear position, the determination of the velocity at the tail wheel is not necessary any more. Thereby alternatives arise for registration of the covered way and velocity. Sometimes radar sensors are installed serially in tractors to determine the slip. In practice, GPS-receivers are increasingly employed as aid for parallel tracking systems, site-specific applications and other implementations. By measurements with different GPS-receivers and varying models of radar sensors with diverse qualities, the sent velocity signals were compared with each other. Measurements on the street and in the field were carried out to examine the influence of the pitching and staggering movements of the tractor. For evaluation, the CV of the velocity-values was calculated, too, for being able to assess the quality of the signals (*Fig. 2*).

The results of the street and the field differ only slightly. Except of the low-cost-receiver, this shows a very low variation resulting by smoothing of the signals by the manufacturer, all measured values lie in nearly one range of dispersion. A tendency of lower CV's at less velocity with radar sensors in comparison with the GPS-receivers can be recognised. With increasing velocity the values converge and the radar sensors as well as the GPS-receivers show a significantly lower dispersion. Only the radar sensor with a small angle of reflected ray, which allows a more exact measurement of the driving velocity according to the manufacturer, shows a marginal higher dispersion of the values. At higher driving speeds the GPS-receivers mounted on the roof of the tractor are exposed to bigger pitching and staggering movements, however no significant worsening of the signals could be determined.

By comparing single velocity values of a RTK-GPS-receiver with two GPS-receivers with different qualities of the signal correction, no differences in the dispersion of signals showed up. *Figure 3* shows velocity-values of three different GPS systems of one manufacturer that have independently of their structure and their signal of correction an approximately big dispersion. The RTK-system was recorded with a frequency of 5 Hz, at a smoothening of 1 Hz no significant differences to the other receivers could be recognised. At the comparison of the position accuracy distinct differences can be determined. Independently of the position accuracy the velocity signal is even nearly identical of the GPS receivers with a signal of correction. In advanced measurements with GPS receivers by other manufacturers of similar quality, no differences could be determined, either.

Due to constantly varying interferences on the tail wheel of seed drills the dose of the seed quantity cannot be sufficiently accurate. By using path independent modules alternative sensors for measuring the exact velocity can be applied. Thereby radar sensors and GPS receivers offer an excellent possibility of determining the exact velocity. In case of problems or a breakdown of single signals the availability of the signal of highest quality can be examined by a list of priority for warranting an everlasting operational reliability. A further alternative is the gear signal of the tractor. Low-cost GPS receivers are not adequate for determining the velocity, since too big inaction of 3 to 5 s during acceleration and deceleration emerges.

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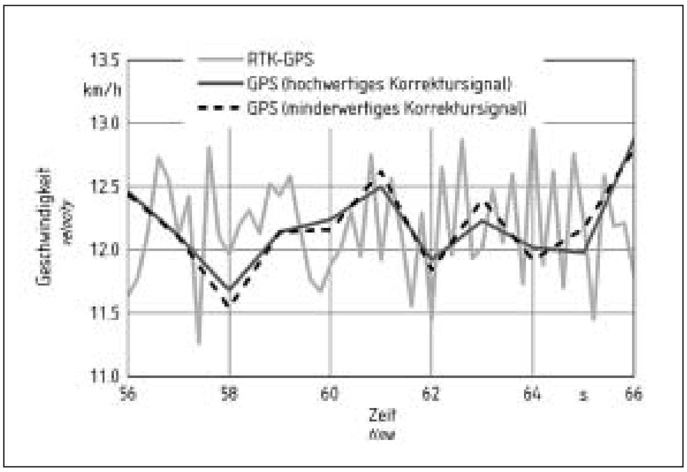

Fig. 3: Velocity-values of three different GPS systems of one manufacturer at 12 km/h