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Methode zur Berechnung und Optimierung der Mineraldünger- verteilung im Bereich eines rechtwinkligen Vorgewendes

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Summary

Solid mineral fertilisers are the most common source of nutrients for crops. Centrifugal broadcasters are one of the available technologies for dosage and distribution of mineral fertilisers in the field. This is a powerful and economic technique to apply mineral fertilisers. To achieve a high quality of work it is necessary to adjust the centrifugal broadcasters settings according to working width and mineral fertiliser. According to the characteristic spread pattern of this spreading system, areas of high mineral fertiliser variability are found in the field. The areas of non-uniformity are defined as rectangular headland, inclined headland, wedge, reduced tramline distance, obstacles and cornering. The operator has to adjust the settings of the centrifugal broadcaster according to the prevailed field areas to achieve a uniform distribution of mineral fertiliser. But the operator has no information about spatial dimensions and mineral fertiliser distribution of the spread pattern. Hence, the adjustment of the centrifugal broadcaster is bases on the experience of the operator.

The aim of this thesis was to optimise the distribution of mineral fertiliser in the area of a rectangular headland. For this reason a program was written to compute the mineral fertiliser distribution of a rectangular field. The optimization was limited to determine optimal activate and deactivate positions for opening and closing outlet shutters at the beginning and the end of a spreading track in a field. The simulations were based on 3D-spread patterns with different working widths of the mineral fertiliser potash, calcium ammonium nitrate, urea and sulphur-acid ammonia. The distribution of mineral fertiliser in the field was computed for different combinations of activate and deactivate positions in one simulation. Uniformity of the mineral fertiliser distribution in the field was evaluated with measured values of coefficient of variation.

The first computations were limited to graphics of the mineral fertiliser distribution in the field using given activate and deactivate positions. Theoretical considerations based on these results determined five possible factors of influence on the activating and deactivating positions. The factors of influence are working width, speed of the tractor, physical properties of the mineral fertiliser, spinning disc and outlet shutter position. Further simulations with variations of the influencing factors within their useful limits were done. The optimal activating and deactivating positions computed by simulations show correlations between the factors of influence and the resulting activating and deactivating positions. The simulation results were used as a data basis to model the activating and deactivating positions. With the models it was possible to appreciate activating and deactivating positions depended on the influencing factors. For each switching position one model was developed and validated. With a coefficient of determination of 0.99 for the activating positions and 0.95 for the deactivating positions the models resulted in a satisfactory accordance between computed and appreciated activating and deactivating positions.

To evaluate the quality of mineral fertiliser distribution the application rates were classified to determine areas in the field with equal application rates. For each mineral fertiliser one example shows the mineral fertiliser distribution and the areas in the field with the according application rates. The usage of the optimal activating and deactivating positions resulted in a good mineral fertiliser distribution for a rectangular field. The computed values for coefficient of variation vary between 11 % for the calcium ammonium nitrate and sulphur-acid ammonia mineral fertilisers and 12% for the potash end urea mineral fertilisers.

Finally, investigations to show the effect of a deviation from the optimal activating and deactivating positions to mineral fertiliser distribution for each mineral fertiliser and one working width were done. The evaluation of the mineral fertiliser distribution was made with coefficient of variation and proportions of the field with a specified application rate. Comparing the influence of the activating and deactivating positions to mineral fertiliser distribution, the activating position has a greater influence.

Within this thesis the computation of the mineral fertiliser distribution with simulations were represent as an opportunity to labour-intensive and cost-intensive field trails to optimise mineral fertiliser distribution. The first approaches and hence resulting conclusions show the potential of this method. Consequently recommendations for further areas with an inadequate uniformity of mineral fertiliser distribution can be made to prepare suitable simulations. By means of the results the mineral fertiliser distribution of these areas can be displayed and the influencing factors derived.

In-field testing took place at three different sites in Germany for a period of three years. These tests provided the database for the evaluation of the effect of variable work depths on agronomic parameters. We defined a depth range as well as depth variants for each individual test to take weather and soil conditions into account, which have an inevitable effect on cultivation.

The tests revealed that germination decreased in particular in those plots where cultivation had been shallow and where larger amounts of straw had been left in the seedbed area. However, reduced germination had no impact on the eventual yield, a phenomenon that is explained by the ability of cereal crop to compensate. While work depth had only a marginal effect on the tillering height of the individual plants it did have a significant effect on yield levels at two test sites. The extensive in-field tests give evidence that there is no immediate correlation between yield levels and cultivation depth, yet at the same time they show that a combination of work depth and weather conditions does have a major effect on yield levels. As a result, shallow cultivation involves a significant risk with respect to sustained yields.

In summary, site-specific cultivation offers new and hitherto unexploited options to protect the resources of the land while optimizing costs and yields. It is in particular the combination of localised cultivation and planting techniques that holds an extensive potential in an overall setting of changing weather conditions.