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41. SIMPOZIJ AKTUALNI ZADACI MEHANIZACIJE POLJOPRIVREDE

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Expert paper

INFLUENCE OF PHYSICAL – MECHANICAL PROPERTIES OF FERTILIZER ON UNIFORMITY OF DISTRIBUTION

MARIJA GAVRILOVIĆ, ALEKSANDRA DIMITRIJEVIĆ, ZORAN MILEUSNIĆ, RAJKO MIODRAGOVIĆ

University of Belgrade, Faculty of Agriculture, Serbia

ABSTRACT

The main purpose of man's activities in crop production is to provide such a final product which will, by its quality and quantity, meet the basic principles of cost-effective and cost-efficient production. High yields are leaving soli with the lower productivity and with much worse physical and mechanical properties. In this sense, application of fertilizers is of a great importance. The aim of this study was to demonstrate how much the uniformity of distribution depends of the applied fertilizers physical-mechanical properties and technical system of application. The paper gives the results of two centrifugal spreaders working quality in relation to physical and mechanical properties of applied fertilizers. Variation coefficients showed that no good uniformity was achieved. Real application varied significantly along the swath having the oscillations from 82% lower to 56% higher than the nominal application rate.

Key words: *fertilizers, mechanical properties, fertilizer disk spreaders, distribution uniformity*

INTRODUCTION

Generally, farmers work to achieve the best results from their farming. This leads them to the area of intensive farming where crop yields are increased through intensified inputs in labour and capital in the form of mechanization, use of nutrients and chemicals for plant protection. In the frame of compensating the lack of organic and mineral materials in the soil farmers are not so careful in the area of fertilizing management (Laegried et al, 1999). The intensive use of fertilizers can lead to the misbalance that is environmental in the nature but also imposes the energy and economy concern. In arable farming the fertilizers used account for the largest cost and energy factor among other farming inputs. In the crop production, energy consumption through the fertilizer application accounts for 2/3 of total energy inputs (Ortiz-Canavate and Hernanz, 1999).

Mineral fertilizer distribution on the field is of a great importance (Scheufler, 2010) and must be accurate and adapted to the nutrient requirements. New technologies in the frame of precision agriculture concept allow application of very precise fertilizers quantities. In this situation it is of great importance to know the physical properties of the used fertilizers since segregation of fertilizers or caking can put question mark to fertilizer application quality (Laegried et al, 1999). Most of the fertilizers are solids and their physical strength is an important aspect of application quality. Particles must be able to withstand the transport, storage and other manipulation procedures. They must not deteriorate into powder or cake into the larger pieces. The fertilizer must not absorb water during transport but, on the other side should dissolve rapidly in the soil after application.

The aim of this paper was to analyse physical properties of the commonly used mineral fertilizers and the efficiency of their application with the disc fertilizer spreaders. The paper should emphasize the importance of the correlation of the physical properties of the mineral fertilizers with their efficient application in the field.

MATERIAL AND METHOD

In this paper working quality of two centrifugal fertilizer spreaders is analysed. Testing of the machines was carried out in production conditions of the Agricultural Company Belgrade during maize production in the season 2009/10. Tested fertilizer was UREA with the nitrogen content of 46% (produced by "AZOT", 75 Churtanoskoe shosse, Berezniki, Perm, Russia). Standard maximal humidity of the fertilizer was 0.5%, specific mass 0.73 g/cm^3, porosity coefficient 0.22 and the angle of the internal friction 27.5^0. Two spreaders analysed (Tab. 1) were Vicon Rota Flow i RCW (Agromehanika Kranj).

Table 1 Basic characteristic of the tested spreaders

Technical data	Vicon Rota Flow	RCW
Capacity, l	2000	3500
Working width, m	10 to 36	10 to 20
Type	Mounted	Trailed
Spreading element	Two discs	Two discs

Testing procedure for the spreaders is defined by ISO 5690/2 and ASAE 343.1. standards. Three probes were carried for each spreader in order to determine working speed, fertilizer distribution uniformity and particle size distribution. Spreaders were tested while distributing fertilizer on the seed bed prepared soil for maze. Nominal application rate was 250 kg/ha.

Uniformity of fertilizer distribution was analysed from the samples gathered along the spreader working width. For sample collection 20 cylinder plastic trays were placed along the spreader width. The tray diameter was 10.5 cm. Sample mass was determined by means of precise weighing machine Kern 572/573/KB/DS/FKB/FCB Version 5.8, 04/ 2010 with the precision level of 0.01 g. Particle size distribution within the sample was determined with the Vicon Greenland Art.nr. meter 797770150 with the hole diameters of smaller than 2 mm, larger than 2 mm and larger than 3.3 mm.

RESULTS AND DISCUSSION

Testing results for the VICON RS – XL spreader

Working speed of the spreader was 12.63 km/h in the first probe and in the other two 11.8 km/h. Air temperature in the field was 23 ºC, air relative humidity 40.9% and wind speed 1.5 m/s. Results of the gathered sample mass are show in Figure 1. It can be seen that spreader has no uniform distribution along the working width. Better uniformity can be observed in the central part and on the fertilizer left side.

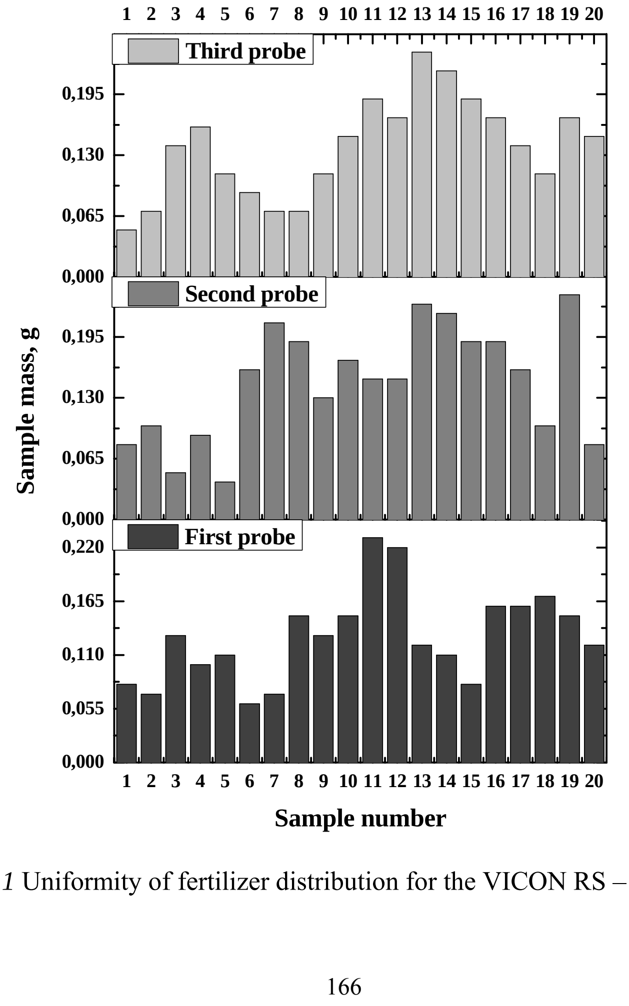

Figure 1 Uniformity of fertilizer distribution for the VICON RS – XL spreader

Based on the measured sample mass it was possible to calculate the real application rate. As uniformity of distribution varied, so did the application rate. Average values are shown in Table 2. It can be seen that average application rate was lower than nominal (30-40% lower). The lowest value of application rate was 45.98 kg/ha and the highest was 275.86 kg/ha. In the first probe application rate varied from 68.97 to 264.37 kg/ha, in the second probe from 45.98 to 275.86 kg/ha and in the third probe application varied along the working width from 54.47 to 275.86 kg/ha.

Table 2 Uniformity distribution parameters for the VICON RS – XL spreader

Parameter	I probe	II probe	III probe
Average sample mass, g	0.13	0.15	0.14
Standard deviation, g	0.0458	0.0588	0.0513
Variation coefficient, %	35.23	39.2	36.64
Average application rate, kg/ha	149.4	172.41	160.92

Variation coefficients confirm the fact that distribution along the spreader width is not uniform. The possible source of variation could be windy conditions during filed testing and poor seedbed preparation.

Testing results for the RCW spreader

Measured working speed of the spreader was 13.09 km/h in the first probe, in second 12.41 km/h and 12 km/h in the third probe. Working width of spreaders was 12 m. Microclimatic conditions were the same as for the Vicon spreader. Fertilizer samples along the working width of the spreader were collected in the 15 plastic trays placed on the 0.8 m distance.

Based on the measured sample mass it was possible to calculate the real application rate. As uniformity of distribution varied, so did the application rate. Its average value (Tab. 3) was closer to the nominal application rate if compared with the Vicon spreader. It was 17% lower and maximum 8% higher compared to the nominal value.

The lowest value achieved was 45.98 kg/ha and the highest 390.8 kg/ha. Along the spreader working width application rate varied in the first probe from 91.95 to 367.82 kg/ha, in the second probe it varied from 45.98 to 390.8 kg/ha and in the third probe the lowest application rate was 57.47 kg/ha and the highest was 379.31 kg/ha. The variation coefficient was higher than 40% in all probes and also verifies the conclusion that the good distribution uniformity was not achieved. The reasons for this can also be searched in windy conditions and poor seedbed preparation. Similar conclusions can be made for this spreader like for the first one emphasizing the need for optimizing the overlapping of the spreader working width.

If the sample distribution on the figure 1 and 2 are looked at, it can be seen that distribution pattern for the first spreader is not obvious. It seems like so called “w” pattern that consists of three areas with higher application rate. This pattern is often associated with the twin-spinner spreaders and needs to be corrected by overlapping and better adjusting of the spreader itself. But overlapping itself can only lead doubling of the fertilizer quantities applied in the places where fertilizer has already been applied. The second spreader has some kind of pattern that is often called “pyramid pattern” (Stewart and Bandel, 2002). This makes it more suitable for the modelling and optimisation. Although this is an acceptable pattern, the effective swath width is only 50% of the theoretical. For the tested spreader calculated effective swath width was 7.2 m of total 12 m having the effectives of 60%.

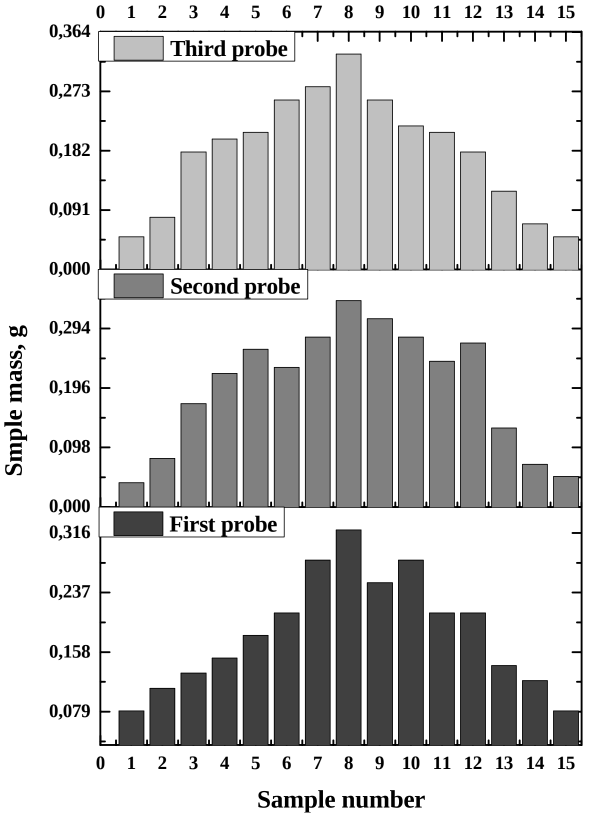

Figure 2 Uniformity of fertilizer distribution for the RCW spreader

Table 3 Uniformity distribution parameters for the RCW spreader

Parameter	I probe	II probe	III probe
Average sample mass, g	0.18	0.20	0.18
Standard deviation, g	0.0732	0.097	0.0851
Variation coefficient, %	40.67	48.5	47.28
Average application rate, kg/ha	206.90	229.89	206.90

Further analysis was carried in order to define particle size distribution for defining the possible correlation between distribution uniformity and particle size distribution. Three samples were taken - fertilizer from the storage, from the spreader prior to application and fertilizer after the application (Tab. 4).

Table 4 Particle size distribution in the samples

Particle size	Fertilizer from the storage, sample mass 85.5 g	Fertilizer in the spreader, sample mass 85.9 g	Fertilizer after application, sample mass 85.8 g
> 3.3 mm	0.82 %	0.93%	0.93%
> 2 mm	96.84 %	95.00%	94.63%
< 2 mm	2.34 %	4.07%	4.44%

Results show that the samples are of a good uniformity. The influence of manipulation prior to application is evident since the percentage of the smaller particles is higher after the transportation to the field. The spreader itself caused further destruction of the particles having as a consequence higher percentage of the particles for the application that are smaller than 2 mm in the diameter. Part of the fertilizer poor distribution uniformity along the spreader working width can be justified by this higher share of smaller particles susceptible to windy conditions.

CONCLUSIONS

Filed testing of the two disk fertilizer spreaders showed that, even with the same working conception, their distribution patterns were different. For the first spreader the pattern was unacceptable and for the second was acceptable. Real application varied significantly along the swath having the oscillations from 82% lower to 10% higher rate in the case of first spreader and 82% lower to 56% higher application rate for the second spreader. Variation coefficients showed that no good uniformity was achieved. The reasons for poor spreader patterns can be searched in the windy conditions, incorrect swath width due to no properly adjusted overlapping and the problem with the poor field conditions that resulted in uneven terrain that affected the driving pattern of the spreader. Further analysis of the particle size distribution showed that fertilizer manipulation prior to application (storage, transportation...) caused the creation of larger number of smaller particles that were susceptible to wind conditions during the field testing.

Result show that the mechanical properties such as particle size influence the overall spreader efficiency and that lot of care should be taken in processes of manipulation with the fertilizers prior to their application. Optimisation and modelling for calculating the optimal overlapping of the spreader working width, based on the mechanical properties of the fertilizer, local weather conditions during the application and the characteristic of the spreader will be future part of the research.

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