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The Effect of the Design of the Spreading Device on the Working Width and Evennes of Spreading in the Case of Centrifugal Spreaders

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Abstract. Today a significant part of solid fertilizers are spread by centrifugal spreaders all over the world, and it is general in Hungary as well. Their popularity is due to their multiple usage, simple construction, low maintenance demand, easy operation and low price. The field performance of spinning disc fertilizer spreaders basically depends on two factors: the forward speed and the working width. As there are some technical, operational and energetic limits of increasing the forward speed, my set objective in this study is to make further developments related to these machines' working width. Rising the working width one can lower the damage of the soil, the costs of operation, and at the same time the area of overlapping falling on unit area, and so the unevenness of spreading. Uneven fertilizer distribution will result in yield loss. The main objectives of the examinations presented hereinafter were to explore the relationships between the parameters considered important from the above mentioned point of view.

Keywords: centrifugal spreader, spreading device**,** unevenness of spreading, working width.

INTRODUCTION

The nutrient content of the soil determines the quantity and the quality of the yield. In Hungary, artificial fertilizers are dominant in nutrient supply, as the organic manure producing capacity of the country can only cover one fifth (0.5 animal /ha) of total nutrient demand. Besides the quantity and proportion of the agents, determined by the demand of the plant, the high quality of application is getting more and more important.

Today a significant part of solid fertilizers are spread by spinning disc fertilizer spreaders all over the world, and it is general in Hungary as well. Their popularity is due to their multiple usage, simple construction, low maintenance demand, easy operation and low price.

The field performance of spinning disc fertilizer spreaders basically depends on two factors: the forward speed and the working width. As there are some technical, operational and energetic limits of increasing the forward speed, my set objective in this study is to make further developments related to these machines' working width.

Rising the working width one can lower the damage of the soil, the costs of operation, and at the same time the area of overlapping falling on unit area, and so the unevenness of spreading. Uneven fertilizer distribution will result in yield loss.

The most significant factors affecting the working width of centrifugal fertilizer distributors and the evenness of their spreading are: the physical properties of applied fertilizers; the volume of fertilizer flow; the location of feeding on the surface of the spinning disc ; the number of blades; the length of blades; the shape of blades; the pitch angle of blades with the direction of the radius; the discs height position; the axial distance of the discs; the number of rotation of the discs; the diameter and the shape of the discs.

From the above listed factors I studied the location of dosage on the surface of the spinning disc, the number, the length, the pitch angle of blades in the function of working width and spreading evenness. All the other factors were constant. I did not examine the design of the feeder device, but the evenness and the symmetry of dosage were regularly checked.

I performed my examinations on the measuring track of the Department of Machinery, Faculty of Agricultural Sciences, Debrecen University. The measuring track capable to perform out-doors measurements, and so during the examinations we tried to eliminate the effects of external influences (irregularities in field surface, together with inclination of terrain, the wind, etc.)

MATERIALS AND METHODS

The measuring track consists of a concrete track and a row of collecting trays, set up perpendicularly to the track. The area of the measuring trays is 500x500 mm square and they are equipped with a grid to prevent particles from escaping. The line of the trays is raised above the ground to 800 mm. Under the measuring trays there are numbered collecting boxes. After repeating the test three times the boxes are collected and the quantity of theirs is measured with an accuracy of 0.1 g. The values are fed into a computer and with the help of target software the computer determines the main qualitative characteristics of the spreading device.

Depending on the spreading width, determined by the parameters of the applied spreading device, I used the measuring track from 25 to 40 meters. To characterize the transversal unevenness of spreading, in compliance with international standards, I used the coefficient of variation (CV):

$$CV = \frac{100}{\bar{x}_i} \frac{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x}_i)^2}}{n - 1} \ \%,$$

where:

x_i	is the average of fertilizer quantities from three replications on one measuring site;
$\bar{x}_i$	is the average of grain volume from three replications on all the measuring sites;
n	is the number of measuring sites.

Permissible value of CV is 15% (MSZ-05-10. 0283).

The two-disc spreader of the experimental machine can be equipped with two and three-bladed spinning discs. The blades are of different length. The pitch angle of the blades is adjustable in three stages, according to Fig.1. The angle of the spreading blade included with the radius in **A** position is 40^o, in **B** position 35^o and in **C** position 30^o backward to the direction of rotating. In the case of two blades the longer blade is indicated first, and the shorter afterwards, e.g. A/A. In the case of three blades the long blade is indicated first, than the medium, and than the short one, e.g. A/B/C.

There is a device on the experimental machine which is to adjust the location of feeding on the surface of the spinning discs in several directions. The adjustable feeding locations can be seen in Fig.2. Later these are indicated as e.g. A9, B8.

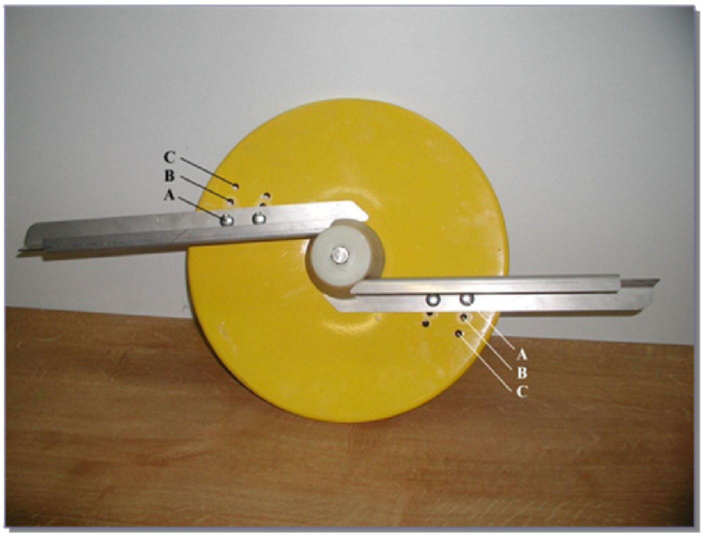

Fig.1 Possibilities of adjusting the pitch angle of blades

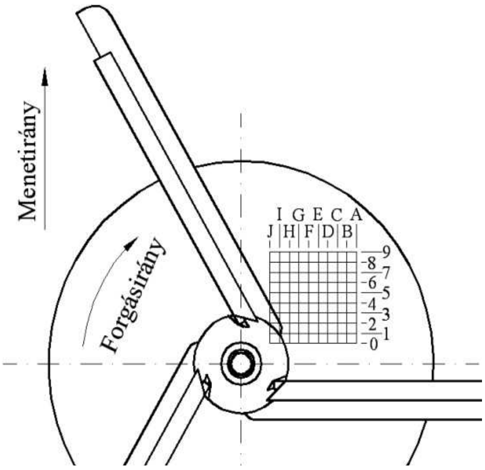

Fig.2 Locations of feeding related to the surface of the spinning disc *(Menetirány: Direction of travelling; Forgásirány: direction of rotation of the spinning disc)*

A feeding location can also be given with its coordinates, r_o; ψ_o, as it is shown in Fig.3.

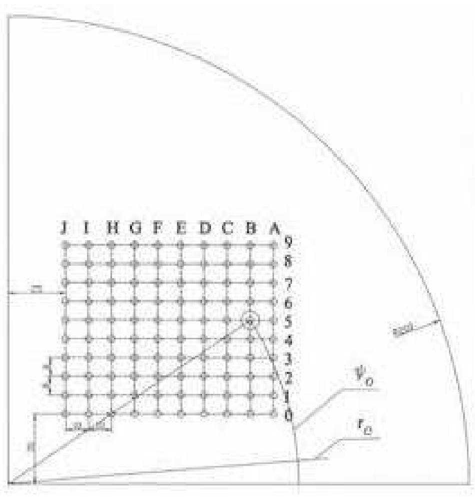

Fig.3 Coordinates of the feeding locations

RESULTS AND DISCUSSIONS

1. The working width in the function of the feeding location

The diagrams, shown in Fig.4 illustrate the relation between the coordinates of the feeding locations (r_o; ψ_o) and the obtained working width: it can be seen clearly, that there is a linear connection in the given direction. Decreasing the values of r_o and ψ_o in the marked direction, the working width will increase. When other fertilizer types were used, and when three-bladed disc was examined, the same result was obtained.

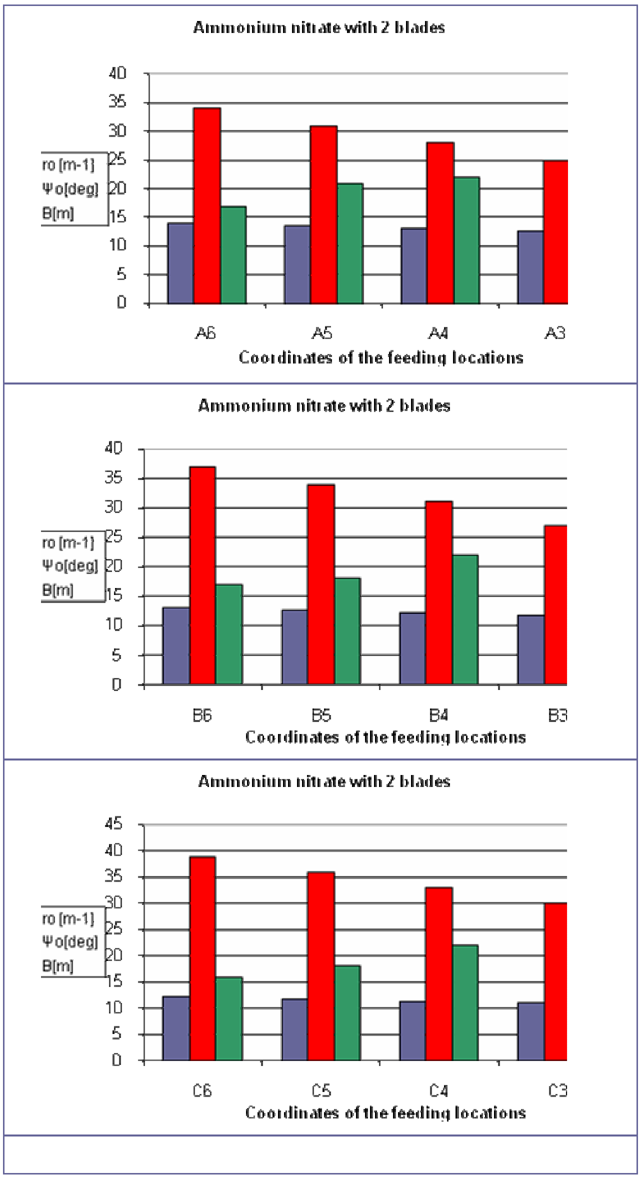

Fig.4 Relation between the coordinates of feeding locations and the obtained working width

2. The effect of the pitch angle of the blades on the working width

When the blades were set in A/A position (Fig. 1.) the spreading curve had two minimal values, i.e. at the working width of 12 meters, and 25 meters (Fig. 5), but 25 metres can not be considered as working width, because the unevenness is higher than 15%.

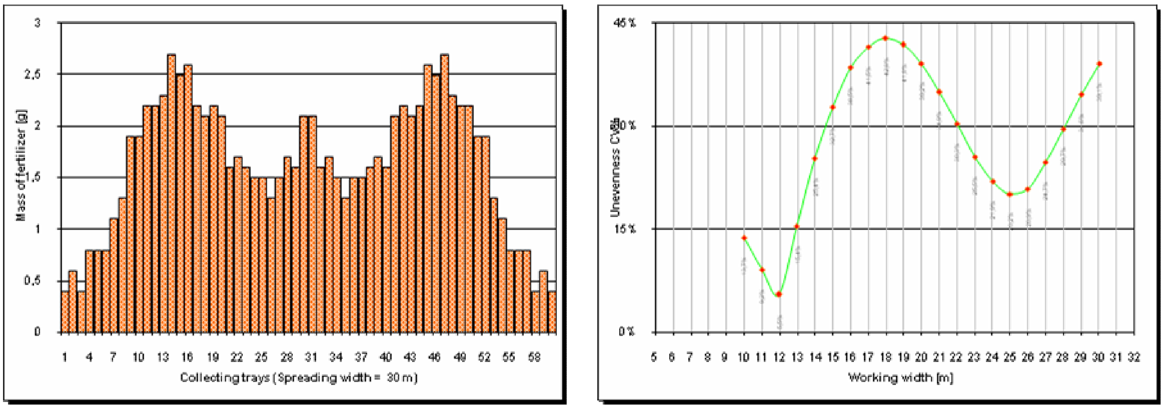

Fig. 5 Transversal spreading pattern and spreading curve on C2 feeding location, in A/A blade position

The experiments were carried out with two- bladed discs, and the pitch angle of both blades was set in three positions. According to the results, the alteration of the pitch angle of the longer blade has a greater effect on the transversal spreading pattern, and so on the working width. Setting the blades in B/A position (the longer blade in B, the shorter one in A position), the working width increased from 12 meters to 28 meters (fig. 6).

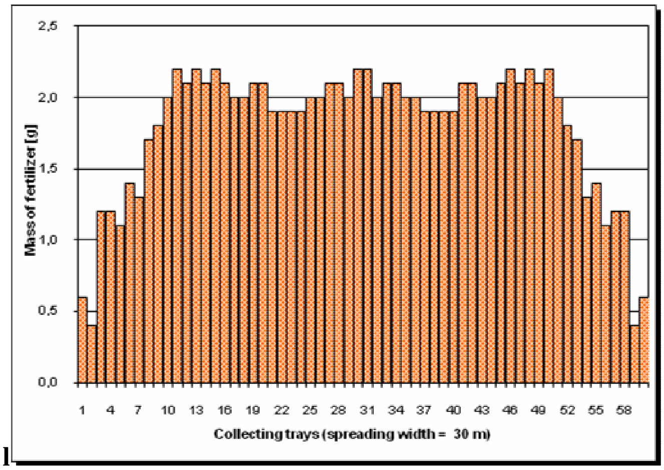

Fig.6 Filling in the centre of the transversal spreading pattern, adjusting the pitch angle of the longer blade

3. Increasing the working width by altering the length of the spreading blades

According to the basic lows of physics, by increasing the length of the blades we can increase the cast distance of the fertilizer particles, and so the spreading width can increase. Increasing the length of the blades the discharge velocity of particles will increase. However, there are constructional limits of increasing the length of blades. Then length of the blades was altered in different combinations.

According to the measurements, considering the working width and the evenness of spreading, the 350/300/300 mm length combination was better than the 350/350/350 mm combination. Further increasing the length of one blade the experiments were performed by using three combinations of blade lengths. According to the experiment results the most advantageous is to use three blades of different length. By using the 400/350/300 mm blade length combination on an optimal feeding location we were able to reach a relatively large working width (e.g. on B4 feeding location, 26 metres working width).

4. The effect of the number of the blades on the value of the working width and the evenness of spreading

Two conclusions were drawn according to the experiment results: there is a linear relation between the coordinates of the feeding location ($r_o; \psi_o$) and the obtained values of working width, in both cases, using two or three blades. The obtained working width was always larger by using two blades (Fig. 7).

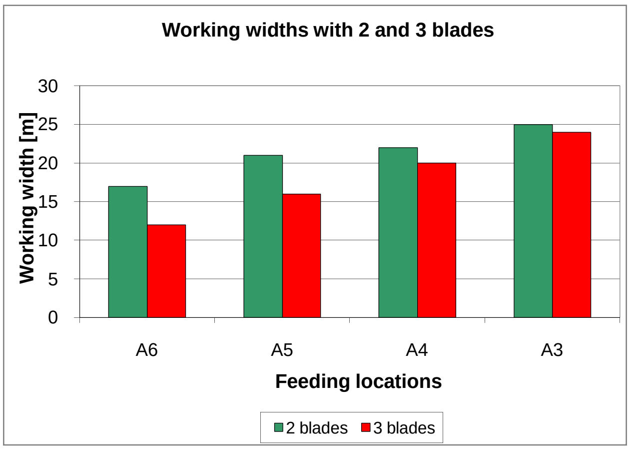

Fig.7 The obtained working widths by using two and three blades

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