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The impact of structural and operational parameters of the centrifugal disc spreader on the spatial distribution of fertilizer

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Abstract

The objective of this study was to specify the impact of structural and operational parameters of the centrifugal disc spreader on the spatial distribution of fertilizer varied in terms of physical properties (urea, ammonium sulfate, nitrochalk). The spatial distribution was characterized by parameters of the stationary spread pattern in the polar coordinate system: average angle and average radius of the stationary spread pattern of fertilizer. In the study, the selected parameters which significantly affecting spread quality were: rotation speed of the disc, feed position of fertilizer on the disc and the vanes angle on the disc. In order to determinate the impact on spatial distribution, the results were statistically analyzed based on the analysis of variance. The study showed that the factors impacting greatly the average angle of the stationary spread pattern are: the feed position of fertilizer on the disc, the vanes angle on the disc and the fertilizer type. Finally the fertilizer type and the rotation speed of the disc influence greatly the average radius of the stationary spread.

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Keywords: centrifugal disc spreader; mineral fertilizers; stationary spread pattern; spatial distribution.

1. Introduction

The fertilization quality using centrifugal disc spreaders is assessed primarily by an image of the transverse distribution of fertilizer on the surface of the field, which affect three groups of factors (structural and operational

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parameters, physical properties of fertilizers, external conditions). In operational conditions the settings of transverse distribution of spread fertilizer are based on the spreading tables or mobile measuring test stations (Kweon and Grift, 2006; Lawrence et al., 2006; Olieslagers et al., 1996; Tissot et al., 2002).

An important parameter determining the efficiency of spreading fertilizer is the throwing width according to the European Standard EN 13739 which is defined as the distance between the left and right border of a single crossing through entire field. While the term working width is defined as maximum spreading area between outward and return passes and it achieves total coverage, at which coefficient variation of transverse distribution does not exceed the limit value 15% (PN-EN 13739-2: 2004).

In order to assess the main operating parameters of centrifugal disc spreader the spatial distribution of spreading fertilizer should be determined, which shows the amount of mass fertilizer referred to the surface of spreading pass unit. Dintwa et al. (2004) distinguished several types of fertilizer distributions to estimate the quality of spread process. For example, the first one is tangential distribution pattern that shows the location of the fertilizer around the disc and specified distance (radius) measured from its center. The other is static (stationary) distribution pattern represented by two-dimensional distribution of fertilizer on a field in the absence movement of centrifugal disc spreader. The parameters of this distribution are defined by the average angle and average radius of the stationary spread pattern.

It is known, that standard centrifugal disc spreaders are designed to achieve a uniform distribution across an entire field after overlapping [Jones et al., 2008]. Even in agriculture is possible to observe problems with deficit or overdosing fertilizers, which are reflected through the image of multi-colored stripes on the surface of the field crop. Further research in this subject, the relationships between the type of fertilizer and spreader design parameters can minimize this adverse phenomenon. However, it is necessary to improve the fertilizer application quality especially to avoid growing concerns about environmental impact of fertilizers applied to the soil.

Nomenclature

$\bar{\beta}$	average angle of the stationary spread pattern of fertilizer
$\bar{R}$	average radius of the stationary spread pattern of fertilizer
f_{ij}	mass fraction of particles in the collector tray, g
β_{ij}	angle of the ij-th collector of particles in the collector tray, °
n	number of rows of trays
m	number of columns of trays
r_{ij}	radius of the ij-th collector of particles in the collector tray, m.

2. Materials and methods

The study about the impact of structural and operational parameters of the centrifugal disc spreader on the spatial distribution of fertilizer had been carried out in an indoors measuring position was shown schematically in Figure 1. It consisted of trays with dimensions 0.5 m × 0.5 m × 0.15 m, made in accordance with PN-EN 13739-2 2004, which arranged in sixteen columns and eleven rows (0.5 m distance between rows and columns). On the right-hand edge of the ninth column trays and at a distance 0.7 m from the first edge of the first row was located in the center of the centrifugal disc spreader [with coordinates (0,0) in the 0XY system].