QUALITY RESEARCH OF DOSAGE AND SUBSURFACE APPLICATION OF BIG-SIZED GRANULES FERTILIZER DURING STRIP-TILL FOR SOWING OF MAIZE

Jan Szczepaniak, Tomasz Szulc,
Włodzimierz Talarczyk, Paweł Dudziński
Industrial Institute of Agricultural Engineering, Poznan, Poland
janek@pimr.poznan.pl

Abstract: The article concern to the scientific and research works related to the development of mechatronic control system of sowing unit in the tilling-and-sowing combined machine. The essence of the project is the use in the combined machine of innovative control system responsible for the seeding process. The system will control the work of seeding unit (drive) and will maintain a predetermined depth of seeds sowing. Grooved or pinned units used in seeding are characterized by variability in application rate as a function of the changing conditions of work (e.g. on the slopes). In the proposed solution, on the basis of the identification of the sensitivity of the sowing machine on the changing conditions of work, the control algorithm will be developed, which after application to a controllable propulsion system equipped with the necessary sensors will eliminate inaccurate dosing. Project/Grant No K.2/IN2/64/182979 is co-financed from the budget allocated for science. Patent No P395909 was made as a part of the grant.

Introduction
The article presents selected aspects of the following research project: "A low-cost and environmentally friendly system of fertilization and seeding of maize". The project is carried out in a consortium composed of three research institutes, two universities and a fertilizer's manufacturer. The aim of the project is to reduce expenses related to the maize cultivation by the use of specialized NPS fertilizer and equipment for simultaneous strip cultivation, precise fertilizing and maize sowing.

Low-cost maize cultivation
A low-cost and environmentally friendly system of fertilization and seeding of maize differs from commonly used systems. The primary difference is a reduced number of operations (fig. 1). It allows simultaneous strip cultivation, maize sowing and comprehensive fertilizing by the starting fertilizer dosed shallowly and new fertilizer, in the form of large granules dosed deeply under the ground (fig. 2). The basic dose of the new large granular fertilizer (fig. 3) is supposed to be sufficient until the end of seeded maize vegetation.

Fig. 1. Scheme of maize cultivation technology: a) traditional tillage, b) low-cost tillage
Parameters of the new large granule fertilizer differ from those which have been hitherto used, mainly due to its size (diameter approximately 10 mm), thus there was a necessity to determine its dosing in adjustable portions. On the other hand, strip methods of plunge fertilizing that have been used so far, allow only to place the fertilizer shallowly, as a starting dose (max. up to 10 cm), wherefore methods for deeper dosing (up to 30 cm) had to be analyzed.

Structure of the research model for plunge fertilizing

To find the solution for stated problem, research model for plunge fertilizing had to be developed. Before building the model, analysis had been carried out concerning the technical possibilities of fertilizer dosing in a form of large granules and in adequate portions. The basic requirements which machine has to meet were the possibility to dose variable portions of fertilizer as large granules to a depth up to 30 cm in a portion up to 1000 kg·ha⁻¹ [1, 2].

To fulfill these requirements, laboratory tests on developed and built unit for fertilizing were carried out. Suggested solution consists of five basic elements distributing only one seed row (fig. 4):

- coulter disc,
- unit for removing crop residues (row cleaners),
- ripper tooth for loosening soil up to 30 cm,
- plates for keeping the soil in cultivated row,
- loosened soil's pressing unit and fertilizer dosing unit with tank and with the possibility of dosing in desired portion.
Because of large size of fertilizer granules and large dosing depth, it was found that the row-type sowing will be the most suitable. This can be accomplished for example by a peg-type unit or vane-type unit (fig. 5), which were employed in the fertilizer sowing unit. It has great adjusting capabilities, starting from outlet size through sowing shaft rotary speed to changeable seeding wheel. Sizes of the proposed seeding units were adjusted according to dimensions of the new large granule fertilizer.

The large granules of fertilizer, according to developed conception, fall gravitationally in the sowing pipe to the tooth's shaft. This solution extorted the flattened sowing pipe, which is hidden behind the tooth's shaft. Simultaneously, the pipe cross section area has to be sufficiently large to ensure free fall of the largest portion of fertilizer.

Fig. 4. Scheme of the machine for large granules plunge fertilizing: 1-main frame, 2-coulter disc, 3-removing crop residues unit, 4-ripper tooth with sowing pipe, 5-loosened soil pressing unit, 6-fertilizer tank, 7-fertilizer applicator with rotation speed adjustment

Summary
According to obtained tests results, it can be stated that developed single-section-model for plunge fertilizing performed the operations properly. The sowing apparatus powered by electric motor, dosed the fertilizer in adequate amounts, moving the granules to the sowing pipe. Working section, consisted from coulter disc, wheels, cleaning stars, ripper tooth, plates and roller were correctly cultivated the soil strip, ensuring excellent cleaning from crop residues, deep aeration and secondary soil condensation. The sowing pipe, installed behind the tooth's shaft, with its outlet sheltered by the tooth's foot, delivered large fertilizer granules to the soil appropriately.

Fig. 5. Variants of sowing units for large granule fertilizer, a) vane-type unit, b) peg-type unit

Acknowledgement
This study was supported by the National Centre for Research and Development Project No. PBS1/B8/4/2012.

Literature