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COMPARATIVE STUDIES OF GRAIN FLOW SENSOR IN ROW DRILLS AND SINGLE SEEDERS

Summary

The paper presents the results of comparative laboratory tests of three types of photoelectric sensors used for the control of seed sowing. The study aimed to determine the grain counting errors in terms of uneven dosing of wheat grain that occurs in row drills and single seeders in repeated sowing process. Grains were administered one by one at regular intervals and also in double or triple passes. A measure of the accuracy of the count is called visibility factor P_n, defined as the ratio of the number of counted seeds to the number of sown seeds. For individually dosed grains the visibility factor P_n the highest number was reached by the sensor III, while for wheat grains dispensed in triple passes, sensor II and III reached a similar rate of visibility factor ($P_nII = 79.2$; $P_nIII = 77.5$). Further studies are planned for other types of grains such as small canola grains to verify the usefulness of the sensor built on the basis of the image sensor.
***Key words**: grain flow sensor, wheat, visibility factor, row drills and single seeders*

BADANIA PORÓWNAWCZE CZUJNIKÓW PRZEPŁYWU ZIARNA DLA SIEWNIKÓW RZĘDOWYCH I PUNKTOWYCH

Streszczenie

W pracy przedstawiono wyniki porównawczych badań laboratoryjnych trzech typów fotoelektrycznych czujników ziarna, stosowanych w kontroli wysiewu. Badania miały na celu określenie błędów zliczania wysiewanych ziaren w warunkach nierównomiernego dozowania ziarna pszenicy, jakie występuje w siewnikach rzędowych oraz punktowych przy wielokrotnym wysiewie. Ziarna podawano pojedynczo w równomiernych odstępach czasu oraz podwójnie lub potrójnie. Miarą dokładności zliczania był tzw. współczynnik zauważalności P_n , zdefiniowany jako stosunek liczby nasion zliczonych do liczby nasion wysianych. Dla ziaren pszenicy dozowanych pojedynczo największy współczynnik zauważalności P_n osiągnął czujnik III, natomiast dla ziaren pszenicy dozowanych potrójnie czujniki II i III osiągnęły podobny współczynnik zauważalności (P_{nII} = 79,2; P_{nIII} = 77,5). Planowane są dalsze badania dla innych rodzajów ziaren, np. ziaren drobnych, jak rzepak, celem weryfikacji użyteczności oraz badania czujnika zbudowanego na bazie przetwornika obrazu.
***Słowa kluczowe**: czujnik ilości ziarna, ziarna pszenicy, współczynnik zauważalności, siewniki rzędowe i punktowe*

1. Introduction

The work is a continuation of research at Poznan University of Technology implemented in a development project No. N 06/2009 R003 0021. The aim of this work is to improve the system of dual count-sown grain for seed drill so that it meets the demands of defined in the literature *precision agriculture* (PA) [1, 2, 3]. Machinery manufactured for precision farming allows for better use of the role production and thereby minimizes costs. Modern precision-controlled seed drills automatically compensates the input with the actual values and therefore control and measurement devices are increasingly being used as the main elements in any system of automatic control. Specially adapted sensors and transducers are an indispensable part of the machine, designed for use in precision farming system [1, 2]. As a result of a broad review of the electronic gear drills, marketed by various manufacturers in the world, it was found that for counting and verifying correct seeding photoelectric sensors are commonly used. Unlike the microphone sensors, they do not interfere with the flow of seeds. Although the patent literature [7, 8] describes the design of the sensors to count the seeds sown, the scientific literature shows no-findings concerning the accuracy of these sensors. Sensors sold on the market, included in the seed control systems, mainly provided by the DJ company are characterized by a fairly complex structure and high price, not allowing to control the seeding in all the seed drill coulters. Therefore, in the framework of this project the task of con-constructing relatively simple sensor was proposed, a sensor that could control seeding in all lines, which is necessary primarily for the detection of blockages.

2. Purpose of the research and research problems

The research was based on a comparison of the three sensors. Sensors I and II were created as part of the next tasks in the development project No. N R003 0021 06/2009, while the third sensor was purchased from the Dickey John company, which is involved in the production and sales of professional sensors. The difference between the sensors is important, as first and second sensor generates a single beam at a distance of 3 mm from the seed tube node, while the third sensor covers the entire width of the node.

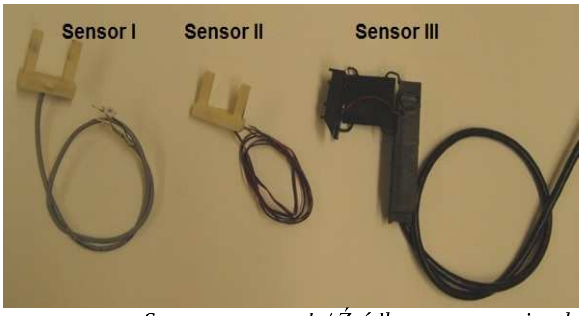
For the purposes of comparative analysis of selected grain flow sensors, a visibility index Pn was set, as well as an indicator measuring the N measurement spread. This paper presents the results of laboratory tests of single dosed seed volume effect. It was assumed that the research will be carried out for grain fed for in single, double and triple mode.

Obtained results of the study should provide empirical evidence to verify the previously developed computer models of the methods of counting grains in seed drill tubes.

3. Facilities research

The subjects of the study were sensors used for counting seeds flying through seed tubes of row and point seed drilling machines. These sensors are operating using photoelectric phenomenon, detecting the interruption of the light beam in the seed tube by the passing grain.

DJ's patented sensor III contains three LEDs as a light source and a photoelectric sensor strip operating on the principle of photovoltaic cell, controlling the entire width of the seed tube. This signal from this sensor is then differentiated and converted into rectangular pulses initiated on the slope of a signal from the photoelectric element. Strengthening of the measurement signal is automatically adjusted according to the background level [7]. In author's solutions of sensors, to avoid the application of large-surface photosensitive element and to simplify the design of the sensor circuits, sensor II uses photoelectric switches made by Hamamatsu company, which provide ready-made rectangular pulses when the sensor is being covered by the grain [10]. To allow the passage of each grain through the optical barrier in the form of a narrow beam, the stream of grains is concentrated on the outer wall of the curved channel [4]. The other sensor based on the author's operates similarly, except that the photosensitive element used is a common IR photodiode and an electronic signal processing circuit is performing similar to sensor made by DJ. Sensors I and II are in the shape of a horseshoe and were made using Rapid Prototyping from ABS plastic. Fig. 1 shows the test subjects - three sensors.



Source: own work / Źródło: opracowanie własne

Fig. 1. Research objects - three different sensors
Rys. 1. Obiekty badań - trzy różne czujniki

4. Methodology and research material

Laboratory tests were conducted on the test stand built at the Department of Working Machines of Poznan University of Technology is shown in Fig. 2.

The test stand includes a dispensing unit, to which a removable seed tube of variable length and configuration with a tested sensor is attached. Grains falling from the dispensing unit only by means of gravity are collected in the container below. Counting the grains observed by sensors was done with the aid of electronic equipment (ME-RedLab 1608) [9] and the recording program written in the RadDelphi Embarcadero 2010 environment. During the test the number of seeds spotted by the sensors in the pneumatic tube is recorded. Seed dosing plate has 20 holes, which allows dispensing of 20 individual seeds , 40 - in the configuration of the two grains, and 60 in the configuration of the 3 grains.

The research material was winter wheat varieties purchased in Poznan Seed Center *(Poznańska Centrala Nasienna).* Prior to testing, measurements of the basic parameters of the material used was performed, in particular: the mass of 1000 seeds (TSW), seed size and seed moisture content in accordance with PN-79/R-65950 standard, because these parameters could affect the results of measurements [5, 6]. The results of the basic parameters of Patras wheat are summarized in table 1.

a) b)

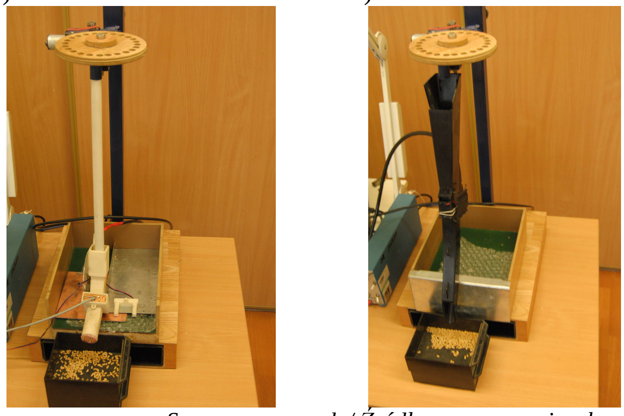


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Fig. 2. Photo of the bench: a) attaching a sensor I and II, b) the fixing of the sensor III
Rys. 2. Zdjęcie stanowiska badawczego: a) zamocowanie czujnika I i II, b) zamocowanie czujnika III

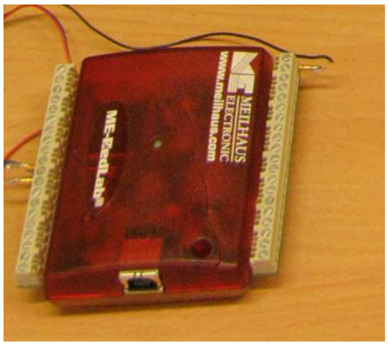

Fig. 3. Electronic system ME-RedLab 1608 used for counting the grains [9]
Rys. 3. Układu elektroniczny ME-RedLab 1608 zastosowany do zliczania ziaren [9]

Table 1. Basic parameters of wheat and oats
Tab. 1. Podstawowe parametry ziarna pszenicy

Type of grain	TSW (g)	Length a [mm]	Width b [mm]	Thickness c [mm]	Moisture [%]
Wheat	43±2	6,70±0,5	3,65±0,38	3,50±0,37	10,5

Source: own work / Źródło: opracowanie własne

5. Test results

Table 2 summarizes the results of the number of grains observed by three sensors in 10 attempts. Column A gives the results for 20 grains falling one by one at regular intervals, column B is for 40 seeds dosed twice, and column C is for 60 seeds dosed in sets of three.

In the course of each series of tests, test results were statistically analyzed. Mean values and standard deviation of the seed volume in each of 10 test runs were calculated. The main parameters are the so-called visibility indicator P_n formulated as a ratio of the average number of grains observed X to the number of seeds sown Z [4] and the measurement result dispersion indicator N, formulated as the ratio of square deviation of observed grains volume to the average volume of grains observed X [4], expressed as a percentage.

Table 2. Summarized results observed by sensors

Tab. 2. Zestawione wyniki zauważonych przez czujniki ziaren pszenicy odmiany Patras

	Sensor I			Sensor II			Sensor III		
No.	A	B	C	A	B	C	A	B	C
1	12	19	33	11	33	47	20	38	46
2	12	21	29	19	31	46	20	37	45
3	12	28	30	15	25	45	20	36	46
4	10	22	35	18	30	50	19	38	47
5	12	33	33	16	31	48	20	39	48
6	14	28	28	16	31	52	19	38	46
7	11	27	32	14	32	46	20	37	45
8	16	25	34	15	33	44	20	38	48
9	10	22	32	18	26	49	20	38	47
10	11	28	29	19	31	48	20	37	47
X	12	25,3	31,5	16,1	30,3	47,5	19,8	37,6	46,5
S	1,83	4,27	2,37	2,51	2,71	2,42	0,42	0,84	1,08
P_n [%]	60,0	63,3	52,5	80,5	75,8	79,2	99,0	94,0	77,5
N [%]	15,21	16,88	7,52	15,62	8,94	5,08	2,13	2,24	2,32

Source: own work / Źródło: opracowanie własne

6. Conclusions

Analysis of the results allows the derivation of the following conclusions:

1. When dispensing individual grains of wheat sensor III, produced by John Dickey company, has reached the highest visibility factor of P_n = 99%, therefore it has been rendered as the most accurate;

2. Dispensing seed in sets of three showed the most accurate results for sensor II, the one with the simplest design. This sensor has reached visibility factor of P_n = 79.2%;

3. The smallest dispersion of results observed (coefficient of variation at 2.13; 2.24; 2.32) was obtained for the third sensor;

4. The single-point measurement and the measurement using the photovoltaic strip covering their entire width of the seed tube, does not provide visibility of all seeds sown in the case of multiple sowing. To improve the accuracy of photoelectric sensors further work has been undertaken on the application of linear image sensors and image analysis methods to accurately count the volume of seeds sown and longitudinal uniformity of sowing, which is required for the purposes of testing seed drills and their regulation.

7. References

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