Effect of drilling quality on biomass yield

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Abstract: The paper is focused on the study and evaluation of quality of the seeding of seeds and its effect on the biomass yield. The aim was to evaluate the space arrangement of the seeds by using of polygon method on one field with the repetition for different forward speeds of the drill machine at 10, 12, 14, 16 and 18 km/h. Field experiments have been conducted with the drill machine with continuous seeding TUME NOVA COMBI 3000 having a double-disc seeding unit. Within the experiments there was used winter wheat, variety Magisters, with seeding rate 220 kg per hectare. For the evaluation there were used digital photographs, which were taken during repeated measurements of the each value of the forward speed after sprouting of crop. These images have been used in order to determine the shape and size of the surface area belonging to the plant. Own software TfPolyM was used for the image analysis. The shape of the polygons belonging to the individual plants was expressed by values of the shape factor Tf. This factor characterizes the suitability the shape of polygon surface related to the individual plant. By comparing of the values of the shape factors for different forward speeds of the drill machine we can determine the optimal value of the forward speed from the point of seed placement uniformity in horizontal level. During harvest of the crop there was analyzed the variability of the biomass yield in relation to values of the forward speed used during seeding. The following parameters of the crop yield were measured: total yield, grain yield, straw yield and chaff yield.

The best values of the shape factor Tf (0.856) were obtained for the forward speed 14 km/h. When the forward speed was higher or smaller the values of the shape factor Tf were decreased.

Average size of polygons was also studied. Increasing of the forward speed up to 14 km/h has caused the increase of the average size of polygons. Further increase of the forward speed up to 18 km/h has resulted in slight decrease of the average size of polygons. Such fact can be caused by imperfect filling of the metering unit on the drill machine.

As the maximal yield 392.74 g/m^2 was found for the case of forward speed 14 km/h. The highest values of the grain yield 222.32 g/m^2 was measured for the drill machine forward speed 14 km/h. Based on the results obtained it can be stated that forward speed of the drill machine effects the placement of the seeds in horizontal level and this fact subsequently effects the yield of biomass.

Keywords: seeder, sowing quality, biomass, operating speed

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1 Introduction

Optimization of the area location of the seeds during seeding process and subsequently of the emerged plants is very important for the increasing of the field emergence rate, for further plant grow and yield obtained (Blackmore et al.,2009).In the same time the competitive effects of growth factors among plants (light, water and nutrients) are decreasing.

The aim of the paper was to evaluate drilling quality of the universal drill machine Tume Nova Combi 3000 from the point of the space arrangement of the plants after emergence by using of polygon method. On a drill machine there were used a double-disc seeding units. During experiments the different values of the forward speed were used and the effect on the biomass yield was analyzed.

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For the evaluation of the area location of the plants the polygon method was used on one field with the repetition for different forward speeds of the drill machine at 10, 12, 14, 16 and 18 km.h^{-1}. Field experiments have been conducted with the drill machine with continuous seeding TUME NOVA COMBI 3000 having a double-disc seeding unit. Within the experiments there was used winter wheat, variety Magisters with seeding rate 220 kg per ha.

2 Material and methods

2.1 Methods used for determination of the area (polygon) location of the seeds

Voronoi method – plants are considered as neighbours, whose polygons due to the polygons location create a common chain of points (they create a common lateral edges).

Delaunay triangulation – as a three neighboring plants consideredthat, is together formed a circle contains withoutother point (plant).

Properties of the polygon layout

Area per one plant, made by polygon is characterized by:

- the size of the area Si (Fig. 1),
- the shape of the polygon – shape factor - ($\overline{T_f}$) (according to Griepentrog).

$$\overline{T_f} = \frac{1}{n}\sum_{i=1}^{n}\frac{O_{ideal}i}{O_{skut}i} \qquad (1)$$

where:

$O_{ideal}i$ – ideal circumference of the polygon i,

$O_{ideal}i = 2\cdot\sqrt{\pi\cdot S_i}$

$O_{skut}i$ – real circumference of the polygon i,

n – number of polygons,

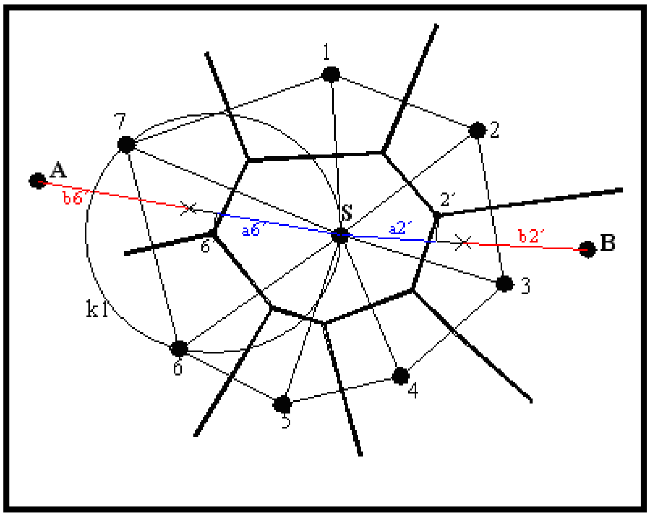

Figure 1 Determination of the area of the polygon for the given plant

2.2 Data evaluation programme TfPolyM

Programme for data evaluation was created in a programming language Delphi. It is used for a determination of the polygon placement of the plants in horizontal level in relation to the placement of neighbouring plants. Programme allows to process a digital pictures (photographs), which were taken after seed emergence. Programme algorithm The program algorithm can be divided into three parts, which are interlinked and they are executed in the following order:

1. Part one: determination of the individual points – identification of the plants within the picture;
2. Part two: determination of the neighboring points;
3. Part three: creation of the polygons.

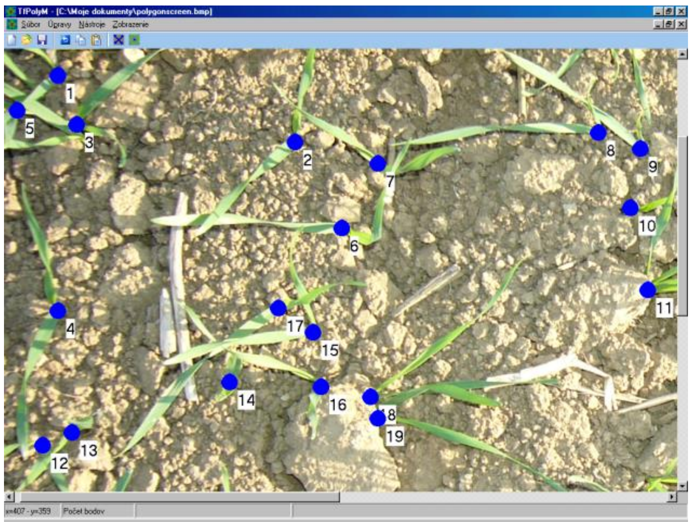

Figure 2 Identification of the plants

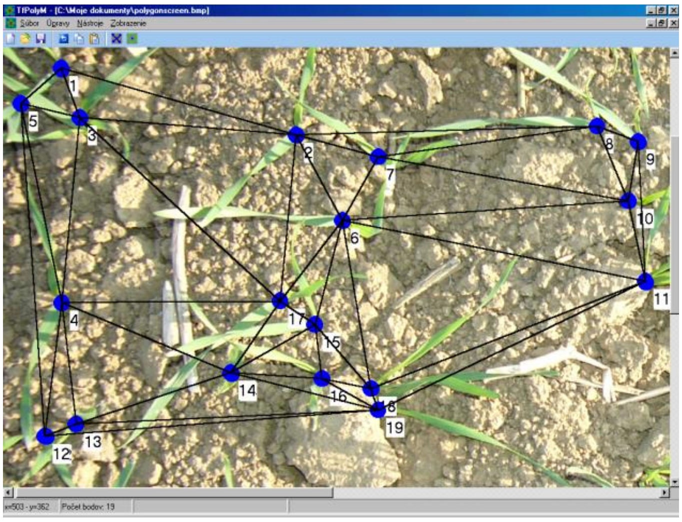

Figure 3 Determination of the neighbouring points

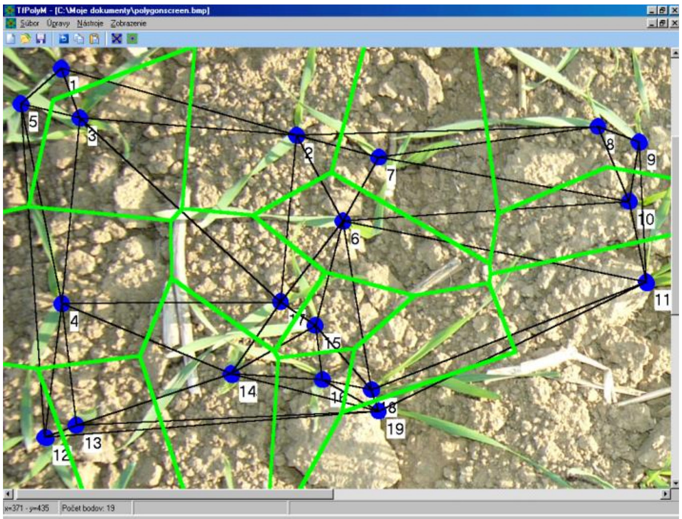

Figure 4 Creation of the polygons

Figure 5 Picture of the cropstand

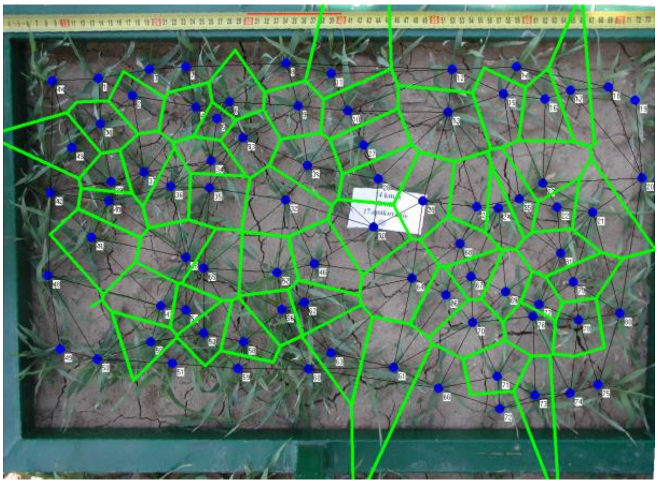

Figure 6 Created polygons

3 Results

For the evaluation there were used digital pictures taken during repeated measurements of each value of the forward speed of drill machine after emergence of the plants. It was in the moment when no other plants have emerged and the crop stands were not closed. It was very easy to identify the individual plants. For the evaluation three was used a special own programmed TfPolyM. Digital pictures have been used for determination of the shape and size of the area falling to a given plant. The shape of the polygons related to individual crops was expressed by the value of shape factors Tf. This factor allows to express the suitability of shape of the polygon area falling to a given plant. Comparing the values of the these shape factors Tf for various forward working speeds of the drill machine we can determine the most appropriate forward working speed in terms of uniformity of seed placement in the horizontal plane for a given seed drill. The best result Tf = 0.8566 was obtained in case of forward working speeds of the drill machine 14 $km.h^{-1}$. or higher or lower forward working speeds of the drill machine there was registered the decrease of values of Tf.

There were analyzed also the mean values of the polygon areas. From results obtained it can be seen that the increase of the forward working speeds of the drill machine up to the 14 $km.h^{-1}$ has caused the increase of the mean values of the polygon areas. Further increasing of the forward speed up to 18 km.h^{-1} has caused the stagnation or even decrease of the mean values of the polygon area. This fact can be caused by imperfect gravity feeding of the seed metering system.

Table 1 Effect of the forward speed of the drill machine on the seeding parameters (mean values)

Forward speed of the drill machine, km.h^{-1}	Mean value of the shape factor, Tf	Mean value of the variation coefficient of the shape factor Tf, %	Mean value of the polygon area, S, mm^2
10	0.8083	13.2	2519.8
12	0.8133	15.2	3332.3
14	0.8566	17.49	3558.1
16	0.8500	17.11	3339.8
18	0.8306	16.89	3036.4

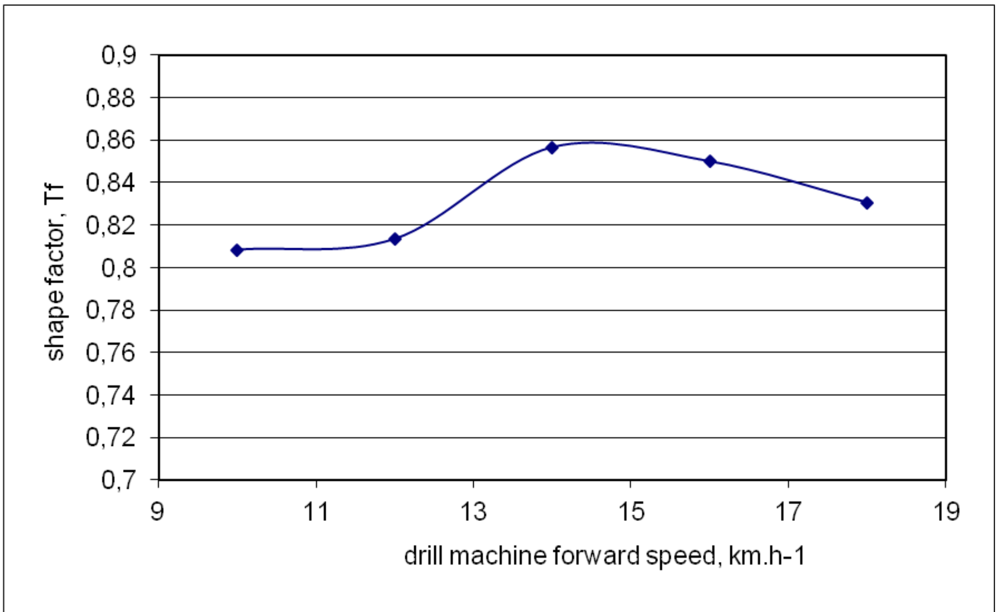

Figure 7 Effect of drill machine forward speed on the values of the shape factor

3.1 Evaluation of the biomass yield

Samples of the crop biomass were collected from the area of one square meter in a stage of full ripeness immediately before the harvest. Samples were taken from the same points where the digital pictures were taken in order to evaluate the shape factor Tf. In order to collect the crop samples there was used the square-form frame allowing to allocate the plants (Figure 8).

Above-the-ground part of the plant was cut in the height of 10-12 cm by scissors. Samples of the crop biomass were collected specially for the drill machine forward working speed of 10,12,14,16 and 18 km.h^{-1}. For each value of the forward working speed there were done three repetitions.

In order to evaluate the samples of the crop it was necessary to separate the wheat grains from the ears. The manual threshing was done. After threshing it was necessary to separate the grains, chaff from the ears and straw (Figure 9).

Figure 8 Square-form frame used for samples collection

Figure 9 The grains and chaff separated from the ears

Table 2 Effect of forward working speed of the drill machine on the biomass yield

Parameter	Unit	Forward working speed of the drill machine,km.h^{-1}				
		10	**12**	**14**	**16**	**18**
Number of	pcs.m^{-2}	161	183	**228**	217	197
Average	m	0,441	0,437	**0,468**	0,513	0,478
Weight of the	g.m^{-2}	296,93	317,83	**392,74**	371,02	368,68
Weight of the	g.m^{-2}	33,02	39,19	**49,4**	42,01	36,02
Weight of the	g.m^{-2}	85,8	91,08	**121,02**	99,14	116,04
Weight of the	g.m^{-2}	178,11	187,56	**222,32**	206,7	**216,66**

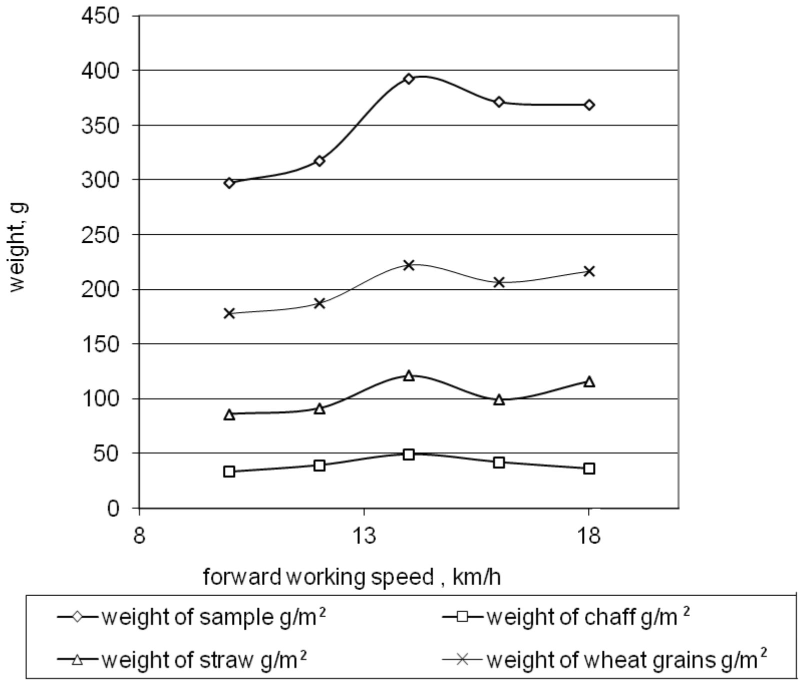

Figure 10 Effect of the forward working speed of the drill machine on the biomass yield (grains, straw, chaff)

3.2 Evaluation of results

Effect of drill machine forward speed on the values of the shape factor is presented on the Picture 7. On the picture we can see that the values of the shape factors Tf are changing in relation to the drill machine forward speed. Optimal value of the shape factor is 0.952, but in the practice it is very rare.The best values of the shape factor Tf we have obtained in case of drill machine forward speed 14 km.h^{-1}. When the drill machine forward speed was higher or lower there was recorded slight decrease of the Tf values. The highest value of the shape factor 0.8566 we have obtained for the drill machine forward speed 14 km.h^{-1}. The minimal value of the Tf was 0,790 for the drill machine forward speed 12 km.h^{-1}. The values over 14 km.h^{-1} are not acceptable from the point of requirements on the seeding quality (seeding depth).

The smallest value of the variation coefficient 12.597 % we have obtained for the drill machine forward speed 10 km.h^{-1}.Increasing of the drill machine forward speed up to 14 km.h^{-1} has caused the increase of values of the variation coefficient at the level of 18.511 %. Further increase of the drill machine forward speed caused the slight decrease of the values of the variation coefficient.

There were analyzed also the mean values of the polygon areas. As it can be seen from the results obtained, the increase of the drill machine forward speed up to 14 km.h^{-1} also has caused the increase of values of the polygon areas. Further increase of the drill machine forward speed at the level up to 18 km.h^{-1} has caused the slight decrease of the values of the polygon areas. The size of average area of the polygon should not depend upon the drill machine forward speed as the value of seeding rate related to the unit area should be the same. Such fact can be caused by improper filling of the seeding mechanism as well as by the low seed gravity force acting on a seeding mechanism. Minimal value 2519.8 mm^2 was found in a case of the drill machine forward speed 10 km.h^{-1} and maximal at the 14 km.h^{-1} even 3558.1 mm^2.

4 Conclusions

Based on a results of experiments focused on creation of the biomass it can be stated that in a case of the drill machine forward speed 14 km.h^{-1} there was found the highest amount of the plants at 228 plants per 1 m^2. When the drill machine forward speed was 10 km.h^{-1}, the number of plants were reduced by 29 %. Over the 14 km.h^{-1} of the drill machine forward speed, there was found only small decrease of the amount of the plants. The unevenness of the amount of plants could be caused by the falling of the seeds during seeding process as the seeds were located much closed each to other and they had not sufficient conditions for their growth. Drill machine forward speed over 14 km.h^{-1} is not acceptable due to the deepening (ticking-off) of the seeding openers and results are very variable seeding depth. Drill machine forward speed significantly effects also the amount of the yield. It was found that in case of the drill machine forward speed 14 km.h^{-1} there was obtained yield 222.32 g per one m^2. In case of the smallest straw yield we have obtained the yield of grains decreased by 20 %. Manufacturer of the TUME drill machines recommends optimal drill machine forward speed within the range 12-18 km.h^{-1}. According to our results, from the point of area location of the seeds during seeding process, the optimal forward speed of the drill machine is 14 km.h^{-1} as at this value the drill machine creates the plant polygons with the highest values of the shape factors. The result is the suitable conditions for the creation of the biomass yield.

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