Effect of manual navigation on quality of work of a fertiliser spreader AMAZONE ZA-M I 12-36

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Abstract: *The aim of the paper is to analyse the effect of the deviations from ideal centre driving line caused by manual navigation to quality of work fertiliser spreader. There was used spinning disc fertiliser spreader AMAZONE ZA-M I 12-36 aggregated with tractor ZETOR 16145. During the experiment there were used DUSLOFERT NPK 10-15-15 fertiliser application rate set for 175 kg.ha^{-1} and working speed was 12 km.h^{-1}. Based on the triangular shape of the spread pattern and 24 m spread width an ideal distance of driving lines was 12 m what means 50 % overlap. The average observed value of the measured driving line distance was 11.86 m and therefore lower in comparison with ideal driving line distance. The minimum and maximum values were 9.23 m and 14.34 m. The maximal observed deviation from ideal driving line was 2.77 m. The effect of accuracy of the manual navigation on the work quality of fertiliser spreader was analysed.*

Key words: *Fertiliser spreader, Fertiliser, Manual navigation, Quality of work.*

INTRODUCTION

The requirements for availability of qualitative and affordable food for the food supply grow due to the population constant rising. Given the limited amount and acreage of agricultural land is needed to increase agricultural production to raise a production capacity of the soil, which can be achieved by providing an optimal plant nutrition and using of organic and industrial fertilizers. Major crop production intensification factors are fertilization and irrigation [1]. Nitrogen fertilisation is an important factor that affects crop yields [2-4]. Fertilisers are applied to the field by fertiliser spreader. The most widely used type of a fertiliser spreaders are those with double spinning discs [5]. Uniformity of the fertiliser distribution on the field is affected by many factors. The most important factors are an overlaps of the driving lines [23-26], working speed [1, 6-8], size of application rate [10] and physical and mechanical properties of fertilisers [9; 11-13]. The work quality of machinery is also affected by the type of spreading system, individual technical solutions used by producers and weather conditions [9; 14-17]. Incorrect application of fertilizers causing negative environmental effect in terms of increasing nitrous oxide [18-20] and carbon dioxide [21] emissions released from soil into the atmosphere. The spread pattern of the fertiliser spreader is strongly affected by the overlap of working width [1, 5, 6, 16, 25, 26, 27]. Satellite guidance of the machinery is not used in all cases. Satellite navigation systems have proved to be an effective tool for an efficient application of fertilisers [22-24]. The aim of the study is to analyse the effect of the deviations from the ideal centre driving line cause by manual navigation on the work quality of the fertiliser spreader.

MATERIAL AND METHODS

The tractor-mounted fertiliser spreader, AMAZONE ZA-M I 12-36, was set according to the fertiliser manufacturer recommendations for the selected fertiliser type. The basic technical parameters of AMAZONE ZA-M I 12-36 fertiliser spreader are shown in Table 1. The tractor ZETOR 16145 was used. The official trade mark of used fertiliser produced by DUSLO Šaľa, a.s. is DUSLOFERT NPK 10-15-15. Used fertilizing application rate was 175 kg.ha^{-1} and working speed was 12 km.h^{-1}. Based on the collecting container dimensions it is possible to create overlaps with deviations graded by 0.5 m. Coefficient of variation is a basic parameter to evaluate the work quality of the fertiliser spreader. Maximum allowed value is given by Standard EN 13739 at value 15 %. During the experiment, distances between the following driving lines were measured.

The distribution uniformity of the fertiliser on the field was also observed. Collecting trays with compartments were used to capture spread fertilisers and their technical parameters meet the Standard ISO 5690 part 1 and part 2. Methodology meets the requirements of Standard EN 13739 and was described in our previous works [1, 5, 6, 9, 11, 16, 25, 26].

Table 1.

Basic technical parameters of the AMAZONE ZA-M I 12-36 fertilizer spreader

Parameter	Value
Working widths	24 m
Payload	2000 kg
Basic capacity	1500 l
Max. slope of land	11 °
Max. pressure in the hydraulic system	18 MPa
PTO shaft speed	540 min^{-1}
Weight without extension	550 kg
Type of scatter blades	OS 20-28 opti-et
Type of application mechanism	Double spinning discs

RESULTS AND DISCUSSION

There were conducted 31 replication of driving line distance measurement. Results are shown in figure 1. Based on the triangular shape of spread pattern and 24 m spread width an ideal distance of driving lines was 12 m, with overlap 12 m what means 50 % overlap. There was measured average value 11.86 m and was lower in comparison with ideal driving line distance. Minimum and maximum values were 9.23 and 14.34 m, respectively. Maximum deviation from ideal driving line was 2.77 m. The recording the amount of fertiliser in individual collecting trays allows to create the transversal spread pattern shown. There were conducted four replications of measurement and average values are shown in figure 2. Based on the minimum and maximum values there were created spread pattern with driving line distance from 9 to 14.5 m graded by 0.5 m (due to dimension of collecting trays). Values of the coefficient of variation calculated for all overlaps are shown in table 2.

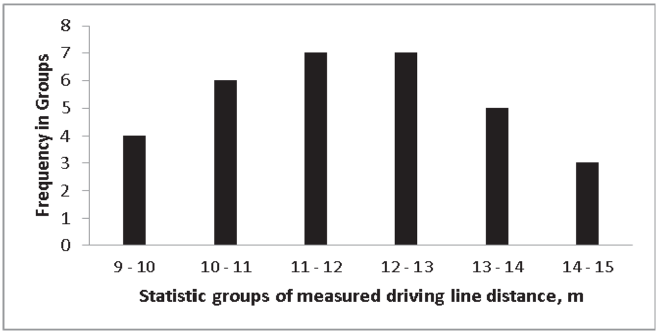

Fig.1. Frequency's distribution bar chart of measured driving line distance

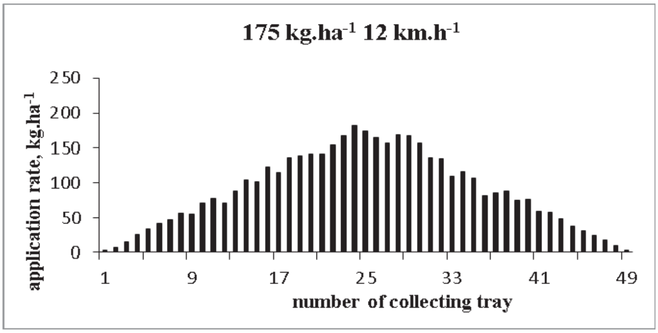

Fig.2. Spread pattern of AMAZONE ZA-M I 12-36 fertiliser spreader

Table 2.
Effect of manual navigation on work quality of AMAZONE ZA-M I 12-36

Driving line distance, m	Overlap, m	CV, %
9	15	17.23
9.5	14.5	15.35
10	14	14.57
10.5	13.5	13.29
11	13	11.54
11.5	12.5	10.22
12	12	9.58
12.5	11.5	10.29
13	11	11.72
13.5	10.5	12.85
14	10	14.96
14.5	9.5	15.38

CV= coefficient of variation

Results presented in table 3 show effect of overlap on the work quality of fertiliser spreader. Minimum value of coefficient of variation was 9.58 % with driving line distance 12 m. Ideal overlap of triangular spread pattern with triangular shape is 50 %. With working width 24 m it means overlap 12 m what is 50 %. The AMAZONE ZA-M I 12-36 fertiliser spreader was spreading fertiliser for application rate 175 $kg.ha^{-1}$ with working speed 12 $km.h^{-1}$ and meets the requirements of standard for maximum value of coefficient of variation with 2 m deviations from ideal driving line. The work quality of fertiliser spreader is significantly affected by overlaps - distance of driving lines chat is depended on the machinery operator. Those results are in agreement with study of the effect of satellite navigation on work quality [25] where 1 m accuracy of satellite navigation systems was found sufficient and also with our previous study of effect of manual navigation on quality of work [26].

CONCLUSIONS

The aim of the study was to analyse the effect of manual navigation on work quality of AMAZONE ZA-M I 12-36 fertiliser spreader aggregated with ZETOR 16145 tractor during the application of DUSLOFERT NPK 10-15-15 fertiliser. The increase in deviation from ideal driving line resulted in decrease of the overlaps. A deviation from ideal driving line has significant effect on the work quality of fertiliser spreader and meets the requirements of standard for maximum value of coefficient of variation with 2 m deviations from ideal driving line. The work quality of fertiliser spreader is significantly affected by overlaps – distance of driving lines chat is depended on the machine operator.

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Докладът е рецензиран.