# EFFECT OF MANUAL NAVIGATION ON QUALITY OF WORK OF KUHN AXERA 1102 H-EMC FERTILISER SPREADER

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**Abstract.** The aim of the study is to analyse the effect of the deviations from the ideal centre driving line caused by manual navigation on the work quality of the selected fertiliser spreader. The spinning disc fertiliser spreader, KUHN AXERA 1102 H-EMC, was used during the experiments aggregated with the tractor ZETOR 16145 and Urea prilled 46 %, was used as a fertiliser. The used fertilising application rate was set on 200 $kg \cdot ha^{-1}$ and the working speed was 12 $km \cdot h^{-1}$. The average observed value of the measured driving line distance was 11.56 m and therefore lower in comparison with the ideal driving line distance. The minimum and maximum values were 7.83 m and 15.2 m, respectively. The maximal observed deviation from the ideal driving line was 3.2 m. The effect of accuracy of the manual navigation on the work quality of the fertiliser spreader was analysed. The coefficient of variation, as a basic parameter for evaluation of the quality of work of the fertiliser spreader, did not meet the requirements of the standards (max value 15 %) with deviation higher than 2 m. Based on the results; manual navigation of the fertiliser spreader depends upon its operator and is unsuitable for reliable application of fertilisers.

**Keywords:** fertiliser spreader, fertiliser, manual navigation, quality of work.

## Introduction

Nitrogen fertilisation is an important factor that affects crop yields [1-3]. Fertilisers are applied to the field by a fertiliser spreader. The most widely used type of fertiliser spreaders are those with double spinning discs [4]. Uniformity of the fertiliser distribution on the field is affected by many factors. The most important factors are overlaps of the driving lines [5], the working speed [6-8], the size of the application rate [9; 10] and physical and mechanical properties of the fertilisers [9; 11-14]. The work quality of machinery is also affected by the type of the spreading system, individual technical solutions used by producers and weather conditions [9; 15-18].

The need for using fewer amounts of fertilisers means they must be applied in a right way and fertiliser losses should be reduced to an absolute minimum. An optimal application of fertilisers, minimisation of the spoilage of fertilisers, improvement of the existing and development of possible new application techniques, all of this requires thorough knowledge of the processes and factors that affect the spreading of fertilisers [19]. Incorrect application of fertilizers causes negative environmental effect in terms of increasing nitrous oxide [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 the working width [22]. Satellite guidance of the machinery is not used in all cases. Satellite navigation systems have proved to be an effective tool for efficient application of fertilisers [23; 24].

The aim of the study is to analyse the effect of the deviations from the ideal centre driving line caused by manual navigation on the work quality of the fertiliser spreader.

## Materials and methods

The tractor-mounted fertiliser spreader, KUHN AXERA 1102 H-EMC, was set according to the fertiliser manufacturer recommendations for the selected fertiliser type. The basic technical parameters of the KUHN AXERA 1102 H-EMC fertiliser spreader are shown in Table 1. The tractor ZETOR 16145 was used. During the experiments, urea prilled 46 % fertiliser was used. The used fertilizing application rate was 200 $kg \cdot ha^{-1}$ and the working speed was 12 $km \cdot h^{-1}$. The prilled urea is carbonic acid diamide – $CO(NH_2)_2$ in the form of white granulate. It is well-soluble in water. This product is protected by an anticaking surface treatment. It contains 46 % of nitrogen. The official trade mark of this fertiliser produced by DUSLO Šaľa, a.s. is UREA PRILLED and the basic parameters are shown in Table 2.

During the experiment, the 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. The methodology meets the requirements of the Standard EN 13739 and was described in our previous works [4-6; 9-11; 18; 20; 21; 25]. Based on the collecting container dimensions it is possible to create overlaps with deviations graded by 0.5 m. The coefficient of variation is a basic parameter to evaluate the work quality of the fertiliser spreader. The maximum allowed value is given by the Standard EN 13739 at the value 15 %.

Table 1

**Basic technical parameters of the KUHN AXERA 1102 H-EMC fertilizer spreader**

| Parameter | Value |
|---|---|
| Working widths | 12-42 m |
| Payload | 3500 kg |
| Basic capacity | 1100 l |
| Minimum filling height | 0.95 m |
| Hopper width | 2.80 m |
| Filling width | 2.70 m |
| Weight without extension | 550 kg |

Table 2

**Basic technical parameters of the KUHN AXERA 1102 H-EMC fertilizer spreader**

| Parameter | Value |
|---|---|
| Total nitrogen content in the urea form (N) | 46 % |
| Biuret content | max. 0.6 % |
| Content of particles below 0.5 mm | max. 3 % |
| Content of particles from 0.5 to 3.5 mm | min. 90 % |
| Content of particles over 10 mm | 0 % |

## Results and discussion

There were conducted 73 replications of the driving line distance measurement. The results are shown in Fig. 1. Based on the triangular shape of the 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 the average value 11.56 m and it was lower in comparison with the ideal driving line distance. The minimum and maximum values were 7.83 and 15.2 m, respectively. Maximum deviation from the ideal driving line was 3.2 m.

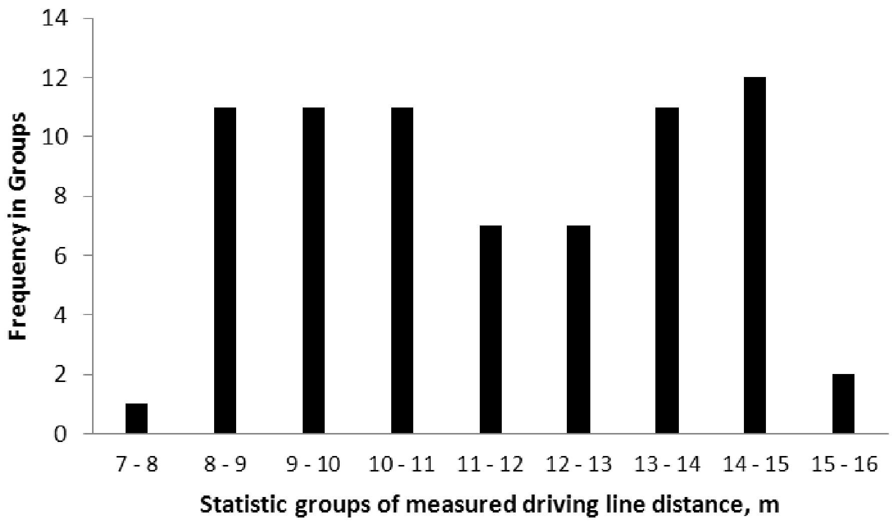


Fig. 1. **Frequency distribution bar chart of measured driving line distance**

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 the average values are shown in Fig. 2. Based on the minimum and maximum values there were created spread patterns with the driving line distance from 7.5 to 15.5 m graded by 0.5 m (due to dimension of collecting trays). The values of the coefficient of variation calculated for all overlaps are shown in Table 3.

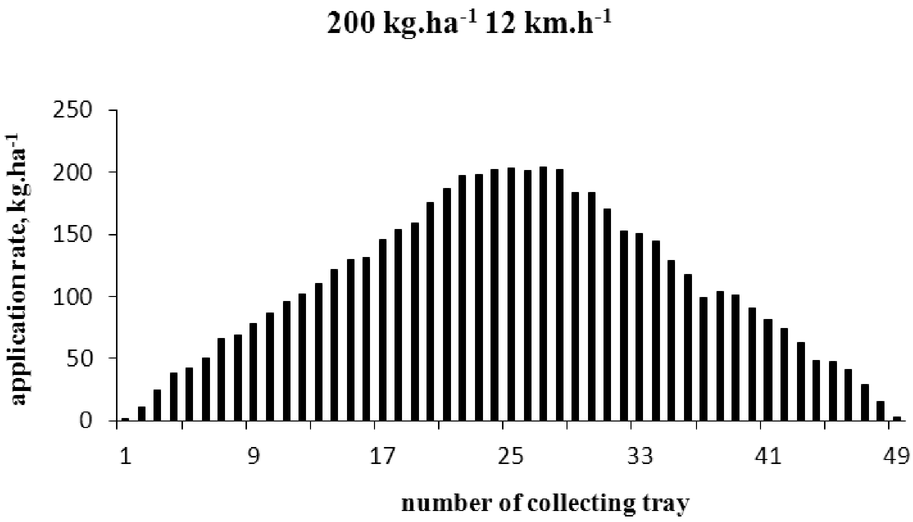


Fig. 2. **Spread pattern of KUHN AXERA 1102 H-EMC fertiliser spreader**

Table 3

**Effect of manual navigation on work quality of KUHN AXERA 1102 H-EMC**

| Driving line distance, m | Overlap, m | CV, % | Driving line distance, m | Overlap, m | CV, % |
|---|---|---|---|---|---|
| 7 | 17 | 23.06 | 11.5 | 12.5 | 9.74 |
| 7.5 | 16.5 | 21.58 | 12 | 12 | 8.36 |
| 8 | 16 | 20.07 | 12.5 | 11.5 | 8.39 |
| 8.5 | 15.5 | 18.78 | 13 | 11 | 10.03 |
| 9 | 15 | 16.81 | 13.5 | 10.5 | 12.49 |
| 9.5 | 14.5 | 15.56 | 14 | 10 | 14.82 |
| 10 | 14 | 14.84 | 14.5 | 9.5 | 15.93 |
| 10.5 | 13.5 | 12.02 | 15 | 9 | 17.56 |
| 11 | 13 | 10.35 | 15.5 | 8.5 | 19.22 |

CV= coefficient of variation

The results presented in Table 3 show the effect of overlap on the work quality of the fertiliser spreader. The minimum value of the coefficient of variation was 8.36 % with the driving line distance 12 m. Ideal overlap of the triangular spread pattern with triangular shape is 50 %. With the working width 24 m it means overlap 12 m what is 50 %. The KUHN AXERA 1102H-EMC fertiliser spreader was spreading the urea prilled fertiliser for the application rate 200 kg.ha$^{-1}$ with the working speed 12 km·h$^{-1}$ and it meets the requirements of the standard for the maximum value of the coefficient of variation with 2 m deviations from the ideal driving line. The work quality of the fertiliser spreader is significantly affected by overlaps – the distance of the driving line chat is dependent on the machinery operator. These results are in agreement with the study of the effect of satellite navigation on the work quality [25] where 1 m accuracy of satellite navigation systems was found sufficient.

## Conclusion

The aim of the study was to analyse the effect of manual navigation on the work quality of the KUHN AXERA 1102 H-EMC fertiliser spreader aggregated with the ZETOR 16145 tractor during the application of fertiliser, urea prilled. A deviation from the ideal driving line has a significant effect on the work quality of the fertiliser spreader and meets the requirements of the standard for the maximum value of the coefficient of variation with 2 m deviations from the ideal driving line. The work quality of the fertiliser spreader is significantly affected by overlaps – the distance of the driving line chat is dependent on the machine operator. The increase in deviation from the ideal driving line resulted in the decrease of the overlaps. In addition, it has resulted in the increase of the coefficient of variation over the allowed values defined in the standards. During additional application of fertilisers using tramlines is the way to solve these inaccuracies. However, it becomes problematic for basic or regenerative fertilisation where it is not possible to follow that kind of navigational factors. With regard to the availability of the satellite navigation technology these findings contribute to the need for the introduction and wider spread of its use in agricultural practice. It is possible to increase the work efficiency of agricultural machinery, better control the fertiliser application rates and also help increase the protection of the agricultural soil quality and the environment as a whole.

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