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ANALYSIS OF THE WORK QUALITY OF THE VICON RS-L FERTILIZER SPREADER WITH REGARD TO APPLICATION ATTRIBUTES

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Abstract: Within our research we have tested spinning disc fertilizer spreader VICON RS-L and fertilizer calk ammonium nitrate with dolomite (trade mark LAD 27) was used. Experiment was conducted on a flat land with balanced micro-relief after harvest of the perennial forage crops. It was carried 6 variants of experiment with two working speeds 8 $km.h^{-1}$ and 12 $km.h^{-1}$ and with three fertilizer application rates 100 $kg.ha^{-1}$, 200 $kg.ha^{-1}$ and 300 $kg.ha^{-1}$. Each variant of experiment was repeated four times. The fertilizer spreader was set according to the manufacturer requirements for this type of fertilizer and for the maximum spreading width (in our case for 42 meters). The value of the coefficient of variation was used as a basic parameter to assess the quality of fertilizer spreader work. Obtained results have been compared with the national standard STN EN 13739, which defines maximum value of coefficient of variation 15 %. For the spreader line spacing 24 m the coefficient of variation varied within the range 7.87 % - 13.60 % and for 36 m spacing line varied within the range 25.87 % - 38.11 %. Working speed negatively affects the uniformity of fertilizer application. With increasing of working speed the quality of work was decreased. We have recommended to reduce the working speed of the fertilizer spreader to optimize the spreader spacing line in order to achieve higher work quality of the fertilizer spreader – more uniform fertilizer distribution. Irregularity of distribution fertilizer on the field has a negative environmental effect.

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Key words: *fertilizer spreader, quality of work, working speed, uniformity distribution, spread pattern*

INTRODUCTION

Using of the fertilizers can be considered as a very important factor to intensify the crop production. Work quality of the fertilizer spreaders during fertilizer application significantly affects the whole cropping system. Incorrect application rate of fertilizer can resulted in increased cost of fertilizers, reduction of the crop grown and also negative environmental effects. For effective application it is necessary to know the transversal uniformity of the fertilizer distribution on the field surface. Quality of work fertilizer spreader depends also upon the working speed and also on the size of application rate. Requirements for quality and affordable food for food security widening population are constantly rising. Given the limited amount of agricultural land and the need to increase agricultural production to increase the production capacity of soil, what can be achieved by ensuring optimal use of plant nutrition and mineral fertilizer. Fertilization and irrigation are the main factors of crop production intensification.

Because the cost of fertilizers are not inconsiderable financial items for the farms it is necessary to know these precious materials used correctly and efficiently with the highest efficiency and effectiveness [1]. Effective application requires extensive technical and informational support related to data acquisition and processing of soil, the field and crop [2]. It is necessary to comply with agronomic and environmental principles in the application of fertilizers which emphasize the even distribution of fertilizer to the soil surface within the application (or navigation) work width of the machine [3]. Work quality of the application of machinery is affected by the type of spreading system, producers individual technical solution themselves, the physical and mechanical properties of fertilizer and weather conditions [4]. Development of an advanced society is conditioned by the increase of care on three existential elements of the environment, namely: water, soil and air. The main source of emissions in the atmosphere is constantly intensified agriculture. The need for using less fertilizer means that the fertilizer must be applied in the right way and that fertilizer spoilage is bought to an absolute minimum. Optimal application of fertilizer, minimization of the spoilage of fertilizer, improvement of existing and development of possible new application techniques, all require a thorough knowledge of the processes and the factors that affect the spreading of fertilizer [5].

Inaccurate application of fertilizer causes the local over dose of fertilizer on the field resulting in increased release of CO_2 and N_2O form the soil into the atmosphere. Improving the work quality of fertilizer spreader has a positive environmental effect.

In order to save fuel and reduce the soil compaction the area of trafficked land was reduced and the distance between spacing lines was increased. Tested fertilizer spreader VICON RS-L was used in the arable production systems with 24 m and 36 m spacing lines distances. The aim of the experiment was to compare the work quality of fertilizer spreader used in both technology and evaluate the effect of work speed and application rate on the spreading uniformity.

MATERIAL AND METHODS

Experiment was conducted on a flat land with balanced micro relief after harvest of the perennial forage crops. There were carried 6 variants of experiment with three fertilizer application rates 100 kg·ha^{-1}, 200 kg·ha^{-1} and 300 kg·ha^{-1} and with two working speeds 8 km·h^{-1} and 12 km·h^{-1}. Each variant of experiment was repeated four times. Fertilizer spreader was set according to the manufacturer requirements for this type of fertilizer and for the maximum spreading width (in our case for 42 meters). Double spinning disc VICON RS-L was connected with tractor ZETOR 16145.

Table 1. Basic technical parameters of the spreader VICON RS-L

Technical parameters	Unit	VICON RS-L
Type of application system	-	Centrifugal double disc
Working width	(m)	9 - 42
Base hopper capacity	(l)	1650
Maximum capacity	(l)	3200
Filling height	(m)	1.12

Figure 1. Fertilizer spreader VICON RS-L with tractor ZETOR 16145

Used calk ammonium nitrate (CAN) has the form of a grey-white ammonium nitrate granulates with the grounded dolomite decreasing the fertilizer natural acidity. Fertilizer is protected by ant caking surface treatment [6]. The official trade mark of this fertilizer produced by the manufacturer DUSLO Šala, Ltd. is LAD 27.

Table 2. Technical specification of Calk ammonium nitrate [6]

Technical specification	Content (%)
Total nitrogen content (N)	27
Ammonium nitrogen content	13.5
Nitrate nitrogen content	13.5
Content of total magnesium oxide (MgO)	4.1
Content of magnesium oxide (MgO) soluble in water	1

Figure 2. Fertilizer calk ammonium nitrate (LAD 27)

Table 3. Particle size distribution of Calk ammonium nitrate [6]

Particle size distribution	Value (%)
Content of particles from 2 to 5 mm	min. 90
Content of particles under 1 mm	max. 1
Content of particles over 10 mm	0

Basic requirements given by standard ISO 5690/1:

- tolerance of deviation from the required speed during the test (8 km·h^{-1} = ± 0.4 km·h^{-1}; 12 km·h^{-1} = ± 0.6 km·h^{-1}),
- filling tray capacity of fertilizer spreader among 10 % to 80 %,
- maximum wind speed under 2 m·s^{-1} (7.2 km·h^{-1}),
- maximum air moisture content 65 %,
- air temperature between 10°C to 25°C,
- dimensions of collecting trays 500 mm x 500 mm [7-9].

In order to measure the temperature, moisture and speed of air there was used an Anemometer Testovent 4000. This device allows measure all of this factors. All conditions (temperature, moisture content and speed of air) were observed during the test and the match the requirements of the standard.

Figure 3. Anemometer Testovent 4000

To capture fertilizers during measurements of the uniformity distribution there were used collecting trays with compartment. Their technical parameters meet the standard ISO 5690/1.

Figure 4. Collecting trays and their distribution over the field

Set up of the fertilizer spreader: at the beginning of the measurement the fertilizer spreader was set up by the manufacturer recommendations with regard to the specific properties of the tested fertilizer. When measurements were adjusted the three different application rate of fertilizer was used: 100 kg·ha^{-1}, 200 kg·ha^{-1} and 300 kg·ha^{-1}. Graded trays were chosen based on capturing the largest possible range of application rate with which the machine can work. Uniformity of application is greatly influenced by working speed of the machine. We used two sets of speed 8 km·h^{-1} and 12 km·h^{-1}. In the way we created six variations of the experiment. Each variant of experiment was repeated four times.

Putting fertilizer spreader into operation: application machine was put into operation 50 m before the line formed by collecting trays for fertilizer. After entering the lateral line machine continued in the work another 50 m and then was stopped.

Locations of collecting trays: collecting trays were placed perpendicular to the driving direction, in order to cover the image of the entire width of the machine. Total covered width was equal to 50 m. Manufacturer indication for maximum spread width is 42 m. To facilitate the passage of the tractor it was necessary to create the space for the tractor wheels. Width of the gap can only be integer multiples of the width of the collecting tray which was used. In our case we selected for each wheel width of 1 m what is equal to 2 collecting trays. Between the tractor wheels there was left the place for one collecting tray, which was located on the axis drive work. Two collecting trays were omitted on each side of the axis of tractor passage and a one collecting tray was placed in the axis of travel.

Quantity of captured fertilizer: fertilizer captured in each tray was weighted to the nearest hundredth of grams. Weight fertilizer in stock skipped lines had to be calculated. Centrifugal fertilizer spreader have triangular transversal spread pattern.

Evaluation of the work quality: evaluation of transversal uniformity distribution was done by comparing the coefficient of variation of values obtained. In the calculation we consider a driving assembly in the field, and consequently the right side of spread pattern overlaps the right side and left side overlaps the left side of the spread pattern. The overlap value reached 20 m for 24 m spacing line and 8 m for 36 m spacing line width.

Standard STN EN 13739-2 was used to calculate the coefficient of variation (CV):

$$CV = \frac{1}{x}\sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}{N}} * 100 \; ; \quad (\%) \qquad (1)$$

We calculated the coefficient of variation in individual variants of the experiment and for the 20 m and for 8 m overlaps.

RESULTS AND DISCUSSION

The aim of the study was to determine and compare the work quality of fertilizer spreader VICON RS-L using CAN 27 fertilizer when using application rate of fertilizer 100 $kg.ha^{-1}$, 200 $kg.ha^{-1}$ and 300 $kg.ha^{-1}$ and working speed 8 $km.h^{-1}$ and 12 $km.h^{-1}$.

Recording the amount of fertilizer in individual collecting trays allows to create the transversal spread patterns (Chart 1.).

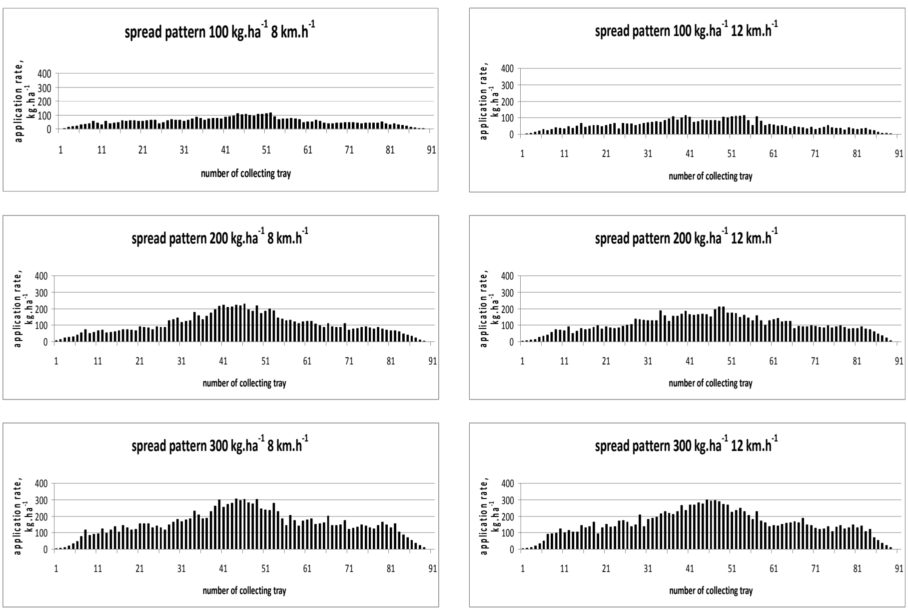

Chart 1. Spread patterns of fertilizer spreader VICON RS-L

From the data obtained it was possible to create spread patterns with overlap 20 m (Chart 2) and with overlap 8 m (Chart 3.) for each of six variants of experiment. Overlap 20 m means 24 m spacing line and overlap 8 m means 36 m spacing line.

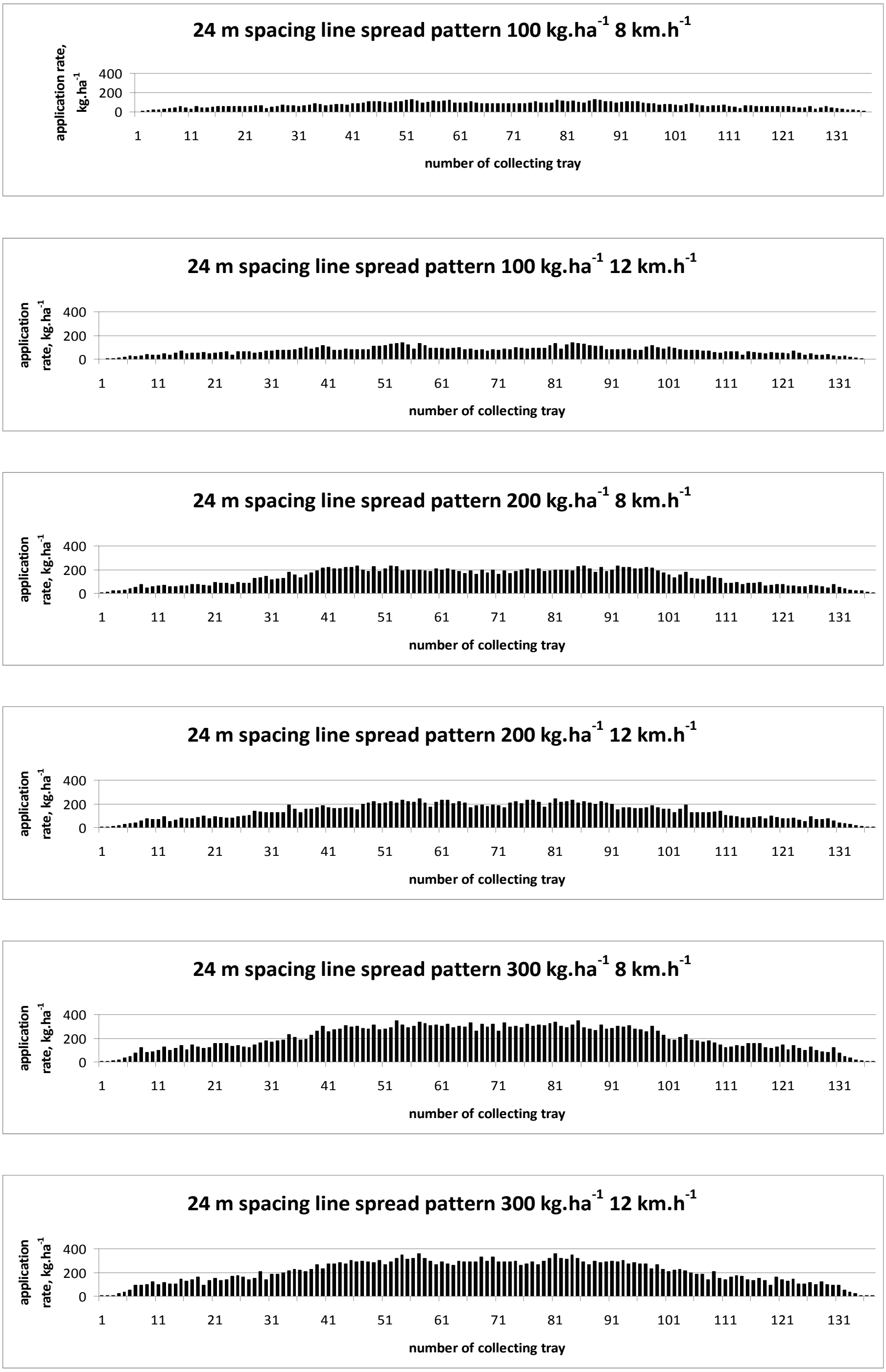

Chart 2. Spread patterns 24 m spacing line of fertilizer spreader VICON RS-L

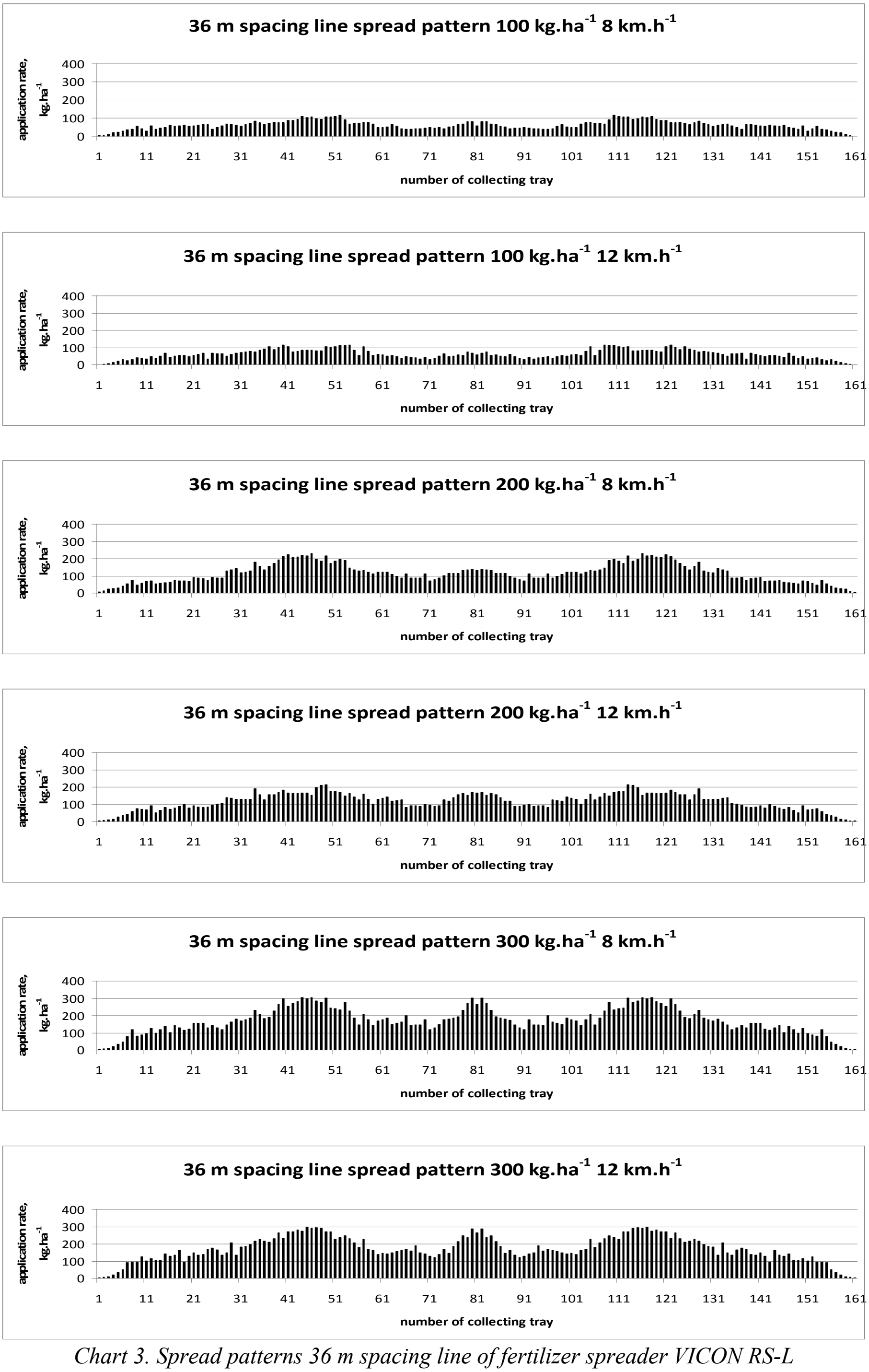

Chart 3. Spread patterns 36 m spacing line of fertilizer spreader VICON RS-L

Table 4. Values of coefficient of variation for all variants of experiment

Spacing line (m)	Overlap (m)	Coefficient of variation CV (%)						
		Application rate (kg·ha^{-1})						Average value of CV (%)
		100	100	200	200	300	300	
		Working speed (km·h^{-1})						
		8	12	8	12	8	12	
36	**8**	**35.31**	**38.11**	**25.87**	**32.63**	**27.72**	**28.35**	**31.33**
34	10	32.57	34.70	29.28	23.15	26.10	25.59	28.57
32	12	28.93	30.10	25.38	19.08	23.48	22.53	24.92
30	14	23.42	24.48	20.94	15.16	21.02	21.01	21.01
28	16	17.61	19.13	16.46	13.90	18.33	17.04	17.08
26	18	12.69	16.58	11.62	11.12	13.47	9.75	12.54
25	19	12.14	17.06	9.08	10.51	10.66	8.49	11.33
24	**20**	**10.84**	**13.60**	**8.84**	**11.20**	**7.87**	**8.24**	**11.10**
23	21	13.09	14.01	8.92	11.41	8.85	8.61	12.10
22	22	15.87	17.44	10.51	12.83	10.59	10.75	13.67

CONCLUSIONS

During the field experiment there was tested the fertilizer spreader VICON RS-L with calk ammonium nitrate (trade mark LAD 27) produced by DUSLO Šala, Inc. From the requirements of the national standard STN EN 13739 to the maximum value of the coefficient of variation as a basic parameter for assessing the quality of work 15 % results that fertilizer spreader can be used in management of 24 m spacing lines distance when fertilizer spreader meets the requirements of the standard for each six variants of experiment. Value of coefficient of variation range between 7.87 % to 13.60 %. Used in management 36 m spacing lines distance fertilizer spreader do not meet the requirement of the national standard because value of coefficient of variation range is from 25.87 % to 38.11 %. Realistically achieved spreading width is 44 m. This value is about 2 m more than maximum spreading width (from manufacturer's maximum value of spreading width). It may be caused by physical properties of fertilizer. Higher working speed has negatively effect on the fertilizer spreader work quality. The quality of work is decreased with increasing of the working speed in all variants of experiment. Based on the results obtained it is possible to formulate the recommendations for reducing working speed and optimal management. Fertilizer spreader VICON RS-L cannot be used with 36 m spacing lines while maintaining the quality of work, compliance with requirements of the national standard.

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ANALIZA KVALITETA RADA RASIPAČA ĐUBRIVA VICON RS-L PREMA NAČINU PRIMENE

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Sažetak: **U** našem istraživanju testirali smo rasipač đubriva sa rotacionim diskom VICON RS-L sa amonijum-nitratnim đubrivom sa dolomitom (marka LAD 27). Ogled je izveden na ravnom zemljištu posle žetve krmnog bilja. Izvedeno je 6 varijanti ogleda sa dve radne brzine 8 km·h^{-1} i 12 km·h^{-1} i sa tri norme đubrenja 100 kg·ha^{-1}, 200 kg·ha^{-1} i 300 kg·ha^{-1}. Svaka varijanta je ponovljena četiri puta. Rasipač je bio podešen prema zahtevima proizvođača za ovaj tip đubriva i za maksimalni radni zahvat (u našem slučaju za 42 m). Vrednost koeficijenta varijacije uzeta je kao osnovni parameter za procenu kvaliteta rada rasipača. Dobijeni rezultati su poređeni sa nacionalnim standardom STN EN 13739, koji definiše maksimalan koeficijent varijacije od 15%. Na rasponu rasipanja od 24 m koeficijent varijacije je iznosio 7.87% - 13.60%, a za 36 m 25.87% - 38.11%. Radna brzina je je negativno uticala na ujednačenost rasipanja. Sa povećanjem radne brzine kvalitet rada se smanjivao. Preporučili smo smanjenje brzine rasipača radi optimizacije širine rasipanja i dobijanja boljeg kvaliteta rasipanja – veća ujednačenost rasipanja. Neujednačeno rasipanje đubriva na parceli negativno utiče na sredinu.

***Ključne reči**: rasipač đubriva, kvalitet rada, radna brzina, ujednačenost rasipanja, put rasipanja*

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