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Effect of nitrification inhibitors on fertiliser particle size distribution of the DASA® 26/13 and ENSIN® fertilisers

T. Šima[1,*], J. Krupička[2] and L. Nozdrovický[3]

[1,3]Slovak University of Agriculture in Nitra, Faculty of Engineering, Department of Machines and Production Systems, Tr. A. Hlinku 2, 94976 Nitra, Slovak Republic; [*]Correspondence: tomasko.sima@gmail.com
[2]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Agricultural Machines, Kamýcká 129, 16521 Prague, Czech Republic

Abstract. Effectiveness of the spinning disc fertiliser spreaders is affected by the physical properties of the fertiliser. One of the most important factors is the fertiliser particle-size distribution which depends upon the size of the fertiliser particles. The aim of the paper was comparison of two very similar fertilisers from the same manufacturer DUSLO, Inc. using granulated nitrogen fertiliser with sulphur content DASA® 26/13 and nitrogen fertiliser ENSIN® containing sulphur and nitrification inhibitors dicyandiamide DCD and 1, 2, 4 triazole – TZ. Comparison was done by evaluation of the particle-size distribution of the fertiliser separated at first in the vertical air flow by K-293 Laboratory screening machine with steeply increasing flow speed. The airflow speed was regulated by airflow volume from 60 to 150 $m^3 h^{-1}$. Secondary separation was done by sieve screening of the samples by Haver EML digital plus Test Sieve Shaker. Sieves with square holes with dimensions 1 mm, 2 mm, 3.15 mm, 5 and 10 mm were used. Both fertilisers meet the requirements of the manufacturer for grain-size distribution. Air flow separation shows higher variability of weight of the ENSIN fertiliser particles in comparison with DASA fertiliser. Air flow 130 $m^3 h^{-1}$ separated all the particles of DASA fertiliser. To separate all ENSIN® particles there was used air flow to 150 $m^3 h^{-1}$. These differences affect the quality of work of the spinning disc fertiliser spreader and cause non-uniformity in the field distribution of fertiliser which has negative environmental and economical effects.

Key words: fertiliser, particle, sorting, airflow, nitrification inhibitors.

INTRODUCTION

Fertilisation is an important factor that affects crop yields (Ložek et al., 1997; Kajanovičová et al., 2011). Correct application of fertilisers has both positive economical and environmental effects (Nozdrovický et al., 2009; Šima et al., 2011; Šima et al., 2012[a]; Šima & Dubeňová, 2013). Quality of work of the spinning disc fertiliser spreaders is affected by many factors (Macák & Nozdrovický, 2009; Šima et al., 2012[b]; Šima et al., 2012[c]). One of the most important factors is the fertiliser particle-size distribution which depends upon the size of the fertiliser particles (Macák et al., 2011; Macák & Nozdrovický, 2012). The differences and variability in physical properties of fertilisers causes problems during the field application by the commonest spinning disc fertiliser spreaders (Macák & Nozdrovický, 2010[a]). The effectiveness of mineral fertilisers in plant cultivation depends upon the particle stability and speed of their transformation to a solution state acceptable for plants. This process depends upon the particle's dimension, so that the dimension of particles is one of the main parameters that influence fertiliser effectiveness (Krupička & Hanousek, 2006). The need for using fewer amounts of fertilisers means that it must be applied in the right way, and fertiliser losses are reduced to an absolute minimum. An optimal application of fertilisers, minimisation of the spoilage of fertilisers, improvement of existing and development of possible new application techniques, all requires a detailed knowledge of the processes and factors that effect the spreading of fertilisers (Hofstee, 1993). The aim of the paper is the study of the granulometric composition of two very similar nitrate fertilisers from the same manufacturer when vertical airflow and sieve separation are used. These being granulated nitrogen fertiliser with sulphur content DASA® 26/13 and nitrogen fertiliser ENSIN® containing sulphur and nitrification inhibitors dicyandiamide DCD and 1, 2, 4 triazole – TZ.

MATERIAL AND METHODS

Experimental measurements were conducted in the laboratory of the Department of Agricultural Machines, Faculty of Engineering at Czech University of Life Sciences in Prague, Czech Republic. During experiments we have used two very similar fertilisers from the same manufacturer DUSLO, Inc. There was granulated nitrogen fertiliser with sulphur content DASA® 26/13. Nitrogen is in an ammonium and nitrate form and sulphur is in a water-soluble sulphate form. The granulate has a pink to brown colour and surface treated by a coating agent. The other fertiliser used is a granular nitrogen fertiliser ENSIN® containing sulphur and nitrification inhibitors dicyandiamide DCD and 1, 2, 4 triazole – TZ. The granulate is treated by a coating agent and has a green colour. The nitrification inhibitors ensure transformation of ammonium nitrate to nitrogen nitrate in the soil. The advantages of ENSIN® usage compared to DASA® 26/13 are that the fertiliser is applied in one dosage and re-application of the fertiliser is not necessary. It allows farmers to save time and money, increase crop yields and allow a better quality of crops, the fertiliser is especially environment friendly reducing nitrate leaching and reducing emissions of nitrous oxide into the atmosphere.

The chemical composition of DASA® 26/13 and ENSIN® fertilisers is presented in Tables 1 and 2, respectively. Grain-size distribution of DASA® 26/13 and ENSIN® fertilisers are shown in Table 3.

Table 1. Chemical composition of DASA® 26/13 fertiliser

Technical specification	Content, %
total nitrogen content (N)	26
ammonium nitrogen content	18.5
nitrate nitrogen content	7.5
sulphur (S) soluble in water	13

Table 2. Chemical composition of ENSIN® fertiliser

Technical specification	Content, %
total nitrogen content (N)	26
ammonium nitrogen content	18.5
nitrate nitrogen content	7.5
sulphur (S) soluble in water	13
dicyandiamide DCD and 1, 2, 4 triazole content	0.37–0.74
DCD:TZ ratio	10:1

Table 3. Grain-size distribution of the DASA® 26/13 and ENSIN® fertilisers

Dimension,	Content of particles, %	
mm	DASA® 26/13	ENSIN®
< 1	max. 1	max. 1
2–5	min. 90	min. 90
> 10	0	0

Total weight of sample was 25 kg. From the sample there was taken 6 individual specimens of 0.5 kg weight. There were created 6 replications of measurement (n = 6).

Fertilisers were separated at first by K-293 apparatus in the vertical air flow stream with steeply increasing flow speed. The airflow speed was regulated by airflow volume from 60 to 150 $m^3 h^{-1}$. The next step of airflow speeds was set up for 10 $m^3 h^{-1}$. Secondary, there were conducted sieve analysis by Haver EML digital plus Test Sieve Shaker for every class of fertiliser sorting in the vertical airflow. Sieves with square holes with dimensions 1 mm, 2 mm, 3.15 mm, 5 and 10 mm were used. By this method, the samples of fertiliser were sorted into 6 classes of particles.

RESULTS AND DISCUSSION

Average values (six replication n = 6) of obtained data for DASA® 26/13 and ENSIN® fertilisers are presented in tables 4 and 5, respectively. There where f_{id} (%) and f_{im} (%) means mass classes in percent of the specimen mass and percentage of the grain number in the total class particles.

Table 4. Averaged relative weight frequencies of DASA® 26/13 fertiliser, (n = 6)

V, $m^3 h^{-1}$		70	80	90	100	110	120	130
v, $m s^{-1}$		8.54	9.76	10.98	12.2	13.42	14.64	15.86
f_{im}, %		0.27	0.32	0.35	1.20	8.58	34.59	35.96
f_{id}, %	< 1 mm	0	0	0	0	0	0	0
	1–2 mm	0.1	0.1	0	0	0	0	0
	2–3.15 mm	0.04	0.19	0.99	2.94	0.83	0	0
	3.15–5 mm	0	0	1.48	14.07	41.04	26.69	8.11
	5–10 mm	0	0	0	0	0.38	1.12	1.92
	> 10 mm	0	0	0	0	0	0	0

f_{im} – grain number in the total class particles, f_{id} – mass classes in percent of the specimen mass, V – airflow quantity, v – airflow speed.

Table 5. Averaged relative weight frequencies of ENSIN® fertiliser, (n = 6)

V, m^3 h^{-1}		70	80	90	100	110	120	130	140	150
v, m s^{-1}		8.54	9.76	10.98	12.2	13.42	14.64	15.86	17.08	18.30
f_{im}, %		0.27	0.32	0.35	1.20	8.58	34.59	35.96	16.59	1.69
f_{id}, %	< 1 mm	0	0	0	0	0	0	0	0	0
	1–2 mm	0.03	0.01	0.10	0	0	0	0	0	0
	2–3.15 mm	0.02	0.12	0.27	0.57	0.59	0.20	0	0	0
	3.15–5 mm	0	0	0	4.23	20.48	39.98	25.83	4.76	0
	5–10 mm	0	0	0	0	0.17	0.57	0.75	1.22	0.16
	> 10 mm	0	0	0	0	0	0	0	0	0

f_{im} – grain number in the total class particles, f_{id} – mass classes in percent of the specimen mass, V – airflow quantity, v – airflow speed.

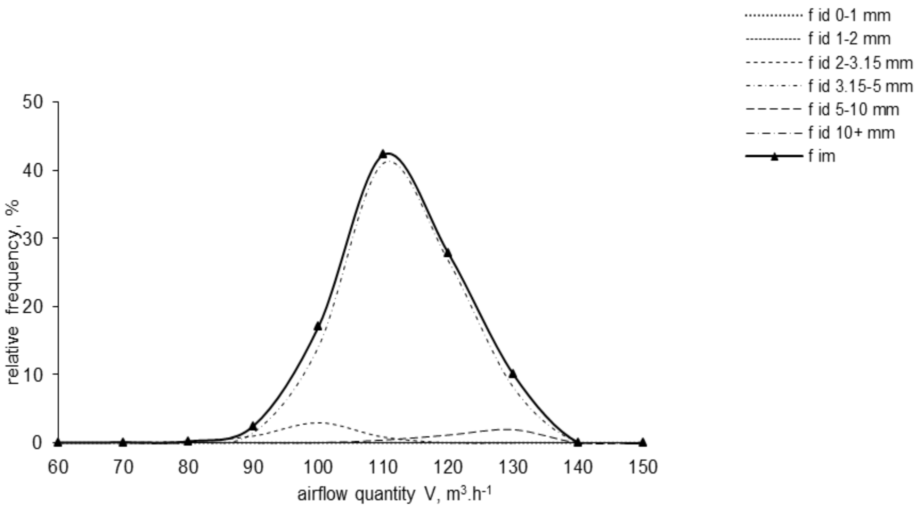

Figure 1. The effect of the airflow quantity on relative weight frequencies of DASA® 26/13 fertiliser particles, f_{im} – grain number in the total class particles, f_{id} – mass classes in percent of the specimen mass.

DASA® 26/13 and ENSIN® fertilisers content 96.37% and 97.05% particles with dimension from 2 to 5 mm, respectively. Both fertilisers contain no particles under 1 mm and no particles over 10 mm. Based on these results, particle-size distribution of DASA® 26/13 and ENSIN® fertilisers is in conformity with the demanded range given by the manufacturer and also meets the requirements of national standards. Content of fertiliser particles under 1 mm (dust particles) may be caused by minimal manipulation of the fertiliser bags. Both fertilisers were packed into polyethylene bags containing 25 kg of the fertiliser. There is the possibility to replace sieve analysis by air flow analysis to separate the class of particles with dimension from 3.15 mm to 5 mm by air flow speed from 90 to 130 m^3 h^{-1} and from 100 to 140 m^3 h^{-1} for DASA® 26/13 and ENSIN® fertilisers, respectively. The effect of the airflow quantity on relative weight frequencies of DASA® 26/13 and ENSIN® fertilisers particles f_{im} and f_{id} is shown in the figures 1 and 2. Most used method for detection of the fertiliser size distribution is screen analysis. This method can be replaced by photo-optical image analysis (Macák & Nozdrovický, 2010[b]) and aerodynamic particle testing. Classical screen analysis can be replaced by aerodynamic particle testing and it can be used directly in evaluation of the aerodynamic spreading of the fertiliser in the field conditions. Photo-optical analysis may be used for monitoring of particle-size distribution of fertilisers, but only by screen analysis and aerodynamic particle testing is it possible to separate particles.

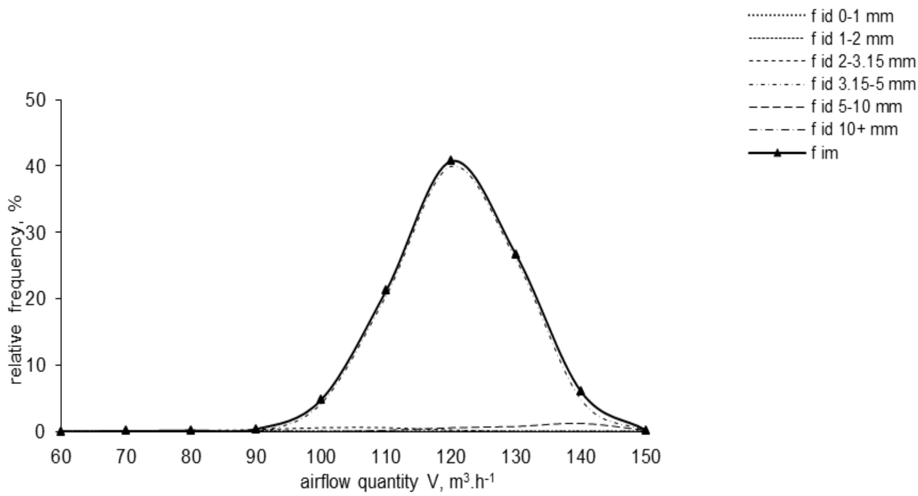

Figure 2. The effect of the airflow quantity on relative weight frequencies of ENSIN® fertiliser particles, f_{im} – grain number in the total class particles, f_{id} – mass classes in percent of the specimen mass.

CONCLUSION

The aim of the paper was the study of the granulometric composition of two very similar nitrate fertilisers from the same manufacturer. For the separation of particles, vertical airflow and sieve separation were used. There were used granulated nitrogen fertiliser with sulphur content DASA® 26/13 and nitrogen fertiliser ENSIN® containing sulphur and nitrification inhibitors dicyandiamide DCD and 1, 2, 4 triazole – TZ. Both fertilisers meet the requirements of the national standards and are in conformity with the demanded range given by the manufacturer. Classical screen analysis can be replaced by photo-optical analysis for the monitoring of grain-size distribution of fertilisers. To separate the particles of fertiliser it is possible to use screen analysis or aerodynamic particle testing.

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