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GRANULOMETRIC STUDY OF NPK 20-8-8 AND DOLOPHOS FERTILIZERS

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Physical properties of commercial fertilizers play important role from precision application point of view. Granulometric evaluation is usually performed by sieve separation according ČSN 01 5030 standard. The main subject of this work is the presentation of separation results when vertical airflow is used with NPK 20-8-8 and Dolophos fertilizers. The sample was divided into 8 individual specimens of 0.5 kg weight that was measured repeatedly. Every class of the specimen was than sieved on the sieves with holes 2 mm, 3.5 mm, and 5 mm resulting four new subclasses characterized by the sieve mesh dimension. It was achieved by statistical evaluation that relative frequencies are in agreement with N-distribution. It is clear from achieved values that in NPK 20-8-8 fertilizer samples there are 92.25 % of particles with dimension from 3.15 to 5 mm and 7.0 % with dimension from 2 to 3.15 mm. In fertilizer Dolophos there are 50.87 % of particles with dimension from 3.15 to 5 mm and 47.54% with dimension from 2 to 3.15 mm.

Keywords: airflow, fertilizer, granulometry, particle, sorting.

INTRODUCTION

The effectiveness of mineral fertilizers in plant cultivation depends on the particle stability and speed of their transformation to solution state to be acceptable by plants. This process depends on the particles dimensions, so that the dimension of particles is one of the main parameters that influence the fertilizer effectiveness.

Application of solid commercial fertilizers plays important role in precision farming technologies. The application quality is dependent on chemical composition and physical properties of fertilizer (Jager and Hegner, 1987). Important from physical properties point of view is the grading of aggregate evaluation (Bartoš and Waradzin, 1981) that is still performed by standard ČSN 01 5030. The dimension of particulars only is characterized by this way.

In this paper we continue in the previous research program, in which the granulometric study Synferta-P, Synferta N-17 and Synferta N-22 were studied. In contrary to the similar study of other authors screen and airflow sorting were combined. This paper contains results obtained when this method is applied on two mineral fertilizers NPK 20-8-8 and Dolophos.

Particles are preferably a readily soluble material that, after distribution of the granules in the soil, releases the nitrogen source particles to permit the action of water and microorganisms on the particles (Allan et al., 1989). Experiments with particles can be designed differently. An elutriator was designed and constructed in which an airflow is supplied by a centrifugal fan (Csizmazia, 2000). Methods for measuring the coefficient of friction, the coefficient of restitution, the aerodynamic resistance coefficient, and the breaking force (particle strength) of fertilizers (Hofstee, 1992) were taken into account. The breaking force feature was skipped. The problem of particle destruction was overcome by fertilizer selection. Opposite solution was studied in Japan. The control of fertilizer discharge was studied for different designs of distributors and an experimental accurate fertilizer distributor with a rotary vessel type feeder was developed (Kudoh, 1989) what shows that dissolution of fertilizer also makes some problems. Consequent logistical problems are equally difficult for both pumping liquids, and transportation of particles by the air.

The size of particles makes the fertilizer's shelf life and stability of particulars behavior in the airflow more stable in storage and better acceptable by the plant. The fertilizers studied are resistant against particle destruction in the airflow. Therefore, experiments studying motion of particles through the air were accompanied by grading of particles.

MATERIALS AND METHODS

Experimental material was supplied by its producer DÜKA. Total weight of the supplier sample was 25 kg. The sample was divided into 8 individual specimens of 0.5 kg weight that was measured repeatedly. The homogenization of the individual specimens was saved by previous mixing of the sample and then by stochastic composite sampling (ten parts per specimen). At first step the specimens were separated by using the laboratory air sorter, in the vertical air flow stream with steeply increasing flow speed (Fig. 1). The airflow speed was regulated by airflow volume from 75 to 155 $m^3.h^{-1}$ for NPK 20-8-8 and from 85 to 165 $m^3.h^{-1}$ for Dolophos. The steps of airflow speeds are given in Tables 1 and 2. The results of this separation were expressed by the mass classes f_{im} in percent of the specimen mass.

Figure 1. Laboratory Air sorter K – 293

Labels: 1 – adjustable damper hoppers, 2 – vertical (aspiration) channel, 3, 4 – tanks, 5 – control panel with buttons, 6 – small and large graduated cylinder, 7 – cylinder adjusting screws, 8 – fan

Every class of the specimen was than sieved on the sieves with holes 2 mm, 3.5 mm, and 5 mm resulting four new subclasses characterized by the sieve mesh dimension. They were marked as fid expressed by percentage of the grain number in the total class particles.

RESULTS AND DISCUSSION

Mean values of the obtained data: f_{im} [%] (based on 0.5 kg specimen) and f_{id} [%] are presented in Tables 1 and 2. The averages were calculated from measurements repeated eight times. The results are graphically presented in Figures 2 and 3.

Table 1. Averaged relative weight frequencies of NPK 20-8-8 fertilize

V [$m^3.h^{-1}$]		75	85	95	105	115	125	135	145	155
v (m/s)		9.15	10.37	11.6	12.82	14.04	15.26	16.48	17.7	18.91
f_{im} [%]		0	11.55	14.45	22.06	25.4	19.74	6.08	0.71	0
	< 2 mm	0	0.5	0	0.13	0	0	0	0	0
	2–3.15 mm	0	4.85	0.59	1.53	0.01	0	0.01	0.01	0
f_{id} [%]	3.15–5 mm	0	6.17	13.88	20.41	25.38	19.71	6.01	0.69	0
	> 5 mm	0	0	0	0.01	0.05	0.03	0.03	0	0

Table 2. Averaged relative weight frequencies of Dolophos fertilizer

V [m^3.h^{-1}]		85	95	105	115	125	135	145	155	165
v (m/s)		10.37	11.6	12.82	14.04	15.26	16.48	17.7	18.91	20
f_{im} [%]		1.78	3.22	9.92	21.95	25.89	22.64	10.56	3.02	1.02
	< 2 mm	0.15	0.25	0.54	0.08	0.04	0.02	0.01	0	0
	2–3.15 mm	1.4	2.41	5.95	14.68	13.38	7.45	2.23	0.05	0
f_{id} [%]	3.15–5 mm	0.23	0.56	3.43	7.19	12.45	15.12	8.27	2.69	0.92
	> 5 mm	0	0	0	0	0.02	0.05	0.05	0.28	0.09

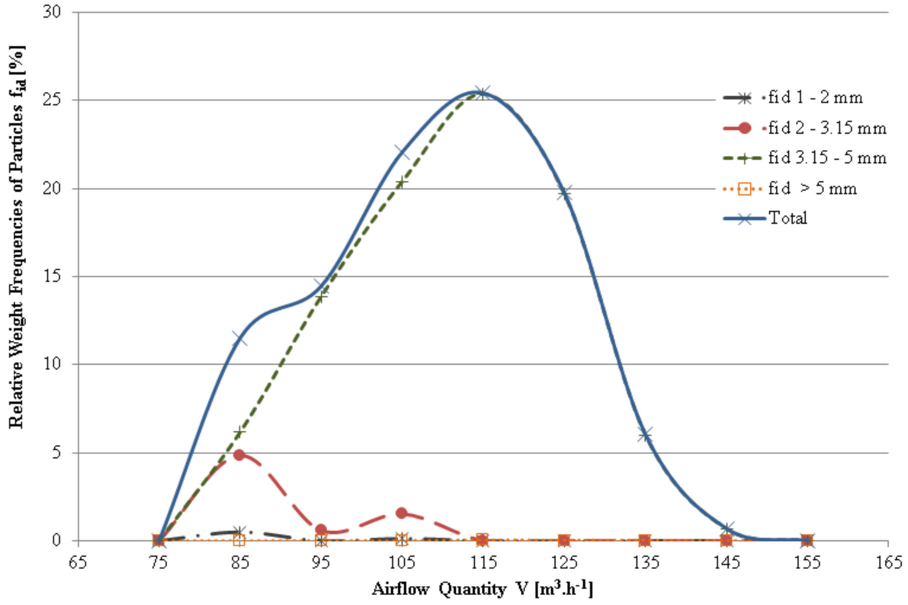

Figure 2. The dependence of relative weight frequencies of particles f_{id} (%) of NPK 20-8-8 fertilizer on the airflow quantity V [m^3.h^{-1}].

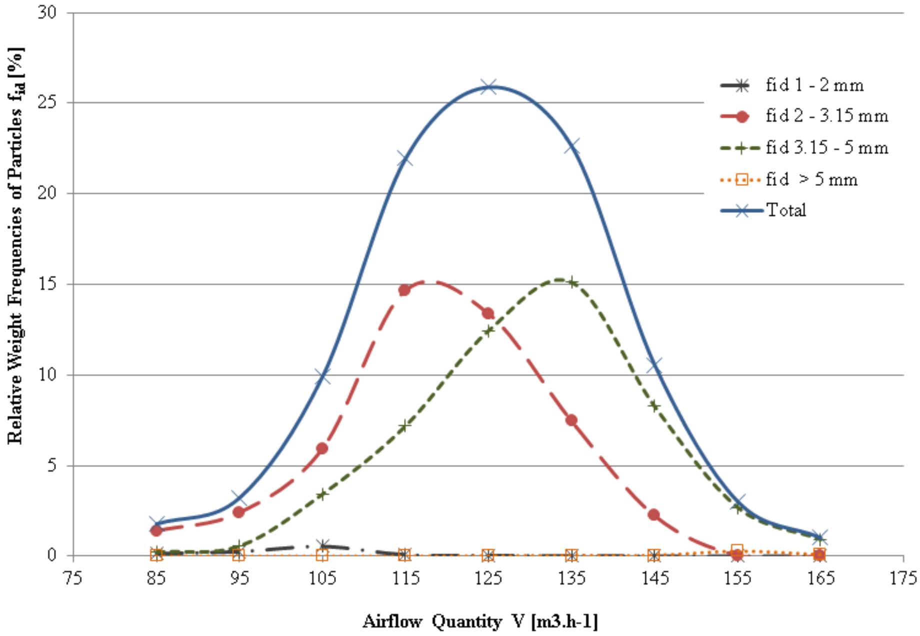

Figure 3. The dependence of relative weight frequencies f_{id} [%] of Dolophos fertilizer on the airflow quantity V [m^3.h^{-1}].

It was achieved by statistical evaluation that relative frequencies are in agreement with N-distribution. It is clear from achieved values that in NPK 20-8-8 fertilizer samples there are 92.25 % of particles with dimension from 3.15 to 5 mm and 7.0 % with dimension from 2 to 3.15 mm. In fertilizer Dolophos there are 50.87 % of particles with dimension from 3.15 to 5 mm and 47.54 % with dimension from 2 to 3.15 mm. It means that 99.25 % particles of NPK 20-8-8 and 98.41 % of particles of Dolophos are between 2 and 5 mm and this is in agreement with the demanded range (ČSN 01 5030).

The method that was used for the critical airflow speeds is applicable for different dimensions and weights of particles groups. The method could be used in this form also for determination of the critical airflow speeds in case of other products in form of particles. In our case, the critical airflow speed of NPK 20-8-8 fertilizer ranges from 10.37 to 17.70 m s^{-1}. In the case of Dolophos fertilizer, the critical speed falls within the interval 10.37–20.00 m.s^{-1}.

Influence of granulometry was studied by other authors. Ning et al. (2015) reported the necessity of uniformity granulometric composition in single doses of fertilizer. This is important for application conditions. Yuan et al. (2010) emphasize the need to describe the distribution of fertilizers to set the quantity of fertilizer. Lower granulometry influence can be seen in the pneumatic fertilizer spreaders (Tajudeen et al., 2014). Here it is necessary reflect changes in the air flow entraining fertilizer (Zhou and Jiang, 2001). Granularity is also noticeable impact when moving the drops (Rahemanand Jindal, 2001). Granularity affects all processes associated with the movement in the air flow.

CONCLUSIONS

Classical screen analysis was enriched by aerodynamic particle testing that can be used directly in evaluation of the aerodynamic spreading of the fertilizer in the field conditions. The data for two tested fertilizers, i.e. NPK 20-8-8 and Dolophos, are in agreement with demanded range. Measurement data are usable particularly in terms of the precise application of mineral fertilizers.

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