Determining the main physical characteristics of fertilisers

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Abstract: Evenly distributed fertilisation is an important demand in agricultural technology. Environment-friendly cultivation technology requires distributing different types of fertilizers more accurately and evenly. For this reason, it is necessary to develop fertilizer spreader machines continuously. In developing this machinery, it is essential to know the physical properties of fertilizers. This study deals with the main factors influencing fertilisation, including surface characteristic, particle (granule) shape, particle hardness, particle size range, specific particle weight. We can determine the following characteristics: particle size and particle size distribution, bulk density, moisture content, and the angle of repose. Six different fertilizer types were examined for their most significant physical characteristics from the aspect of the dispersion of fertilizer particles. The measured moisture content, space filling and fraction characteristics affect storage and transport properties.

Keywords: fertilizer, agricultural, environment-friendly, precision application of fertilizer

Introduction

Fertilizers are indispensable in nutrient replenishment, which is an essential part of crop production. The precision application of fertilizers is necessary in order to perform modern nutrient management, as it guarantees the stable yield and quality of culture crops without harming the environment. This environmental friendly and cost-effective method is the location-specific "precision" nutrient replenishment, which makes it possible to perform nutrient application adapted to the local endowments and needs of the given plot. The physical characteristics of the used fertilizers greatly differ from each other as they significantly affect the physical distribution of fertilizers applied on the soil. During this research, we examined the physical characteristics of six different fertilizers widely used in nutrient replenishment.

Materials and methods

Measurements were performed in the material analysis laboratory of the Institute of Land Utilisation, Regional Development and Technology of the Faculty of Agricultural and Food Sciences and Environmental Management of the University of Debrecen at 20°C and a relative humidity of 30-40 %. Fifty kg airtight fertilizer bags were available for each fertilizer type.

The following fertilisers were used for the analyses:

I. NH_4NO_3
II. YARA Mila 13:13:21
III. Genezis NS 21:24
IV. Potassium chloride (60% Potash)
V. Genezis CAN 27%N
VI. MAP NP 12:52

Based on the sensory evaluation of the particles, it can be concluded that their consistency is representative of each type. No agglutination and friability were observed with the samples.

Methods used during measurements

Figure 1. Fertilisers after drying

Figure 2. Sieving

Figure 3. Determination of bulk density

Measurement of moisture content

A 25g sample was heated for 72 hours to 103 ± 1°C temperature in a drying oven. This examination had three replications. Samples were place on aluminium trays **(Fig.1.)** Following heating, samples were weighted using an analytical scale with 0.01g accuracy. Moisture content was calculated from weight measured before and after drying (Csizmazia et. al. 2006).

Particle composition of fertilisers

A sieve analysis (**Fig.2**) was performed to determine the characteristics of particle size distribution. Using a mechanical shaker, 100g samples of each fertilizer type were shaken for three minutes with three replications. The following sieve sizes were used: 1 mm; 1.25 mm; 2 mm; 2.5 mm; 4 mm. The sample and the leftover after sieving were weighed using an analytical scale with 0.01g accuracy (Battáné et al. 2002; Csizmazia 2008).

Determining bulk density

A 1000 cm^3 measurement pot of 100 mm diameter and 127.4 mm height (**Fig.3**) was used to determine bulk density. Fertilizers were slowly poured into the measurement pot from a height of 150 mm without compaction and with three replications. After the top was skimmed off, the sample weight was measured using an analytical scale of 0.01g accuracy (Gindert-Kele. 2005).

Globularity

Globularity (g_a) was determined as described by Sitkei, (1981). Based on the ratio of the geometric effective diameter and the largest diameter, $g_a = (d_1 d_2 d_3)^{1/3}/d_3$, where d_1 is the largest size and d_2 and d_3 are the two sizes perpendicular to d_1. In the case of a regular globe, this value is one unit (Csizmazia 2011).

Results and discussion

Moisture content and particle composition of fertilizers

Table 1 shows the moisture content and particle composition of the examined fertilizers. Based on the performed measurements, sample 2 contained the highest amount of moisture and the lowest amount of pulverized fraction (<1) as a result of the sieved fractioned

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measurement, which equals to elated to the examined sample; therefore, it does not cause any significant problem during the application of the fertilizer. Sample 4 (potassium chloride) contained the lowest amount of moisture. As for its structure, this fertilizer type is mostly coarse and irregular shaped and it has the hardest particle. Accordingly, this fertilizer is the least hygroscopic and, as a result, it is the least sensitive of all examined fertilizers to the humidity of the storage environment. Of particle size determination of the pattern uniformity can be inferred. The higher the amount of pulverized fraction is in a sample, the more hygroscopic and uneven the dispersion is. **Table 1** and **Figure 4** show the measurement of the examined samples by fraction.

Table 1.: The particle composition and moisture content of fertilizers

Fertilizer type	**I.**		**II.**		**III.**		**IV.**		**V.**		**VI.**	
Humidity	4.18		5.03		1.36		0.44		2.94		4.44	
Particle size	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**	**g**	**%**
< 1	9.25	9.25	0.05	0.05	9.58	9.58	0.05	0.05	0.04	0.04	0.15	0.15
1 - 1.25	3.22	3.22	0.04	0.04	1.67	1.67	0.07	0.07	0.01	0.01	0.09	0.09
1.25 - 2	6.88	6.88	0.79	0.79	7.68	7.68	3.66	3.66	4.5	4.5	1.7	1.7
2 - 2.5	70.27	70.27	9.24	9.24	15.46	15.46	16.82	16.82	7.76	7.76	5.64	5.64
2.5 - 4	9.84	9.84	81.91	81.91	49.75	49.75	76.28	76.28	77.2	77.2	82.73	82.73
> 4	0.1	0.1	7.9	7.9	15.87	15.87	3.28	3.28	10.1	10.1	9.68	9.68
Total	99.56	100	99.93	100	100.01	100	100.16	100	99.61	100	99.99	100

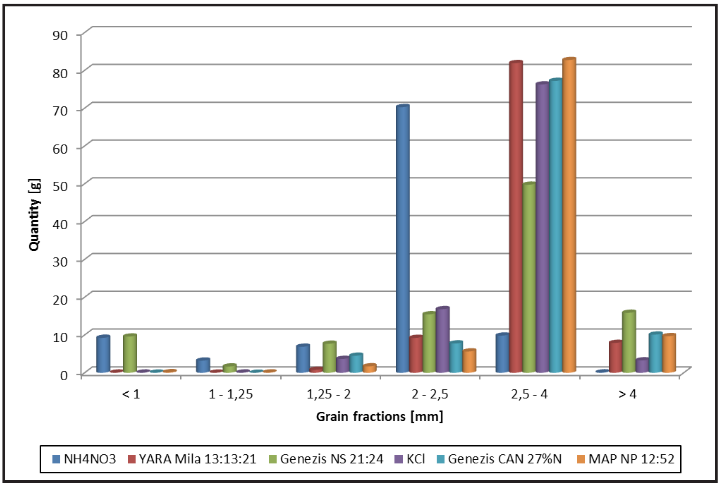

Figure 4. Particle fractions

Of the examined samples, Genezis NS 21:24 contained the highest amount of pulverized (<1) fraction and the highest amount of particles above 4mm, which is considered to be significant value. Therefore, this fertilizer type is rather variable in terms of its water binding capacity and dispersion. There is an unusually high value in the 2-2.5 mm range, which was provided by the NH_4NO_3 sample. Therefore, 70.27% of the examined sample belongs into this range, which significantly exceeds the respective values of the other samples. Consequently, it can be concluded that there is a favorable impact on working width in the case of NH_4NO_3. That is due to the favorable particle size for the same speed,

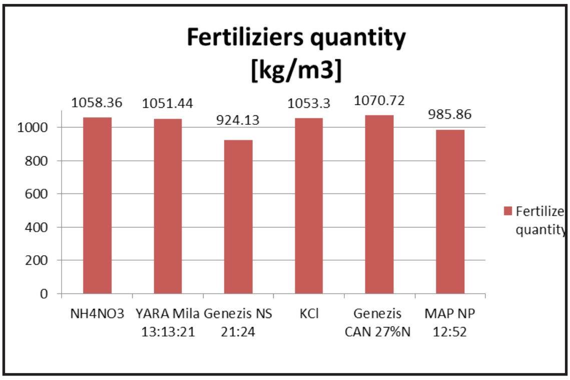

Figure 5. Fertiliser weight per cubic metre

larger working breadth is achieved with the a centrifugal fertilizer spreader.

Bulk density of fertilizers

The bulk density of fertilizers is in connection with the capacity demand which arises during transport. The bulk density of the examined fertilizers is shown on **Figure 5**. It can be observed that Genezis CAN 27%N has the highest bulk density which is related to its imperfect globularity (0.871).

Conclusions

Six different fertilizer types were examined for their most significant physical characteristics from the aspect of the dispersion of fertilizer particles. The measured moisture content, space filling and fraction characteristics affect storage and transport properties. In addition, the change of working width and dispersion plays a very important role in the case of each fertilizer type. The obtained results show these characteristics of the examined fertilizers in a quantified way which leads us to conclude to the existence of even dispersion and even working width as these are indispensable factors in precision technology. Finally, yet importantly, these results may also provide a background for the production characteristics of the examined fertilizers, thereby reducing the pulverization of fertilizers.

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