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OBTAINING VARIOUS GRADES OF NPK FERTILIZERS FROM AMMONIUM PHOSPHATE AND UREA WITH THE ADDITION OF MICRONUTRIENTS

Introduction

Estonian agriculture has to be provided with NPK fertilizers, the $N:P_2O_5:K_2O$ grade ratio of which on various crops must be 1:0.5:0.9, 1:0.7:0.7, 1:1:1, and 1:1.5:2 (the last one is chloride free). Enrichment of a part of these fertilizers with micronutrients (B, Cu, Mo, Co, Mn) has been recommended.

The possibility of obtaining various grades of urea-ammophoska from ammonium phosphate, urea, and potassium salts is discussed in this paper.

The process of obtaining urea-ammophoska from ammoniated slurry of wet-process phosphoric acid was first demonstrated by TVA (USA) in 1964 and the first plant using this process was put into operation four years later in India. Production of urea-ammophoska on the basis of solid ammonium phosphate was developed by Fisons Ltd. (England) [1–4]. Today urea-ammophoska is produced in India, Japan, Norway, the Netherlands, Spain, and Guatemala. Granulation of urea-ammophoska is carried out in a rotary drum granulator or by compaction [3, 5]. In the former Soviet Union this process was studied both with phosphoric acid and solid ammonium phosphate used. Granulation of the products by extrusion, compaction, and mixing in "pugmill" has been tested [6–8]. The initial data for designing plants of urea-ammophoska have been issued.

As the possibilities of obtaining urea-ammophoska of the grades needed for Estonian agriculture, as well as the influence of micronutrients on the quality of the products have not been studied yet, we set these problems as objective of the present research.

Materials and Methods

As initial components commercial fertilizers were used: ammonium phosphate made from Kola apatite (10.8% N, 51.7% P_2O_5), urea (46.2% N), potassium chloride (58.5% K_2O), and potassium sulphate (48% K_2O) ground to —1 mm. These fertilizers were mixed during 1 min, the resultant mixture was granulated on a pan granulator by heating it with a flameless gas burner. Granulation occurred within 10—30 min at 90—105 °C with a partial melting of the mixture and was accompanied by some volatilization of ammonia. Hot granules were cooled and then stored in hermetic polyethylene bags.

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In the experiments, all the four above-mentioned grades of urea-ammophoska and three grades with micronutrient additives were obtained. Powdered calcium metaborate (17.5% B), molybdenum containing waste (3.5% Mo), pure $CoSO_4 \cdot 7H_2O$, $CuSO_4 \cdot 5H_2O$, and $MnCl_2 \cdot 4H_2O$ were used as micronutrient sources. These materials were first mixed together in the ratios needed and then with potassium chloride.

The samples of urea-ammophoska were analysed for various forms of phosphorus by a spectrophotometric method, using the formation of the yellow or blue complexes [9]. Dissolving of the available phosphorus was carried out by means of 2% citric acid as proposed in [10]. Nitrogen was determined by distillation and titration of ammonia [11] after decomposing urea with the help of sulphuric acid [12], potassium by flame photometric method [9], moisture by drying samples at 65—70 °C [9], pH of the samples from 10% solutions. The products were tested on the crushing strength of granules 2—3 mm during storage [13]. The critical relative humidity of granules of the same size was determined by Pestov's method [14].

Data of obtaining urea-ammophoska

Characteristics	Sample 1	2*	3	4*	5	6	7*
$N:P_2O_5:K_2O$ grade ratio	1:0.5:0.9		1:0.7:0.7		1:1:1	1:1.5:2	
Granulation time, min	30	16	13	10	11	13	16
Maximum temperature of granulation, °C	105	100	102	102	100	103	105
Product analysis, %:							
total P_2O_5	11.8	11.7	17.4	16.5	19.0	17.9	18.0
available P_2O_5	11.6	11.4	17.2	16.3	18.9	17.8	17.9
water-soluble P_2O_5	11.2	10.6	16.3	15.6	18.1	16.3	14.7
water-soluble N	22.0	21.5	21.5	21.8	18.6	11.5	10.8
water-soluble K_2O	20.6	20.4	15.9	15.8	18.7	24.8	25.4
H_2O	0.1	0.2	0.4	0.3	0.2	0.2	0.3
sum of fertilizer nutrients	54.2	53.3	54.6	53.9	56.2	54.1	54.1
P_2O_5 availability degree	98	97	99	99	99	99	99
water-soluble P_2O_5/avail. P_2O_5 ratio	96	91	94	96	95	92	82
Loss of ammonia, %	14	18	20	11	3	3	7
pH of 10% solution	4.5	4.7	4.4	4.4	4.3	4.7	5.0
Critical relative humidity, %	62	63	62	64	—	58	—
Granule hardness, MPa:							
after 1 week	3.4	3.9	3.6	4.1	3.7	4.9	2.2
after 1 month	3.2	3.7	3.4	3.8	3.6	4.6	1.9
after 6 months	2.2	3.3	3.0	3.4	3.3	4.3	1.5
Requirement of basic materials per 1 ton of fertilizer nutrients, kg							
ammonium phosphate	425	429	622	598	660	646	649
urea	860	866	856	822	590	333	335
potassium chloride	681	686	560	538	590	—	—
potassium sulphate	—	—	—	—	—	1044	1049

* Micronutrients added (%): sample 2 — 0.05 B, 0.02 Mo, 0.001 Co; sample 4 — 0.30 Cu, 0.05 B; sample 7 — 0.30 Cu, 0.05 B, 0.20 Mn.

Results and Discussion

The results of this work (Table) show that the obtained samples of urea-ammophoska contained 53.3—56.2% fertilizer nutrients (N+available $P_2O_5+K_2O$). The availability of phosphorus ranged from 97 to 99%. Consequently the reversion in the availability of phosphorus in the process did not exceed 3% rel. The loss of water-soluble phosphorus was higher, but in products the ratio of water-soluble phosphorus to the available form was sufficient from agrochemical point — over 80%. Losses of ammonia, caused by thermal decomposition of urea, were in the experiments of obtaining products of 1:0.5:0.9 and 1:0.7:0.7 ratio higher than in the studies made by Borisov et al. [7]. The 10% solution of the products had pH in the range 4.3 to 5.0.

The granule hardness of samples 1—6 was 3.4—4.9 MPa after 1 week storage. During further storage the strength of the granules decreased, but was still satisfactory (over 2 MPa) after 6 months. The critical relative humidity of the samples ranged from 58—64%, therefore the fertilizers were little hygroscopic.

The addition of micronutrients usually had positive influence on the technological data of the process and on the quality of products. For example, in case of obtaining fertilizers of grades 1:0.5:0.9 and 1:0.7:0.7 adding micronutrients accelerated granulation and increased the hardness of granules. The addition of copper and boron to urea-ammophoska of grade 1:0.7:0.7 decreased the loss of ammonia. However, in some experiments unfavourable effects of micronutrients on physical properties were observed, for instance, decreasing of granule strength by obtaining a chlorine-free fertilizer of 1:1.5:2 ratio (sample 7). In this case, but also by adding micronutrients to urea-ammophoska of grade 1:0.5:0.9 an increase in NH_3 loss was observed.

The required amount of the basic materials per 1 ton of fertilizer nutrients increased with the increasing of nitrogen loss (see experiments 3 and 4 in particular).

A greenhouse evaluation of samples of urea-ammophoska was carried out by the Estonian Research Institute of Agriculture and Land Improvement.

Compared with commercial granular mixed fertilizer of 1:1:1 grade produced in the Ukraine on the basis of superphosphate, ammonium nitrate, and potassium chloride, the yield of barley in the case of using urea-ammophoska of 1:0.7:0.7 and 1:1:1 ratios was by 10—20% higher. The addition of micronutrients to fertilizers of grades 1:0.5:0.9 and 1:0.7:0.7 resulted in the increase in the yield of barley and ryegrass by 2—3%.

Thus, the present investigations show that obtaining urea-ammophoska of various grades and with the addition of micronutrients by using thermal granulation of the mixture of the initial components is technologically feasible. The products have a high content of plant nutrients, in most cases fair physical properties and satisfactory agrochemical efficiency. As a negative point a high loss of ammonia in the process of receiving some grades of the fertilizer must be mentioned. For decreasing that loss granulation has to be carried out at a lower temperature. The products are not as hygroscopic as mentioned in [15] and may be stored in hermetic bags for 3—6 months.

The economic advisability of producing urea-ammophoska in Estonia is to be specified. Of the main components needed for its production, urea is produced in Estonia, ammonium phosphate not far — in Kingissepp, Leningrad District, and potassium chloride in Byelorussia.

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NPK-VÄETISTE ERI MARKIDE SAAMINE AMMOONIUMFOSFAADIST JA KARBAMIIDIST MIKROELEMENTIDE LISAMISEGA

Uuriti karboammofoska eri markide (1:0,5:0,9, 1:0,7:0,7, 1:1:1, 1:1,5:2) saamist mikroelementide (B, Cu, Mo, Co, Mn) lisamisel, kasutades toorainena pulbrilisi väetisi ammooniumfosfaati, karbamiidi ja kaaliumkloriidi või -sulfaati. Granuleerimine toimus taldrikgranulaatoril segu soojendamisega kuni 90—105 °C, kusjuures täheldati ammoniaagi eraldumist.

Produktid sisaldasid 53,3—56,2% toimeaineid ja nende kriitiline relatiivne niiskus oli 58—64%. Graanulite säilitamisel hermeetilises pakendis oli nende tugevus kuue kuu jooksul rahuldav (1,5—4,3 MPa).

Эрнст ААСАМЯЭ, Эдгар АРУМЭЭЛ, Марве ЭЙНАРД

ПОЛУЧЕНИЕ РАЗНЫХ МАРОК NPK-УДОБРЕНИЙ ИЗ АММОФОСА И КАРБАМИДА С ДОБАВКОЙ МИКРОЭЛЕМЕНТОВ

Исследовано получение карбоаммофоски марок 1:0,5:0,9; 1:0,7:0,7; 1:1:1 и 1:1,5:2 с добавкой микроэлементов (B, Cu, Mo, Co, Mn). Сырьем служили порошкообразные удобрения — фосфат аммония, карбамид и хлорид или сульфат калия. Гранулирование проведено на тарельчатом грануляторе при нагревании смесей до 90—105 °C. Процесс сопровождался выделением аммиака. Продукты содержали 53,3—56,2% питательных веществ и имели гигроскопическую точку, равную 58—64%. Прочность гранул при их хранении в герметичной таре в течение 6 мес. была удовлетворительной (1,5—4,3 МПа).