— De pair avec cela se réalise une économie annuelle dans les dépenses courantes pour l'achat et l'utilisation de l'eau ammoniacale en comparaison avec l'ammonitrate, qui est pourtant le moins cher des engrais azotés solides (tabl. 13).

Tableau 13: Comparaison des dépenses pour l'utilisation d'eau ammoniacale et d'ammonitrate (en milliers de roubles).

Indices	Amm. aq. 200 mille t	Ammonitrate 112,5 mille t
Prix de revient de l'engrais (prix commercial)	3 500	6 580
Transport à l'exploitation	270	250
Transport au champ	50	70
Préparation pour l'épandage	—	230
Epandage avant semis	460	590
Epandage pour la végétation	240	430
Total	4 520	8 150
Economie	3 630	—
Dépenses par ha	5,4	9,7
Dépenses en %	100	180

— Ainsi l'économie annuelle en dépenses courantes pour une utilisation de 200 mille t d'engrais liquide représente une somme importante, environ 3,6 millions de roubles.

— Nous pouvons pleinement affirmer que l'utilisation des engrais azotés liquides sera très rentable dans le développement futur de la «chimisation» de l'agriculture.

— Possédant ainsi, un avantage remarquable dans l'utilisation de l'eau ammoniacale même en comparaison avec le moins cher des engrais ordinaires, l'ammonitrate, nous ne pensons cependant pas que l'ammoniaque anhydre conviendrait moins bien. Mais nous nous trouvions devant la mission de **réaliser** les avantages de la fertilisation avec des engrais azotés liquides le plus tôt possible. La réalité de la solution de cette mission fut découverte justement dans l'utilisation de l'eau ammoniacale. Nous nous imaginons qu'au fur et à mesure de l'amortissement-équipement pour l'eau ammoniacale, au fur et à mesure que l'agriculture s'emparera de la technique et des méthodes pour son utilisation, nous pourrons, région par région supprimer l'utilisation de l'ammoniaque anhydre.

— Devant nous se dessine l'utilisation future non seulement des engrais azotés, liquides, mais d'engrais complexes ou mélangés liquides, contenant, en plus de l'azote du phosphore et de la potasse. Le réalisme de cette vision est garanti par le très grand programme de notre pays pour la production d'énergie électrique à bon marché, indispensable pour produire l'acide phosphorique à partir des phosphorites des nombreuses mines de notre pays.

— Il est vrai que les engrais composés liquides ne laissent pas espérer les mêmes avantages économiques dans la production que les engrais azotés. Toutefois les nombreux avantages d'organisation et de technique dans l'utilisation des engrais composés liquides dans le secteur de l'exploitation exigent leur fabrication progressive pour pouvoir plus tard les introduire dans la chimie de l'agriculture. Mais un large emploi des engrais azotés et des engrais composés liquides appelle la nécessité d'avoir pour tels ou tels un équipement unifié.
Et comme les engrais composés liquides devront être des solutions (car autrement ils cristalliseraient) avec faible tension de vapeur, comme ceux de l'eau ammoniacale, la direction prise dans notre pays pour l'utilisation de la fertilisation azotée avec ammoniaque liquide nous semble de ce point de vue fondée.

— Dans les différents pays les conditions naturelles comme les conditions économiques et d'organisation sont tellement différentes, que le problème de la production et de l'utilisation des engrais liquides pourra être réalisé à leur manière. Sans doute y auront-ils également un avenir grand et brillant.

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Die Verwendung von stickstoffhaltigem Dünger in flüssiger Form

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Zusammenfassung

In der UdSSR wurde die Idee, Ammoniak in reiner Form als Dünger zu verwenden, bereits Anfang der dreissiger Jahre entstand. In Versuchen zeigte sich dann, dass der praktische Düngewert des Ammoniaks der gleiche ist wie der von gewöhnlichen stickstoffhaltigen Düngemitteln.

Düngungsversuche werden in der Praxis seit 1956 durchgeführt, und zwar sowohl mit wasserfreiem Ammoniak als auch mit anderen stickstoffhaltigen Düngemitteln in flüssiger Form (Ammoniakates und Ammoniakwasserlösungeni mit 18—20 % Stickstoff).

Dabei ergab sich, dass Ammoniakwasserlösungen ohne weiteres in der Praxis verwendet werden können. Diese Lösungen unterscheiden sich vom wasserfreien Ammoniak dadurch, dass sie einen schwächeren Druck hervorrufen und vom Ammoniaka-

is inhibited by low soil temperature but temperatures much above freezing allow bacteria to nitrify the ammonia to a leachable form. NELSON and UHLAND **(13)** have correlated soil temperature and amount of rainfall to determine areas in the United States best suited to fall application of ammonia. The most suitable area consisted of a group of states extending from North Dakota to Texas, in which both soil temperature and rainfall during winter are relatively low. The least suitable region was the southeastern portion of the country, in which the opposite conditions exist.

Agronomic value: The growing usage of nitrogen fertilizers in liquid form has raised many questions in regard to agronomic effectiveness as compared with solid sources of nitrogen. As pointed out earlier, any differences should be due entirely to the presence of free ammonia, since it matters little whether ammonium nitrate or urea are applied to the soil as liquids or solids. There have been many agronomic tests carried out, most of them to compare anhydrous ammonia and solid ammonium nitrate since the latter is the major solid nitrogen fertilizer in the United States. ADAMS et al. **(1)** have reviewed this work and assembled it under the crops tested, which were corn, hay and pasture, rice, oats and barley, wheat, and sugar cane. They concluded that there is no intrinsic difference between liquid and solid forms of nitrogen; with other factors equal, a similar crop growth response is obtained. There are differences in response, of course, between the ammoniacal, nitrate, and urea forms of nitrogen. However, these differences are the same whether the nutrient compound is in the liquid or the solid form.

Ammonia is sometimes slower in response than solutions containing nitrate, since the ammonia must have time to convert to the nitrate form before it can be used to best advantage by many types of plants. However, this does not appear to be a disadvantage in most cases and probably is often an advantage. The same comparison can be made between urea and ammonium nitrate, with the further consideration that the urea must hydrolyze to ammonia before it can be nitrified. This is claimed to be an advantage for urea. However, urea is subject to the drawback that surface-applied material may hydrolyze and the resulting ammonia be lost to the atmosphere. Since the principal surface-applied solution is urea-ammonium nitrate, this is an important problem. The hydrolysis rate may be increased by the action of urease, an enzymatic catalyst for hydrolysis found in vegetation. Application on bare soil, however, can result in high loss. VOLK **(30)** found that losses from urea-ammonium nitrate solution (100 lb. N/acre) on bare moist soil after 7 days ranged from 0.1 to 29.4 %, depending on soil type. Most of the soils lost less than 5 %. The higher losses were associated with soil pH higher than 6.0.

Liquid mixed fertilizer

The use of liquid fertilizers containing two or more plant nutrients has not grown as fast as use of nitrogen liquids. A major reason for this is that, in addition to any advantage from savings in handling and application costs, the nitrogen liquids can be produced at less cost than solid nitrogen fertilizer. Liquid mixed fertilizers do not offer a comparable production cost advantage, mainly because superphosphate is a low-cost solid competitor that has no counterpart in the solid nitrogen fertilizer field.

However, use of liquid mixed fertilizer has grown at a fairly rapid rate in the United States during the past 10 years. Most of the early usage was on the Pacific coast, where significant production began in the latter part of the 1940—50 decade. By 1953, the annual production was over 20 000 tons. At about that time, the first mixing plant was built in the central portion of the country. Since then, numerous plants have been installed and, at present, there are over 400 throughout the country.

The total production is difficult to estimate. If it is assumed that the average annual production per plant is 2000 tons, then total production is on the order of 800 000 tons per year. This represents only about 5 per cent of the total mixed fertilizers produced, whereas nitrogen liquids now comprise more than half of the total nitrogen fertilizer used.

One reason for the rapid increase in number of plants is the low investment required per plant. The equipment is simple in design, in many cases consisting only of tanks, pumps and meters. In contrast, plants for solid mixed fertilizers are relatively complex and expensive. This is especially true for plants making granular, homogeneous fertilizers, which require equipment for ammoniating, drying, screening and cooling. A simpler type of plant — involving only mixing of granular raw materials — is growing in popularity. However, the solids metering and handling equipment required generally makes such plants more expensive than a liquid mix plant.

Most liquid mixed fertilizer plants are small and have a limited sales area; in contrast, plants for making nitrogen liquids usually are quite large. In making liquid mixes, it is more economical to transport concentrated raw materials to a local point and mix them than to mix at some distant point and ship the relatively low grade mixture to the use point.

The majority of the plants are located in the states of Ohio, Indiana, Illinois and Iowa, in the central portion of the country, and in California on the Pacific coast. Growth in the southeastern region, one of the major fertilizer consumption areas, has been slow because of the relatively low cost of competing ordinary superphosphate. However, several plants have been built in the Southeast in the past 5 years.

The basic operation in production of liquid mixed fertilizer is neutralization of phosphoric acid with ammonia to produce a solution of ammonium phosphate. Only enough ammonia is added to give a neutral solution (pH of about 6.6). Liquid mixed fertilizers do not contain free ammonia because ammonium phosphate has very low solubility when the ratio of ammonia to phosphate is high. The ratio used in commercial practice is that which will give an N : P_2O_5 weight ratio of 1 : 3. The standard solution produced when neither additional nitrogen nor potash is needed is 8—24—0. However, in most instances some other nutrient ratio is desired; the adjustment is made by adding a supplemental nitrogen material and/or potassium chloride to the ammonium phosphate solution. The nitrogen material used normally is urea-ammonium nitrate solution similar to that used as a nitrogen liquid for direct application. This solution is used because it is the lowest cost nitrogen material available that is suitable for use in making liquid mixes. Urea alone is preferable because it gives higher solubility in conjunction with the other materials. However, its higher cost has prevented any extensive use.

Potassium chloride is almost the sole source of potash. The crystallized, «white» type is in general use because it contains no insoluble impurities.

The phosphoric acid generally used is the electric furnace, or white type. This is used also because of the absence of impurities. Wet-process (or «green») acid, is less expensive in most areas but the impurities in it precipitate when the acid is ammoniated. This may not affect usability of the product to any significant degree and some producers market the resulting thin slurry. However, most producers started production with furnace acid and their customers became accustomed to a clear product. This has deterred the use of wet-process acid.

Most of the production units are of the batch type. A batch tank, usually about 1000 gallons in capacity, is provided for mixing the constituents. Many plants utilize meters to measure the raw materials; water, acid, ammonia and urea-ammonium nitrate solution are introduced continuously through the meters until the amounts needed for the batch have been fed. A cooler is sometimes used to remove the heat resulting from the reaction between ammonia and acid. Potash is weighed and is fed to the mix tank with a solids conveyor.

Another plant type involves use of a weigh scale rather than meters. The mixing tank sits on the scale and materials are

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