indicating waterlogging; the soil under the forest had better drainage due to tree roots and no evidence of overmoistening.

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# NITROGEN STABILIZATION IN DARK GRAY SOIL UNDER HIGH DOSES OF MINERAL FERTILIZER IN THE WESTERN FOREST STEPPE

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Urea and ammonium nitrate are the most widely used nitrogen fertilisers for various crops, with annual demand forecast to increase by 1.5-2% in the coming years.

Once applied to the soil, urea undergoes catalytic hydrolysis by the enzyme urease, leading to an increase in soil pH around the granules and $NH_3$ losses. As ammonia volatilises, an average of 16% of nitrogen applied worldwide is lost to the atmosphere. In warm and humid agricultural regions, losses can reach 40% or more.

Nitrification inhibitors are many and varied.

The use of urease inhibitors is an effective way of reducing $NH_3$ losses. Several compounds act as urease inhibitors, but only N-(n-butyl)thiophosphoric triamide (NBPT) is used worldwide and is the most successful on the market. Sales of thiophosphoric triamide have grown by 16% per year over the past 10 years.

Another nitrogen stabiliser, nitrapyrin, was the first commercially available inhibitor, introduced in 1974 as N-Serve® (Dow Agrosciences LLC, Indianapolis, IN). Nitrapyrin is volatile and is therefore mainly used as a solution when applied to soil. It is a chlorinated pyridine compound with the formula $ClC_5H_3NCCl_3$. As a soil bactericide, Nitrapyrin acts as an inhibitor of the formation of the enzymes amine monooxygenase and nitrite oxide reductase, which prevents the hydrolysis of urea by Archaea, Nitrosomonas, Nitrospira and possibly others. Its effect on the soil bacteriocenosis and inhibition of nitrification lasts for 8-10 weeks. It then decomposes in both soil and plants.

Both thiophosphoric triamide and nitrapyrin improve plant nitrogen nutrition. The former retains ammonium forms in the soil absorption complex, while the latter inhibits their nitrification, thus retaining more nitrogen supplied by fertilisers in a form readily available to plants. This prevents the loss of soil nitrogen through leaching or wash-out of nitrate ($NO_3$) or gaseous nitrogen emissions ($NH_3$, $N_2$, $N_2O$).

The urease inhibitor N-(n-butyl)thiophosphoric triamide (NBPT) is commercially available as N-STAB (manufactured by Agrochemichni Tekhnologii LLC). Nitrapyrin, a nitrification inhibitor, is commercially available as N-Lock™ Max (produced by Corteva Agriscience). Nitrapyrin was submitted to the EPA and declared safe for use in 2005.

Along with winter wheat, corn is the main cereal crop to which most nitrogen fertilisers are applied. We have therefore chosen this crop to test N conversion inhibitors with intensive fertilisation on the dark grey podzolic soils of the Western Forest-Steppe.

Ukraine's 2021 corn area was 5.5 million hectares. Corn ranks first among other crops in terms of grain harvested and exports - 42 million tonnes and 27 million tonnes respectively in 2021. The average corn yield in Ukraine in 2021 is 7.68 t/ha, close to the record of 7.84 t/ha (in 2018); in the Lviv and Ternopil regions it is 9.4 and 10.2 t/ha, respectively. However, the potential for its increase is still significant.

Fertiliser costs in corn production technology are among the highest compared to other major crops grown in Ukraine and globally. The standard fertiliser rate for achieving the target of 10 t/ha corn yield in the Western Forest-Steppe zone is N130-150P30-40K30-40, which in monetary terms at purchase prices for the 2023 harvest was about $350/ha. At the same time, nitrogen fertiliser accounted for more than half of the cost (about $180/ha).

In the 2022 season, fertiliser costs were 154% higher than in 2021 and the average corn EBITDA was $44/ha, the lowest in 5 years. The core corn area is concentrated in the Ukrainian Forest-Steppe zone.

The yield potential of corn hybrids is not being fully exploited. Corn produces a large amount of biomass and therefore has a higher demand for nutrients, especially nitrogen, than other cereals. As a long-season crop, corn is quite demanding in terms of mineral nutrition and can absorb nutrients from fertilisers throughout its life cycle. To produce 1 tonne of grain with the appropriate leaf mass, corn uses on average 24-30 kg of nitrogen, 10-12 kg of phosphorus and 25-30 kg of potassium from soil and fertiliser. Therefore, to produce a 10 t/ha grain yield in the Western Forest-Steppe, it consumes on average 240-300 kg of nitrogen, 100-120 kg of phosphorus and about 250-300 kg of potassium from the soil.

In the Western Forest-Steppe, the efficiency of mineral fertilisers is high under conditions of sufficient moisture, but fertiliser rates, including microelements, application methods and timing in general require further study. Due to the constant increase in fertiliser prices, optimising the nitrogen nutrition of corn and increasing the efficiency of nitrogen uptake from applied fertilisers by choosing the right fertilisation technology based on different soil types and climatic conditions, the timing and methods of nitrogen fertilisation and the use of inhibitors that slow down the process of nitrogen transformation in the soil, thus prolonging the period of its availability, remains a high priority.

In addition to the objective of achieving high yields through high nitrogen nutrition, growers need to monitor the overall growing conditions and limit possible emissions of nitrogen to the atmosphere as well as nitrate leaching outside the rhizosphere causing environmental pollution.

Fertilisers are an effective and sometimes critical factor in not only increasing yields but also improving the quality of corn grain. Fertilisers can alter metabolic processes and help plants to accumulate more nutrients - proteins, fats, carbohydrates, etc. Improving the quality of corn grain should focus on increasing its protein content. This can be achieved primarily by increasing the nitrogen supply to the plants.

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## ПРОДУКТИВНІСТЬ ПШЕНИЦІ ОЗИМОЇ ЗАЛЕЖНО ВІД СПОСОБІВ ОСНОВНОГО ОБРОБІТКУ ҐРУНТУ

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