Effective cultivation of corn on the drylands with the use of CAM liquid fertilisers by the "Tuman" innovative complex

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Abstract: In the presented material of the Samara State Agrarian University and Don State Technical University, the results of research on improving technologies for cultivating grain corn on the drylands using nitrogen, mineral, liquid fertilisers based on a carbamide-ammonia mixture — CAM are considered: CAM-32, CAM+S produced by PJSC "Kuibyshev-Azot" (Togliatti, Samara region), introducing them with an innovative, agrochemical, modular, multifunctional complex "Tuman..." (LLC "Pegas-Agro" — Samara). With a significant demand of corn for moisture and nitrogen fertilisers, it is very difficult to get a high yield without irrigation on the drylands, and therefore various technologies for using more effective liquid fertilisers instead of solid ones are being investigated in a region with insufficient moisture supply: in the Samara region of the Volga region of the Russian Federation. CAM has specific properties to cause "burns" of corn leaves; corn is a promising, highly productive crop with a great need for a macronutrient-nitrogen in the composition of a carbamide-ammonia mixture, and therefore to minimise this disadvantage, special extension hoses should be applied to hose sprayers, but they also have a technological disadvantage: corn foliar feeding requires additional moisture in the form of intense summer precipitation for the delivery of fertilisers through the soil layer to the root system zone. Thanks to the appearance of the foreign "Duport" aggregate, this problem is solved by special injection working bodies when applying CAM in the soil internally. The successful import substitution of the Duport unit was carried out by LLC "Pegas-Agro" (Samara, Russia) as well as by many other enterprises, creating a special module: the multi-injector "Tuman" for injecting more effective CAM.

1 Introduction

The current unfavourable food situation in the world due to the lack of food for many countries requires the leading producers of agricultural products, which includes Russia, to

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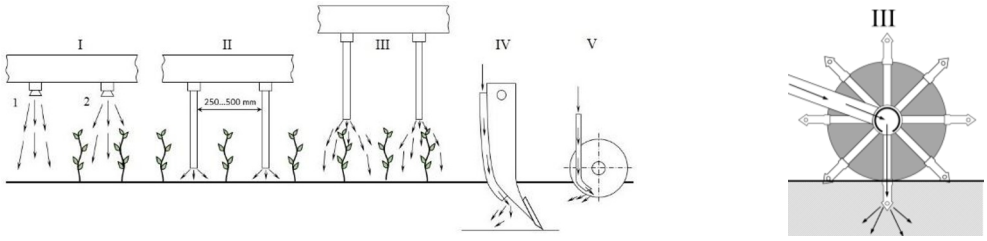
increase the production of food, especially from plant-growing raw materials, as much as possible, despite the negative projected global warming and critical droughts recurring from year to year in many regions and in particular in the Russian Federation [1-3]. In solving this problem, it is necessary to further expand the planting of highly productive crops, which include corn [4-6], improve its cultivation technologies using innovative technical and technological products, in particular the use of nitrogen fertilisers [7-10] preferably in liquid form [1,4,8] based on a carbamide-ammonia mixture — CAM (CAM-32, CAM+S). CAM is a unique highly effective liquid fertiliser with a prolonged effect due to the versatile effect of three forms of nitrogen on plants: nitrate, ammonium and amide ones, and only the amide form can be absorbed by the vegetative part of agricultural plants [1, 6]. Chemical enterprises in Russia, including PJSC "Kuibyshev-Azot", produce more than 3.5 million tons of CAM, which is enough to increase the fertility of 35 million hectares of agricultural land. As it is known, nitrogen is the main macronutrient for the formation of crop yields. The Russian agrochemist D.N. Pryanishnikov emphasised that the main condition determining the average height of the crop is the degree of nitrogen supply of plants. The specific type and chemical composition of CAM with a certain degree of aggressiveness towards the plant and the ability to cause their "burn", especially such a promising agricultural crop as corn, influenced the need to create special technologies and technical means for its application [11, 13], which is fully solved by the innovative multifunctional modular complex "Tuman" of LLC "Pegas-Agro" (Russia), which has been described in research conducted by the Samara State Agrarian University in the years, which have different climatic conditions [14-16].

The aim of our study is to improve the technology of corn cultivation for grain using innovative liquid nitrogen and sulfur-containing mineral fertilisers based on a carbamide-ammonia mixture: CAM (CAM-32, CAM+S) produced by PJSC "Kuibyshev-Azot" using various methods of its application: superficially on leaves (I), foliar feeding (I-II) and intrasoil injection (III) (Fig. 1) by a "Tuman" multifunctional modular unit. At the same time, the justification of optimal methods and norms of CAM application is solved, depending on soil fertility and moisture supply of crops.



a) b)

Fig. 1. Technical and technological methods of CAM application by machine complexes of LLC "Pegas-Agro": a) sprayer through large-drop nozzles and extension hoses; b) multi-injector internally in the soil.

2 Results and discussion

Three-year studies (2018-2020) conducted by Samara SAU and DSTU for assessing the effect of liquid nitrogen and nitrogen and sulfur-containing mineral fertilisers based on CAM

and solid mineral fertilisers: ammonium nitrate in equal nitrogen equivalent on corn yield in approximately the same weather conditions (conditions with insufficient moisture — droughts), showed (Fig. 2,3) a steady trend over the years of the predominant influence of liquid fertilisers compared to solid ones. Thus, the average yield of corn for three years was 63 c/ha when using solid fertilisers (ammonium nitrate); with the one-time use of liquid mineral fertilisers based on CAM-32, 78 c/ha; thus, the yield increased by 24%; with fractional application of CAM-32, the yield was 82 c/ha and the yield increased by 30%; with fractional application of CAM-32+S, the yield was 84 c/ha and the yield increased by 33% (fertilisers were applied with the calculation of the same nitrogen equivalent) (Fig. 3).

Fig. 2. Hybrid corn NK "Falcon" ("Syngenta") in the experimental area

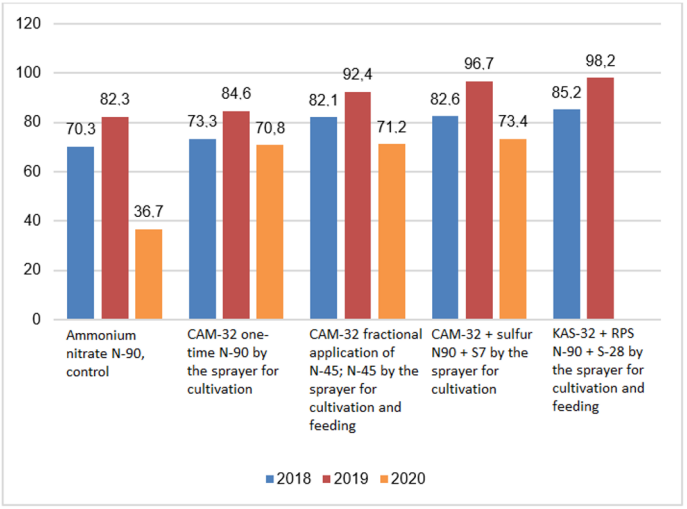


Fig. 3. Yield of corn (c/ha): hybrids — "Pioneer 7709" (2018); NK "Falcon" (2019, 2020)

The advantage of the technology of application CAM nitrogen liquid fertilisers is determined by several factors: 1 — fertilisers CAM-32 contain 32% nitrogen, of which 8% nitrate, 8% ammonium, and 16% amide nitrogen with different efficiency and duration of action on plants, that is, there is a prolonged effect; 2 — fertilisers CAM-32 are liquid and they have no competition with plants due to moisture on the dissolution of commonly used solid nitrogen fertilisers; 3 — specially designed liquiliser aggregates, in our case, the "Tuman-2M" multi-injector manufactured by LLC "Pegas-Agro" (Samara, Russia), apply

fertilisers more efficiently: as the intrasoil injection, which also eliminates “burns” of leaves by aggressive CAM. The study of the most common method of applying CAM with sprayers with large-drop nozzles that ensure the flow of droplets from the leaves still does not exclude their “burns”. In this connection, the Samara SAU conducted research and determined the optimal concentration of CAM to exclude “burns”: 5% (Fig. 2).

Fig. 4. Corn treated with large-drop nozzles with liquid CAM: CAM-32 (on the right), CAM-32+S (on the left), and 5% solution of CAM-32+S (centre) (2021)

The experiments were conducted on the same plots as the main research. CAM-32 and CAM+S were applied with a knapsack large-drop sprayer at the rate of 35 liters of solution per 1 ha. At the same time, a safe CAM-32 concentration of 5% of the active substance was experimentally adopted. The processing of corn crops was carried out in the phase of 5-7 corn leaves. Visual assessment of crops shows the “burn” of leaves with concentrated fertilisers CAM-32 (Fig.4 — on the right) and CAM+S (Fig.4 — on the left) compared with treated crops with a 5% solution of CAM+S (Fig.4 — in the centre) — without “burn”. Corn treated with concentrated CAM-32 and CAM-32+S recovered over time, but its development somewhat lagged behind the crops treated with 5% CAM-32 solution. Measurements of plant height showed that the average height of corn treated with 5% CAM-32 solution was 120.8 cm, with concentrated CAM-32 - 93.6 cm, with CAM-32+S - 96 cm, that is, due to the “burn”, stem growth slows down. The technological method of processing crops with 5% CAM solution increases the yield by 3-8%.

The Samara SAU also conducted studies on the effectiveness of CAM application when foliar feeding of corn crops was carried out with extension hoses (Fig. 5) with the graphic data shown in Figure 3.

Fig. 5. Processing of corn with liquid fertilisers CAM-32, CAM+S with extension hoses on the “Tuman-2” sprayer, traces of CAM on the soil after passage

Samara SAU together with DSTU and Samara enterprises for the production of nitrogen fertilisers PJSC "Kuibyshev-Azot" and the machine-building enterprise LLC "Pegas-Agro" conducted research to assess the effectiveness of the innovative technology of intrasoil injection of liquid nitrogen fertilisers CAM-32 and CAM+S on corn with a "Tuman-2M" multi-injector (Fig. 6).

Fig. 6. Operation of the "Tuman-2M" multi-injector from LLC "Pegas-Agro" when applying CAM: work with corn on narrow support wheels, traces of injection needles

Fertilisers were applied at the rate of 200 and 400 l/ha or according to the current nitrogen: N-52 and 104 kg/ha in comparison with the control (without fertilisers). CAM-32 was applied into the soil by injectors with needles to the depth of sowing of corn seeds: 6-8 cm. At the same time, a good adaptation of the "Tuman-2M" aggregate and "fit" into the 70 cm row spacing without damage and injury to plants is shown as a result of the optimal design of the injection wheels and their placement on the frame, including due to the transition of the aggregate to narrower wheels compared to its work on winter grain feeding with the complete set of the injection aggregate: "Tuman-2M" multi-injectors with wide support wheels. As a result of the research, the following results were obtained: with an increase in nitrogen in the soil after the application of CAM-32, at the rate of application of CAM — 200 l/ ha — 0.23%, at the rate of 400 l /ha — 0.30% compared with the control — 0.21%, or the increase in the amount of nitrogen and its effect on the vegetation of corn increases by 19% and 42%, which is essential for the development of the plant. Favourable weather conditions in 2022 in terms of precipitation and the applied CAM-32 fertilisers provided more active development of crops and the formation of corn cobs with a high yield of good quality grain on the drylands. (Fig. 7, Table 1).

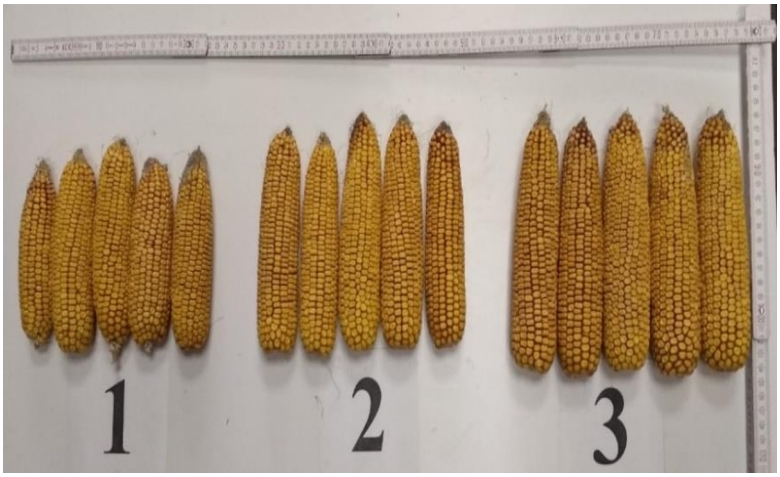


Fig. 7. Corn cobs in experiments with the application of CAM-32: 1 — control; 2 — 200 l/ha; 3 — 400 l/ha (2022).

Table 1. Yield of corn ("PHENOMENON" hybrid) of the "Syngenta" company when applying CAM-32 liquid fertilisers with different rates by the "Tuman-2M" multi-injector from LLC "Pegas-Agro" (2022)

Rate of application CAM+S, l/ha	Density of corn standing before harvesting, mln. pcs/ha			
	57.0	47.0	40.8	35.7
1 - Control, 0 l/ha	42.2	35.1	30.3	26.8
2 - 200 l/ha	64.9	53.7	45.7	41.0
3 - 400 l/ha	89.1	73.5	64.3	56.4

With the density of corn standing of 47.0 million pcs/ha in the experiments before harvesting, the yield at the control was 35.1 c/ha; with the applying of CAM with a norm of 200 l/ha by a multi-injector, the yield increased to 53.7 c/ha or by 53%; with the application of CAM with a norm of 400 l/ha, the yield doubled in dryland conditions.

3 Conclusions

Scientific and industrial research conducted by Samara State Agrarian University to evaluate innovative technologies for the production of corn on drylands without artificial irrigation using innovative liquid nitrogen and nitrogen and sulfur-containing mineral fertilisers — carbamide-ammonia mixture CAM-32 and with a mesoelement — sulfur CAM+S sprayer and multi-injector, respectively, "Tuman-2" and "Tuman-2M" of LLC "Pegas-Agro" (fertilisers and machinery are manufactured in Samara, Russia) showed the advantage of liquid CAM fertilisers compared with solid ones: ammonium nitrate in the same nitrogen equivalent both in years favourable for humidification (2022), and especially in dry years with insufficient moisture supply in 2018-2021).

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