
included within each experiment. Seeding rates were adjusted according to the thousand-grain weight of each cultivar. Crop management and plant-protection measures followed the regional recommendations used for winter wheat production in the sub-humid Steppe. Such management was intended to reduce the influence of uncontrolled pest and disease development and to allow treatment effects to be interpreted more clearly.

The response of the varieties was evaluated using a set of agronomic, structural and grain-quality parameters. Yield structure was characterized on 25–30 representative plants collected from each treatment. Individual plants were measured and threshed separately. The variables included plant height, number of grains in the main spike, grain weight of the main spike, grain weight per plant, the proportion of grain in total plant biomass, and thousand-grain weight. Grain quality was assessed using a Spektran-119R analyzer. Protein determination was performed on 10-g grain samples, while gluten and its major protein fractions were also evaluated.

The experimental design therefore made it possible to compare the effects of the two compounds at several concentrations and to determine whether the observed response depended primarily on treatment dose, genotype, or the interaction between these factors. The general yield response to CA-79 followed the same concentration-dependent pattern that was observed for CA-64. The important difference was that the increase caused by CA-79 was generally larger than the corresponding effect of CA-64. This consistency is important from an agronomic point of view. A growth regulator that improves performance only under highly favorable conditions has limited value because its effectiveness cannot be reproduced reliably. In the present study, CA-79 at 0.02% generated a relatively uniform yield advantage in all three years. The response therefore suggests not only stimulation of maximum productivity, but also a certain buffering effect under less favorable seasonal backgrounds.

Among the investigated genotypes, Khvylya Dnipra, MIP Roksolana and LG Magirus appeared particularly promising when baseline productivity and responsiveness to treatment were considered together. LG Litopys also responded strongly, especially to CA-79. Vezha showed a positive reaction as well, although its absolute productivity remained below that of the leading varieties.

The overall yield data demonstrate that both CA-64 and CA-79 may increase winter wheat productivity, but only within a restricted concentration interval. The concentrations of 0.01 and 0.02% were stimulatory, whereas increasing the concentration to 0.04% reversed the response. The highest productivity was consistently associated with CA-79 at 0.02%. This treatment exceeded CA-64 at the same concentration in all varieties and during all three years.

Thus, CA-79 at 0.02% can be regarded as the principal treatment for stimulating grain productivity within the conditions of the present experiment. CA-64 at 0.02% also produced a reliable positive effect, although its activity was somewhat weaker. The 0.04% concentration of either compound should not be considered suitable because the response shifted from stimulation toward inhibition.

Changes in total grain yield can arise from different combinations of structural components. Therefore, analysis of the individual elements of productivity is essential

for understanding how the regulators influenced yield formation.

The main traits examined were grain number in the main spike, grain weight in the main spike, grain weight per plant and thousand-grain weight. For CA-64, all varieties followed the same general concentration-response pattern. Low and intermediate concentrations improved the majority of yield components, while the highest concentration reduced them.

At 0.01% CA-64, grain number per main spike increased by approximately 4–6% relative to the untreated control. The improvement in grain weight per main spike was much stronger and reached approximately 20–28%. Grain weight per plant increased by about 20–23%, while thousand-grain weight rose by approximately 4–7%.

The 0.02% concentration caused a substantially stronger response. On average, grain number increased by approximately 6%, grain weight per main spike by about 46%, grain weight per plant by approximately 39%, and thousand-grain weight by about 10%.

These values show that the largest treatment effects were not associated merely with the formation of more grains. Instead, the compounds primarily affected grain filling and the accumulation of dry matter in the reproductive organs. This conclusion is supported by the much larger changes in grain weight per spike and per plant compared with the more moderate change in grain number.

At 0.04%, CA-64 no longer produced a stimulatory response. Grain number decreased by approximately 1–2%, grain weight per main spike declined by almost 17%, grain weight per plant by approximately 10%, and thousand-grain weight by about 5%. Thus, increasing the concentration beyond the optimal range caused a clear deterioration of several components responsible for final yield.

Among the investigated structural characteristics, the most biologically meaningful differences were observed for grain weight per main spike, grain weight per plant and thousand-grain weight. Thousand-grain weight showed particularly important variability and can therefore be regarded as one of the most informative indicators of treatment response.

The effect of CA-79 on yield structure was qualitatively similar but quantitatively stronger. At 0.01%, the number of grains per main spike increased by approximately 5%. Grain weight per main spike increased by as much as 30%, grain weight per plant by up to 24%, and thousand-grain weight by approximately 5%.

The strongest response again occurred at 0.02%. At this concentration, grain number increased by approximately 7%, grain weight per main spike by approximately 49%, grain weight per plant by approximately 42%, and thousand-grain weight by around 11%.

These values indicate that CA-79 at 0.02% exerted the strongest overall influence on productivity formation. The compound affected several complementary elements simultaneously: more grains were formed, the mass of grain accumulated in the main spike increased substantially, total grain production per plant was enhanced, and individual kernels became heavier.

When the CA-79 concentration was raised to 0.04%, all major advantages

disappeared. Grain number was reduced by about 1%, grain weight per main spike by up to 16%, grain weight per plant by up to 9%, and thousand-grain weight by approximately 4–5%. The similarity of this response to that observed for CA-64 confirms that the transition from stimulation to inhibition is associated primarily with dose rather than with a unique toxic effect of only one compound.

Direct comparison of CA-64 and CA-79 confirms the greater activity of CA-79. Both compounds were beneficial at 0.01–0.02%, but at the optimal 0.02% concentration, CA-79 produced approximately 3% greater grain weight per main spike, about 3% greater grain weight per plant and around a 1% advantage in thousand-grain weight relative to CA-64.

Therefore, CA-79 appears to affect not only the establishment of reproductive sinks but also the subsequent filling of those sinks. The treatment promoted more efficient conversion of assimilates into grain dry matter, which ultimately resulted in a larger increase in final productivity.

The initial productivity of the tested cultivars differed substantially. Under control conditions, the highest natural potential was characteristic of LG Magirus, MIP Roksolana and Khvylya Dnipra. These varieties combined relatively strong baseline performance with a pronounced reaction to the optimal treatments.

Vezha had lower initial values for several traits but nevertheless responded positively to both compounds. LG Litopys started from a relatively lower level for some productivity characteristics, yet its response to stimulation was substantial, particularly under CA-79.

The genotypes most responsive in terms of yield structure were LG Magirus, LG Litopys, MIP Roksolana and Khvylya Dnipra. Vezha also demonstrated improvement, although the magnitude of the response was somewhat smaller.

This pattern suggests that the final agronomic effect of a growth regulator cannot be predicted solely from the baseline productivity of a cultivar. High-performing cultivars may respond strongly, but lower-performing material can also show a large relative improvement. Consequently, optimization of growth-regulator use should include both genotype and dose rather than relying on one treatment scheme for all varieties.

Factor analysis demonstrated that treatment concentration was the principal source of variation for several major agronomic and quality characteristics. The traits most strongly associated with compound dose were grain yield, grain weight of the main spike, grain weight per plant, thousand-grain weight.

Both CA-64 and CA-79 demonstrated the capacity to modify winter wheat performance, but their beneficial action was restricted to a clearly defined dose interval. The response of nearly all investigated traits followed the same general sequence: moderate stimulation at 0.01%, maximum stimulation at 0.02%, and suppression at 0.04%. The most effective treatment in the experiment was CA-79 at 0.02%. This concentration produced the strongest increase in grain yield, the most pronounced improvement in yield-structure characteristics. CA-64 at 0.02% also had a clear stimulatory effect, but its influence was consistently weaker. The superiority of CA-79 was particularly evident for grain weight per main spike, grain weight per plant

and thousand-grain weight. The concentration of 0.04% should be considered excessive for both compounds because it resulted in reductions in yield, yield components. This confirms that accurate dose regulation is essential when these substances are used as growth-regulating agents. Genotype substantially modified the expression of the treatment effect. Khvyliya Dnipra, MIP Roksolana and LG Magirus combined strong baseline productivity with a pronounced positive response, while LG Litopys also responded particularly well to CA-79. Vezha showed a positive, although somewhat weaker, reaction. Overall, the results indicate that CA-64 and especially CA-79 may be considered promising growth-regulating compounds for winter wheat. Their practical effectiveness, however, depends on strict concentration control and appropriate varietal selection. The most promising approach is therefore not the universal application of a single treatment scheme, but the development of genotype-specific protocols in which compound identity and dose are adjusted to the biological characteristics of individual varieties.

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