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Влияние регуляторов роста на рост, продуктивность и качество урожая томата в условиях дельты Волги



РЕЗЮМЕ

Актуальность. Томат считается важной овощной культурой, которая играет большую роль в сохранении здоровья человека, поэтому исследования морфологических, физиологических и пищевых свойств томата актуальны. Фермеры часто используют некоторые химические вещества, которые имеют сходную структуру и активность с эндогенным растительным гормоном, называемым (экзогенным), в качестве недорогой альтернативы для регулирования роста растений и увеличения урожайности. Влияние многих из этих веществ на рост и качество сельскохозяйственных культур еще не изучено.

Методика. Целью данного исследования является оценка влияния четырех регуляторов роста (Крезацин, Хитозан, Циркон и Энерген) на рост, продуктивность и качество двух российских сортов томата (Моряна и Супергол) в условиях дельты Волги.

Результаты. Результаты показали, что использование Энергена на сорте Моряна усилило большинство изученных признаков (всхожесть – 83,1%, свежая масса вегетативных частей – 241,9 г, сухая масса вегетативных частей – 74,4 г, количество цветков / растений – 51,0, количество плодов / растений – 35,6, урожайность растений – 2,44 кг, сумма сахаров – 5,1°Brix, содержание аскорбиновой кислоты – 25,6 мг/100 г. Применение Энергена на сорте Супергол дало максимальное значение высоты растений (85,6 см), массы плода (72,6 г); в то время как при использовании Крезацина на сорте Моряна было достигнуто самое высокое содержание сухого вещества в плодах (6,77%) и кислотность (0,53%). Применение Циркона на сорте Моряна привело к увеличению количества листьев на растении (56,8) и содержания нитратов (27,6 мг/кг). Максимальный LAI (150,1 см²) получен при использовании хитозана на сорте Супергол, тогда как его применение на сорте Моряна дало самый высокий уровень каротиноидов (4,12%).

Ключевые слова: сорта, томат, регуляторы роста, высота растений, аскорбиновая кислота.

Effect of growth regulators on productivity and quality of tomato crop under Volga delta conditions

ABSTRACT

Relevance. Tomato considered a significant vegetable crop that plays a prominent role in the field of human health. At present, there are large numbers of tomato cultivars with a wide range of morphological and sensorial characteristics which determine their use. Farmers often use some chemical substances which have similar structure and activity with endogenous plant hormone called (exogenous) as a low-cost alternative to regulate plant growth and increase yield. Thus, the use of Plant Growth Regulators (PGRs) has become an important component of the agro-technical procedures for most cultivated species.

Methods. This study aims to evaluate the effect of four growth regulators (Krezacin, Chitosan, Zircon and Energene) on growth, productivity and quality of two Russian tomato varieties (Morian and Superjol) under delta Volga conditions. Each type applied three times on both cultivars (Soaking tomato seeds before sowing, spraying on plants at vegetative phase, spraying on plants at flowering phase with three replications).

Results. The results showed that; combination between Energene and cultivar Moriana enhanced the most of studied characters (Germination – 83.1%, fresh weight of Aerial parts – 241.9 g, dry weight – 74.4 g, Number of No flowers/plant – 51.0, No fruits /plant – 35.6, fruit set – 69.8%, plant yield – 2.44 kg, TSS – 5.1°Brix, Content of Ascorbic Acid – 25.6 mg/100 g); Interaction between “Energene x Superjol” gave the maximum value for Plant height (85.6 cm), Fruit weight (72.6 g); while “Krezacin x Moriana” registered the highest fruit dry matter (6.77%) and Acidity (0.53%); Applying Zircon on Cultivar Moriana increased number of leaves/plant (56.8) and nitrate contents (27.6 mg/kg); the maximum LAI (150.1 cm²) obtained from interaction between Chitosan and cultivar Superjol whereas, “Chitosan x Moriana” treatment gave the highest level of Carotenoids (4.12%).

Keywords: tomato cultivars, Growth regulators, Plant height, Ascorbic Acid.

Introduction

Tomato considered a significant vegetable crop that plays a prominent role in the field of human health – as raw or culinary processes – due to diversity vitamins, acids, sugar, and minerals. At present, there are large numbers of tomato cultivars with a wide range of morphological and sensorial characteristics which determine their use. There are studies on morphological, physiological and nutritional properties of tomato from different regions [9]. Nevertheless, still, now there are no reports on Russian tomato cultivars.

Farmers often use some chemical substances which have similar structure and activity with endogenous plant hormone called (exogenous) as a low-cost alternative to regulate plant growth and increase yield. Plant Growth Regulators (PGRs) have a wide category of compounds that can promote, inhibit or change plant processes at very low concentrations. Thus, the use of PGRs has become an important component of the agro-technical procedures for most cultivated species. New, natural and synthetic substances are still being discovered [3]. Effect many of these substances not yet been studied on growth and quality of crops, in light of this, our research aims to study responses of two tomato cultivars for different types of growth regulators.

Material and methods

The study was carried out on two Russian tomatoes cultivars (Moriana and Superjol) by applying four types of growth regulators in addition to control's treatment (distilled water). The materials which applied as follow; Krezacin: Active substances (Orthocresoxyacetic acid triethanolammonium salt), applied dose as active substance (10 ml); Chitosan: Active substances (Chitin), applied dose as active substance (40 ml); Zircon: Active substances (Hydroxycinnamic acid), applied dose as active substance (30 ml); Energene: Active substances (Humic Acid), applied dose as active substance (300 ml). Each type applied three times on both cultivars (Soaking tomato seeds before sowing, spraying on plants at vegetative phase, spraying on plants at flowering phase with three replications).

Collecting data

Morphological and physiological characteristic such as plant height, number of leaves, leaf area index, weight of shoots and leaves (fresh and dry) were measured at both of vegetation, flowering and fruiting phase. Length of root system measured at vegetation phase. Leaf Area Index measured using non-destructive method. Biochemical properties were evaluated in the fruit ripening stage; to determine dry matter fruits weighed before being oven dried at 105°C. The percentage was then determined by the difference in weights before and after oven drying; Sugar content was determined by a refractometer with a range of 0 to 32 ° Brix. Acidity (TTA) of the tomato was measured by the methods described by [12]. Ascorbic acid was determined by the 2,6-dichlorophenolindophenol method. Carotenoids and Nitrates were determined on the basis of the standards of association of analytical communities. Data were statistically analyzed with the help of Costat program followed by Turkey's HSD test at ($P < 0.05$).

Results and Discussions

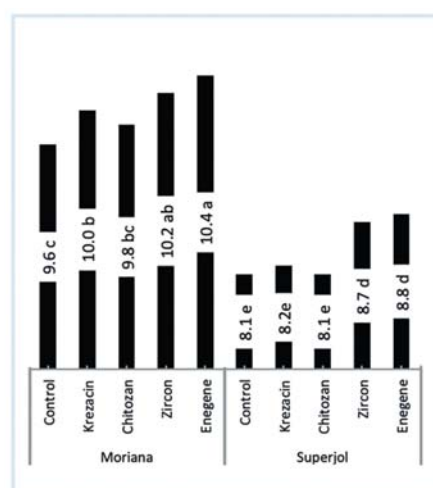
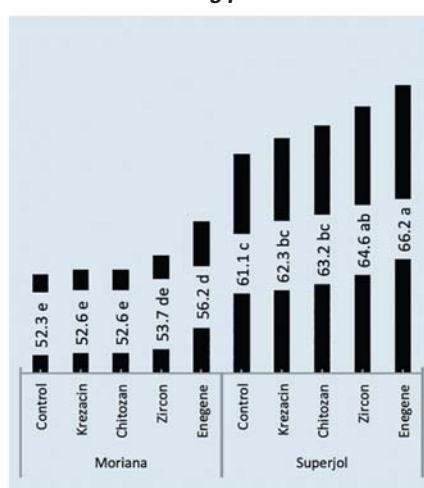
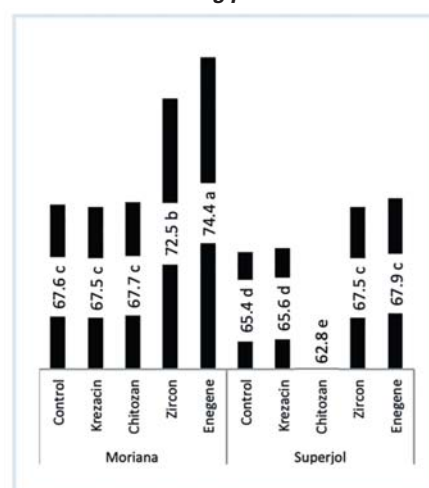
Germination percentage (Table №1) significantly depends on both tomato cultivars and applied growth regulators. The highest percent (83.10%) observed on Moriana when soaked on Energene, while treated seeds of cultivar Superjol by "Chitosan" registered the minimum percent (74.71%) which not differs from the result of "Krezacin x control" on each cultivar.

Characteristics tomato plant at vegetation phase: Data in Table (№1) showed that tomato plant height influenced by the interaction between cultivar and growth regulators. Generally, applying growth regulators improved the height of tomato plant comparing to control. The interaction between Superjol and Energene gave the highest plants (22.3 cm), while the shortest plant (17.8 cm) obtained from non-treated Moriana seeds; Soaking seeds on Krezacin inhibited elongation epicotyl and hypocotyl in both cultivars (6.6-5.8 cm), while other treatments were statistically similar within each cultivar. The shortness epicotyl and hypocotyl maybe due to the presence of ethylene in Krezacin.

Table 1. The effect of growth regulators on germination percentage and Tomato plant characteristics at (vegetation phase)

Parameters tomato plant		Germination Percentage, %	Plant Height, cm	Epicotyl and Hypocotyl elongation, cm	N ^o of Leaves /plant	Fresh weight, g	Dry mater, g
Moriana	Control	78.9 b	17.8 d	7.4 a	11.6 a	10.8 cd	2.2 b
	Krezacin	79.2 b	19.8 bc	6.6 b	11.7 a	10.7 cd	2.3 b
	Chitosan	79.7 b	18.8 c	7.5 a	11.6 a	11.1 bc	2.3 b
	Zircon	81.6 ab	20.1 bc	7.4 a	11.7 a	11.6 ab	2.5 ab
	Energene	83.1 a	20.7 b	7.3 a	11.8 a	11.9 a	2.7 a
Superjol	Control	74.7 c	19.7 bc	6.3 b	10.6 b	10.1 e	1.7 d
	Krezacin	75.0 c	19.6 bc	5.8 c	10.8 b	10.2 e	1.8 cd
	Chitosan	74.5 c	19.1 bc	6.3 b	10.9 b	10.3 de	2.0 bc
	Zircon	79.4 b	21.9 a	6.5 b	10.8 b	10.7 cd	2.1 bc
	Energene	79.1 b	22.3 a	6.4 b	11.0 b	10.9 c	2.3 b

Means within the same column followed by a common letter (s) are not significantly different at $P \leq 0.05$

Fig. 1. The effect of growth regulators on root length (cm) at vegetation phase**Fig. 2. The effect of growth regulators on the height of tomato plant (cm) at flowering phase****Fig. 3. The effect of growth regulators on Dry matter (gm) of Aerial parts at fruiting phase**

Means within the same figure followed by a common letter (s) are not significantly different at $P \leq 0.05$

Applying growth regulators didn't increase the number of leaves per plant in each cultivar comparing to its control treatment, whereas Moriana has the highest number of leaves per plant (11.6-11.8) comparing to Supergol (10.6-11.0), this is agree with the results of [11], who reported that the genetic material of crop cultivars affect the nature of growth such as plant height, number of leaves and branches number; Soaking tomato seeds on Energene solution improved fresh weight, dry weight and root length (Fig. 1) of tomato plant, and the interaction between Energene and Moriana gave the maximum results in these parameters (11.9 g, 2.6 g, and 10.4 cm, respectively).

Our results also agree with [13] who reported that Energene enhanced the absorption of mineral nutrients by plants, increased the permeability of membranes of root cells to tomato cultures; Leaf Area Index (LAI, cm^2) was measured to assess the impact of growth regulators to maximize the use of sunlight

and improve the efficiency of photosynthesis process in both cultivars. Data showed that cultivar Superjol had a higher rate of LAI (43.8-44.6 cm^2) than Moriana (41.2-42.4 cm^2). Applying growth regulators didn't effect on LAI of Superjol comparing to its control. Whereas, soaking Moriana' seed on chitosan reduced leaf area index (41.2 cm^2) comparing to other treatments.

Characteristics tomato plant at flowering phase:

Applying growth regulators affected on morphological and physiological parameters of tomato plant (Table № 2) comparing to control treatment such as Plant height (Fig. 2), № of leaves/ plant, leaf area, Fresh weight and Dry weight ($P < 0.05$). Applying Energene enhanced tomato parameters in both cultivars comparing to other doses, and Moriana cultivar had a maximum results on № of leaves/ plant (32.6), Fresh weight (158.6 g) and Dry weight (31.0 g) whereas,

Table 2. The effect of growth regulators on morphological and physiological Parameters of two tomato cultivars at flowering phase and fruiting phase

		Morphological characteristics of tomato plants at flowering phase				Morphological characteristics of tomato plants at fruiting phase			
		№ of leaves/ plant	LAI, cm^2	Fresh weight, g	Dry weight, g	Plant height, cm	№ of leaves/ plant	LAI, cm^2	Fresh weight, g
Moriana	Control	30.6 bc	103.4 d	155.1 bc	29.9 b	72.5 g	54.2 c	120.8 cd	237.4 b
	Krezacin	31.9 ab	106.0 d	152.9 c	27.3 de	72.7 g	54.9 b	120.1 cd	233.2 c
	Chitosan	32.1 ab	103.7 d	154.5 bc	27.8 d	72.5 g	54.7 bc	121.0 c	234.9 c
	Zircon	31.8 ab	105.6 d	156.8 ab	28.7 c	74.3 f	56.8 a	117.5 d	239.1 b
	Energene	32.6 a	106.2 d	158.6 a	31.0 a	76.0 e	56.3 a	115.2 d	241.9 a
Superjol	Control	28.3 d	128.6 ab	136.2 ef	24.8 g	82.9 cd	46.2 f	148.8 a	222.2 e
	Krezacin	28.0 d	127.3 ab	135.3 f	24.7 g	82.3 d	47.2 e	144.6 b	221.7 e
	Chitosan	27.8 d	125.9 b	137.2 ef	25.1 g	83.9 bc	46.3 f	150.1 a	220.3 e
	Zircon	28.4 d	130.2 ab	138.7 de	26.2 f	84.9 ab	47.1 e	147.0 ab	225.5 d
	Energene	29.1 cd	132.1 a	140.5 d	26.9 ef	85.6 a	48.2 d	144.7 b	227.4 d

Means within the same column followed by a common letter (s) are not significantly different at $P \leq 0.05$

Table 3. The effect of growth regulators on quantity and quality Parameters of two tomato fruits cultivars

		Flowering and crop parameters of tomato plants				Chemical analyses of tomato fruits			
		N. flowers/ plant	N. fruit / plant	Fruit weight, g	Plant yield, kg	Dry matter, %	TSS (°Brix)	Acidity, %	Carotenoids, %
Moriana	Control	49.5 a	33.6 c	63.0 e	2.10 bc	5.5 c	4.31 c	0.45 c	3.57 b
	Krezacin	49.5 a	34.0 bc	65.2 d	2.22 b	6.7 a	4.85 ab	0.53 a	4.14 a
	Chitosan	49.8 a	34.6 b	65.0 d	2.25 b	6.4 a	4.52 bc	0.52 a	4.12 a
	Zircon	50.4 a	34.5 b	68.0 c	2.35 a	5.9 b	4.77 ab	0.47 bc	4.10 a
	Energene	51.0 a	35.6 a	68.1 c	2.44 a	6.5 a	5.10 a	0.48 b	4.09 a
Superjol	Control	45.5 c	28.3 f	71.4 b	1.97 c	5.2 c	4.13 d	0.38 d	3.26 c
	Krezacin	46.4 c	29.2 ef	71.5 b	2.08 bc	6.4 a	4.75 ab	0.40 d	3.55 b
	Chitosan	45.8 c	29.1 ef	71.9 ab	2.07 bc	6.1 ab	4.25 cd	0.38 d	3.60 b
	Zircon	46.1 b	29.9 de	72.3 ab	2.16 b	5.9 b	4.60 ab	0.39 d	3.53 b
	Energene	46.2 b	30.4 d	72.6 a	2.23 b	6.2 a	4.73ab	0.40 d	3.56 b

Means within the same column followed by a common letter (s) are not significantly different at $P \leq 0.05$

Superjol gave highest values on Plant height (66.2 cm) and leaf area (32.6 cm²). The minimum results of Plant height (52.3 cm) and leaf area (103.4 cm²) obtained from non-treated Moriana, and the combination between Krezacin and Superjol registered the minimum Fresh (135.3 g) and Dry (24.7 g) weight of Aerial parts. The least number of leaves per plant obtained from "Chitosan" x Superjol (27.8). Our results in harmony with those observed from [2] reported that, applying Energene significantly increased mineral nutrients uptake, stimulated chlorophyll content and accumulation of minerals in leaves.

Characteristics tomato plant at fruiting phase: Data in table № 2 showed that, significant variations in tomato morphological and physiological traits (Plant height, № of leaves/ plant, leaf area, Fresh weight and Dry weight) during

fruiting phase as affected by both factors. In its entirety, the maximum values of № of leaves/ plant (56.8), Fresh weight (241.9 g) and Dry weight (74.4 g) obtained from Moriana applied with Energene (Fig. 3). On the other hand, Superjol gave the maximum means for Plant height (Energene – 85.6 cm) and LAI (Chitosan – 150.1 cm²). The vegetative growth represented on LAI of tomato plant continued when Chitosan applied similarly to control treatments, while reduced, as an indicator of the transition to flowering and fruiting stages, when other growth regulators applied (Krezacin, Zircon and Energene).

Flowering and Crop Parameters: A significant variation was found on the number of flowers per plant due to application of plant growth regulators. The maximum number of flowers per plant (51.1) was obtained from cultivar Moriana

Fig. 4. The effect of growth regulators on Fruit set of tomato plants

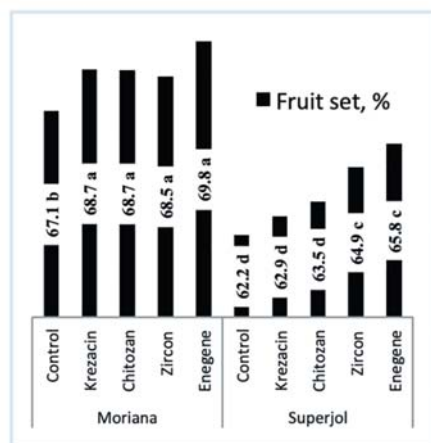


Fig. 5. The effect of growth regulators on Ascorbic acid contents of tomato plants

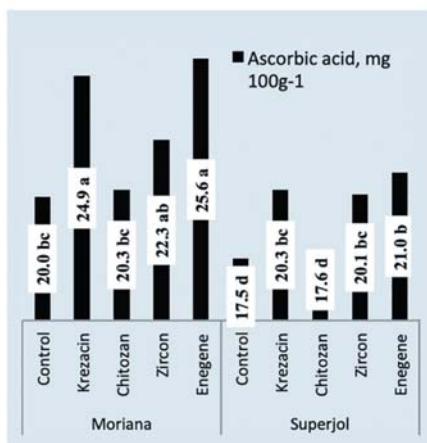
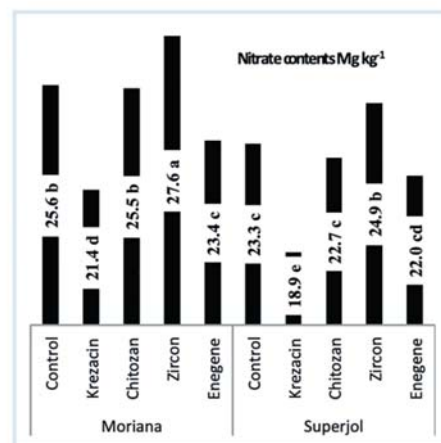


Fig. 6. The effect of growth regulators on Nitrate contents of tomato plants



Means within the same figure followed by a common letter (s) are not significantly different at $P \leq 0.05$

treated by Energene, while the minimum number of flowers per plant (45.5) was recorded from Superjol (non-treated). Applying Energene and Zircon produced a higher number of flowers per plant over other Superjol's treatments, while same data obtained in all Moriana's treatments. The maximum number of fruits per plant (35.6) was recorded from combination between Moriana x Energene while the minimum number of fruits per plant (28.3) was recorded from "Superjol x control". Moriana recorded the highest fruit set's percentage (from 67.1 to 69.8%) in its all treatments, while Superjol's treatments located from 62.2 to 65.8% (Fig. 4).

Resulted superior in respect of a number of fruits per plant was found after applying Energene might be caused that, growth regulators apparently reduced the heat effect and thus increased the number of fruits set in tomatoes [10]. The maximum average fruit weight obtained from cultivar Superjol (Energene – 72.6 g) whereas the minimum average observed in Moriana treatments (Energene – 68.1 g). In both cultivars, Energene enhanced tomato yield comparing to other doses, whereas Moriana gave the maximum yield per plant (Energene – 2.44 kg). These results in harmony with [6] they noted that a higher weight of fresh fruit may be associated with the possibility of possessing higher stomata conductivity, better genetic structure and a higher potential for the transport of photosynthetic materials within plants.

Chemical Analyses of tomato fruits: Data show that (Table № 3) applying different growth regulators enhanced dry matter over control in each cultivar, and Krezacin recorded the maximum percent in both cultivars (Moriana – 6.7%; Superjol – 6.4%); TSS content of "Moriana x Energene" was the highest (5.10°Brix), while "Superjol x Control" was the least sugar contents (4.13°Brix). All of the applied growth regulators enhanced TSS content of tomato fruits comparing to their control treatment within cultivar. Our results agree with those obtained from [4] who observed that the values commonly obtained for soluble solids of different cultivars of tomato fruit range from (4-6°Brix); Acidity was significantly different between the tomato cultivars tested and varied from (0.38-0.40%) in Superjol fruits to (0.45-0.53%) on Moriana fruits.

In Superjol, applying growth regulators didn't effect on tomato fruits acidity comparing to control, while in Moriana's treatments Energene had a maximum acidity percent (0.53%). Our result is in agreement with [8], who evaluated

acidity in the fruit of 12 tomatoes genotypes and reported that fruit acidity varied from (0.256 to 0.704 mg/100g); Changes on Carotenoids content depends on both cultivars and the applicable materials. Generally, Moriana had a higher (3.57-4.14%) than Superjol (3.26-3.60%). Using growth regulators improved Carotenoids contents in each cultivar compared to its control and all applied material statistically found similar. Our results are consistent with [5] who found that all the differences observed in the antioxidant content of tomato cultivars such as carotene are associated with the genotype, as well as with growth regulators.

The range of Ascorbic Acid (Fig. 5) on Moriana was (20.0-25.6 mg/100 g), while on Superjol located between (17.3-21.0 mg/100 g). Applying growth regulators (Krezacin, Zircon, and Energene) enhanced AA contents, and Energene gave the highest concentration in both cultivars (Moriana – 25.6; Superjol – 21.0 mg/100 g) comparing to "Chitosan" which shared the minimum results with non-treated variants (Moriana – 20.3; Superjol – 17.6 mg/100 g). This result is consistent with [14], who reported a significant improvement in Ascorbic content as a result of applying Energene on tomato plants.

According to WHO, adults consume 20-70 mg nitrate daily, the maximum amount of nitrate daily entering the body should be less than 3.65 mg/kg [7]. The content of nitrates in tomatoes can be increased depending on various parameters associated with the plant and the environment, such as varieties, maturity, temperature and nutrients. Applying Krezacin reduced the amount of Nitrates (Moriana – 21.4; Superjol – 18.9 mg/kg) comparing to other variants (Fig. 6), while the maximum concentration of Nitrate obtained from "Zircon" (Moriana – 27.6; Superjol – 24.9 mg/kg). Naturally, nitrate is not toxic to humans; however, the conversion of nitrate to nitrite in the human body and its accumulation in high concentrations is very dangerous for the organism [1].

Conclusion: The established patterns of decrease in tomato plants under the influence of growth regulators of the effect of abiotic stresses (high temperatures, salinization, drought, and high intensity of solar insolation) suggest a positive effect of the studied growth regulators on nonspecific protective plant reactions. This is evident Energene applied to cultivar Moriana, which improved most of the vegetative parameters, yield (2.44 kg) and quality of fruits (TSS – 5.1°Brix; Vitamin C – 25.6 mg/100 g).

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