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The influence of amino acids on the activity of antioxidant enzimes, malonic dialdehyde content and productivity of garlic (*Allium Sativum* L.)

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Abstract. The research was carried out in 2017–2019 in the conditions of the Right-Bank Forest Steppe of Ukraine. The results of study, the effect of spraying by certain amino acids; salicylic(300 ppm), gibberellin (150 ppm) and ascorbic acids (200 ppm) on garlic (*Allium sativum* L.) plants are presented in the article. It was found that amino acid solutions improves the antioxidant state: the activities of SOD, CAT, POD, GR, GST in treated leaves tended to increase, the activity of SOD was higher than the control of 7.5–15.0%; CAT (27.4–45.9%); POD (7.0–83.0%); GR (5.4–49.9%); and GST (14.8–41.3%). It was noted that the content of chlorophyll *a*+*b* in the leaves significantly increased (2.6–10.8%), The use of amino acids increased the accumulation of dry matter by 1.4–4.0%. The yield increase was 1.14–2.27 t ha^{-1} (7.7–15.3% compared to control). The content of B vitamins in the garlic cloves was greatly influenced by gibberellic acid, where increasing the amount of B vitamins reached to 21.9% relative to control The use of salicylic and ascorbic acids increased the amount of B vitamins by 7.6 and 8.2%, respectively. The most significant increasing of C vitamin content was observed by spraying of plants with ascorbic acid (+12.5%), whereas by spraying with salicylic and gibberellic acids its content increased by 6.0 and 7.5%, respectively. In the future, the data obtained can be used to reduce the impact of abiotic factors on the physiological state and productivity of garlic plants. Also, the obtained data will serve as a theoretical basis for producers in view of the purposes for which the products are grown (for sale in fresh form, processing or storage).

Key words: *Allium sativum* L., antioxidant enzyme activity, bulb, chlorophyll, vitamins, yield.

INTRODUCTION

One of the important goals of modern agriculture is to get foods that are high in vitamins. The productivity of plants depends on the environmental conditions. Water scarcity is a major limiting factor in crop production under the continental climate and

therefore, there is a constant problem of increasing the drought resistance of vegetables. One possibility to improve the drought resistance of cultivated crops is amino acids, which have a direct or indirect effect on physiological processes. In addition, amino acids are well known as biostimulants that have a positive effect on plant growth, yield and they significantly reduce plant stress caused by abiotic factors (El-Shabasi et al., 2005; Kowalczyk & Zielony, 2008; Abd El-Aal et al., 2010).

Drought is one type of oxidative stress that, at the cellular level, enhances the generation of active oxygen species (AOS), such as superoxide radicals (O_2^-), hydrogen peroxide (H_2O_2) and hydroxyl radicals (OH). Plants have developed different enzymatic and non-enzymatic scavenging mechanisms to control the level of AOS. Superoxide radicals can be converted to hydrogen peroxide enzymatically by superoxide dismutases (SOD). Cellular hydrogen peroxide is removed by catalase (CAT) enzymes and other enzymatic defence systems e.g. ascorbate peroxidase (APX) and other peroxidases. The level of antioxidants and the activities of antioxidant enzymes such as H_2O_2 related SOD, CAT, APX, guaiacol peroxidase (POD), and glutathione related enzymes (glutathione reductase, GR and glutathione S-transferase, GST) are generally increased in plants under stress conditions and in several cases their activities correlate well with enhanced tolerance (Prasad et al., 1994; Foyer et al., 1997).

Salicylic acid is a natural plant hormone and participates in plant responses to various biotic and abiotic factors (Shama et al., 2016). It plays a vital role in plant growth, ion uptake transport, and photosynthesis (Kazemi, 2013) as well as Salicylic acid has a diverse regulatory role in plant metabolism.

Salicylic acid an organic signal molecule has been reported to play a key part in regulating many physiological processes in plants. Its external application has encouraged plant productivity under biotic and abiotic stress conditions (Senaratna et al., 2000). Foliar spray of salicylic acid has been shown to increase vegetative growth, yield and bulb quality of garlic (Bardisi, 2004a and 2004b), Amin et al. (2007) on onion, El-Zohiri (2009) on globe artichoke and Bideshki et al. (2013), Khadr (2015) on garlic, Pradhan et al. (2016) and Prajapati et al. (2016) on onion, Shama et al. (2016) and Meena et al. (2017) on garlic.

The foliar application of salicylic acid promoted growth and development of plants. In this regard (Li et al., 2000), salicylic acid has been found to play an important role in bulb formation. Khadr (2015) specified that spraying of garlic plants by salicylic acid gave the highest indices of plant height, total crude and dry weights, and leaf area. In addition, the highest yields were achieved, and the total content of chlorophyll ($a+b$) increased.

Gibberellic acid (GA_3) plays an important role in the formation of garlic bulbs (Rahim, 1988 and Rahim & Forhad, 1988). Foliar spraying by gibberellic acid stimulates the formation of more cloves in the bulb. Gibberellic acid improves the growth and development of chloroplasts and enhances the efficiency of photosynthesis, which in turn increases yields (Yuan & Xu, 2001). On the basis of experiment Kumar et al. (2014), it is concluded that, gibberellic acid had significant influence on growth, quality and yield of tomato, application of GA_3 showed an increased plant height, number of leaves, number of fruits, fruit weight, ascorbic acid and total soluble solids.

Ascorbic acid exerts a stimulating effect on plants, for example, its use has led to a significant increase in the growth parameters and overall yield of tomatoes in the cold season (Abdel-Halim, 1995). Similar results were found in other plants (Helal et al., 2005; El-Banna et al., 2006).

Ascorbic acid (AA) is an antioxidant molecule and a key substrate for the detoxification of reactive oxygen entities (Foyer & Noctor, 2011; Qian et al., 2014). Physiologically active form of AA is the resonance stabilized anionic form (formed due to deprotonation of the hydroxy group at C_3) which is termed as ascorbate.

Foliar application of ascorbic acid previously increased plant height, leaves number, dry weight of plant and total yield (El-Morsy et al., 2010) on garlic and (Gouda et al., 2015) on potato, and increased bulbing ratio as well as average bulb weight and diameter and clove weight (El-Morsy et al., 2010) on garlic.

Garlic is the second most common species of the Onion Family after onion. It has long been recognized around the world as a valuable condiment for food and a popular remedy for various ailments and physiological disorders. Garlic is also considered to be one of the most important medicinal plants that have broad nutritional properties. (Petropoulos et al., 2018).

In review of all the above, it follows that these amino acids have been studied separately or in certain combinations in different natural conditions, but their effect on the physiological state of plants, productivity and storage of garlic has not been studied and did not compare with each other. Therefore, the comparison of the effect of salicylic, gibberellin and ascorbic acids on plant growth and yield, oxidative state, total content of chlorophylls *a+b* in the leaves, B vitamins and C vitamin content in the bulb became the purpose of the study.

MATERIAL AND METHODS

The research of the influence of amino acids was carried out in 2017–2019 in the conditions of the Right-Bank Forest Steppe of Ukraine on the experimental field of the Department of Vegetable Growing of Uman National University of Horticulture in accordance with generally accepted methods (Bondarenko & Yakovenko, 2001; Ulianych et al., 2019; 2020). The soil of the experimental field is black, puddle, heavy loam with a well developed humus horizon (about 2.9% of humus) in the deep of 40–45 cm. Planting was carried out by the scheme of 45×6 cm at the end of the 5–10 of October.

The total area: for the experiment 400 m², for plot 100 m²; for sampling 10 m². The plots were arranged in a systematic order with a four replication. The location of the plots was systemic.

Plant spraying was carried out after 40 and 50th DAP. In the conditions of the Right-Bank Forest Steppe of Ukraine after 40 and 50th DAP there is an intensive growth of the vegetative mass of garlic plants and it is during this period that the last spring frosts - abiotic stress.

Single factor experiment consisted of foliar spraying salicylic acid (SA) - $C_6H_4(OH)COOH$ (300 ppm) (Shama et al., 2016) gibberellic acid (GA_3) - $C_{19}H_{22}O_6$ (150 ppm) (Abd-Elkader, 2016), and ascorbic acids (AA) - $C_6H_8O_6$ (200 ppm) (Naz et al., 2016) as well as control treatment (foliar spraying with water).

This experiment included the following treatments:

1. Control (foliar spraying with water).
2. Salicylic acid (SA) at 300 ppm.
3. Gibberellic acid (GA_3) at 150 ppm
4. Ascorbic acid (AA) at 200 ppm.

During the investigation, parameters including length and width of leaf, leaf blade area and total leaf area per plant on the 60th day after planting (DAP) were determined, plant height and the number of leaves (per plant, pcs) were calculated by, and the leaf blade area was determined by a calculated (linear) method, using the parameters of length and width of the leaf by the formula:

$$Sn = 0.67 \times ab \quad (1)$$

where Sn – one leaf area, cm^2; a – the largest leaf width, cm; b – leaf length, cm; 0.67 is the coefficient that reflects the configuration of the leaf.

We studied the effect of spraying plants by amino acids on enzymes activity, productivity of plants, pigments contents in leaf, vitamins B complex and vitamin C of garlic cloves, and storability.

Plant material

Garlic (*Allium sativum* L.) cv. Lyubasha.

Assimilating pigments content were determined by spectrophotometric method (Ermakova et al., 1987).

Activity measurements of antioxidant enzymes

Enzyme activities were determined, 10 days after spraying plants by organic acids solutions. A one g of plant tissue from control and treated plants was homogenized on ice in 4 mL extraction buffer (50mM phosphate buffer pH 7.0, containing 1mM EDTA, 1mM phenylmethylsulfonyl fluoride and 1% polyvinylpolypirrolidone). The homogenate was centrifuged for 25 min at 15,000×g and 4 °C. The supernatant was used for enzyme activity assays. The means ± SD were calculated from the data of at least 3 independent measurements. SOD activity was determined spectrophotometrically by measuring the ability of the enzyme to inhibit the photochemical reduction of nitro blue tetrazolium (NBT) in the presence of riboflavin in light (Dhindsa et al., 1981). One unit (U) of SOD was the amount that causes 50% inhibition of NBT reduction in light. The enzyme activity was expressed in terms of specific activity (U mg protein^{-1}). CAT activity was determined by the decomposition of H_2O_2 which, in turn, was measured by the decrease in absorbance at 240 nm (Upadhyaya et al., 1985). One U equals the amount of H_2O_2 (in μmol) decomposed in 1 min. POD activity was determined by monitoring the increase in absorbance at 470 nm during the oxidation of guaiacol (Upadhyaya et al., 1985). The amount of enzyme producing 1 μmol min^{-1} of oxidized guaiacol was defined as 1 U. GR activity was determined by measuring the absorbance increment at 412 nm when 5.5 dithiobis(2–nitrobenzoic acid) (DTNB) was reduced by GSH, generated from glutathione disulfide (GSSG) (Smith et al., 1988). The specific activity was calculated as the amount of reduced DTNB, in μmol min^{-1} protein mg, ε_{420} = 13.6mM cm^{-1}. GST activity was determined spectrophotometrically by using an artificial substrate, 1-chloro-2.4-dinitrobenzene (CDNB), according to Habig et al. (1974). One U is the amount of enzyme producing 1 μmol conjugated product in 1 min, ε_{340} = 9.6 mM^{-1} cm^{-1}. The protein contents of the extracts were determined by the method of Bradford (1976).

Malondialdehyde (MDA) content

MDA content was calculated, taking into account optical density of the sample and its corresponding dilutions under the coefficient of micro molar absorption TBA $\varepsilon = 155\ \mu M\ cm^{-1}$ at the wave length 532 nm and was expressed in $\mu mol\ g^{-1}$ of raw substance. Intensity of oxidative stress was evaluated by the reaction of POL by the accumulation of a final product of peroxide oxidation of lipids malondialdehyde (MDA), by the reaction with thiobarbituric acid (TBA) at 532 nm on spectrophotometer LEKI SS1104 according to the technique (Rogozhin, 2006; Karpenko et al., 2019). The method is based on determining the amount of a coloured product at the wave length 532 nm, obtained as the result of interaction of 2 molecules of TBA with one molecule of MDA as one of the by–products of POL. For this purpose, a 1 g of leaves tissue was homogenized with 3 mL of 50% ethanol and centrifuged 10 min at 7,000 rpm. A 0.5 mL of 1% triton X-100 solution, 0.2 mL of 0.6 M HCl and 0.8 mL 0.06 M of TBA were added to the obtained 0.5 mL of supernatant and heated in the boiling water bath (100 °C) for 10 min and then cooled to 15 °C for 30 min and added 0.2 mL 5 mM solution of Trilon B and 5–10 mL of 96% ethanol. As a control served testtube in which all chemical reagents except TBA were added. MDA content was calculated, taking into account optical density of the sample and its corresponding dilutions under the coefficient of micro molar absorption TBA $\varepsilon = 155\ \mu M^{-1}\ cm^{-1}$ at the wave length 532 nm and was expressed in $\mu mol\ g^{-1}$ of raw substance.

Bulb dry matter (%)

The average dry matter weight (g) of bulbs after curing were measured by drying 10 randomly sampled bulbs in an oven with a forced hot air circulation at 70 °C until a constant weight was obtained. The percentage of bulb dry matter was calculated by taking the ratio of the dry weight to the fresh weight of the sampled bulbs and multiplying it by 100.

Determination of content of vitamins B complex

A weight 50 g was cut into small pieces and extracted with 0.1 NHCL (sodium chloride) on the water bath at suitable temperature and time period. All extracts were filtered through 0.40 micron filter and taken into 100 mL volumetric flask which was added up for mobile phase.

The standard preparation: stock of standard (Sigma Aldrich Analytical grade Reagent) prepared by dissolving 0.01 g of each standard in 100 mL of mobile phase followed by successive dilutions.

High-performance liquid chromatography (HPLC)

Analysis of HPLC (Shimadzu, Model Prominence 20A) equipped with UV detector and Supelco Discovery Cis18 column (25-cm in length and 0.45-cm internal diameter) was used. Mobile phase was 50 m MK_2HPO_4 and MeOH (70:30) at 1 mL min^{-1} flow rate and 10 µL of each sample/standard was injected and monitored at UV 254 nm.

Analysis of vitamin C

Lyophilized samples (each 0.2 g) were ground and added to 30 mL of 3% metaphosphoric acid solution and homogenized at 11,000 rpm for 2 min using a T25 basic ULTRA–TURRAX homogenizer (IKAWerke GmbH & Co. KG, Staufen,

Germany). The volume was made up to 50 mL with 3% metaphosphoric acid solution. The extract (2 mL) was centrifuged at 12,000 rpm for 3 min, and the supernatant filtered through a 0.45 lm polyvinylidene difluoride (PVDF) membrane filter (Whatman I nternational Ltd., Maidstone, UK). All samples were immediately analyzed using an HPLC system, equipped with a PU (2089 pump), an AS (2057 auto injector), and a MD (2010 UV) vis variable wavelength detector (JASCO Corp., Tokyo, Japan). Separation was carried out in a Crest Pak C18S column (15094.6 mm, i. d., 5 lm, JASCO Corp.), and the isocratic elution was carried out with 0.1% trifluoroacetic acid in distilled water as a mobile phase for 15 min (flow rate 0.8 mL min^{-1}). The peak was read at 254 nm using an UV detector and quantification was determined via external calibration against ascorbic acid.

Statistical analysis

For the food and chemical composition, three samples analyzed were performed in three replicates. The results were expressed as averages. The antioxidant activity, and chemical composition were analyzed using a one-way dispersion analysis, followed by the Tvyxi's Honesty Difference (TQ) Test at $P \leq 0.05$ (for yield and bulb weight), 0.01 (for enzyme activities, pigments content in leaf, vitamins B complex and vitamin C in cloves, dry matter) using statistical analysis program (SAS) v. 9.1.3.

RESULTS

The results of the studies showed that the highest increase in plant height was the best by gibberellic acid, and was higher than the control by 10.8%, whereas the use of salicylic and ascorbic acids increased the height of plants by 7.8 and 3.9%, respectively (Table 1).

Table 1. Plant height and leaf area of garlic plant (average 2017–2019)

Variant	Plant height (cm)	Number of leaves (pcs)	Leaf area (cm^2)	Leaf area index (LAI)
Control	63.37	8.73	95.70	1.82
Salicylic acid	68.33*	8.58	103.63*	1.94
Gibberellic acid	70.21*	9.28*	122.20*	2.47*
Ascorbic acid	65.86	9.19*	100.25	2.00*
LSD (0.05)	3.45	0.40	6.06	0.14

Means bearing same * in each column are statistically similar at $p \leq 0.05$.

The main indicator of growth and the index on which the productivity of garlic plants depends is the leaf apparatus, so we studied it thoroughly. The number of leaves per plant increased by 0.46–0.55 pcs $plant^{-1}$ with the use of gibberellic and ascorbic acids (5.3–6.3% of control), while salicylic acid significantly decreased this indicator by 0.15 pcs plant-1 (1.7% of control), while the leaf area increased by 8.3; 27.7 and 4.8% by the use of salicylic, gibberellic and ascorbic acids, respectively. The leaf area/plant and the leaf index had slightly different dynamics, but gibberellic acid showed the best results.

Plants were treated by amino acids, increased the amount of chlorophylls (a + b), but with the use of gibberellic acid, the increase was the most significant (0.17% /dry matter which equal to 10.8% increase compared to control) (Fig 1).

It is known that the impact of unfavourable factors affects the status of oxidative stress (OS). Amino acids activate protective mechanisms and reduce the oxidative stress in plant chloroplasts under stress. According to obtained data in this study, spraying of garlic plants (*Allium sativum* L.) with the amino acids reduced the impact of the oxidative stress caused by adverse weather conditions (Fig 2).

In plants which have been treated with GA and SA, Malondialdehyde (MAD) contents decreased by 16.7 and 16.5%, respectively. Under the influence of AA, MAD content decreased by 11.7% (Fig. 2).

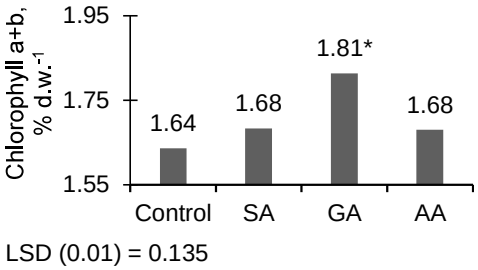

Figure 1. Leaf's total chlorophyll (*a*+*b*) content of the garlic plant (average 2017–2019).
(Means bearing same * in each column are statistically similar at $p \leq 0.01$).

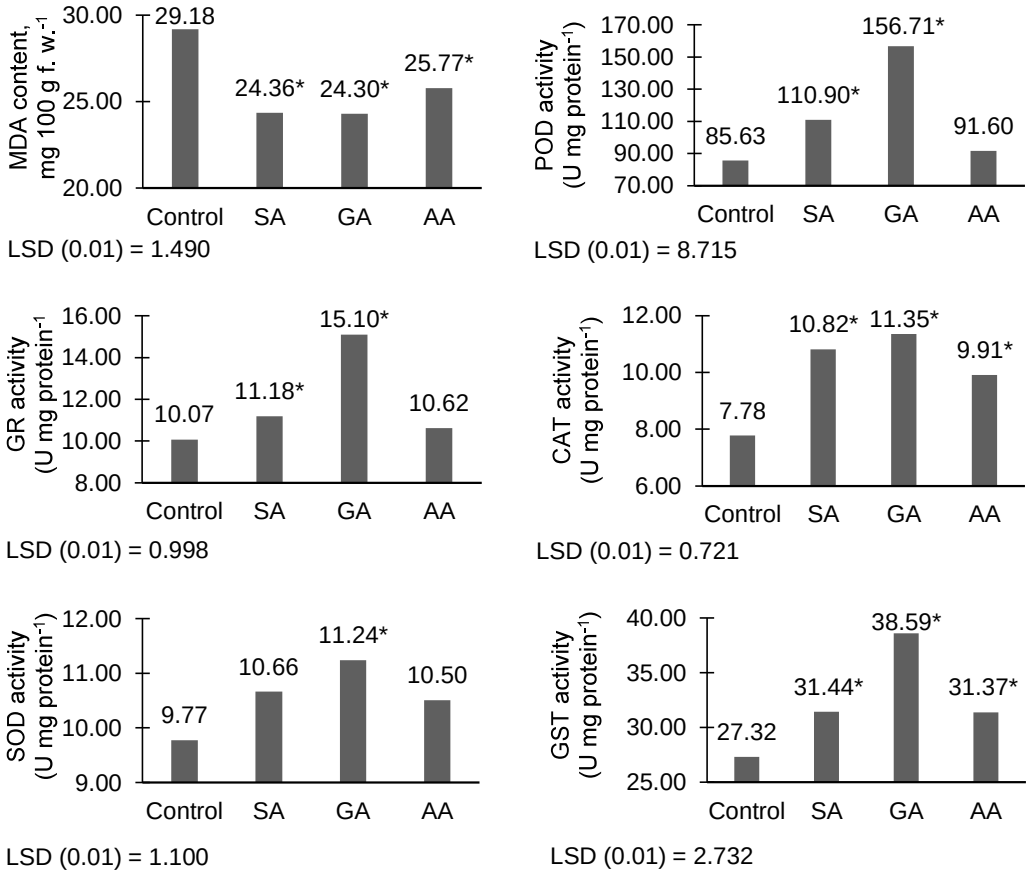

Figure 2. Malondialdehyde content and antioxidant enzyme activity in leaves of the garlic plant (average 2017–2019).
(Means bearing same * in each column are statistically similar at $p \leq 0.01$).

In plants treated by salicylic, gibberellin and ascorbic acids, increases in SOD activity were recorded, 9.1; 15.0 and 7.5% compared to the enzyme activity in the control variant. The use of amino acids ensured the activation of a complex of antioxidant enzymes (Fig. 2).

The activities of SOD, CAT, POD, GR, and GST in leaves treated by amino acids of garlic plants tended to increase (Fig. 2). Thus, SOD activity increses were 7.5–15.0%, CAT (27.4–45.9%); POD (7.0–83.0%); GR (5.4–49.9%) and GST (14.8–41.3%) higher than the control.

The results of the study indicated a significant effect of amino acids on the yield and its structure (Tables 2, 3; Fig. 3). So, the weight of the bulb and the dry matter content, vitamins B and vitamin C, had the best performance in all variants compared to control. The bulb weight increased by 4.73; 9.26 and 4.55 g (LSD (0.05) = 4.05) by the use of salicylic, gibberellic and ascorbic acids, respectively (Table 2).

Table 2. Weight of garlic bulbs (g) (average 2017–2019)

Variant	Weight of bulbs, g			
	2017	2018	2019	Average
Control	59.85	55.27	71.57	62.23
Salicylic acid	64.56*	61.01*	75.30	66.96*
Gibberellic acid	68.93*	65.14*	80.40*	71.49*
Ascorbic acid	64.39	60.85*	75.10	66.78*
LSD (0.05)	3.26	2.95	5.76	4.05

Means bearing same * in each column are statistically similar at $p \leq 0.05$.

The yield growth had the same dynamics. By using salicylic, gibberellic and ascorbic acids, the yield of garlic increased by 1.18; 2.27 and 1.14((LSD (0.05) = 0.89) (Table 3).

Table 3. Yield (t ha^{-1}) of garlic (average 2017–2019)

Variant	Yield, t ha^{-1}			Average	Yield, dry matter, t ha^{-1} (average 2017–2019)
	2017	2018	2019		
Control	14.36	13.26	17.0	14.87	4.65
Salicylicacid	15.48*	14.63*	18.06	16.06*	5.15
Gibberellic acid	16.53*	15.62*	19.28*	17.14	5.29
Ascorbic acid	15.44*	14.60*	18.01	16.02*	5.13
LSD (0.05)	0.73	0.86	1.14	0.89	0.91

Means bearing same * in each column are statistically similar at $p \leq 0.05$.

However, the solids contents of garlic bulbs (dry matter), at the highest amino acid utilization occurred by SA (+2.6%) followed by ascorbic acid (+ 2.5%) of the control. Gibberellic acid did not cause increase in dry matter (Fig. 3).

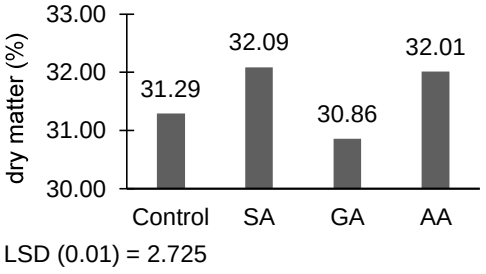

Figure 3. Bulb's dry matter content (average 2017–2019).

(Means bearing same * in each column are statistically similar at $p \leq 0.05$).

The study of the content of vitamins B_6 (Fig. 4) in garlic cloves showed that the best effect on their accumulation was by gibberellic acid, where the increase in the amount of vitamins B reached to 21.9% of control.

The use of salicylic and ascorbic acids increased their amounts to 7.6 and 8.2%, respectively.

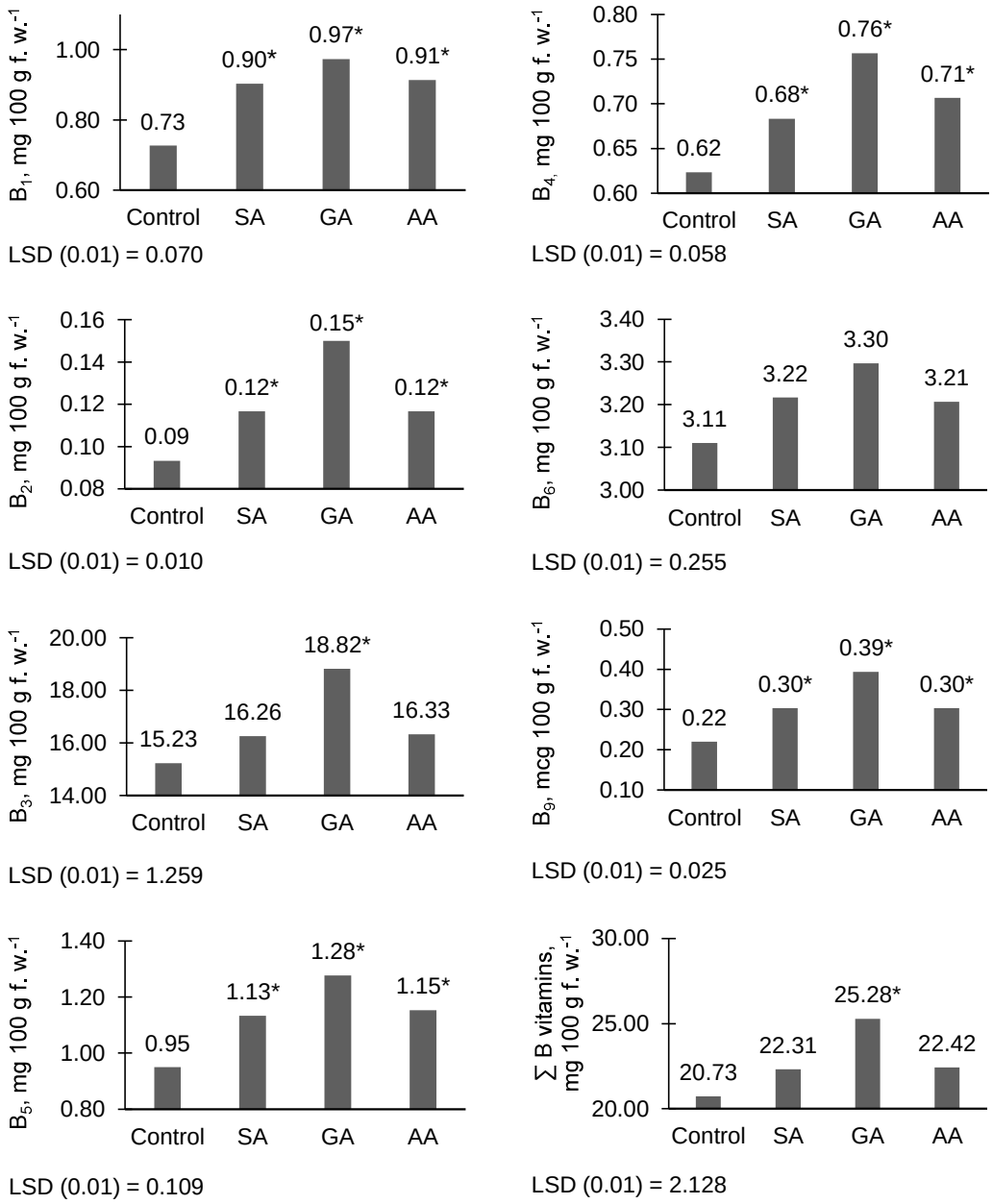

Figure 4. Vitamins B complex content (average 2017–2019).
(Means bearing same * in each column are statistically similar at $p \leq 0.01$).

The most significant increase in vitamin C content was observed for spraying of plants by ascorbic acid (+12.5%of control), whereas for spraying by salicylic and gibberellic acids, its content increased by 6.0 and 7.5%, respectively (Fig. 5).

The maximum weight loss of the bulbs (14.8–18.2%) was observed in the first month of storage, regardless of the variants (Fig. 6).

The percentage of weight loss was steadily increased until 6 months of storage, then, it gradually decreased until the end of storage. Salicylic acid treatment had the most pronounced effect on bulb weight loss during storage, compared to the control and other variants. All other treatments showed smaller percentages of weight loss compared to the control during all storage times(Table 4 and Fig. 6).

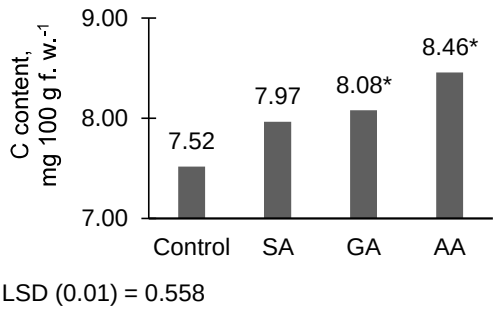

Figure 5. Vitamins C content (average 2017–2019).
(Means bearing same * in each column are statistically similar at $p \leq 0.01$).

Table 4. Bulb weight loss (%) during storage, days after harvest (average 2017–2019)

Variant	days after harvest									∑ weight loss, %
	30	60	90	120	150	180	210	240	270	
	bulb weight loss, %									
Control	18.2	2.2	2.5	2.7	3.0	3.5	3.1	2.6	2.0	39.8
Salicylic acid	14.8*	1.4*	1.6*	1.9*	2.3*	2.6*	2.5*	2.0*	1.3*	30.4*
Gibberellic acid	17.8	1.8*	1.9*	2.2*	2.7*	3.3*	2.8*	2.5	2.5	37.5*
Ascorbic acid	17.3*	1.8*	1.8*	2.1*	2.7*	3.1*	2.6*	2.4*	2.1	35.9*
LSD (0.05)	0.912	0.106	0.108	0.118	0.116	0.169	0.199	0.136	0.076	2.241

Means bearing same * in each column are statistically similar at $p \leq 0.01$.

During the germination of garlic cloves, their marketability is lost. During the storage period, the marketability of garlic bulbs was maintained with the use of GA_3 for up to 140–150 days on average over the years of research.

The use of SA and AA contributed to the extension of the marketability period to 210 days. After 210 days there was a mass germination of cloves. Control bulbs and GK3 germinated after 120 and 140–150 days, respectively. The results of the study indicate that the use of GC3 on garlic crops is impractical if the grown products will be stored for a long time.

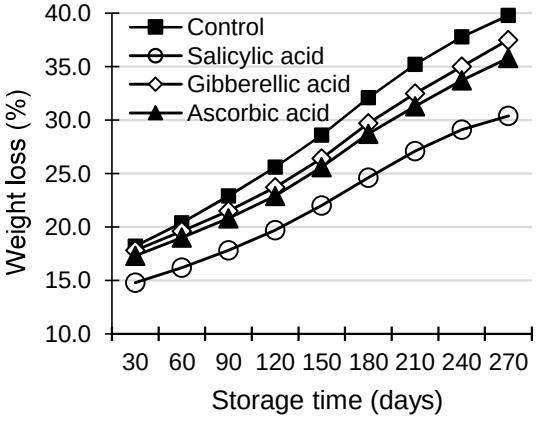

Figure 6. Effect of foliar spray with amino acids on weight loss (%) of garlic during 9 months (270 days) of storage under room temperature (average 2017–2019).

Subsequent storage shows only theoretical data on the weight loss of the bulbs.

DISCUSSION

According to research results, it is followed that the formation of ROS caused significant oxidative destruction in control plant's leaves and bulbs as compared to plants sprayed amino acids. The control plants are characterized by lower antioxidant protection capacity than plants spraying with amino acid.

In multiple studies carried out previously, it has been shown that dehydration of organs induced by drought is the direct sequence of stomatal closure, disorganization of photosynthesis, and inhibition of mechanisms of antioxidant protection(Neill et al., 2002).

Saturated fatty acids are very sensitive to reactive oxygen species (ROS) attack as a single $OH^{\bullet}$ can peroxidize more polyunsaturated acids, being the reason of chain disruptions in the structure and metabolic processes. Taking into account the level of MDA (Fig. 2), it can be concluded that ROS production in garlic plant organs treated with amino acids, and, especially, with gibberellinic acid, is actually much lower as compared to control plants.

In plant cells, there is a certain level of lipid for oxidation, which remains constant due to antioxidant protection systems. The enzyme system, in particular, superoxide dismutase (SOD), which catalyzes the reaction of superoxide radicals ($O^{\bullet-}$), plays an essential role in protecting cells from oxidative degradation. The rate of interaction between SOD and O depends on the degree of cell hydration (Asada, 2006). Depending on the intensity of the stressful fact, the activity of SOD varies differently.

The obtained results indicate that the highest physiological activity is exhibited by gibberellic acid, where the activity of the antioxidant complex is significantly higher against both control and other experimental variants.

The results of this study revealed that foliar spray by amino acids increased vegetative growth parameters. This might be due to the fact that amino acids enhance the metabolism processes in plant tissues.In this respect,foliar application of ascorbic and gibberellic acid resulted in higher growth and yield of eggplant (El-Tohamy et al., 2008; Islam et al., 2008). Our results are similarwith that of Paul et al. (2001); Pourtan, et al. (2004); Abd El-Aal et al. (2010). Similar results on the stimulatory effects of ascorbic acid on other plants were also noticed (Abdel-Halim (1995); Helal et al., 2005; El-Banna et al., 2006).) found that the application of ascorbic acid on tomato plants significantly improved certain plant growth criteria.

CONCLUSION

The antioxidant impact of amino acids manifested itself by a tendency to optimize these parameters; DAM values significantly decreased as compared to those of untreated plants.Amino acids increased the adaptive potential of plants and optimized the processes of growth and productivity. The study found that the use of amino acids improves the garlic productivity as a whole compared to the control. Increase in height of garlic plant, number of leaves, structural elements of yield, and crude and dry weights of the bulb. The highest yield and weight of the bulb were obtained in spraying plants by gibberellic acid, but the accumulation of dry weight was noted by using of salicylic and ascorbic acids.

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