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Research article

Effects of Gibberellic acid, micronutrient fertilizer and Calcium nitrate foliar fertilizer on growth and yield of tomato *Solanum lycopersicum* L. cultivated in Vietnam

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Abstract. In this study, we present the experimental results which evaluate the influence of Gibberellic acid GA_3, micronutrient fertilizer and Calcium nitrate $Ca(NO_3)_2$ foliar fertilizer on the growth and yield of tomato cultivar NHP11 cultivated in a net house located in Thanh Hoa province, Vietnam. The experiment including 8 formulas was laid out in a randomized complete block design (RCBD) with three replications. In treatments with the application of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer, plants were observed to grow better than the control (via some indicators such as plant height, leaf area index, number of flowers per plant, effective flower rate, number of fruits per plant, average fruit weight per plant). The yields differed due to different formulas on tomato. Results indicated that the highest yield was recorded at 50.73 tons ha^{-1} when the combination of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer was applied in F8, followed by the record of 47.31 tons ha^{-1} in F6 (in presence of GA_3 and $Ca(NO_3)_2$ foliar fertilizer), 46.55 tons ha^{-1} in F5 (in presence of GA_3 and micronutrient fertilizer), 45.79 tons ha^{-1} in F7 (in presence of $Ca(NO_3)_2$ foliar fertilizer and micronutrient fertilizer). The yields of tomato in F2, F3, F4 when treated with supplemented separately GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer respectively were higher than those of the control (39.90 tons ha^{-1}) but lower than the yield in mixed formulas. Results show that the treatment combination of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer can promote the growth and yield of tomato.

Key words: tomato, *Solanum lycopersicum*, GA_3, micronutrient fertilizer, $Ca(NO_3)_2$ foliar fertilizer, growth, yield

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Introduction

Tomato (*Solanum lycopersicum* L.), among current cultivated vegetables in the world, is one of the most important crops with the highest yield and largest cultivation area [1]. Tomato fruits contain a huge amount of nutrients including glucid, many organic acids and major antioxidants such as Lycopene, Phenolic, and Vitamin C [2—4]. It also has a high medicinal value thanks to its sweet taste and cooling nature. Phytochemicals in tomatoes can act as antimicrobials and antitoxin agents, reduce the risk of cardiovascular diseases, contributing to the prevention of the formation of free radicals which might lead to cancers, especially prostate cancer [5—7]. In addition, tomato is easily cultivated under various climatic conditions, offering great financial support for many farmer households. As a result, tomato has been widely cultivated in many countries including Vietnam.

Results of studies in the world have shown that Gibberellic acid GA_3, micronutrient fertilizer and Calcium nitrate $Ca(NO_3)_2$ foliar fertilizer play essential roles in vegetative growth. GA_3 is a plant hormone that can regulate the growth of plants, stem elongation, germination, dormancy, flowering, genetic development, and enzyme activation [8]. Micronutrient fertilizer includes a variety of metallic and non-metallic elements. For crops, micronutrient fertilizer is essential because of their role in beneficial enzymes for plant growth. The deficiency of any micro-element in soil might significantly reduce the vegetative yield and quality [9]. $Ca(NO_3)_2$ foliar fertilizer facilitates the process of nutrients and soluble calcium absorption makes the stem bigger and stronger, increases plant resistance to diseases and pests, improves the root length and root branching evolution, thus helping plants absorb more nutrients [10].

Population explosion is a threat to global agriculture. There have been increasing demands for edible products in terms of quantity and quality [11]. When it comes to agricultural research, increasing crop yield is an essential priority [12]. Effects of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer on vegetative growth and yield have become common research topics [10, 13, 14]. However, the comprehensive reports on the influences of GA_3, micronutrients fertilizer and $Ca(NO_3)_2$ foliar fertilizer on the growth and yield of tomato cultivated in Vietnam is quite limited. The purpose of this study was to assess the effects of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer on the growth and yield of tomato cultivated in net houses in Vietnam.

Materials and methods

Research materials. Tomato cultivar NHP11, which is widely cultivated in Vietnam, was provided by Nong Hung Phu Co., Ltd. Organic substrate QD02 consists of alluvium, peat, mushroom residues, burnt rice husk and lime powder. Micronutrient fertilizer B6 includes 2% K_2O, 800 ppm Cu, 50 ppm Mo, 900 ppm Zn, 1000 ppm Bo, 1200 ppm Mg. $Ca(NO_3)_2$ foliar fertilizer comprises $Ca(NO_3)_2$, 26.5% CaO, 15.5% N. Gibberellic acid (GA_3) and NPK fertilizer with the ratio of 4 kg N : 4 kg P_2O_5 : 3 kg K_2O were also used.

Experimental arrangement. The experiment was conducted from November 2018 to March 2019 in a net house located in Quang Xuong district, Thanh Hoa province, Vietnam. The experiment including 8 formulas (table 1) was laid out in a randomized complete block design (RCBD) with three replications.

Table 1

Components of formulas

Formula	Components
F1	Soil + NPK fertilizer + Organic substrate (control)
F2	Soil + NPK fertilizer + Organic substrate + GA_3
F3	Soil + NPK fertilizer + Organic substrate + Micronutrient fertilizer
F4	Soil + NPK fertilizer + Organic substrate + $Ca(NO_3)_2$ foliar fertilizer
F5	Soil + NPK fertilizer + Organic substrate + GA_3 + Micronutrient fertilizer
F6	Soil + NPK fertilizer + Organic substrate + GA_3 + $Ca(NO_3)_2$ foliar fertilizer
F7	Soil + NPK fertilizer + Organic substrate + Micronutrient fertilizer + $Ca(NO_3)_2$ foliar fertilizer
F8	Soil + NPK fertilizer + Organic substrate + GA_3 + Micronutrient fertilizer + $Ca(NO_3)_2$ foliar fertilizer

Experimental technical process. Pots sized 35×40 cm with bottom holes were used. 10 kg of soil were initially put inside, then 4 kg of organic substrate were added into each pot. Each seedling at the height of 20 cm was transplanted into one pot. Seedlings were planted deep with 50% of their stem underground because the root development would soon improve, making the tomato plants much stronger and more resistant. The amount of 0.5 kg of NPK was applied in different growth stages: fertilization before planting seedlings; first supplementary fertilization after the seedlings had new roots for 4—5 days; second supplementary fertilization at the profusely flowering stage; third supplementary fertilization when fruits had been fully mature (15 days after the second supplementary fertilization); fourth supplementary fertilization after first harvesting.

In experimental treatments, for the treatment combination of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer, doses and rates were ensured. GA_3 at a dose of 30 ppm and the rate of 30 mL/m^2 was sprayed into leaves and stems at beginning of the flowering stage and after the first harvesting. Micronutrient fertilizer at a concentration of 0.03% was applied around the stems which were covered by leaves after the seedlings had new roots, before the flowering stage and after the first harvesting. $Ca(NO_3)_2$ foliar fertilizer at a concentration of 0.03% was sprayed into leaves after the seedlings had new roots, before the flowering stage and after the first harvesting.

Data collection. Data on growth, development and yield variables of tomato plants such as: plant height (from the ground to shoot tip, measured with a measuring tape with a precision of 1 mm), number of flower clusters per stem; number of flowers per cluster, effective flower rate (calculated by dividing the number of flowers that produce the fruit by the total number of initial flowers), leaf area measured by CI-202 Leaf Area Meter originated from the USA; Leaf area index (LAI); number of fruits per plant; average fruit weight per plant; actual yield (measured by using the total fruit weight per plant until the end of harvesting).

Those data were collected at 4 different stages: beginning of rooting stage (when above 50% of the seedlings in the treatment had new roots): 8 days after transplanting; beginning of flowering stage (when the initiation of flowers had been recorded in more than 50% of the plants in the treatment): 20 days after transplanting; beginning of harvesting stage (when 50% of the plants in the treatment had reached the harvesting): 70 days after transplanting; after harvesting: 125 days after transplanting.

Statistical analysis. All experiments were conducted three times independently. The results are expressed as mean values and standard deviation (SD). The results were subjected to an analysis of variance (ANOVA). Data were compared according to Tukey's test using IRRISTAT software (version 5.0) for Windows computers.

Results and discussion

Plant height. Plant height, which is one of the major parameters in plant growth, is strongly connected to the resistance and plant yield [15]. Plant height was recorded at 4 different stages. Among formulas, the difference in the fertilizer combinations led to the difference in plant height variables. Obtained data on plant height are illustrated in Table 2.

Table 2

Effects ofGA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer on tomato plant height

Formula	Plant height (cm)			
	Beginning of rooting stage	Beginning of flowering stage	Beginning of harvesting stage	After harvesting
F1	17.50b ± 0.095	41.54d ± 0.076	75.15d ± 0.165	77.32c ± 0.352
F2	17.62b ± 0.027	49.75b ± 0.135	84.67b ± 0.157	86.28b ± 0.265
F3	16.58c ± 0.136	41.67d ± 0.149	77.61cd ± 0.248	78.42c ± 0.146
F4	18.23a ± 0.062	42.58d ± 0.082	76.59cd ± 0.087	78.53c ± 0.312
F5	16.42c ± 0.084	51.03a ± 0.046	88.41a ± 0.160	89.76a ± 0.295
F6	17.08bc ± 0.125	50.16b ± 0.154	86.54ab ± 0.053	89.51a ± 0.119
F7	18.15a ± 0.018	44.02c ± 0.096	78.62c ± 0.169	79.05c ± 0.207
F8	16.31c ± 0.054	51.28a ± 0.068	90.04a ± 0.237	92.18a ± 0.128

Note: Numbers represent mean values of three independent replicates ± SD. In the same data column, values with similar letters represent non-significant differences, values with different letters represent differences in significance ($P \leq 0.05$).

At beginning of the rooting stage, when supplementary GA_3 and fertilizers had not been applied, no significant difference in plant height parameters could be found (Table 2). The highest plant height was observed in F4 (18.23 cm) and the lowest was found in F8 (16.31 cm). The average plant height among 8 treatments was 17.24 cm. From the beginning of flowering to the end of harvesting, plant height variables found in 8 treatments were significantly different. At beginning of the flowering stage, the average plant height among 8 treatments was 46.50 cm, in which the maximum was observed in F8 (51.28 cm), followed by F5 (51.03 cm), F6 (50.16 cm), and F2 (49.75 cm). In these formulas, supplementary GA_3 was applied, and it was one of the major factors that contributed to the development of plant height [16]. Additionally, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer were also applied in F8, leading to the highest plant height value found in this formula. The minimum plant height was found in F1 (the control) at only 41.54 cm. At beginning of the harvesting stage, plants grew quickly, reaching the average plant height of 80.20 cm; the highest plant height was again found in F8 (90.04 cm), followed by F5 (88.41 cm) and the lowest was again found in F1 (75.15 cm). After the harvesting stage, the plant height values continued to increase, but slightly. The maximum plant height was observed in F8 (92.18 cm) and the minimum was observed in F1 (77.32 cm).

Experimental results among 8 treatments show that GA_3 application has a significant impact on tomato plant height [16]. Besides, supplementary $Ca(NO_3)_2$ and micronutrient fertilization can improve the height of tomato plants. In treatments applying isolated micronutrient fertilizer or $Ca(NO_3)_2$ foliar fertilizer or their mixture in absence of GA_3, tomato plants could grow higher than the control group [17], but lower than the plants supplementarily treated with GA_3 in other treatment combinations. It is concluded that GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer have great effects on the plant height of tomato; however, the rates of effect might vary.

Number of flowers and effective flower rate. The production of flowers is the main element contributing to the success of fruit setting [18]. The number of flowers is considered to be the first yield characters of plants [19]. After pollination and fertilization, flowers set and develop into fruits. Fertilizer application promotes the profuse flowering, the number of flowers as well as the effective flower rate [20, 21]. In this experiment, the effects of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer on the number of flowers and effective flower rate of tomato were analyzed.

Table 3

Effects of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer on the number of flowers and effective flower rate of tomato

Formula	Number of flowers per cluster	Number of flowers clusters per stem	Total number of flowers per plant	Effective flower rate (%)
F1	6.12c ± 0.034	5.25d ± 0.063	40.78d ± 0.067	57.06c ± 0.109
F2	7.05b ± 0.046	6.64b ± 0.025	43.88b ± 0.084	61.38b ± 0.086
F3	6.89b ± 0.053	5.49d ± 0.009	42.10c ± 0.049	58.74bc ± 0.157
F4	6.93b ± 0.015	6.37bc ± 0.014	42.15c ± 0.134	60.26b ± 0.050
F5	6.42c ± 0.023	6.71b ± 0.057	44.06a ± 0.019	65.37a ± 0.036
F6	6.92b ± 0.071	6.23bc ± 0.020	43.09b ± 0.107	64.82a ± 0.129
F7	7.07b ± 0.042	6.05c ± 0.016	42.76b ± 0.074	65.16a ± 0.095
F8	8.01a ± 0.058	7.35a ± 0.012	44.19a ± 0.038	66.81a ± 0.048

Note: Numbers represent mean values of three independent replicates ± SD. In the same data column, values with similar letters represent non-significant differences, values with different letters represent differences in significance ($P \leq 0.05$).

As shown in Table 3, the maximum number of flower clusters per stem (7.35), the maximum number of flowers per cluster (8.01), thus the maximum total number of flowers per plant (44.19) and the maximum effective flower rate (66.81%) were all found in F8 (in presence of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer). It could be observed from F5 (in presence of GA_3 and micronutrient fertilizer) that the total number of flowers per plant was 44.06 while the number of flowers per cluster was 6.42 and the number of flower clusters was 6.37 per stem. The differences between results gained from F5 and F8 and those gained from other treatments had statistical significance. In F6 (in presence of GA_3 and $Ca(NO_3)_2$ foliar fertilizer), the number of flowers per cluster was 6.92, the number of flower clusters per stem was 6.23 and the total number of flowers was 43.09 per plant; in F7 (in presence of micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer), the number of flowers per cluster reached 7.07 while the number of flower clusters was only 6.05 per stem, leading to the moderate number of flowers which was only 42.76 per plant. Besides, higher number of flowers per cluster was found in F2 with the total flower number of 43.88 per plant; however, the effective flower rate was recorded at 61.38% only, lower than that gained in F5, F6, F7 and F8. The minimum numbers of flowers per plant and flower clusters per stem were observed in F1 (the control), thus the total number of flowers per plant and effective flower rate were 40.78 and 57.06% respectively. In other formulas (F3 and F4), the total number of flowers and effective flower rate, although higher than those of the control, just reached the average values. Results show that the application of GA_3 spray on tomato could increase the number of flowers and effective flower rate, especially in treatment combination in the presence of micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer. In formulas with isolated $Ca(NO_3)_2$ foliar fertilizer or micronutrient fertilizer, there was also a growth in the number of flowers and effective flower rate, but they were recorded at average values only. It can be referred that GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer all have impacts on the number of flowers and effective flower rate, thus affecting the yield of tomato.

Leaf area index (LAI). There is a close connection between the leaf area index (LAI) and plant photosynthesis. Cultivars with higher leaf area index often gain higher yield production, although the structures of plant populations have a great influence on this index value [22]. If the leaf area index is recorded high, but the population is unreasonably structured, the leaves will shade each other, leading to a decrease in photosynthesis while the demand for respiration increases. As a result, photosynthetic biomass will drop [23]. Experimental results on LAI are presented in Table 4.

Among mentioned formulas, the LAI values for tomato were recorded to increase from the beginning of rooting to the end of harvesting (Table 4). At the beginning of rooting, in absence of supplementary $Ca(NO_3)_2$ foliar fertilizer, micronutrient fertilizer and GA_3, LAI values slightly varied among the formulas. The maximum LAI was obtained in F2 at 0.31 (m^2/m^2) while the minimum was found in F5 at 0.26 (m^2/m^2). From the beginning of flowering to the harvesting, under the influence of plant growth regulator GA_3 and fertilizers, LAI values among the formulas changed sharply with statistical significance. The highest LAI values were recorded in F8 during the experimental period from the beginning of flowering to the end of harvesting. At the beginning of flowering, LAI found in F8 was 1.41 (m^2/m^2), followed by that in F5 (1.35 m^2/m^2),

Table 4

Effects of GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer on tomato leaf area index (LAI)

Formula	Leaf area index (*leaf area / ground area, m^2/m^2*)			
	Beginning of rooting stage	Beginning of flowering stage	Beginning of harvesting stage	After harvesting
F1	0.28bc ± 0.002	1.08c ± 0.007	2.87c ± 0.017	3.29c ± 0.018
F2	0.31a ± 0.005	1.24b ± 0.005	3.05b ± 0.009	3.65a ± 0.007
F3	0.27cd ± 0.001	1.13c ± 0.003	3.17a ± 0.015	3.58ab ± 0.005
F4	0.29ab ± 0.003	1.28b ± 0.001	2.89c ± 0.007	3.34bc ± 0.013
F5	0.26d ± 0.002	1.35a ± 0.001	3.08ab ± 0.012	3.72a ± 0.008
F6	0.29ab ± 0.001	1.26b ± 0.005	3.12a ± 0.005	3.52ab ± 0.007
F7	0.30a ± 0.005	1.14c ± 0.002	2.97bc ± 0.005	3.37b ± 0.021
F8	0.27cd ± 0.003	1.41a ± 0.005	3.19a ± 0.015	3.68a ± 0.010

Note: Numbers represent mean values of three independent replicates ± SD. In the same data column, values with similar letters represent non-significant differences, values with different letters represent differences in significance ($P \leq 0.05$).

F4 (1.28 m^2/m^2) and the lowest was found in F1 (1.08 m^2/m^2). LAI values increased more significantly at the beginning of harvesting. At this stage, the maximum LAI was observed in F8 at 3.19 (m^2/m^2), followed by F3 (3.17 m^2/m^2) and the minimum was obtained in F1 (2.87 m^2/m^2). After the harvesting, the highest LAI value was recorded at 3.71 (m^2/m^2) in F5, followed by F8 (3.68 m^2/m^2). These results were in agreement with those of Hossain et al. (2017) on tomato LAI [22].

Experimental results show that in treatments with the application of micronutrient fertilizer such as F3, F5, F8, LAI values were recorded higher than in other treatments although the lowest value was always found in the control. It proves that the application of isolated GA_3, micronutrient fertilizer, $Ca(NO_3)_2$ foliar fertilizer or their mixture can all increase the LAI value. Therefore, it can be stated that GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer all have effects on the yield of tomato.

Yield components and yield. Yield and yield components are important criteria to assess the effects of elements on the plant [24]. The studied results were shown in Table 5.

Table 5

Yield and yield components of tomato

Formula	Number of fruits per plant	Average fruit weight *(g)*	Actual yield per plant (kg)	Conversion yield (tons ha^{-1})
F1	25.54c ± 0.029	82.19d ± 0.674	2.10d ± 0.008	39.90d ± 0.034
F2	27.55b ± 0.045	86.94b ± 0.405	2.40b ± 0.019	45.60b ± 0.056
F3	26.49bc ± 0.107	85.58c ± 0.268	2.27c ± 0.006	43.13c ± 0.102
F4	27.12b ± 0.097	85.42c ± 0.357	2.32c ± 0.014	44.08c ± 0.149
F5	28.15b ± 0.242	87.08b ± 0.095	2.45b ± 0.054	46.55b ± 0.036
F6	27.93b ± 0.015	89.32a ± 0.175	2.49b ± 0.009	47.31b ± 0.083
F7	27.86b ± 0.026	86.64b ± 0.286	2.41b ± 0.026	45.79b ± 0.018
F8	29.52a ± 0.058	90.36a ± 0.078	2.67a ± 0.032	50.73a ± 0.065

Note: Numbers represent mean values of three independent replicates ± SD. In the same data column, values with similar letters represent non-significant differences, values with different letters represent differences in significance ($P \leq 0.05$).

It can be easily seen that different formulas resulted in radical differences in the number of fruits per plant (Table 5). F8 produced the highest values of the number of fruits per plant at 29.52 fruits, followed by F5 with 28.15, F6 with 27.93 and F7 with 27.86. The lowest numbers were obtained in F1 at 25.54 fruits and F3 at 26.49 fruits. It can be pointed out that the combination of micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer and GA_3 increased the number of fruits per plant. Additionally, applying GA_3 and $Ca(NO_3)_2$ foliar fertilizer or GA_3 and micronutrient fertilizer also increased fruit set percentage when compared to the control. Despite isolated application, GA_3, $Ca(NO_3)_2$ foliar fertilizer and micronutrient fertilizer still contributed to an improvement in the number of fruits per plant, the efficiency was not as good as the ones in the formulas of their mixture.

The average fruit weight was also various from different formulas (Table 5). The same trend was observed in this criterion when F8 had the highest average fruit weight at 90.36 g, followed by F6 at 89.32 g and F5 at 87.08 g. F1 produced the lowest figure at 82.19 g, followed by F4 at 85.42 g. These ranges were statistically significant. So, it can be concluded that mixing micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer and GA_3 in F8, F6 and F5 led to an increase in fruit weight. Meanwhile, applying $Ca(NO_3)_2$ foliar fertilizer and micronutrient fertilizer or supplementing fertilizers separately showed a slight improvement in fruit weight which was lower than combination formulas.

The actual yield per plant and conversion yield show a close relationship among the average fruit weight and the number of fruits per plant with obtained individual yield (Table 5). F8 resulted in the highest yield at 2.67 kg, which was equivalent to 50.73 tons ha^{-1}. In the following places were F6, F5 and F7 at 2.49 kg (equivalent to 47.31 tons ha^{-1}), 2.45 kg (equivalent to 46.55 tons ha^{-1}) and 2.41 kg (equivalent to 45.79 tons ha^{-1}) respectively. The lowest ones were observed in F1 (the control) at 2.10 kg which was equivalent to 39.90 tons ha^{-1}, followed by F3 and F4. All the formulas produced a higher yield than the control and the differences were statistically significant. This means GA_3, $Ca(NO_3)_2$ foliar fertilizer and micronutrient fertilizer increased the yield of tomato when cultivated in the condition of the experiment and when being combined, they provided better effects.

Correlation between some growth indicators and yield of tomato. Growth indicators are correlated with crop yield; therefore, correlation graphs (Fig. 1) were used to evaluate which indicators more closely correlated with the yield. It should be noted that during the growth process, the flowering stage is the essential one contributing to crop yields [19]. Consequently, we use correlation graphs at the beginning of the flowering stage to demonstrate this correlation.

It can be seen that among analyzed indicators (Fig. 1), the number of fruits per plant showed the strongest correlation with yield ($r = 0.99$), followed by average fruit weight per plant ($r = 0.97$). Obviously, these two indicators had direct effects on the yield of tomato. The number of flowers per plant also had fairly close correlation with yield ($r = 0.88$) while leaf area index and plant height had significant influence on the yield ($r = 0.83$ and r = 0.82 respectively).

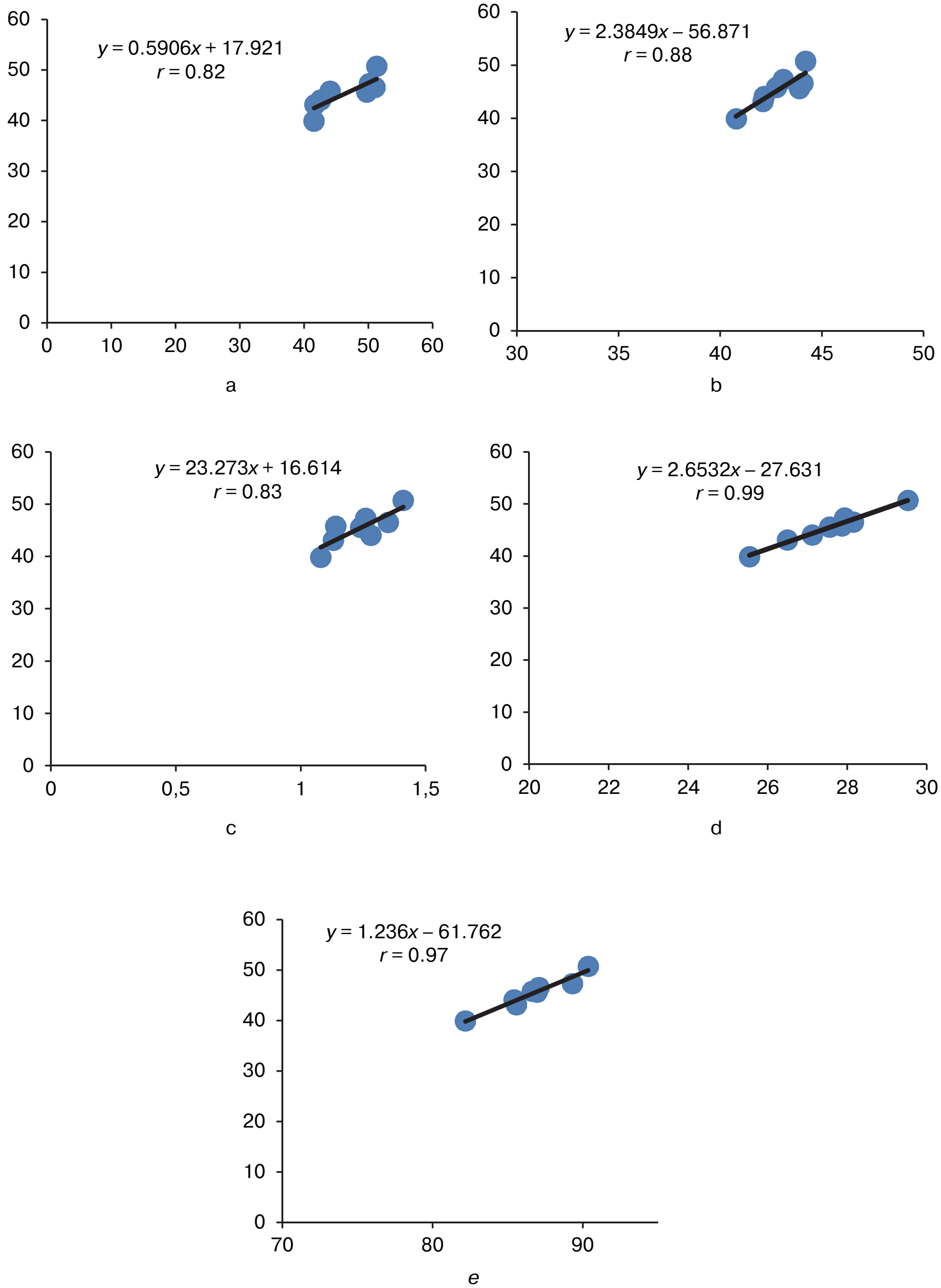

Fig. 1. Correlation between some growth indicators and yield of tomato:
a — between plant height and yield; *b* — between number of flowers per plant and yield;
c — between LAI and yield; *d* — between number of fruits per plant and yield;
e — between average fruit weight and yield

Conclusions

Having been supplemented with GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer, tomato (*Solanum lycopersicum* L.) cultivated in net houses grew faster and better when compared to the control. The results were from some indicators such as plant height, leaf area index, number of flowers per plant, effective flower rate, number of fruits per plant, average fruit weight and actual yield. The formula in which mixed GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer produced the highest yield at 50.73 tons ha^{-1}, followed by the one in which mixed GA_3 and $Ca(NO_3)_2$ foliar fertilizer at 47.31 tons ha^{-1}. The formula of GA_3 and micronutrient fertilizer was in the third place with 46.55 tons ha^{-1} while the fourth-place belonged to the formula of $Ca(NO_3)_2$ foliar fertilizer and micronutrient fertilizer with 45.79 tons ha^{-1}. Other formulas which supplemented separately GA_3, micronutrient fertilizer and $Ca(NO_3)_2$ foliar fertilizer also produced yield higher than the control (yield of the control was 39.9 tons ha^{-1}); however, the figure was not as high as the mixed formulas.

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Научная статья

Влияние гиббереллoвой кислоты, микроудобрения и внекорневого удобрения — нитрата кальция на рост и урожайность томатов *Solanum lycopersicum* L., выращиваемых во Вьетнаме

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Аннотация. Приведены экспериментальные результаты, оценивающие влияние гибберелловой кислоты GA_3, микроудобрения и внекорневого удобрения — нитрата кальция $Ca(NO_3)_2$ на рост и урожайность томатов сорта NHP11, выращенных в закрытом грунте. Исследования проводились в провинции Тханьхоа, Вьетнам. Эксперимент, включающий 8 вариантов, был составлен в рандомизированном полном блочном дизайне с тремя повторностями. При обработке с применением GA_3, микроудобрения и внекорневого удобрения $Ca(NO_3)_2$ наблюдали более высокие показатели роста и развития растений (высота растения, индекс листовой поверхности, количество цветков на растение, эффективная норма цветения, количество плодов на растение, средняя масса плодов на растение) по сравнению с контрольным вариантом. Показатели урожайности томата отличались по вариантам эксперимента. Наивысшая урожайность 50,73 т/га была обнаружена в варианте F8 при применении комбинация GA_3, микроудобрения и внекорневого удобрения $Ca(NO_3)_2$, в F6 с использованием GA_3 и внекорневого удобрения $Ca(NO_3)_2$ урожайность составила 47,31 т/га, в F5 с использованием GA_3 и микроудобрения — 46,55 т/га, в F7 с использованием внекорневого удобрения $Ca(NO_3)_2$ и микроудобрения — 45,79 т/га. Урожайность томатов в вариантах F2, F3, F4 при обработке с использованием GA_3, микроудобрения и внекорневого удобрения $Ca(NO_3)_2$ в отдельности была соответственно выше, чем в контроле (39,90 т/га), но ниже, чем в комбинированных вариантах. Полученные результаты показывают, что комбинация GA_3, микроудобрения и внекорневого удобрения $Ca(NO_3)_2$ может способствовать росту и урожайности томатов.

Ключевые слова: томат, *Solanum lycopersicum*, гибберриловая кислота, GA_3, микроудобрения, внекорневая подкормка, удобрение, нитрат кальция, $Ca(NO_3)_2$, рост, урожайность

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