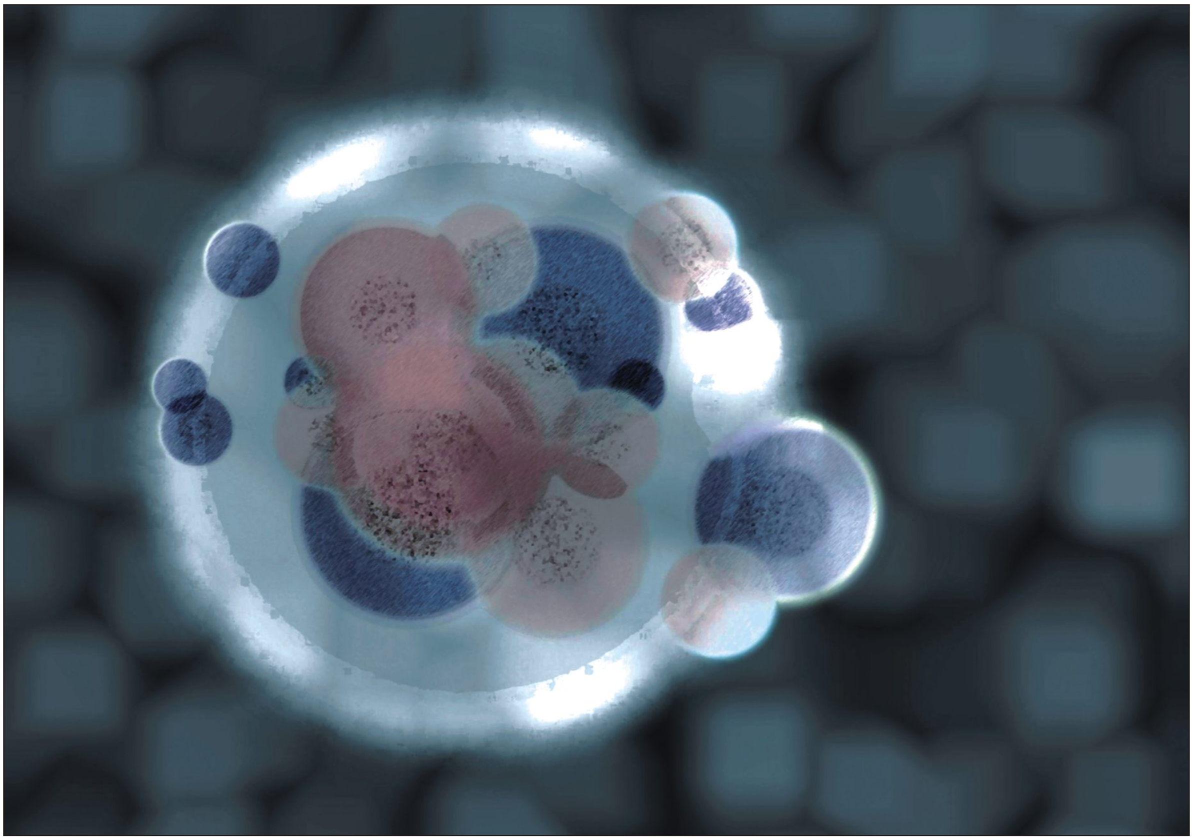

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Research Article
Comparative Response of Cantaloupe Features to Amino Acids, Humic Acid and Plant Oils Towards Downy Mildew Disease

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Abstract

Background and Objective: *Pseudoperonospora cubensis*, is the causal pathogen of cucurbit downy mildew, with behavior as an obligate parasite to crops within Cucurbitaceae family. Control of this pathogen commonly used costly fungicide programs, which a current application developed resistant fungi. The aim of the study was to investigate the vegetative features, biochemical parameters and fruity yield of cantaloupe as a response to amino acids, humic acid and essential oils (anise and thyme) towards downy mildew disease. **Materials and Methods:** The investigation trial was conducted under natural infection with *P. cubensis*, whereas the mixture of amino acids, humic acid (1000 and 2000 ppm), essential oils of thyme and anise (2 and 4 mL L^{-1}) were treated as a foliar spray for plants and compared with fungicide. **Results:** Amino acids and humic acid showed a highly significant decrease in the percentage of disease incidence and severity. As well as, significant response of plant heights, branches number, shoot dry weights and leaves area to amino acids and humic acids has been obtained. Interestingly, the low dose of humic acid (1000 ppm) was more effective compared to a high dose (2000 ppm) in the induction of the afore-mentioned parameters. However, both thyme and anise showed moderate significance at a certain concentration and season. The superiority of amino acids in productivity of yield. **Conclusion:** Amino acids and humic acid were effectively decrease the disease incidence and severity (%) of cantaloupe and improved the vegetation characters, biochemical and fruity yield.

Key words: Amino acids, humic acid, downy mildew, anise oil, fruity yield, cantaloupe, thyme oil

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cantaloupe (*Cucumis melo* L.,) was the too old fruity crop cultivated in Egypt, before being adopted by the Greek and Roman antiquity[1]. Cantaloupe has high potassium content level, folic acid, carbohydrate[2] and other valuable chemical constitutes such as vitamins, minerals, phenolics, flavonoids and carotenoids, which enhanced the medicinal properties[3]. Cantaloupe belongs to the Cucurbitaceae family that includes several species, i.e., watermelon (*Citrullus lanatus* L.), squash (*Cucurbita maxima* L.) and cucumber[4]. Cultivation of the cantaloupe in major production areas was associated with infection of downy mildew pathogen, *P. cubensis*[5,6]. Downy mildew is a serious disease, which threats the cantaloupe production (*Cucumis melo* L.) in the different regions of the world. Downy mildew is an obligate oomycete pathogen of cucurbits and it does not survive from season to season. Its hosts cannot overwinter[7], its extended effect was dramatically reduced sugar content of cantaloupe, affecting the production with a high severity at the time of fruit maturity[8]. Its infection was exclusive to the member of Cucurbitaceae and another 50-60 species including both wild and cultivated forms from about 20 genera are known to be natural hosts[9]. The virulence of *P. cubensis*, may be due to the pathotypes as determined on a standard differential set of Cucurbitaceae taxa or by races[10].

The use of current fungicide exerts selection pressure on the fungus with the development of risk factor of fungicide resistance in the pathogen population[11]. Now a days, the induced systemic immune system is a promising trend of challenge research towards plant pathogens, where associated with local changes at the site of pathogen infection, e.g., hypersensitive response that acting one of the most efficient forms of plant defenses[12].

The mechanism of amino acids not only building the block of proteins but also play roles in the growth and immune responses of plants towards pathogens. Tryptophan is essential for the synthesis of hormones such as auxins. Methionine is a precursor of ethylene, an important plant hormone implicated in the development and stress signaling. Additionally, several studies reported the involvement of amino acids metabolism in plant disease response, e.g., glutamate fermentation by-products confer resistance to pathogen infection in Arabidopsis[13]. The treating of roots of rice with amino acids induces systemic defense and suppresses infection of compatible rice with blast fungus[14].

On the other hand, humic acid was found to play a vital role in sustainable agriculture, which acts as a fertilizer, increase the number of microorganisms in soil, adjust the pH of the soil and also could be affected on the enzymes and hormones[15]. Humic substances are colloidal macromolecules systems, heterogeneous and polydisperse complex which were formed from plant and animal residues during microbial degradation process in soil and sediments[16]. The complex structure of humic substance and clay minerals, significantly affect physical, chemical and biological properties of soil and sediments[17]. Moreover, humus retains macro-nutrients such as phosphate and nitrate beside other metal ions and micronutrients[18]. Consequently, humic substances have a direct influence on the bioavailability of metals in soil, sediments and aquatic systems[19]. The high level of polyphenolic contents enhance the antioxidant properties and the plant resistant to environmental stress, thus improving the products quality[20-22]. The oil of anise is an essential constitute which play a role inthe control of plant infection[23,24]. The chemical composition of essential oil of several *Pimpinella* species has been reported[23-25]. In addition, the anti-fungal activity of anise dried extract and thyme essential oil have been investigated[26-28].

Herein, an attempt of application of some amino acids (their production as a function of fermentation process by *Bacillus subtilis*), humic acid and essential oil of anise and/or thyme has been carried out to reduce the impact of downy mildew progress during cantaloupe cultivation, as well as, improve the immunity, growth and yield productivity.

MATERIALS AND METHODS

Production of biological-based amino acids: Crude amino acids mixture (μg mL^{-1}) was produced by the proteolytic *Bacillus subtilis* ATCC 11774 using liquid state fermentation technique, based on the previous study of El-Hersh *et al.*[29]. The crude amino acid mixture contains (μg mL^{-1}); histidine (103.8), cysteine (112.6), methionine (123.4), arginine (174.3), tyrosine (216.8), serine (272.6), threonine (327.5), isoleucine (336.9), phenylalanine (401.0), valine (414.1), alanine (429.5), glycine (486.6), lysine (521.2), proline (524.9), aspartic acid (552.5), leucine (623.9) and glutamic acid (1185.9). The crude amino acids were kept freeze after production until use.

Humic acid: A commercial product of humic acid (Hammr), containing 86% humic acid and 6% K_2O, was used as a source of humic acid, it was obtained from Egyptian fertilizer development center, Mansoura, Egypt.

Extraction of plant oils: Oils of thyme (*Thymus vulgaris*) and anise (*Pimpinella anisum*) were extracted by petroleum ether for 8 h using Soxhlet apparatus according to AOAC[30].

Variety of cantaloupe: Seeds of cantaloupe (Ideal hybrid) were obtained from vegetable crops research department, Horticulture research institute, Agricultural Research Center, Giza, Egypt.

Experimental procedures: The present investigation was carried out under natural infection at Tag Elezz Research Station, Dakahlia Governorate, Egypt. The soil was loamy-clayey with 37.2% clay, 26.5% silt, 29.7% fine sand and 5.6% coarse sand. The electrical conductivity in soil paste 0.42 dsm^{-1}, field capacity 38.0%, real density 3.1 g cm^{-3} and pH in soil paste 7.4.

The above mentioned crude mixture of amino acids (100%), humic acid (1000 and 2000 ppm) and essential oils (2 and 4 mL L^{-1}) of thyme and anise were evaluated as a proper control of downy mildew and increasing the productivity of cantaloupe plant. The fungicide cuptox 85% w.p. (2.5 g L^{-1}) was used as a control.

Cantaloupe seeds were sown on April 25, 2017 and April 18, 2018. Complete randomized block design with three replicates was applied. During the growth stages, the above treatments were used as a foliar spraying at 25, 40 and 55 days from planting.

Disease assessment: Two downy mildew assessments were measured after 65 days from sowing; Disease Incidence (DI), expressed as infection percentage and Disease Severity (DS) was measured using the color index and infection area[31]. Moreover, disease incidence (%) was calculated as infection (%) as followed:

$$\text{D.I.\%} = \frac{\text{No. of infected leaves}}{\text{Total No. of leaves}} \times 100$$

Growth and yield: After 80 days from sowing, samples were collected to determine the plant height, branches number, shoot dry weight (g) and leaf area (cm^2) per plant. After 110 days from sowing, cantaloupe yield (kg m^{-2}) was determined.

Photosynthetic pigments: The photosynthetic pigments in terms of chlorophylls (total, A, B) and carotenoids in cantaloupe leaves were calculated as stated by Mackinney[32].

Total phenols content: A spectrophotometric technique according to Blainski *et al.*[33] was used to study fresh leaves and fruits polyphenols.

Total flavonoids content: Spectrophotometric manner according to Li *et al.*[34] was used to investigate fresh leaves and fruits total flavonoids.

Polyphenol oxidase and peroxidase assay: Spectrophotometric procedure for increasing the initial rate absorbance at 410 nm according to Seleim *et al.*[35] for separation and capability for PO and PPO was used.

$ABTS^{\cdot+}$ radical scavenging assay: The radical scavenging activity of the sample against $ABTS^{\cdot+}$ cation radical procedure of Christodouleas *et al.*[36]. The percentage of Radical Scavenging Ability (RSA) was estimated by the following equation:

$$\text{RSA (\%)} = \frac{A_o - A}{A_o} \times 100$$

where, A_o is the absorbance of control and A is the absorbance of the sample.

$DPPH^{\cdot}$ radical scavenging assay: The technique of Li *et al.*[34] was used to assess the $DPPH^{\cdot}$ radical scavenging activity. The Radical Scavenging Ability (RSA) of the $DPPH^{\cdot}$ radicals were calculated using the previous equation.

Reducing power capacity: The procedure described by Li *et al.*[34] was used to evaluate the reducing power. The greater reducing power ability achieved by the higher reaction mixture absorbance.

Sugars and starch contents: The technique reported by Abidi *et al.*[37] with a slight modification used to evaluate the total sugars of cantaloupe fruits. Moreover, using an adjustedmanner of Miller[38] for reducing sugars. While calculated non-reducing sugars content by subtraction. Finally, cantaloupe fruits starch was assessed by Ghavimi *et al.*[39].

Statistical analysis: The triplicate values of the treatments were arranged in one-way randomized blocks design using Duncan's multiple range test at probability (p) value of $\leq$0.05. All the statistical analyses were performed by the statistics software package CoStat (version 6.450, CoHort Software, U.S.A).

RESULTS

Field experiment

Disease severity and incidence: Data as shown in Table 1, presented the response of cantaloupe to investigated parameters. Generally, the downy mildew incidence (%) decreased significantly in all treatments, except for anise and thyme oils, which showed a significant decrease in the second season only. However, amino acids and humic acid showed a highly significance on the incidence of the pathogen. Concerning fungicide treatment, it also showed highly significant effect on the incidence of the pathogen in both seasons. In respect to severity (%), the amino acids were more effective followed by humic acid but less than fungicide treatment. Likewise, the essential oil of thyme was significant at two concentrations (2 and 4 mL L^{-1}) compared to control in two seasons. Moreover, anise oil was significant in two seasons, except the concentration of 2 mL showed no significance in the first season only.

Morphological characters: The response of plant heights, branches number, shoot dry weights and leaves area of cantaloupe to amino acids, humic acid, anise and thyme oils, as well as, fungicide during two successive seasons were presented in Table 2. Concerning plant height, both of amino acids and humic acid increased significantly the height of plants compared to control in two seasons. Interestingly, their increasing was significant compared to fungicide treatment. Thyme oil showed significant increases during two seasons, except for the concentration of 2 mL showed a significant decrease in the first season. However, the anise oil at a concentration of 4 mL showed a significant increase in the second season compared to control but the two concentrations significantly decreased plant height in the first season.

Likewise, branches number was increased significantly in the case of amino acids and humic acid in both seasons compared to fungicide and control. The response to anise and thyme oils fluctuated at the different concentrations.

Table 1: Incidence and severity of downy mildew disease on cantaloupe plants

	Downy mildew incidence (%)		Downy mildew severity (%)	
Treatments	2017	2018	2017	2018
Non-treated control	47.38^{ab}	56.11^{a}	9.76^{a}	10.44^{a}
Fungicide	6.83^{e}	4.83^{g}	1.90^{f}	1.42^{h}
Amino acids	2.38^{f}	17.66^{f}	2.57^{e}	2.54^{g}
Humic acid (ppm)				
1000	33.68^{d}	29.78^{e}	5.93^{d}	5.17^{f}
2000	43.10^{c}	41.36^{d}	8.13^{c}	7.73^{e}
Thyme oil (mL L^{-1})				
2	47.83^{ab}	45.83^{bc}	8.09^{c}	8.47^{d}
4	45.41^{bc}	43.04^{cd}	7.95^{c}	8.02^{e}
Anise oil (mL L^{-1})				
2	49.54^{a}	48.67^{b}	9.79^{a}	9.34^{b}
4	48.72^{a}	47.30^{b}	8.59^{b}	8.88^{c}

Means followed by different letters within each column are significantly different according to DMRT ($p\leq 0.05$)

Table 2: Growth performance of cantaloupe plants as a response to amino acids, humic acid and essential oil (thyme and anise)

	Plant height (cm)		Branches No./plant		Shoot dry (g/plant)		Leaf area (cm^2)	
Treatments	2017	2018	2017	2018	2017	2018	2017	2018
Non-treated control	90.33^{e}	82.00^{f}	3.67^{d}	4.00^{c}	14.32^{g}	16.29^{h}	368.9^{f}	387.5^{g}
Fungicide	90.67^{e}	85.00^{ef}	4.00^{cd}	4.33^{bc}	14.35^{g}	16.34^{h}	368.2^{f}	388.0^{g}
Amino acids	143.33^{a}	134.67^{a}	7.00^{a}	6.67^{a}	23.06^{a}	26.87^{a}	525.0^{a}	580.7^{a}
Humic acid (ppm)								
1000	137.00^{b}	128.00^{b}	6.67^{a}	6.33^{a}	21.19^{b}	25.30^{b}	461.1^{b}	492.7^{b}
2000	131.67^{c}	124.67^{b}	5.33^{b}	5.00^{b}	17.83^{e}	20.86^{d}	426.4^{c}	466.1^{c}
Thyme oil (mL L^{-1})								
2	86.33^{f}	94.33^{d}	4.33^{cd}	4.67^{bc}	17.22^{f}	19.14^{f}	389.3^{e}	410.2^{ef}
4	95.67^{d}	104.33^{c}	4.67^{bc}	5.00^{b}	20.23^{c}	21.68^{c}	411.7^{d}	431.1^{d}
Anise oil (mL L^{-1})								
2	84.67^{f}	88.67^{e}	4.00^{cd}	4.33^{bc}	16.83^{f}	18.06^{g}	371.9^{f}	398.0^{fg}
4	88.00^{ef}	97.33^{d}	4.33^{cd}	5.00^{b}	18.67^{d}	20.12^{e}	397.2^{e}	422.0^{de}

Means followed by different letters within each column are significantly different according to DMRT ($p\leq 0.05$)

Generally, both amino acids and humic acid treatments were selected in the further investigation to evaluate the physiological characters of cantaloupe.

Physiological characters

Cantaloupe leaves: The response of chlorophylls (total, A and B) as well as carotenoids to amino acids, humic acid and fungicides was determined (Table 3). The data showed the superiority of the amino acids for the increase of these factors in the leaves and the humic acid is of second order compared to the results of the control. Additionally, leaves content of phenols, flavonoids, PPO and PO enzymes as a response to tested parameters were showed in Table 4.

Obtained results pointed out that positive response had been investigated among the biochemical characters as a response to amino acids and humic acid treatments compared to control. Furthermore, both amino acids and humic acid showed to be more active, in which they caused a significant increase in anti-oxidants markers ($ABTS^{\cdot+}$, $DPPH^{\cdot}$ and reducing power) in leaves (Table 5).

Fruit yield: Depicted data as shown in Fig. 1, presented the cantaloupe yield kg m^{-2} as the treated plants during the two seasons of cultivation. Interestingly, amino acids treatment was superior to other treatments, whereas the humic acid came in the second order followed by fungicide.

Fruit flesh: The content of fruit flesh of total phenols, total flavonoids, polyphenol oxidase and peroxidase enzymes as a response to amino acids and humic acid were determined in Table 6. Data showed the same trend as in the leaves, which there was a positive correlation between these biochemical parameters and tested amino and humic acids. The response of increasing inhibition of both $ABTS^{\cdot+}$ and $DPPH^{\cdot}$, as well as reducing power to amino acids and humic acid were also investigated (Table 7).

Furthermore, saccharides (starch, total, reducing and non-reducing sugars) content were examined (Table 8). The total sugars content was increased significantly in the case of

Table 3: Content of photosynthetic pigments in cantaloupe leaves

Treatments	Chlorophylls (mg g^{-1} fresh weight) A	B	Total	Carotene (mg g^{-1} fresh weight)
Control	2.465^{e}	2.201^{e}	4.666^{e}	0.033^{d}
Fungicide	2.496^{d}	2.530^{a}	5.026^{c}	0.118^{a}
Amino acids	3.006^{a}	2.246^{d}	5.252^{b}	0.104^{b}
Humic acid (ppm)				
1000	2.794^{b}	2.483^{b}	5.277^{a}	0.099^{b}
2000	2.517^{c}	2.405^{c}	4.922^{d}	0.057^{c}

Means followed by different letters within each column are significantly different according to DMRT ($p \leq 0.05$)

Table 4: Total polyphenols and flavonoids as well as defense-related enzymes in cantaloupe leaves

Treatments	Total polyphenols (mg g^{-1} fresh weight)	Total flavonoids (mg g^{-1} fresh weight)	Polyphenoloxidase (U g^{-1} fresh weight)	Peroxidase (U g^{-1} fresh weight)
Control	23.53^{e}	11.90^{e}	14.13^{e}	0.281^{d}
Fungicide	35.40^{a}	14.23^{a}	16.89^{d}	0.369^{b}
Amino acids	30.51^{b}	13.41^{b}	17.35^{c}	0.330^{c}
Humic acid (ppm)				
1000	25.11^{d}	12.41^{d}	18.13^{a}	0.334^{c}
2000	29.34^{c}	12.89^{c}	17.53^{b}	0.360^{a}

Means followed by different letters within each column are significantly different according to DMRT ($p \leq 0.05$)

Table 5: Anti-oxidant capacity of cantaloupe leaves

Treatments	ABTS inhibition (%)	DPPH inhibition (%)	Reducing power OD at 700 nm
Control	10.37^{e}	17.77^{e}	1.245^{e}
Fungicide	13.32^{a}	26.55^{a}	1.673^{a}
Amino acids	10.90^{d}	20.66^{d}	1.608^{b}
Humic acid (ppm)			
1000	11.18^{c}	24.26^{b}	1.471^{d}
2000	11.79^{b}	23.49^{c}	1.567^{c}

Means followed by different letters within each column are significantly different according to DMRT ($p \leq 0.05$)

Table 6: Fruit quality of cantaloupe

Treatments	Total polyphenols (mg GAE/100 g fresh weight)	Total flavonoids (mg QE/100 g fresh weight)	Polyphenoloxidase ($U\ g^{-1}$ fresh weight)	Peroxidase ($U\ g^{-1}$ fresh weight)
Control	6.71^{e}	4.13^{e}	0.522^{d}	0.291^{e}
Fungicide	10.66^{a}	6.47^{a}	0.658^{b}	0.399^{a}
Amino acids	9.03^{b}	5.65^{b}	0.677^{a}	0.382^{b}
Humic acid (ppm)				
1000	7.23^{d}	4.66^{d}	0.521^{d}	0.348^{d}
2000	8.64^{c}	5.13^{c}	0.613^{c}	0.372^{c}

Means followed by different letters within each column are significantly different according to DMRT ($p\leq 0.05$)

Table 7: Anti-oxidant capacity of cantaloupe fruits

Treatments	ABTS inhibition (%)	DPPH inhibition (%)	Reducing power OD at 700 nm
Control	20.13^{e}	41.57^{e}	0.887^{e}
Fungicide	28.98^{a}	57.35^{a}	1.313^{a}
Amino acids	23.09^{d}	47.24^{d}	1.249^{b}
Humic acid (ppm)			
1000	24.69^{c}	49.27^{c}	1.111^{d}
2000	25.92^{b}	51.55^{b}	1.208^{c}

Means followed by different letters within each column are significantly different according to DMRT ($p\leq 0.05$)

Table 8: Carbohydrate content of cantaloupe fruits

Treatments	Starch ($mg\ g^{-1}$ fresh weight)	Total sugars ($mg\ g^{-1}$ fresh weight)	Reducing sugars ($mg\ g^{-1}$ fresh weight)	Non-reducing sugars ($mg\ g^{-1}$ fresh weight)
Control	1.40^{a}	40.14^{e}	2.77^{d}	37.37^{e}
Fungicide	1.33^{a}	48.90^{a}	3.33^{b}	45.58^{a}
Amino acids	1.30^{a}	42.83^{d}	3.08^{c}	39.75^{c}
Humic acid (ppm)				
1000	1.23^{a}	44.83^{b}	3.11^{c}	41.71^{b}
2000	1.20^{a}	43.11^{c}	3.45^{a}	39.66^{d}

Means followed by different letters within each column are significantly different according to DMRT ($p\leq 0.05$)

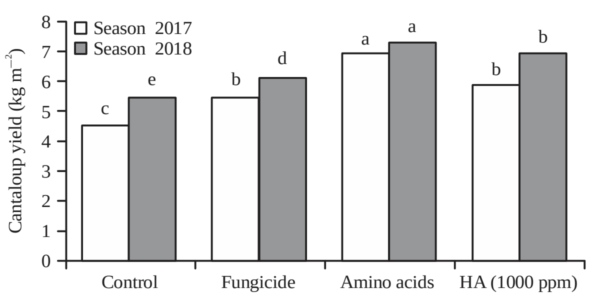

Fig. 1: Yield of cantaloupe fruits obtained as response of amino and humic acids during the two growing seasons
For each season, columns superscripted by different letters are significantly different according to DMRT ($p\leq 0.05$)

amino acids and humic acid compared to control, respectively. Likewise, both of reducing sugars and non-reducing sugars significantly increased in a response to amino acids and humic acid. However, the starch content of fruit not showed any significant response towards the treatments.

The best results for total polyphenol and flavonoid content of cantaloupe were found in the following order: fungicide>amino acids>humic acid in leaves (Table 4) and fruits (Table 6). Subsequently, the polyphenoloxidase and peroxidase activities depend on the content of total polyphenols and flavonoids.

DISCUSSION

The variation in the response may be dependent on the plant species and even cultivars, as well as variability in the spectrum of pathogens that resistance can be induced against pathogens[40]. The accumulation of end product of these biochemical processes, such as phenolics, saponins and terpenes were widely distributed in higher plants as the defense against pathogens injury and they can serve as physical barriers against environment stress[41,42]. Generally, the pathogenesis process usually associated with the generation of some antioxidant and anti-inflammatory agents[43,44].

Here, the results illustrated the role of amino acids as a foliar treatment in decreasing significantly the downy mildew incidence (%) and disease severity (%) in cantaloupe cultivar compared to control (Table 1). These findings could be confirmed from the chemical analysis of leaves and fruits that showed a highly significant increase of flavonoids, carotenoids and anti-oxidant enzymes that play a vital role in resistance of pathogens and scavenging free radical associated with pathogenesis process[41,42]. Moreover, amino acids showed a vital role in plant defenses, development, homeostasis, growth and have a significant effect on plant height, branches number, shoot dry weight and leaf area (Table 2). The obtained results were in agreement with the previous reported results of Kadotani *et al*.[14]. Further, inoculation of *Arabidopsis thaliana*, with avirulent *Pseudomonas syringae* Pv. Tomato (pto) expressing ovrRPT2 gene activates the transcription of genes involved in amino acid biosynthesis[45]. Another study investigated that in the present of low levels of proline, glutamine and alanine showed strong resistance against various types of bacteria, fungi and oomycetes[46].

On the other side, there was a significant correlation between decreasing disease incidence percentage, disease severity percentage and humic acids threshold. Likewise, the positive response was found in plant heights, branches number, shoot dry weight and leaf area as the humic treatments (Table 2), these results could be due to the effective role of humic acid on soil, which has an effect on the physical, chemical and biological properties of soil. Moreover, humus matter has a nutritional function as the source of N, P and S for plant growth, biological function as well as, improving tilth, aeration and retention of moisture[47].

The content of cantaloupe of polyphenol, flavonoids, antioxidant enzymes (peroxidase and polyphenol oxidase) significantly were affected by humic acid treatment compared to control.

Moussa *et al*.[48] reported the positive correlation between immunity of potato against bacterial wilt disease and flavonoids, polyphenols and antioxidant enzymes.

Gholami *et al*.[49] reported that the humic acid with vermicomposting increases the chicory yield and phytochemical properties. In addition, Calvo *et al*.[50] described the role of humic acids on plants, growth, yield and nutrients uptake. Further, the decrease in disease incidence and severity may be due to the functional group of humic acids[51].

Flavonoids and carboxylic acids had extended effect as anti-oxidant, antimutagenic and antiviral agents[52].

Humic acids were also reacted with heavy metal to reduce its toxicity[19], this feature indicated obviously the role of humic substances in the sustainable culture in contaminated soil with heavy metals. Moreover, humic substances fInd their way in soil stabilizing and fertilizer, which retains macronutrients, i.e., phosphate and nitrate, besides metal ions and micronutrients[18]. Another investigated study showed the phenolic groups of humic acid was responsible for antioxidative ability. The total antioxidant capacity of humic acids by CUPRAC method varied between 0.15 and 0.27 molGAEAC kg^{-1} humic acid according to their source[17].

Otherwise, The response of disease incidence and /or disease severity to thyme and anise that used as essential oil could be attributed to active chemical constitutes that showed the antioxidant and antifungal activities26-28. The higher concentrations of both thyme and anise showed to be active compared to low concentration. Generally, both of amino acids and/or humic acid threshold showed high significant towards the cantaloupe features compared to essential oil of thyme and anise. In addition, the increasing in both of the inhibition percentage of $ABTS^{\cdot+}$ and $DPPH^{\cdot}$ and reducing the power of antioxidant was recorded in amino acids and humic acid in fruits (Table 7). Contrarily, the content of fruit of starch not responded to treatments, whereas saccharides (total, reducing and non-reducing sugars) were responded to amino acids and humic acid (Table 8).

In general, the response of chlorophylls (total, A and B) beside to carotenoids, flavonoids and polyphenols to amino acids and humic acid, all these parameters reflected on healthy of cantaloupe plants and yield productivity as shown in Fig. 1, which showed the superiority of amino acids threshold to other treatments in the productivity of yield during the two seasons.

CONCLUSION

Amino acids and humic acid, showed a vital role in disease incidence, disease severity, plant height, branches number, chlorophyll A, B, flavonoids, carotenoids and antioxidant enzymes. Both thyme and anise oil had significant effect at a certain concentration but with less activity compared to amino acids and humic acid. Thereby, the substitution of fungicide with amino acids or humic acid acting as a safe procedure for the environment and human, ultimately healthy cantaloupe with high productivity and tasty fruits.

SIGNIFICANCE STATEMENT

This study discover the comparative response of cantaloupe features to amino acids, humic acid and plant oils that can be beneficial for treatment of downy mildew disease. Amino acids and humic acid were effectively play a vital role in decreasing the disease incidence and severity (%) of cantaloupe and improved the vegetation characters, biochemical and fruity yield. This study will help the researcher to uncover the critical areas of biotechnology that many researchers were not able to explore. Thus a new theory on increasing the resistance of pathogens that may be arrived at.

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