Journal homepage
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Anbar Journal of Agricultural Sciences
(University of Anbar – College of Agriculture)

EFFECT OF ACIDS AND ORGANIC NUTRIENTS ON CAULIFLOWER GROWTH AND YIELD AND WATER USE EFFICIENCY AND FERTILIZER PRODUCTIVITY OF A MODIFIED NFT HYDROPONICS SYSTEM

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Article info

Received: 2024-11-08
Accepted: 2024-12-30
Published: 2024-12-31

DOI-Crossref:
10.32649/ajas.2024.185831

Cite as:
Zaili, Sh. A., Salman, A. D., Muhanna, T. J., and Hikmat, S. (2024). Effect of acids and organic nutrients on cauliflower growth and yield and water use efficiency and fertilizer productivity of a modified nft hydroponics system. Anbar Journal of Agricultural Sciences, 22(2): 1651-1661.

Abstract

conducted aimed at investigating the physiological effects of acids and organic nutrients on cauliflower development and yield as well as water use efficiency and fertilizer productivity. Alnahar F_1 hybrid cauliflower seeds were used in the RCBD experiment with three replications involving two types of nutrients, i.e., karma trio acid and Algaton 20 at 0.5 and 1ml. L^{-1} concentrations each, as well as the control treatment. The means were compared at a significance level of less than 5%. The findings demonstrated the considerable superiority of the Algaton 20 1 ml.L^{-1} treatment in the leaf content of nitrogen, phosphorus, potassium, chlorophyll, plant height, leaf count, leaf area, plant and root dry weight, head diameter and weight, total yield, water use efficiency, nitrogen, phosphorus, and potassium recovery efficiency, and fertilizer productivity, at 3.85, 0.69, 2.74%, 419.70 mg.100 g fresh weight, 43.0 cm height, 33.0 leaves plant^{-1}, 568.81 dsm^2. plant^{-1}, 198.00, 13.0 g. plant^{-1}, 25.50 cm head size, 1872.0 g. plant^{-1}, 103.99 t. ha^{-1}, 112.32 kg.m$^{3-1}$, 19.76, 13.45, 14.28%, and 42.67 kg yield, respectively compared to the T0 treatment. The findings show the possibility of culturing cauliflower hydroponically and increase its productivity through spraying with Algaton 20 at a 1 ml. L^{-1} concentration.

Keywords: Brassica oleracea var. botrytis, Seaweed, Humic acid, Fulvic acid, ABEER solution.

تأثير الأحماض والمغذيات العضوية في نمو وحاصل القرنابيط وكفاءة استعمال المياه والمغذيات وإنتاجية السماد تحت نظام الزراعة المائية بتقنية فلم المحلول المغذي NFT

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الخلاصة

نفذت تجربة حقلية في جامعة بغداد – كلية علوم الهندسة الزراعية – المحطة البحثية B خلال الموسم الخريفي 2021- 2022 بهدف دراسة التأثير الفسلجي للأحماض والمغذيات العضوية في نمو وحاصل القرنابيط وكفاءة استعمال المياه والمغذيات وإنتاجية السماد تحت نظام الزراعة المائية بتقنية فلم المحلول المغذي NFT المحور، استخدمت بذور القرنابيط هجين Alnahar F_1 في التجربة التي نفذت ضمن تصميم RCBD وبثلاثة مكررات شملت نوعين من المغذيات هما Karma Trio Acid بتركيزين 0.5 و1 مل لتر$^{-1}$ و Algaton 20 بتركيزين 0.5 و1 مل لتر$^{-1}$ فضلا عن معاملة القياس، وتم استعمال اختبار LSD لمقارنة متوسط المعاملات وعلى مستوى احتمال 5%، ويمكن تلخيص النتائج كالاتي: تفوق النباتات المعاملة بالمغذي العضوي Algaton 20 1 مل.لتر$^{-1}$ معنويا في النسبة المئوية N و P و K في الاوراق ومحتوى الاوراق من الكلوروفيل وارتفاع النبات وعدد الاوراق والمساحة الورقية والوزن الجاف للنمو الخضري والمجموع الجذري وقطر ووزن القرص والحاصل الكلي وكفاءة استعمال المياه وكفاءة استرداد النتروجين والفسفور والبوتاسيوم وإنتاجية السماد والتي سجلت 3.85 و0.69 و2.74% و419.70 ملغم.100غم وزن طري$^{-1}$ و43.0 سم و33.0 ورقة.نبات$^{-1}$ و568.81 دسم^{2}.نبات$^{-1}$ و198.00 غم نبات$^{-1}$ و13.0 غم و25.50 سم و 1872.0 غم و103.99 طن.هـ$^{-1}$ و112.32 كغم م$^{-3}$ و19.76 و13.45 و14.28% و42.67 كغم حاصل كغم سماد$^{-1}$ على الترتيب مقارنة بنباتات معاملة القياس، نستنتج امكانية زراعة القرنابيط مائيا وزيادة انتاجية برش النباتات بالمغذي العضوي Algaton 20 بالتركيز 1 مل لتر$^{-1}$.

كلمات مفتاحية: القرنابيط، طحالب بحرية، حامض الهيومك، حامض الفولفيك، محلول ABEER.

Introduction

Drought and desertification issues have increased since the early twentieth century due to rapid population increase and climatic changes represented by high temperatures, global warming, declines in rainfall rates, the spread of salinity, and others (2). Other challenges facing the agricultural sector include the prevalence of plant diseases, infections, and soil problems related to fertility and deterioration, and the excessive use of chemicals (14 and 29). These issues need to be addressed to find solutions that are both environmentally friendly and high-yielding. Soilless cultivation, particularly hydroponics, is one such approach that has gained popularity worldwide (32) where the crops grown in this system differ from country to country (20).

Human existence and agricultural irrigation rely critically on water resources making it imperative to use them efficiently (8 and 23). Water use has increased dramatically in tandem with rapid population growth, while consumers seek more diversity in their food choices. In addition, freshwater of good quality is precious. Thus, water shortages, resulting from drought, depletion of groundwater, excessive use of water, or poor quality due to salinity and pollution, is one of the greatest threats facing life on earth. There is thus an urgent need to use water wisely while minimizing the drainage of fertilizers and chemicals into natural water sources (25). Improving nutrient use efficiency (NUE) and water use efficiency (WUE) is one of the modern research issues (30). Evaluating systems of crop production that can be greatly influenced by the management of fertilizers and growing media must be highly efficient and effective to present the expected economic, social, and environmental benefits.

Fertilizer use efficiency is therefore an essential concept. Made from organic waste, the use of manufactured organic fertilizers has become more predominant as they do not harm the environment and benefit human, animal, and plant health in addition to raising production and enhancing their quality (9). Adding humic acid raises plant height, number of leaves, leaf area, diameter and weight of the flower disc, and cauliflower total yield (6). (3) found that organic fertilization with fulvic acid increases the absorption of leaves and stimulates plant productivity as it is considered a non-toxic chelating additive. (33) noticed that fulvic acid promoted the growth of tomato plants, leading to an increase in marketable yield in production. (11) reported that spraying zucchini squash with the organic nutrient Algaton was effective on the fresh and dry weight of the plant and the percentage of N and K in fruits, as well as on early and total yield, for the fall and spring seasons.

Particularly, foliar application of fertilizer achieves the required nutritional balance and helps to prevent physiological or biological instabilities in the life cycle of plants. As fertilization is a vital agricultural application of significant benefit to plant life, numerous studies have been conducted to increase crop efficiency by including micronutrients from various sources (mineral, biological, and organic). (31) noted that applying humic acid to corn fields over two seasons has a considerable effect on the plants, increasing production and enhancing nitrogen use efficiency. (21) found that spraying cauliflower with marine algae extract significantly increased the dry weight of the shoot system and the proportion of N, P, and K in the head. Current trends seek to reduce the use of chemical fertilizers and instead use nutrients and organic compounds that do not harm or negatively affect humans and the environment (1).

Cauliflower (*Brassica oleracea* L. var. botrytis) belongs to the family Cruciferae. It grows naturally near the Mediterranean Sea and is cultivated for its flowery disk, which contains carbohydrates, protein, vitamins, and minerals with exceptionally high phosphorus levels (18). This research investigated the physiological effects of organic acids and nutrients on cauliflower growth and yield and the efficiency of water and nutrient use and fertilizer in the hydroponic system based on a modified nutrient film technique (NFT).

Materials and Methods

This field experiment was conducted at Research Station B of the Faculty of Agricultural Engineering Sciences, University of Baghdad, during autumn 2021-2022. It utilized a hydroponic system with a modified nutrient film technique (NFT) technology. The Alnahar F1 hybrid cauliflower seedlings in this experiment were relocated on 14/10/2021 and planted 30 cm apart and 60 cm between tubes, with 5 plants per experimental unit. A nutritional solution was then applied (28).

Table 1: Alternative nutrient solution (ABEER).

Stage of Vegetative Growth			
Type of fertilizer	**Weight (g. L^{-1})**	**Type of element**	**Element concentration (mg.L^{-1})**
30- 10- 10 +10	0.75	Total Nitrogen	225
		P_2O_5	75
		K_2O	75
		SO_3	75
Disper Complex GS	0.25	EDDHSA- Fe	12.5
		EDTA -Mn	10
		EDTA- Zn	1.5
		EDTA -MgO	5
		EDTA -Cu	1.25
		B	1.75
		Mo	0.75
Disper Mg	0.341	MgO	42
Disper Ca	Sprinkled (1g L^{-1}) on plants every 15 days		
Flower Growth Stage			
20 -20 -20	0.75	$N-NH_4$	150
		P_2O_5	150
		K_2O	150
Disper Complex GS	0.25	EDDHSA- Fe	12.5
		EDTA -Mn	10
		EDTA- Zn	1.5
		EDTA -MgO	5
		EDTA -Cu	1.25
		B	1.75
		Mo	0.75
Disper Mg	0.341	MgO	45
Disper Ca	Sprinkled (1g L^{-1}) on plants every 15 days		

Three plants were selected at random from each experimental unit and the following measurements were made. The Kjeldahl micro (22) equipment was used to determine the nitrogen content of the leaves, a spectrophotometer (12) evaluated their phosphorous content, and Goodwin's procedure (16) was used for measuring leaf pigment content. At the end of the season, leaf number (leaf. plant^{-1}), plant height (cm) and leaf area (dcm^2 plant^{-1}) were measured. Watson and Watson (34) found that a sensitive scale helped in determining the dry weight of the roots and shoots (g. plant^{-1}). Harvest produced the weight and diameter of the flower heads (cm. head^{-1}) as well as the total yield (tons. Ha^{-1}). Computed fertilizer-use or fertilizer recovery efficiency (%), Ali (7), water use efficiency or productivity (kg m^{-3}), and fertilizer productivity (kg yield per Kg fertilizer) was also measured.

Results and Discussion

Table 2 shows that the use of foliar seaweed dramatically affected the nutrient content and growth parameters of the cauliflower plant. The treatment with seaweed at 1 ml L^{-1} (T4) resulted in a significant increase in the leaf content of nitrogen, phosphorus, potassium, and chlorophyll, plant height, leaf count, leaf area, plant dry weight, and root dry weight at 3.85, 0.69, 2.74%, 419.70 mg.100g fresh wt.$^{-1}$, 43.0 cm, 33.0 leaf. plant^{-1}, 568.81 dsm^2. plant^{-1}, 198.00 and 13.0 g. plant^{-1} respectively. This was not significantly different from spraying with 0.5 ml. L^{-1} organic nutrients in T1 in leaf content of each N, P, K, chlorophyll, plant dry weight, the T3 treatment for chlorophyll, and T2 treatment in K leaf content compared to T0 which recorded 3.22, 0.59, 2.26 %, 367.76mg.100g fresh wt.$^{-1}$, 29.0 cm, 22.0 Leaf. plant^{-1}, 326.41 dsm^2. plant^{-1}, 127.00 and 7.0 g. plant^{-1}, respectively.

Table 2: Effect of acid and organic nutrient spraying on leaf nutrient content and growth parameters of hydroponically cultivated cauliflower plants.

Treatment	N	P	K	Chlorophyll	Plant height	Number of leaves	Leaf area	Dry weight of plant	Dry weight of root
		(%)		(mg.100g fresh wt^{-1})	(cm)	(Leaf. plant^{-1})	(dsm^2. plant^{-1})	(g.plant^{-1})	(g.plant^{-1})
T0	3.22	0.59	2.26	367.76	29.0	22.0	326.41	127.00	7.0
T1	3.66	0.67	2.63	401.96	36.0	30.0	490.90	181.00	11.0
T2	3.41	0.63	2.51	381.90	33.0	27.0	347.20	143.00	9.0
T3	3.35	0.61	2.44	396.10	32.0	29.0	410.60	163.00	9.0
T4	3.85	0.69	2.74	419.70	43.0	33.0	568.81	198.00	13.0
LSD 5%	0.39	0.04	0.28	29.51	1.1	1.4	24.10	31.97	0.95

Foliar spraying with organic nutrients is a clean method for increasing production due to its substance content that encourages growth and production and maintains consumer health and the cleanliness of the environment. Therefore, the superiority of the treatment involving spraying with algae extract at the concentration of 1ml.L^{-1} is due to the highly increased percentage of micro and macronutrient content in the algae leaves. Together with the correct agents for the spraying process, it increases the concentration of these elements. Due to their vital role in the plant, it is reflected in improved vegetative and root growth parameters and enhanced vital processes, including carbon assimilation, resulting in higher dry weight of vegetative growth. This could also lead to higher vegetative and root growth parameters (Table 2) from spraying marine algae, such as Algaton 20, due to its richness of elements, including plant hormones, especially cytokinins. These have an essential role in etioplasts differentiation and transforming them into chloroplasts, and then in their division and increase in their numbers (19).

CK also increases the size of the cells diagonally, whether for the vegetative or root parts, and stimulates the vascular cambium cells' division and growth, leading to an increase in the size of the plant (4) represented by higher number of leaves and leaf area. Furthermore, nitrogen is an integral component of protein and chloroplasts (5 and 13) as its uptake plays an essential role in plant growth and development (35). In plants, phosphorus plays a vital role in forming bio membranes along with nitrogen. It also aids in creating energy and organic compounds, particularly proteins, that contribute to forming the chlorophyll molecule, As for potassium, it is used as a catalyst in the formation of pigment (27), which positively impacts the process of carbon assimilation and its resulting products, ultimately improving the plant's root and vegetative growth parameters.

Table 3 shows that foliar application of seaweed significantly affected the yield parameters and water use efficiency of cauliflower plants grown under hydroponic conditions. The 1 ml. L^{-1} treatment (T4) of seaweed gave a significant increment in diameter and weight of head, total yield and water use efficiency at 25.50 cm. $head^{-1}$, 1872.0 $g.plant^{-1}$, 103.99 $t.ha^{-1}$, and 112.32 $Kg.m^3$ respectively This did not significantly differ from spraying with 0.5 ml. L^{-1} organic nutrients (T1) for the same parameters compared to the control treatment (T0) which recorded 19.50 cm. $head^{-1}$, 1109.0 $g.plant^{-1}$, 61.61$t.ha^{-1}$ and 66.54$Kg.m^3$, respectively.

Table 3: Effect of acid and organic nutrient spraying on production metrics and water use efficiency of hydroponically grown cauliflower plants.

Items	Diameter of head (cm. $head^{-1}$)	Weight of head ($g.plant^{-1}$)	Total yield (ton ha^{-1})	Water use efficiency ($Kg.m^3$)
T0	19.50	1109.0	61.61	66.54
T1	22.25	1538.0	85.44	92.28
T2	20.00	1145.0	63.61	68.70
T3	19.60	1156.0	64.22	69.36
T4	25.50	1872.0	103.99	112.32
LSD 5%	0.92	367.0	20.39	22.02

Cauliflower heads are a repository for attracting and storing carbon assimilation products, resulting in an increase in their weight and compounds content, and affecting plant and eventually total yield. The higher yields from spraying Algaton 20 may be due to improvements in the parameters of vegetative and root growth (Table 2) from the nutrients needed by the plant to promote enzymatic and hormonal activity, thus enhancing production and quality (6). Starting from nitrogen, which improves the content and productivity of crops, it is similar to phosphorus, passing through potassium, which is distinguished by its ability to improve the product quality and increase the leaves' effectiveness to produce nutrients contributing directly to plant growth and development.

Improving water efficiency in agriculture is a critical step in conserving water resources. Consequently, higher water use efficiency when spraying with algae might be ascribed to an increase in the potassium percentage in the plants of these treatments (Table 2), since water absorption by cells and tissues is associated with potassium absorption. An essential osmotic component, potassium helps plants retain water and use it more effectively (26). Moreover, it plays a crucial and widely recognized function in the physiological and biochemical processes of the plant, especially in regulating the opening and shutting stomata process and water absorption, thereby optimizing water use efficiency (17).

Table 4 shows that the most significant increase in the levels of nitrogen, phosphorus, and potassium rehabilitation efficiency, determined by the quantity of fertilizer utilized as a nutrient source, along with the highest enhancement in fertilizer productivity, occurred under the 1 ml L^{-1} seaweed treatment (T4), achieving 19.76%, 13.45%, 14.28%, and a yield of 42.67 kg. kg^{-1} of applied fertilizer.

Table 4: Impact of acid and organic nutrient application on fertilizer recovery and productivity of hydroponically produced cauliflower plants.

Items	Fertilizer recovery (%)			Fertilizer productivity
	Nitrogen	Phosphorus	Potassium	kg yield. Kg fertilizer
T1	14.17	2.59	10.57	23.99
T2	2.24	0.84	4.02	2.01
T3	7.66	1.37	6.19	2.62
T4	19.76	13.45	14.28	42.67
Standard deviation	7.63	5.97	4.57	19.46

Appropriate hydroponics have an important role in the efficiency of water use and the efficiency of the added fertilizer units, and together with proper management of the added fertilizer, it pumps nutrient solutions at concentrations that suit the plant’s needs. Thus, the two major factors important for plant growth and development, namely water and nutrients, are linked and ensure that they are delivered to the root zone without loss through leaching, volatilization, or fixation. The efficacy of the spraying treatment with 1 ml.L^{-1} algae extract in enhancing fertilizer use efficiency may be attributed to the environmental issues and biological enhancements in the plants. Together with the availability of energy required for the absorption process, it elevates macronutrient concentrations in the plant (Table 2), thereby improving recovery efficiency.

Agricultural techniques, accompanied by environmental balance and correct fertilization, increase productivity and quality while reducing negative environmental impacts. One of the techniques that can improve fertilizer efficiency and management is hydroponics. The reason behind the superiority of such treatment in increasing fertilizer productivity are the factors it provides for the plant's proper growth, represented by nutrients available for absorption and clean energy transfer. This reflects positively on vegetative growth parameters, plant yield (Table 3) and fertilizer productivity. Accordingly, it is recommended that cauliflower plants grown hydroponically be sprayed with 1 ml L^{-1} concentration of the Algaton 20 organic nutrient to obtain maximum water use efficiency, improved efficiency in nutrient recovery, and the highest fertilizer productivity.

Conclusions

It is recommend that hydroponically cultivated cauliflower plants be sprayed with the organic nutrient Algaton 20 at a 1ml L^{-1} concentration to achieve the highest production per unit area. This result does not differ significantly in most of the measured parameters, including total yield, from spraying with organic acids at 0.5 ml L^{-1} concentration.

Supplementary Materials:

No Supplementary Materials.

Author Contributions:

Methodology, writing, original draft preparation. Authors, writing, review and editing. authors have read and agreed to the published version of the manuscript.

Funding:

This research received no external funding.

Institutional Review Board Statement:

The study was conducted in accordance with the protocol authorized by the Ministry of Higher Education and Scientific Research, Iraq.

Informed Consent Statement:

No Informed Consent Statement.

Data Availability Statement:

No Data Availability Statement.

Conflicts of Interest:

The authors declare no conflict of interest.

Acknowledgments:

The authors are thankful to the College Dean, and the Head of the Horticultural and Landscape Gardening Dept. College of Agricultural Engineering Sciences, University of Baghdad, Iraq. We would also like to thank the Editor-in-Chief of the Anbar Journal of Agricultural Sciences.

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