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(Article Review)

VITAMINS AND THEIR EFFECTS ON PLANT

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ABSTRACT

Vitamins are safe substances that do not harm humans or animals. These vitamins are used to improve plant growth and flower formation; they are in fact organic substances that exist in several forms, and considered as micro essential nutritional supplements for proper growth and production. In addition, they perform various functions such as forming, building new tissues as well as participating in the physicochemical processes. Not only this, but they also have a rapid and tangible effect on the functions and growth of plants. As well as its important role in the synthesis of natural hormones within the plant.
The study aims at identifying the types of vitamins, the places in which they exist, their role and effects on growth and crops.

Key words: vitamins, plant, flower, growth, yield

الفيتامينات وآثرها في النبات

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الخلاصة:

تعد الفيتامينات من المواد الآمنة التي ليس لها ضرر على الانسان والحيوان وتستخدم من اجل تحسين نمو النبات وتكوين الازهار وهي عبارة عن مواد عضوية توجد بعدة صور وتعد من المكملات الغذائية الدقيقة والأساسية للنمو والانتاج السليم تقوم بوظائف مختلفة من خلال تكوين وبناء انسجة جديدة، وتشارك في العمليات الفسيوكيميائية وتكون ذات تأثير سريع وملموس لقيام النبات بوظائفه ونموه، فضلا عن اهميتها في تكوين الهرمونات الطبيعية داخل النبات. ونظراً لأهمية هذا الموضوع فقد هدفت هذه الدراسة إلى التعرف على انواع الفيتامينات واماكن تواجدها ودورها وآثرها في نمو وحاصل النبات.

الكلمات المفتاحية: الفيتامينات، النبات، الازهار، النمو، الحاصل.

INTRODUCTION

The term 'vitamins' is derived from the word *vitamin* which is coined by the Polish biochemist Casimir Funk in 1912 who isolated a group of micronutrients essential for life. The word *vita* means 'life', while the word *amine* refers to the compounds that contain Nitrogen. Later, it was discovered that not all vitamins contain Nitrogen, but the name has not changed due to its widespread use. Vitamins are organic substances that exist in many forms; they are essential and complementary to healthy growth that helps in building tissues. Therefore, they help the tissues to carry out their proper functions through their participation in the physiological reactions to the continuation of the various functions of the plant as well as the structure of new tissues.

Vitamins are vital organic compounds available in small quantities in order to maintain their normal state, and are essential to the proper plant growth and development. These compounds act as coenzyme regulators and are involved in increasing the utilization of metabolites (**Hassanein *et al.*, 2009**). Some vitamins can be considered as antioxidants as they are one of the new ways to help the plant withstand any environmental conditions and increase the plant growth and cell cycle. They can also protect the plant from any reactive oxygen seasoning (ROS) and increase the rubiscosubunit as well photosynthetic pigments. As a result, there can an increase in the content of chlorophyll, photosynthesis rate, and plant productivity (**Chen & Gallie, 2006**). It has been proved that spraying or applying vitamins on the plant from the outside is successful in mitigating the negative effects of the stresses which plants are exposed to (**Khan *et al.*, 2006**).

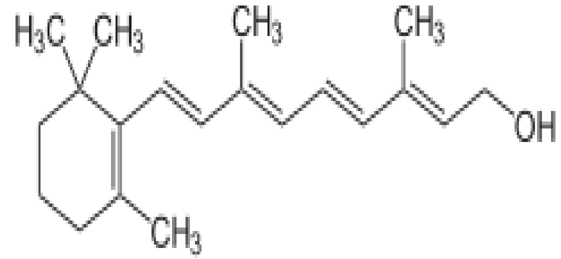
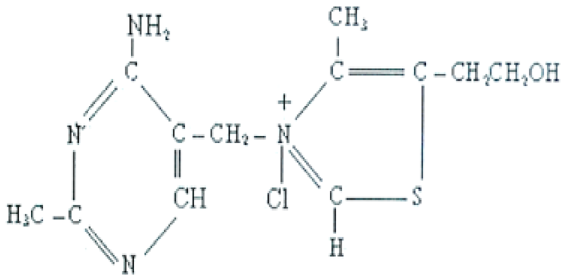
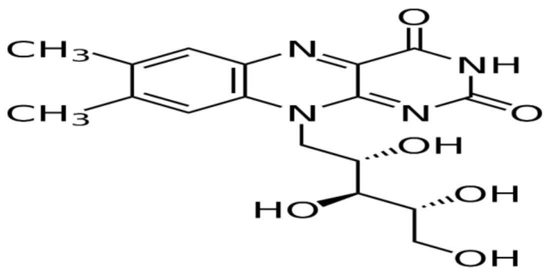
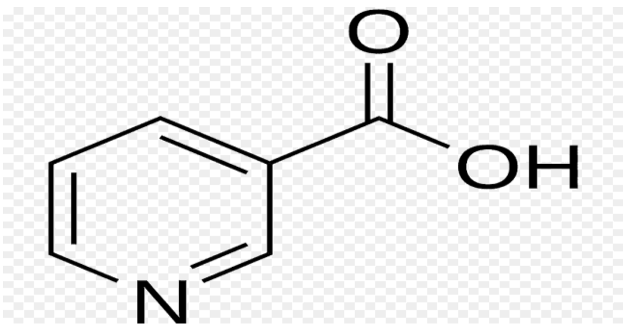
One of the approved strategies is the use of antioxidants to overcome the damage resulted from the interaction of active oxygen species (**Munir & Aftab, 2009**). This strategy is also useful for its ability to catch free radicals or active oxygen produced during the process of photosynthesis and respiration (**Foyer *et al.*, 991**).

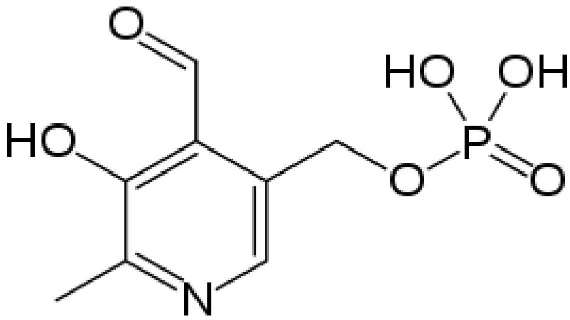
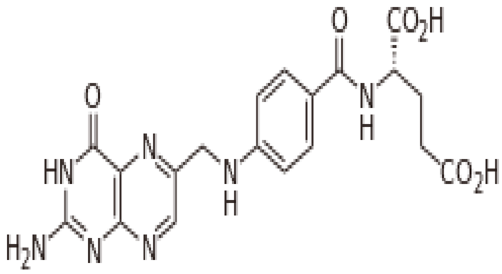
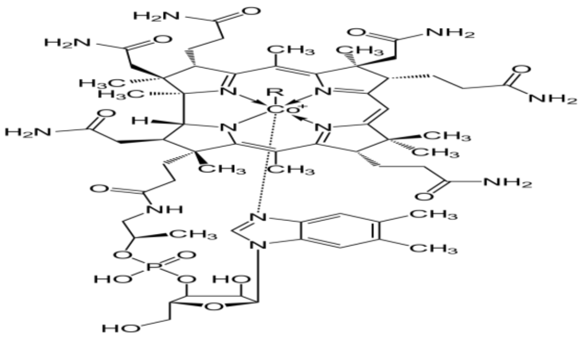
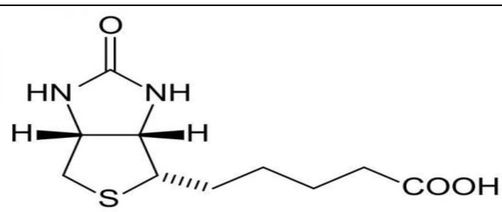
Therefore, the application of the use of vitamins externally gained great attention, as it works to resist the effects of salinity stress on the plant, improve growth, and increase yield, quantity and type (**El-Bassiouny *et al.*, 2005**).

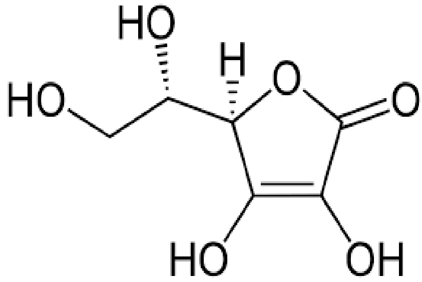
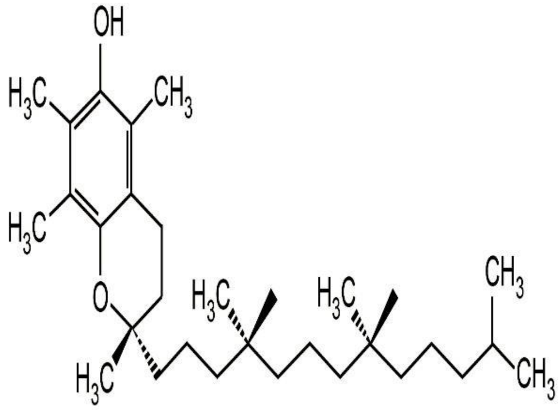
Tocopherols (Vitamin E) are powerful antioxidants involved in many physiological processes such as plant growth and development, aging, stress tolerance, prevention of lipid oxidation, and plant protection from rot (**Kumar *et al.*, 2012**). A vitamin can be considered as a group of molecules associated with nutrients that an organism needs in small quantities for proper metabolism. way. It is not possible to obtain the essential nutrients in the living organism through Biosynthesis. Even if this happens, it will not be in sufficient quantities. Thus, it must be obtained through nutrition. Some organisms can synthesize vitamin C, but many other species cannot. The term vitamin does not include the other three nutrient groups such as minerals, essential fatty acids or amino acids. Most vitamins are not single molecules; the groups of related molecules are called quasi Vitamins (Vitamir). The World Health Organization stated that there are thirteen vitaminsknown as vitamin A (retinol), vitamin A Vitamin B_1 (thiamine), vitamin B_2 (riboflavin), vitamin B_3 (niacin), vitamin B_5 (pantothenic acid), vitamin B_6 (pyridoxine), vitamin B_7 (biotin), vitamin B_9 (folic acid), vitamin B_{12} and vitamin C (ascorbic acid), vitamin D, vitamin H (biotin) and vitamin E (tocopherols and tocotrienols).

This study aims to shed light on the importance of vitamins in the formation of natural hormones within the plant as well as the roles they play within the plant. Some of these vitamins are of great effect according to the role they play inside the plant. The below table (1) illustrates this idea.

Table (1): Vitamins, their formula, chemical composition and the role of vitamins inside the plant.

No	Vitamin	Chemical formula	Chemical composition	The role of vitamins inside the plant
1	Retinol vitamin A	C21H18ON3SCl2		acts as a regulator of the growth and differentiation of cells and tissues
2	Thiamine vitamin B1	C21H18ON3SCl2		has a major role in stimulating growth and regulating the growth process within the planet
3	Riboflavin Vitamin B2	C17H20N4O6		is involved in photosynthesis and participates in the transfer of electrons (oxidation and reduction processes), the activation of photosynthesis and the formation of natural auxins that stimulate growth within the plant.
4	Nicotinic Acid Vitamin B3	$C_6H_5NO_2$		works as an enzymatic assistant in the transmission of hydrogen and tryptophan, which are considered the raw material for nicotinic and auxin acids. Therefore, this acid has a major role with the help of auxin acid in the formation of roots.

5	Pyridoxine, pyridoxal, and pyroxamine Complex Vitamin B6	$C_8H_{11}NO_3$		this acid is present in all parts of the plant (stem, leaves, roots and seeds) This indicates its importance within the plant. - it plays an important role in stimulating root growth - it acts as a catalyst for biochemical changes -it acts as ammonia and carbon dioxide removal reactions - it participates in the formation of amino acid tryptophan and thus affects the formation of auxin which has an important role in the growth of plants (vegetative, flowering and root) - it has an important role in the representation of carbohydrates and fats (**Al-Daoudi, 1990**)
6	Folic acid Vitamin B9	C6O7N19H19		-it is important in amino acid metabolism, regulates cell division and elongation, and is a coenzyme in many metabolic pathways as well as DNA formation and free radical scavenging (**Andrew *et al.*, 2000; Fardet *et al.*, 2008; Naheif & Mohamed, 2013**). -By stimulating the biosynthesis of clicin, which works on the synthesis of porphyrins and chlorophyll in chloroplasts.
7	Cobalamin Vitamin B12	$C_{63}H_{88}CoN_{14}O_{14}P$		-it acts as a cofactor for enzymes (coenzymes) or as natural compounds
8	Biotin Vitamin H	S3O2N16H10C		-it has a role in regulating the processes of construction and demolition within the plant "essential in the Krebs cycle"

9	Ascorbic Acid Vitamin C	C6O8H6		-it activates the processes of photosynthesis. -it is an important regulator of the oxidation and reduction states of protoplasm. - it affects the oxidation and activity of enzymes inside the plant. - It is involved in the transition of hydrogen from NADPH to oxygen "oxidation and elimination by botanicals."
10	Tocopherol Vitamin E	C2O50H29		-it is available in all parts of the plant, but its greatest presence is in the chloroplast membranes. - it is mainly concentrated in plastids and acts as an - amphiphilic lipid antioxidant. α-tocopherol plays a protective role to membrane system in the cell of higher - plants (**Fryer, 1992; Wang & Quinn, 2000**); -it assists in maintaining membrane stability (**Munné-Bosch & Falk, 2004**) and regulates the transport of electrons in the photosystem-II system (Munné-Bosch & Alegre, 2002).. - Tocopherols play a regulatory role in a range of different physiological phenomena including plant growth and development, senescence, preventing lipid peroxidation and interact with the signal cascade that convey abiotic and biotic signals (**Sattler *et al*., 2004; Baffel & Ibrahim, 2008; Soltani *et al*., 2012**). -vitamin E fulfills at least two different functions in chloroplasts at the two major sites of singlet oxygen production: it preserves PSII from photoinactivation and protects membrane lipids frophotooxidation (**Havaux *etal*., 2005**). α tocopherol levels change differentially in response environmental constraints, depending on the magnitude of the stress and the species' sensitivity to stress. -this vitamin is considered a natural antioxidant and a fat-soluble type -it consists of 8 units divided into two groups, the first group is distinguished by its saturated side chain, while the second group is distinguished by its unsaturated side chain. Each group includes alpha, beta, and sigma, both groups act as antioxidants by giving hydrogen to free radicals (**Smirnoff *et al*., 2005**)

Locations of vitamins in plants:

Thiamine (Vitamin B_1)

Thiamine is found in high concentrations in the active growth areas of the plant. There are indications that the formation of thiamine occurs in leaves that mostly depends on the presence of light. Thiamine is transmitted from the leaves to the roots in the bark. Therefore, its role lies in stimulating and regulating growth in plants.

Riboflavin (Vitamin B_2)

Riboflavin is generally found in plants in a bound form. Riboflavin is a part of the coenzymes flavin mononucleotide (FMN) and flavin adenine nucleotide (FAD), which are involved in biological oxidation. There is a belief that flavin mononucleotide (FMN) is involved in photosynthesis; therefore, its role lies in the activation of photosynthesis and the formation of auxins along with its participation in the transmission of electrons. Riboflavin is produced in quantities in all parts of the plant. As a result, the signs of its deficiency are invisible on the plant clearly. Yet, Riboflavin can be involved in the auxin loading mechanism.

Nicotinic acid (Niacn)

The biological importance of nicotinic acid is known when it exists generally in the form of NAD and NADP as an enzyme coenzyme in many processes of hydrogen transfer. Also, it has a role in the formation of roots and the simulation of their growth. Nicotinic acid is abundant in the plants. It is also available with riboflavin in unusually high concentrations in wheat grains. In fact, tryptophan has been suggested as a precursor to nicotinic acid and auxin. This notion has led to the study of the possibility of an interaction between auxin and nicotinic acid. It was found that nicotinic acid has an auxiliary effect with auxin in the formation of roots.

Pantothenic acid (Vitamin B_5)

Pantothenic acid is found in most parts of the plant; yet, the highest concentrations of this acid were found in the aliron layer of wheat grains. pantothenic acid rarely exists in a separate form; rather, is found in the form of coenzyme A. Coenzyme A is involved in the transition reactions from one part to another. As such, it is of great importance in the biological changes of carbohydrates and lipids. Therefore, this acid can be involved in the photosynthesis of plants.

Pyridoxine, pyridoxal, and pryidoxamine

(Vitamin B6 complex)

Vitamin B6 is present in all parts of the plant such as stems, leaves, roots, seeds and fruits. However, there are indications that most of the vitamin available in the roots is transferred from the leaves. Vitamin B6 is an indispensable factor to the growth in root cultures, it was noted that the deficiency in cell division in separated roots is an outcome of the lack of vitamin B6. The competition of dexosperdixin with perdixin causes a deficiency in the growth of tomato root culture that is ignored by increasing pyridoxine. This indicates its effective role in stimulating root growth.

The most important physiological role of vitamin B6 lies in its participation in pyridoxal phosphate as a coenzyme in biological amino changes. The reactions of the removal of ammonia and carbon dioxide are among the most important functions of this vitamin. It has been suggested that vitamin B6 may be involved in the formation of tryptophan and nicotinic acid.

Biotin (Vitamin H)

Biotin is found in all parts of higher plants. This vitamin is active in the vital changes of aspartic acid and carbon dioxide removal reactions of intermediate materials of the Krebs cycle, it has an important role in this cycle in terms of regulating the construction and demolition processes and the formation of oleic acid.

Ascorbic acid (Vitamin C)

Ascorbic acid is found in all parts of the plant. The highest concentrations are found in green leaves and in most fruits and vegetables, the most of it is found in the form of ascorbic acid, but there are small amounts found in an oxidized form. Ascorbic acid is rapidly oxidized to dehydroascorbic acid which in turn can be reduced again by copper-containing enzymes. There is an enzyme ascorbic acid oxidase in the plant- and, due to the enzyme ability to oxidize- its role lies in the fact that it is a cofactor in the phosphorous processes of photosynthesis as well as an important regulator in the oxidation and reduction states of the protoplasm. Also, it is an influencer in the state of oxidation and the activity of some enzymes important within the plant.

Types of vitamins

Vitamins can be divided into two types:

A. Group of fat-soluble vitamins (A, D, E, and K)

B.Group of water-soluble vitamins, including B and C

The effect of some vitamins on root growth and vegetative part of field crop plants:

The results of the study conducted by **Dawood *et al* (2014); Zeboon & Baqir (2023**) to evaluate the process of spraying or applying vitamin E with different concentrations ranging between (400, 800, 1000 and 1200 mg L^{-1}) indicated that there is an effect on growth and grain quality of two varieties of wheat (sids12 and sids13) for two seasons of cultivation. The process of spraying or applying vitamin E during the stages (120 DAS and 100 DAS) at a concentration of 1000 mg L^{-1} showed a significant increase in all growth traits as well as the proportion of carbohydrates in leaves and grains in addition to an increase in protein content especially in grains.

Results indicated (**Abdullatif *et al.*, 2016**) indicated that spraying vitamin E at a concentration of 100 mg L^{-1} led to the improvement of all the characteristics of vegetative, flowering and root growth of Eustoma plant of the Croma variety.

Sadak & Dawood (2014) indicated that the foliar application of α-tocopherol had a prospective effect in reducing the negative effect of salinity on flax plants. Ascorbic acid (C6 H8 O6) is found in all living organisms and plant cells, the greatest amounts of this acid exist in the leaves and flowers, especially in the parts that are actively growing (Smirnoff et al, 2001, Ebrahim, 2005).

Recently, at the level of international research, the use of vitamins including vitamin C, has increased in order to increase its resistance to various stresses. The plant naturally produces free radicals in the cell, and when exposed to these stresses, the free radicals are produced in large quantities that affect growth. Hence, the plant uses certain mechanisms to get rid of them. One of these mechanisms isthe use of enzymatic and non-enzymatic antioxidants (Ascorbic acid) which are the first lines of defense against these radicals. These antioxidants are of great importance in plant growth and development, their presence ensures the survival of cells in the best condition in addition to the role of vitamin C in many metabolic activities it performs, including regulating plant growth (although it does not apply to it the conditions for considering any substance as a growth regulator), especially improving the growth of reproduction (**Ali & Musallam, 2008; Barth *et al.*, 2006, Ahmed & Abdel, 2017; EL- Delfi & Safi, 2023**).

The results of the study conducted by (**Mohamed, 2013**) showed that the combined individual applications of vitamins like B_{12} at 50 ppm, C at 500 ppm and folic acid at 50 ppm stimulated plant height significantly compared to the treatment comparison.

The maximum effect is noticed when spraying wheat plants with vitamin C, folic acid and vitamin B_{12} in a double or triple manner compared the manner in which these vitamins are sprayed individually. One of the main roles played by these vitamins is the promotion of cell division as well as the biosynthesis of organic foods, natural hormones, and plant dyes, which was confirmed by (**Robinson, 1973; Ortli, 1987; Samiullah *et al.*, 1988; Tzeng & Devay, 1989**). The obtained results were identical to those made by (**Gamal & Reda, 2003; Alttallah *et al.*, 2004; Abd El-Baky, 2009; Al- Qubaie, 2012**)

(**Al-Janabi & Hammadi, 2016**) concluded that when spraying bean plants with three concentrations of vitamin B_6 which include (0, 100, and 200) mg L^{-1}, the plants treated with a concentration of 200 mg L^{-1}gave them the highest average weight of 100 seeds, the biological and seed yields reached 141.07g, 6.025mg ha^{-1}, and 10.613 mg ha^{-1} as compared to the treatment comparison which gave the lowest mean of 124.09 gm, 4.181 mg ha^{-1}, and 8.532 mg ha^{-1}, respectively.

The results of the study conducted by (**Al-Dulaimi *et al.*, 2017**) showed that when an experiment was made to activate sunflower seeds with four concentrations of vitamin B_6 (0, 2, 4, 6) mg L^{-1}, the concentration of 4 mg L^{-1} exceeded by giving the highest average of leaf area estimated at 4756 cm^2 and 3176 cm^2 for Spring and Autumn seasons according to treatment comparison that gave the lowest average which amounted to 4209 cm^2 and 2884 cm^2 for both seasons respectively.

The results of the study conducted by (**Al-Saadi, 2022**) indicated the superiority of vitamin B_6 when sprayed at a concentration of 200 mg L^{-1} over the mung bean plant in the characteristics of vegetative and flowering growth including the number of branches, leaves, leaf area and leaf chlorophyll content with an average of 13.87 plant $branches^{-1}$, 110.64 plant $branches^{-1}$, 1992.67 cm^2 of plant, and 1.98 mg g^{-1} of leaves fresh weight as compared to the treatment comparison giving the lowest $^{-1}$ mean of 10.35 plant $branches^{-1}$, 83.48 plant $leaves^{-1}$, 1760.83 cm^2 of $plants^{-1}$, and 1.27 mg g^{-1} of leaves fresh weight for the characteristics respectively. The results are consisting with (**Baqir & Zeboon, 2020; Mahmood &Al- Hassan, 2017a & Mahmood &Al- Hassan, 2023**).

Effect of some vitamins on quality and yield of field crop plants:

Ascorbic acid (vitamin C) is one of the main antioxidants in the plant to increase productivity. Also, alpha-tocopherol (vitamin E) is a major antioxidant that plays a role in plant protection in environmental stress conditions.

The results of the study carried out by (**Dawood *et al.*, 2014**) indicated that spraying vitamin C at a concentration of 1000 mg L^{-1} leads to a significant increase in grain production and its protein content.

(**El- Wadi *et al.*, 2016**) confirmed that when conducting an experiment to find out the effect of foliar spraying on maize with three concentrations of vitamin B_6 (50, 75 and 100) mg L^{-1} in addition to the treatment comparison (without spraying) proved that the concentration of 50 mg L^{-1} by giving the highest average of grain yield, the number of corncobs. Also, the total average of yield reached 14.4 gm of plant^{-1}, 23.6 corncob^{-1} and 6.3310 mg ha^{-1}, respectively, as compared to the treatment comparison which gave the lowest average of 2.3 gm of plant^{-1}, 23.6 corncobs^{-1}, and 308 mg ha^{-1} respectively.

The results of the study conducted by (**AL-Hilfy & Zeboon, 2016; AL-Hilfy & Zeboon, 2018**) showed that spraying the plant with vitamin C at a concentration of 4 gm L^{-1} had a significant effect on the yield of wheat grains and its components. This process gave the highest average of yield estimated 6,820 and 6,879 mg L^{-1} as compared to the no-spray treatment estimated 4,882 & 4,906 mg L^{-1}.

The results of the study performed by (**Al-Tamimi, 2017**) showed that the spaying of vitamin C on the mung bean plant at a concentration of 152 mg L^{-1} proved its effectiveness in the weight of one thousand seeds, the number of pods and the yield of one plant, the total average of yield estimated 51.05 gm, 21.96 pods^{-1}, 10.29 gm and 1.37 ton ha^{-1}.

(**Younis *et al.*, 2020**) showed that when conducting an experiment to find out the effect of foliar spraying on groundnut plants with three concentrations of B_6 (50, 100 and 150) mg L^{-1} in addition to the treatment comparison (without spraying) that plants treated with a concentration of 100 mg L^{-1} gave a high average number of pods and weight of 100 seeds, the total seed yield estimated 15.00 plant pods^{-1}, 87.38 g and 404.06 mg ha^{-1}.

(**Hantoush, 2021**) noticed that in his experiment to find out the effect of spraying vitamin B_6 on broad bean plants at different stages (vegetative growth stage, flowering stage, vegetative growth and flowering stage together, especially the vegetative growth and flowering stage that the plant gave the highest percentage of protein which amounted 21.90. % as compared with the treatment comparison that gave the lowest average of 20.04%. These results consist with (**Jaddoa *et al.*, 2017; Baqir & Al-Naqeeb,2019; SAFI *et al.*, 2022; Al-ziady & Hussain, 2023**).

The results of the study carried out by (**Al-Saadi, 2022**) showed that spraying vitamin B_6 at a concentration of 200 mg L^{-1} on the mung bean plant led to a significant increase in the number of flowers, the fertility rate and the number of pods. This led to- in the yield of mung been seeds- the total average of yield to reach 138.33 of plant flower^{-1}, 66.63%, 92.68 of plant pods^{-1}, 1.97 mg ha^{-1}and 10.26 mg ha^{-1}, respectively, as compared to the treatment comparison giving the lowest mean of 114.13 of plant flowers^{-1}, 52.37%, 61.57 pods, 1.77 mg ha^{-1} and 9.34 mg ha^{-1} for the characteristics sequentially.

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