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Immune Diagnosis Of Potyvirus Bea Common Mosaic Virus (Bcmv) And Its Biological Resistance With Spirolina Platensis And Some Medicinal Plants On Two Bean Cultivars Under Open Cultivation Conditions

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Abstract

This study was carried out in the laboratories of the College of Agriculture, Tikrit University and in the Al-Aswad area of Al-Khalis district / Diyala governorate, the spring loop of the bean plant for the season 2021, where it aimed to diagnose the local isolate of Potyvirus Bea common mosaic virus (BCMV) based on the symptoms it causes on bean plants in the field and those caused on indicator plants (Phaseolus vulgaris, Vigna unguiculata, Vicia faba, Pea (Pisum sativum), and groundnut (Arachis hypogaea) and Medicago sativa all responded to artificial inoculation with virus-infected bean leaf extract. Where the plants infected with BCMV virus showed mosaic symptoms between the veins of the leafs, leaf curling down, deformation and plant stunting. It also aimed to biologically control the virus with some organic food supplements and medicinal plants. The results of the examination with the BCMV Immuno strip showed a positive interaction with Flash Kits containing the anti-virus detection serum, the sedimentation line appeared clearly on the test strip, which indicates the presence of BCMV virus in the bean plants that were grown for the purpose of maintaining the isolation of the virus, and in the plants that detect it as well. It was noted that the treatment of Spirolina alga (S. platensis) was superior in reducing infection with the virus and for all traits compared to the treatment of turmeric, black seed, as it stimulated the self-resistance of plants against the virus through decreasing indicators of infection and severity and increasing growth and yield, especially in the local variety infected with BCMV virus, as it gave the lowest percentage and severity of the infection was 50.50 and 17.43%, respectively, in the field experiment.

Keywords: Potyvirus Bea common mosaic virus, Spirolina Platensis, medicinal plants

Introduction

The bean crop (Phaseolus vulgaris L) belongs to the legume family, which is one of the important and basic families in human nutrition and an important source of proteins, carbohydrates and plant minerals in the diet of humans and animals, in addition to its role in maintaining soil fertility and improving its characteristics through its symbiotic ability to fix nitrogen (Ambachew et al. 2015). Research indicates that the average productivity in developed countries 1944 kg/ha (Gupta et al., 2020), and in Iraq (68 kg / ha), there are many abiotic and biotic factors that have a negative impact on bean production and cause yield losses, the most important of which are Viral Diseases (Babovic,2003). There are many viruses that infect bean plants, but the most important economically are the potyviruses (Kumar et al., 1994). BCMV and BCMNV are among the most important and can cause severe damage to bean plants. The percentage of losses as a result of viral infection can reach 100%, with yield losses of about 35-98 % (Kiliç, 2020). Bean common mosaic virus Potyvirus belongs to the Potyvirida family (Feng et al., 2014). Viral particles are filamentous flexible, 750 nm long and 15 nm wide, containing ssRNA, (Mukouk et al. (2008). These viruses are transmitted in a non-permanent way by aphids and seeds, in addition to their mechanical transmission, which is why they are considered one of the most dangerous viruses in spreading and the possibility of them becoming epidemic (Hongying et al., 2002). Several methods were adopted to diagnose viruses, the first of which was the study of symptoms on detecting plants, and it is considered one of the basic methods in the diagnosis and detection of viruses and their strains (Ghalyal et al., 2006). Given the importance of this virus and the insufficiency of studies in the region to produce its antibody, to diagnose it immunologically, and its biological resistance, and the expectation of its spread at a high rate as a result of its multiple transmission methods, we decided to carry out this study according to the following aim: Immunological diagnosis of the virus present in the fields of Diyala Governorate. The response of some varieties to infection with the virus and its pathogenic effects on it.Biological virus resistance and evaluation of the efficiency of some natural factors in stimulating growth and increasing yield. These factors included S. Platensis cube powder, N. Sativa seed powder, and plant root powder C. Longa.

Materials and Methods

Samples collection

Samples of cowpea plants infected with BCMN virus were collected from different fields in Diyala governorate, including (Al-Khalis district and Bani Saad sub-district), it exhibited symptoms in the form of dark green and light mosaic, leaves coiled, distorted in shape and stunted plants, as indicated by the scientific references in this regard . It was initially diagnosed based on symptoms by Prof. Dr. Maadh Abdul Wahab Al-Fahd, in the Virology Laboratory / Tikrit University. The samples were preserved in plastic containers containing mixed soil with peat moss at a ratio of 1:1 and kept in the greenhouse in order to increase the isolation of the virus until the cultivation season for the field experiment.

Diagnosis of BCMV virus

Diagnosis using indicator plants

Followed the method of Qasim and Ali (2012) in preparing the viral vaccine and infection of the indicator plants (Table 1). The plants were monitored until symptoms of infection appeared for a period of 7-15 days from the date of artificial infection to ensure the presence of the virus.

Table 1: Indicator plants for BCMV

No.	Indicator host
1	Vigna unguiculata
2	Phaseolus vulgaris
3	Vicia faba
4	Pisum sativum
5	Arachis hypogaea
6	Medicago sativa

Immuno diagnosis of BCMV by immuno strip test assay

The test was carried out by immunostaining strips containing anti-BCMV serum and prepared in the form of (Flash Kits) obtained from the American company Biofords Agdia, according to the program developed by the company that provided the diagnostic kit.

Preparing the agricultural land

The experiment was carried out during the spring agricultural season 2021 in one of the agricultural fields in the village of Al-Aswad /Al-Khalis district in Diyala Governorate. The experimental land was prepared in terms of agricultural operations (plowing, sterilization of the land with solar pasteurization, smoothing, leveling). Uncultivated land was used for a period of one year. The experiment was conducted by randomized complete block design, as the experiment was divided into six blocks, three blocks for each cultivar, the distance between one block and another is 1 m. Each block contains five experimental units, they were treated with nutritional supplements and medicinal plants, and two treatments were taken as controls, one of which was protected by a boring cloth and free from infection with the virus (without treatment), while the second control treatment was infected with the virus as well without treatment. The length of the experimental unit was 4 m and its width was 70 cm. It was equipped with a drip irrigation system. The seeds were sown on February 15, 2021, as each variety was planted in 3 blocks. The distance between one plant and another is 45 cm. The soil was irrigated according to the needs of the plant. The weeds were manually controlled as soon as it appeared in the field.

Cultivars that were used in planting

Bean cultivars, both the local variety and the Contender variety, produced by the Spanish company BATLLE, were obtained from the local markets for the sale of agricultural supplies.

Treatments used to induce virus resistance

The experiment included five treatments on two cultivars of bean plants

1) Treatment with Spirolina platensis, symbolized by (S.p)
2) Treatment with the black seed Nigella sativa, symbolized by (N.S).
3) Treatment with turmeric (Curcuma longa), symbolized by (C.l)
4) Control (1) treatment infected.
5) Control (2) treatment not infected.

3-3. Preparing treatments used in the experiment

The food supplement represented by spirolina, S. platensis, was obtained from the Malaysian company DXN, which specializes in the production of organic food supplements, the marketed company is Raed Al-Khair Company in the form of cubes and they were later ground. N. Sativa and C. Longa are in powder form and were purchased from the local markets.

3-4. Treatment with the materials used in the experiment Plants were treated immediately after seedling emergence by spraying on the foliage and watering around the base of the plants at the same time at a rate of gm / liter of water. plant^{-1}. The second treatment was after the first symptoms appeared on the plants, and the third treatment was done when the plant reached the flowering stage, in the same amount as above. This method was applied to each of the treatments (C.L, N.S, P.S).

3-5. incidents of viral infection in the field

After the emergence of seedlings in the field, pots containing plants inoculated with the virus were brought and placed in the field with 3 pots per block. The plants were left for natural infection in the presence of the biological vector of the virus (Aphis fabae). The symptoms were monitored and the first symptoms of infection

0

1

2

were recorded 7 days after placing the potted plants with virus. The infection was diagnosed according to phenotypic symptoms and immune tapes, and after the symptoms appeared, the vector insect was controlled with Operon (24%) SC according to the instructions for use found on the pesticide box produced by May Trade.

3-6. Studied traits

3-6-1: Criteria of injury

Criteria of injury was adopted in calculating the rate and severity of infection with the virus according to the following equations:

$$\text{Infection rate}\,(\%) = \frac{\text{No. of i infected plants}}{\text{Total no. of plants}} \text{x}100$$

$$\text{Severity of infection}\,(\%) = \frac{\text{N plants of class 0x0} + ... + \text{N plants of class 5x5}}{\text{Total N plants examined x 6 top class}} \text{x}100 \quad \text{(Mckinney,1923)}$$

healthy plant
(no visible disease symptoms)

light yellow

Increased yellowing from the edges of the leaf towards the center of the leaf blade

3

Yellowing, mottled, and the beginning of leaf curling

4

Increased mottled and the appearance of banded veins of the leaf blade

5

Increasing the reduction of the leaf area and the appearance of distortions

Figure 1. Pathological index for the severity of BCMV infection

3-6-2 Measuring some growth indicators and yield

The relative content of total chlorophyll in the leaves was measured by means of a chlorophyll meter type SPAD and leaf area according to the method described by . The method (Mohammed and Al Fahad, 2018) was adopted in calculating the percentage of chlorophyll, leaf area and dry weight of the vegetative and root system. adopted in measuring the height of the plant. The flowering readings were taken in the first stages of flowering of the plant to the beginning of the fruit set, and the flowers in each plant were calculated periodically, then the average was taken for one replication, and the number of pods was estimated by harvesting each treatment for one replicate periodically.

3-7 Statistical analysis

The data of the experiment were analyzed using a randomized complete block design (R.C.B.D) and the results were tested according to Duncan's Multiple Range Test at a probability level of 5%.

Results and Discussion

First: Isolation and identification of BCMV virus on bean plants

1.The apparent symptoms of BCMV virus on cultivars

The cultivars of bean plants to which the BCMV virus was mechanically transmitted showed symptoms of external infection on the fresh leaves one week after inoculation (Figure 2), where the leaves became pale color, followed by light and dark green mottles gradually on the surfaces of the leaves, and some branches or parts of them appeared symptoms of chlorophyll deficiency (yellow). As the disease progressed, parts of the leaves became raised, wrinkled, or deformed. As the stages of the disease progressed, the leaves began to wrap downward or wrap around themselves, and plants that were infected in the early growth stages are severely stunted

Most of the area of the leaf is mottled | Crinkle and roll the leaves down | Green and yellow areas of the leaf | Sever yellowing of the leaf

Figure 2. External pathological symptoms of BCMV virus on bean plants of local variety and cultivar Contender

2. Diagnosis of BCMV virus by different indicator plants

The results of the experiment indicated that the BCMV virus can be easily transferred to other related leguminous plants through mechanical inoculation. Symptoms and incubation period differ according to the type of host and the degree of its response and sensitivity to infection (Table 2). where the follow-up of pathological symptoms indicated that they appeared after 7–21 days from the date of artificial infection with the virus as seen in Figure (3).

A- On cowpea plant V. unguiculata (Figure 3-A) On cowpea plants cultivar Riyadh cowpea and local variety 7 days after mechanical inoculation, mosaic symptoms followed by an increase in yellowing from the edges of the leaf towards the center of the leaf blade.

B- On the bean plant Phaseolus vulgaris (Figure 3-B). The infection resulted in three bean cultivars (Local, BATLLE and Top Harvest) after 7 days of infection, light yellow symptoms followed by an increase in yellowing, mottled, wrinkled leaves, firmness in the veins of the leaf blade, reduction of leaf area and appearance of distortions.

C- On the bean plant Vicia faba(Figure 3-C), the symptoms appeared after 14 days in the form of yellowing, mottled, and turning of the leaves downward

D- On pea plant Pisum sativum (Figure 3-D), pea plants responded to mechanical infection with the appearance of mild yellowing symptoms with mottled, followed by a wavy wrinkle that includes all the leaf blade and not its edges only after 14 days of pollination

E- On the groundnut plant Arachis hypogaea (Figure 3-E), the groundnut plants of the local variety responded to mechanical infection with the appearance of symptoms after 21 days in the form of yellowing and light mottled,

F- On alfalfa Medicago sativa (Figure 3-F), alfalfa plants of the local variety responded to mechanical infection with the appearance of symptoms after 21 days with the appearance of mild yellowing and wrinkling of leaves,

Table 2. Responses of the indicator plants to artificial infection with the common mosaic virus on BCMV beans.

+ means the appearance of pathological symptoms of the virus

No.	Indicator host	Response
A	Vigna unguiculata	+
B	Phaseolus vulgaris	+
C	Vicia faba	+
D	Pisum sativum	+
E	Arachis hypogaea	+
F	Medicago sativa	+

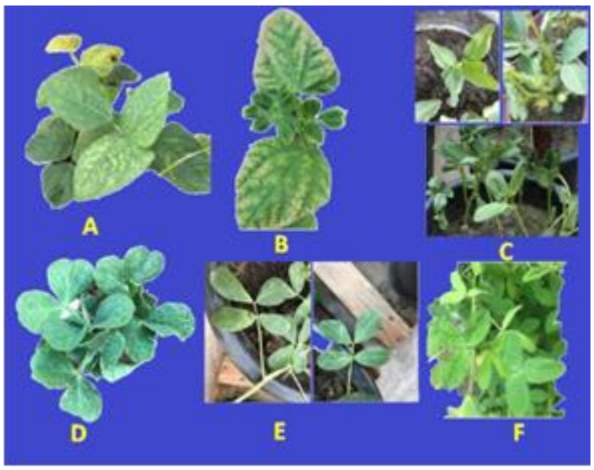


Figure 3. Symptoms of infection with BCMV virus on indicator hosts

3.Diagnostic results of BCMV virus on bean plants using the Immunostrip test

The results of the examination with Immunostrip (Figure 4) for BCMV virus showed a positive test, which indicates the presence of BCMV virus in the bean plant that showed symptoms of yellowing, mottled, stunted and deformed. The extracts extracted from the leaves of these plants gave a positive reaction with Flash Kits containing the anti-BCMV antiserum. Where the sedimentation line appeared in brown color, according to what the company producing the serum said.

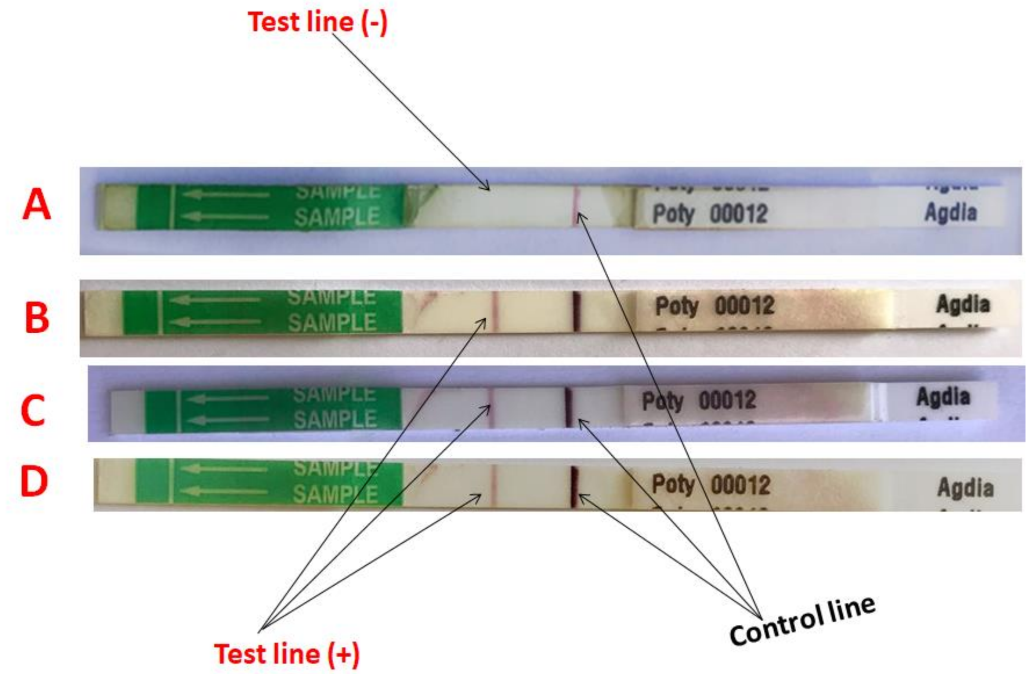


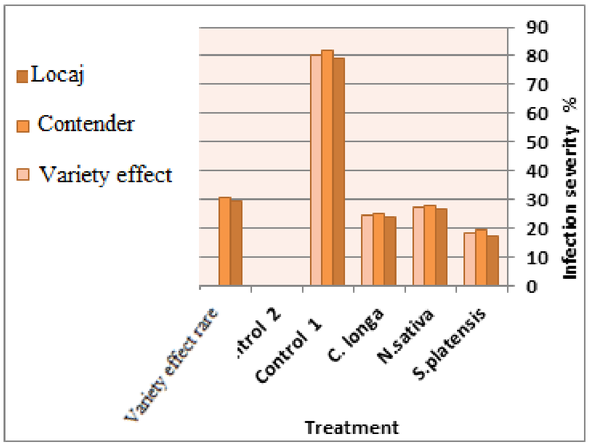
Figure 4. The results of the interaction between plant extracts infected with BCMV virus and its antiviral serum. (A) Interaction with healthy (protected) plant extract. (B) Interaction with infected leaf extract (virus isolate). (C) Interaction with infected leaf extract (field experiment). (D) Interaction with infected leaf extract (indicator plants).

From the study of symptoms on host plants and indicator plants, in addition to the results of serological tests, it can be concluded that the virus under study is Potyvirus Bean Common Mosaic Virus (BCMV).

Second: The effect of the used treatments and cultivars and their interaction on the percentage and severity of infection, percentage of chlorophyll and leaf area of two cultivars of bean infected with BCMV under open cultivation conditions.

It is clear from Figures (5,6,7,8) that all treatments reduced the percentage of infection and the severity of BCMV infection and increased the amount of chlorophyll and leaf area of bean plants compared to the control treatment (Control 1 infected). The treatment of S. platensis was superior and gave the lowest infection rate, 53.09%, and the lowest infection severity, with an average of 18.51%. It also gave the highest percentage in the amount of chlorophyll and leaf area, which amounted to 46.33 spad and 499.88 cm^2 respectively compared to Control 1 (infected) which gave 100%, 80.52%, 27.85 Spad and 212.36 cm^2, respectively. As for the varieties, the local variety gave the lowest infection rate in all treatments, where the percentage of infection for the local variety was 53.64%, and it gave the lowest percentage in the severity of infection, reaching 29.39%, and it gave the highest percentage in the amount of chlorophyll spad 42.06 and an increase in the leaf area 478.52 cm^2. The superiority of the local variety may be due to its possession of genetic resistance factors specific to the variety in showing resistance in bearing viral infection, or it may be due to the production of inhibitory or low substances for the replication of the virus as a result of stimulating resistance genes when infected with the virus or as a result of the use of treatments, which led to the raising of some enzymes related to growth and reduction of infection. This conclusion confirmed by an increase in the percentage of chlorophyll, leaf area, plant height, and an increase in the dry weight of the root and vegetative system, and thus the growth rate of plant cells is faster than the rate of virus multiplication inside the cell. In addition, the resistance of plants increases as they age, and they are not infected at the beginning of the growth stages in large proportions. The resistance of cultivars to viral infection is due to the genetic status, which is due to determine the physiological and phenotypic traits and the self-resistance of the cultivar against infection with the virus, whenever these genes excel in giving the relative upper limit of the resistance traits, it is reflected in reducing or preventing the presence of a sufficient number of virus particles needed to cause or develop infection and the emergence of symptoms. The algae S. platensis had a clear effect in inhibiting the virus and reducing the infection rate for all cultivars. The superiority of S. platensis may be due to the fact that it contains a variety of active substances and bioactive compounds in the biological system, as well as its various morphological, physiological and genetic characteristics which enables it to resist plant pathogens such as viruses, fungi and bacteria. Its main advantage is that it is rich in proteins, vitamins, minerals and other compounds, such as fatty acids, polyphenols, sugars and pigments, such as carotenoids and chlorophyll, which stimulate plants to resist pathogens through various mechanisms. It is believed that, in addition to its antiviral effect, it also has a nutritional effect, so it was reflected in an increase in growth and yield indicators. Spirolina contributes to increasing the synthesis of chlorophyll and compensating for the imbalance in nitrogenous bases as a result of viral infection by containing the growth regulator cytokinins, The superiority of the mentioned treatment is due to the fact that it contains many antiviral compounds, the most important of which are polysaccharides, which have an antiviral role inside and outside living tissues, and cyclic peptides and alkaloids. A mechanical explanation for the effect of the algae may be due to the fact that it contains growth stimulants and free amino acids that improve the efficiency of the metabolism process inside the leaf by increasing the efficiency of the photosynthesis process and stimulating root growth as well as playing a similar role to natural growth hormones and improving the formation of lignin in plants and this increases their tolerance for viral infection. In addition, high molecular weight compounds of proteins act in the early stages of infection either by preventing the virus from penetrating the host cell, competing for the site of virus receptors on the leaf surface, or by altering the physiology of the host cells so that they no longer receive the virus. The low molecular weight compounds act in the late stages of the infection process, as they are able to enter the leaf and may reach sites where the virus replicates in the cell . The reduction in the average leaf area may be due to the fact that the virus changed the nature of the structure of the middle layer, which contains the osteoblasts and cork cells in the phloem tissue (Al Fahad, 1999). As well as the reason for the deposition of some callus cells in the plasmodesmata, and this in turn leads to obstructing the transfer of nutrients from one cell to another, in addition to the presence of the virus in these vital passages between cells .shortage of nutrients and a weakness in the growth of plant cells in general,. In addition, the virus works to increase cell respiration by accumulating carbohydrates and sugars in the cells of the leaves, so these cells die gradually, and the severity of the infection increases with time, so the plant that is at an early stage of its life is more likely to die, this is enhanced by the effect of high heat, which increases respiration and evaporation of water from leaf cells, thus making infected cells more likely to die completely. In addition, the spirolina algae contain phosphorous, which contributes to increasing the vegetative system and leaf area, and this is reflected in the ability of the plant to absorb nutrients, and thus increase the outputs of the photosynthesis process for the manufacture of food,. The chemical composition of algae indicates that it contains macro and micro nutrients, and the balance between them in plants improves the growth of the root and vegetative groups, and this is in line with what was mentioned by Kazim (2012). A number of researchers indicated that the action of algae in plants is similar to the mechanism of the effect of growth regulators because they contain auxins and gibberellins, which increase the absorption of nutrients and the division and elongation of cells, which means an increase in the leaf area in addition to the activation of enzymes, and this is consistent with his findings of Mohammed and Al Fahad (2019), and Jensen (2004).

Third: The effect of the used treatments and cultivars and their



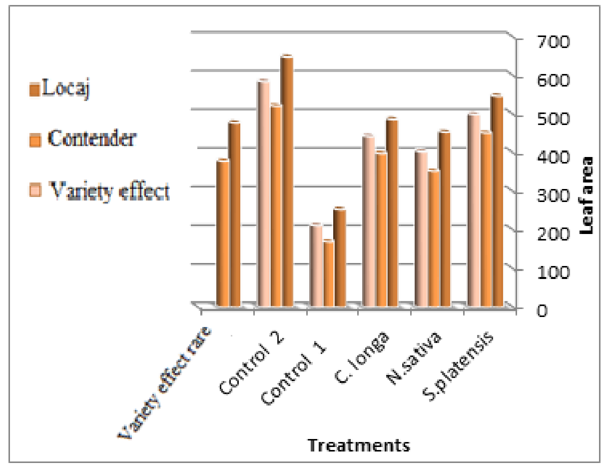
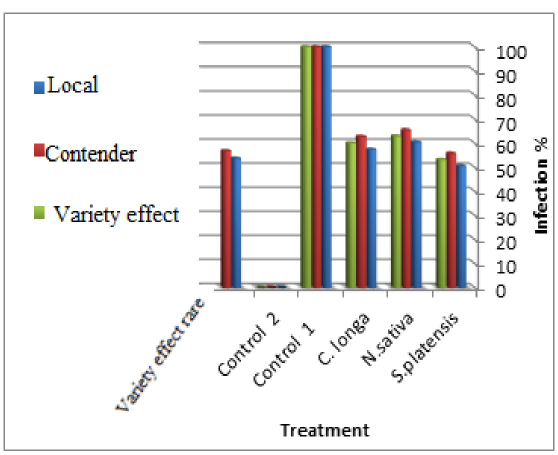


Figure 5. Effect of the treatments used and cultivars and their interaction on the percentage of infection of two bean cultivars infected with BCMV.

Figure 6. Effect of the treatments used and cultivars and their interaction on the percentage of infection severity of two bean cultivars infected with BCMV.



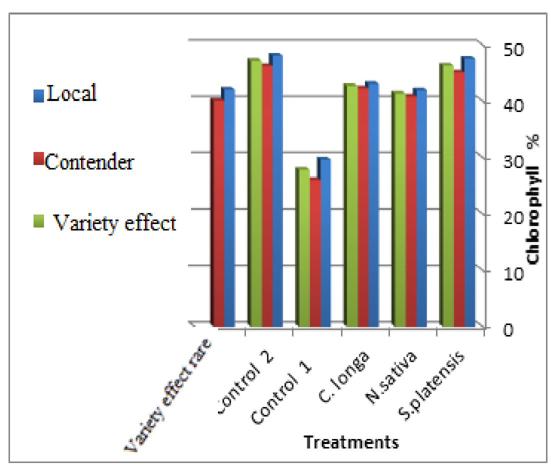
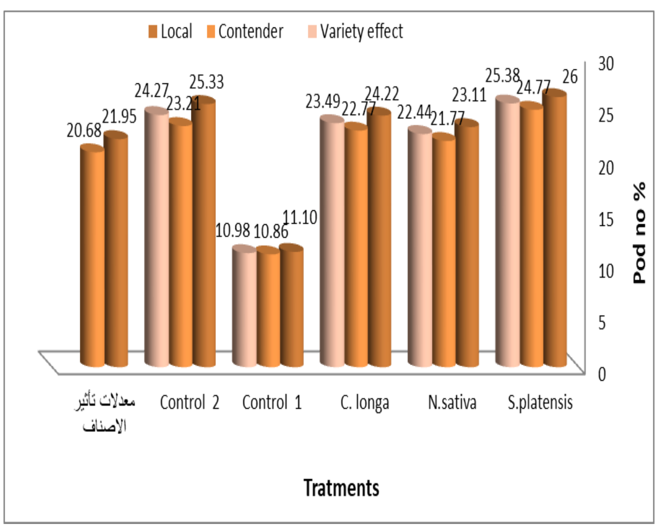


Figure 7. Effect of the treatments used and cultivars and their interaction on the chlorophyll ratio of two cultivars of bean

Figure 8. Effect of the used treatments and cultivars and their interaction on the leaf area of two bean cultivars infected with BCMV.

interaction on the number of flowers, pods and dry weight of the shoot and root system of two cultivars of bean infected with BCMV under open cultivation conditions.

The results in Figures (9, 10, 11, 12) indicate that all treatments achieved a significant increase in the number of flowers, pods, the dry weight of the vegetative and root system compared to the control treatment (Control 1 infected). The S. platensis treatment in all the studied traits outperformed the rest of the treatments in which the number of flowers and pods and the dry weight of the shoot and root system reached 25.94, 25.38, 53.51 and 3.12, respectively compared to Control 1 (infected) which gave 11.55, 10.98, 28.65 and 1.46. respectively. As for the cultivars, the local variety gave the highest percentage in the number of flowers and pods and the dry weight of the vegetative and root system, as it reached 22.46, 21.95, 47.79 and 2.94, respectively. It is evident from the results obtained in the growth criteria and the increase in yield. The effect of algae in increasing the flowering rate of BCMV-infected beans may be due to the chemical composition of S. platensis, which contains many vitamins, macro and micro nutrients and growth regulators such as auxins, cytokines, polysaccharides and polyproteins important in securing a basic base for stimulating flowering and fruit permanence after setting. This also supported the balanced increase in vegetative growth, which is reflected in the high rates of absorption of nutrients, water and solar energy needed to create compounds for flowering and fruit set, . It is known that growth regulators have a role in increasing most of the vegetative characteristics, including flowering and fruit set, as well as reducing the pathological damage of the virus and compensating for the deficiency that occurred as a result of infection, especially with regard to the compensated cytokinins as a primary similar structure to the nitrogen bases in nucleic acid of plant cells that the virus exploited for its benefit, cytokinins have a direct effect to prevent the replication of the virus through many mechanisms, including the creation of compounds that are effective against the virus, especially if they are similar in chemical composition with the composition of some nitrogenous bases in the nucleic acid of the virus, or it works to inhibit the genes responsible for the production of proteins that are directly related to the inhibition of the virus and the induction of resistance, which leads to a reduction in the symptoms of infection and an increase in the percentage of fruit set and plant productivity, and this is also consistent with what Youssef (2018) found. It has been proven that infection with BCMV virus has an effect on the quantity of yield by reducing the flowering rate of plants or sterility of flowers and leaf distortions and reducing in the percentage of chlorophyll, and this results in a reduction in the number of pods and this is indicated by previous research (El-Bramawy et al.، 2012), it is not excluded that the genetic composition of the varieties has an effect on the response to infection and its reflection in reducing the yield as a result of poor growth and a reduction in the amount of chlorophyll and leaf area, and this approaches what Al Fahad (2020) indicated. The reason for the superiority of spirolina algae in increasing the number of pods may be attributed to the fact that it contains specialized effective compounds, including polysaccharides and peptides, which contribute to increasing the yield, and this is consistent with what was mentioned by Al-Samarrai et al. (2012), the addition of extracts consisting of marine algae and the foliar spray process led to an increase in vegetative growth and production due to the availability of essential nutrients that the root is unable to provide and that the algae works to increase the root system and vegetative growth by increasing the leaf area because it contains the above compounds, this is reflected in the high rate of absorption of nutrients, which in turn is reflected in the increase in the number of fruits set, the number of fruits and the weight of the yield. The reason for the superiority of spirolina is that algae increases the intensity of vegetative growth, because it contains growth regulators such as cytokines, which can stimulate the growth and resistance of the plant, so that the rate of absorption of nutrients is high, and this is reflected in the increase in dry weight of the root and vegetative systems,. In addition to the chemical composition of S. platensis, it contains micro and macro nutrients, and in balancing them in the plant leads to an improvement in the root and vegetative systems, and this is close to what Kazim (2012) pointed out. In addition to spraying algae on plants led to an increase in the dry weight of the plant, which was confirmed by or the reason may be due to the fact that S. platensis contains nitrogen that enters the composition of nucleic acids, RNA, DNA and amino acids, and previous studies reported that it contained more than 50% of organic protein which is important in the process of photosynthesis, and thus leads to an increase in the vegetative system and the accumulation of dry matter in it, It also enters into the composition of the chlorophyll molecule, thus increasing the ability of the plant to carry out the process of photosynthesis, and thus led to an increase in the dry weight of the vegetative system, and this is consistent with what Muhammad and Al Fahad (2018) mentioned. It was found that soaking eggplant seeds in a suspension of spirolina with the powdered leaves of the affected plant for 24 hours before planting them led to an increase in the dry weight of the plant. Algae play an important role in the production of compounds that have a major role in the induction and formation of large transverse roots such as auxins and gibberellins, which lead to an increase in the root system, and the increasing the concentration of these hormones is positively reflected on the increase in vegetative growth, which in turn leads to an increase in cell division and root growth, which is positively reflected in an increase in the ability of plants to absorb mineral elements. Thus, it increases the outcomes of the photosynthesis process, as well as because it contains most of the nutrients that help in increasing growth and thus increasing the dry weight of the root system, These results are confirming by what we obtained in previous experiments, which contributed to the increase in leaf area and height, and this is reflected in the increase in dry weights of the root and vegetative system.



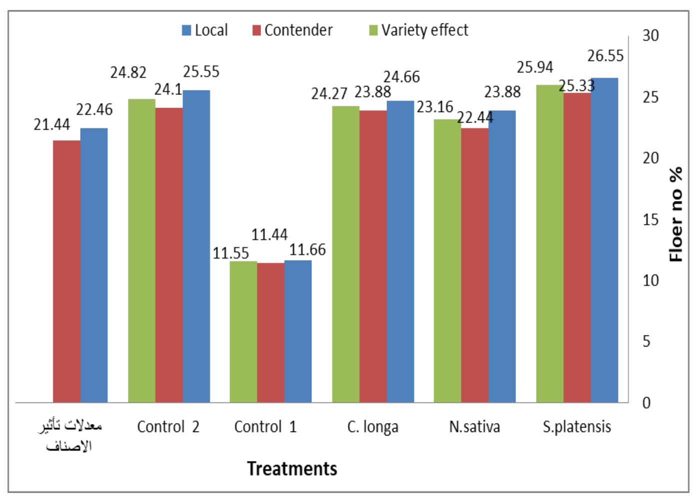
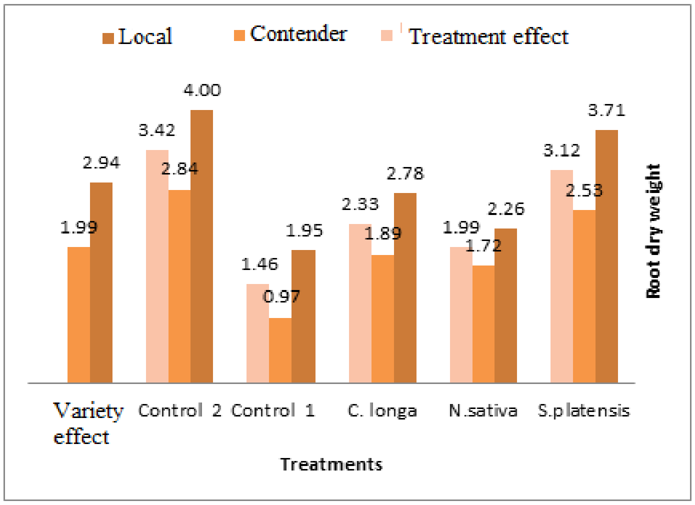


Figure 9. Effect of the used treatments and cultivars and their interaction on the percentage of flowers of two bean cultivars infected with BCMV.

Figure 10. Effect of the treatments used and cultivars and their interaction on the percentage of pods of two bean cultivars infected with BCMV.



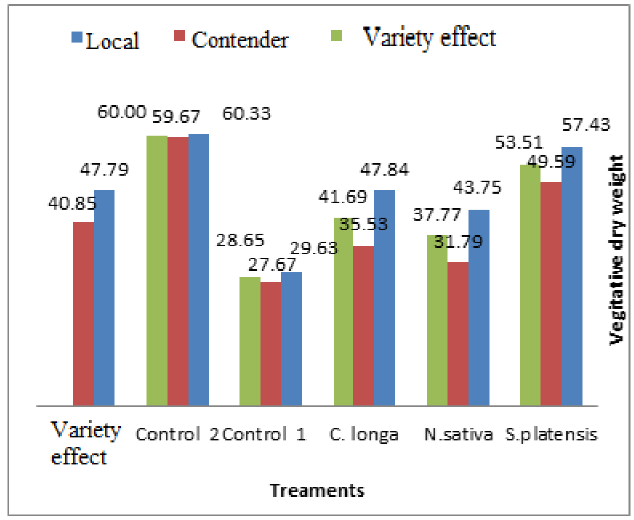


Figure 11. Effect of the used treatments and cultivars and their interaction on the dry weight of the vegetative system of two infested bean cultivars.

Figure 12. Effect of the used treatments and cultivars and their interaction on the dry weight of the root system of two infested bean cultivars

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