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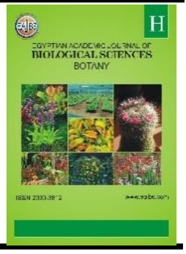

Effect of Using The Entomopathogenic/Endophytic Fungus, *Beauvaria bassiana* on Quality of Sweet Potato Crop and Associated Insects Under Sohag Governorate Conditions

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ABSTRACT

This work was conducted during two successive seasons (2018 and 2019) at the experimental research station, Shandweel, Sohag, Egypt to study the effectiveness addition methods of the fungus, *Beauvariabassiana* on growth, yield quality and some of the chemical constituents, moreover, associated insects and their damages to vegetative and storage roots growth were calculated of sweet potato plants growing under Sohag governorate conditions. The obtained results indicated that the different addition treatments of *B. bassiana* wereshowed an increase in growth traits when the plants were sprying twice by *B. bassiana* given the highest values of plant length, fresh weight compared with other treatments studied in both seasons. The gained results of yield and its contents included that addition of *B.bassiana*in soil twice gave the best values of total yield, marketable yield, theaverage weight of storage roots as well as highest dry matter percentage of storage roots compared with other treatments, at the same time the control treatment showed the lowest of values of all studied traits in both seasons. Soil application of *B. bassiana* twice was affected significantly on chemical constituents of sweet potato storage roots (nitrogen%, phosphorus%, potassium%, Protein% and starch%) except potassium% and starch in the first season. Twice foliar application of fungus was the most effective application on leave defoliators and recorded the lowest number of whiteflies.

INTRODUCTION

Sweet potato, *Ipomoea batatas*L.of family, convolvulaceae is one of the most broadly disbursed root crops in the most growing world. In Egypt, sweet potato is considered a famous vegetable crop, it has been normally cultivated for both consuming and starch manufactures, even as the foliage parts and different refuse roots are utilized to feeding animals (El-Seifi *et al.*, 2014). This crop conceded a rich source of vitamin a&c, carbohydrates, antioxidants, minerals, fiber and protein (woolfe, 1992).

Beauveria bassiana (Baisamo) Vuillemin is a soil saprophyte, entomopathogen and plant endophyte (Roy *et al.*, 2006 and Ownley *et al.*, 2008) The use of endophytic fungi as bio-control agents has been widely studied in recent years (Vega *et al*. 2008 and Biswas *et al*., 2012). Most bio-control measures of these fungi are based on an exogenous application which is very costly as the presence of unsuitable conditions may kill most of the conidia

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resulting in multiple applications. With an endophytic establishment, the beneficial fungi can be present continuously in the host plant which is more economic and ecologically friendly. *B. bassiana* is an important environmentally friendly bio-control agent and its potential to colonize the plants has been widely recognized. In the past decades, many microorganisms have been isolated and investigated for use as a biocontrol agent. Now, many promising strains are available for release into the environment and especially with the renewed interest in biocontrol await further exploitation for large-scale application in agriculture (Glare *et al.*, 2012). Parsa *et al*. (2013)*B.bassiana* is a fungal entomopathogen with the ability to colonize plants endophytically. As an endophyte, *B. bassiana* may play a role in protecting plants from herbivory and disease.

Saad and Fathi (2004) Surveys conducted over two successive seasons showed that 20 insect species belonging to orders viz, Homoptera, Lepidoptera, Hemiptera, Orthoptera, Thysanoptera, and Coleoptera attack sweet potato. The homopterans were the dominant insects. The total of beneficial insects associated were thirteen species belonging to six orders viz., Coleoptera, Odonata, Hemiptera, Diptera, Dermaptera, Nuroptera. The early planting date harbored the lowest number of insect species, while the late planting increased the population. The variety NcSu925 (Kafr EI-Zyat) was the most resistant to all groups of insects studied. The aim of this study was to investigate the effect of *Bbassiana* fungi application on growth, yield and associated insects of sweet potato under Sohaggovernorate conditions.

MATERIALS AND METHODS

This work was carried out at the experimental farm of Shandweel Agricultural Research Station, Sohag Governorate during the two successive summer season, 2018 and 2019 to study the effect of using the entomopathogenic/endophytic fungus, *Beauvaria bassiana* on the quality of sweet potato crop and associated insects. The initial preparation of the experimental soil is presented in Table (1).

Table 1: Physical and chemical properties of the soil of the experimental site

Sand%	Silt%	Clay%	Texture	Total N%	P (ppm)	K (mg/100g)	Organic minor %	PH (1:1)
22.5	34.5	43	clay	0.26	9.14	30.14	0.78	7.7

The experiment was included 6 treatments (including control treatment) sorted in Randomized Complete Blocks Design with three replicates. Each experimental plot was14 m^2 consists of five ridges each ride having 70 cm width and 4 m in length at 30 cm apart. Transplants were transported on the18th and 20th in April seasons 2018 and 2019, respectively.

The fungus, *B. bassiana* was maintained on PDA, (potato dextrose agar) medium, which PDA containing 200 g/L of potato extract, 20 g/L of glucose, and 20 g/L of agar at pH 7.0 (Yong Jia*et al*., 2013). The culture medium was inoculated with agar containing fungal discs and incubated at 28 ± 2 ºC under constant shaking conditions (100 rpm) in dark for 14 days. Fungal conidia were harvested from 3-week-old PDA cultures. The conidial suspension was prepared in sterile 0.1% Tween 20 solution and the conidia concentration was adjusted to 1×10^8 conidia ml^{-1}.

Six treatments of fungus application were used as follow:

1- Control (zero fungus application)
2- Foliar application at 6th and 10th Jul 2018 and 2019 seasons respectively.
3- Foliar application at 5th and 27th Jul 2018 and at 7thand 31stJul 2019.
4- Soil addition at 5th and 7th Jul, 2018 and 2019 seasons respectively.

5- Soil addition at 5th and 27th Jul 2018 and at 7th and 31st Jul 2019.

6- Foliar application at 5thand 7th Jul 2018 and 2019 seasons respectively and soil addition at 27th and 31stJul 2018 and 2019 seasons respectively.

All experimental plots were fertilized with 40Kg/fed. (Ammonium nitrate 33.5) with 40Kg of P_2O_5 fed.(Superphosphate 15.5%) and 72Kg K_2O/fed. (Potassium sulfate 48% K_2O) were added on two equal parts at three and seven weeks after transplanting. The normal cultural practices have been done as usual for the sweet potato crop.

Recorded Data:

During the two experimental seasons the following data were recorded as follow:

Vegetative Character:

A month before harvest, five plants were randomly taken from each replicate to determine, the main stem length (cm), the number for branches/plant and weight of vines/plants (Kg), and dry matter (D.M) of vines%.

Yield and Quality:

Sweet potatoes were harvest on the15th and 19th in September 2018-2019 seasons, respectively, total yield per plot was recorded and converted to total yield/fed. (ton), marketable yield (ton), number of storage roots/plant) weight of root (g), rootlength (cm), root diameter(cm)and percentage of dry matter (D.M) in storage roots.

Storage Roots Chemical Constituents:

Randomly samples of 5 cured storage roots of sweet potato were taken to determine Nitrogen%, Phosphorus% and Potassium%according to methods described by Kock and McMeekin (1924), Murphy and Rily (1962) and Brown and Lilleland (1946), respectively. Starch content (%) in storage roots was determined using A.O.A.C. (1970).

Insect Examination:

1- The population of aphid and weight fly were calculated fortnightly for all treatments, of which 45 leaves were chosen randomly from each plot and transferred to the laboratory in paper pages.

2- Forty-five leaves of plants were chosen from each plot of the experiment (picked up from top, middle and base of sweet potato plants) in paper bags then transfer to the laboratory to count damage according toKasopers (1965).

3- Fifteen roots were chosen from each plot and the damages were estimated according to Kasopers (1965) as follow:

$$\%\ \text{of Damage} = \frac{\text{Sum of } (n \times v)}{Z \times N}$$

Where;

N = Total number of collected leaves/tubers.

Z = Score of the highest category (5).

n = No. of leaves/tubers for each category.

v = Score of each category.

Statistical Analysis:

Data were statistically analysis using Complete Blocks Design, and LSD at 0.05 level was used to compare the means of all data of the two seasons as mentioned by Gomaz and Gomaz(1984).

RESULTS AND DISCUSSION

Vegetative Growth Characters:

The endophytic, *Beauvaria bassiana*had positive effect on sweet potato plants shown Table (2). The highest values of vegetative growth characters, i.e. plant length, the number of branches/plants, fresh weight and dry matter percentage of branches were observed when the plants spraying with *B. bassiana* twice in both seasons, except dry matter percentage in the second season. On the other hand, the lowest values of these parameters were recorded in the untreated plants by *B. bassiana* (control) in two successive seasons. The beneficial effect of active *B.bassiana*foliar application on thegrowth character of sweet potato plants may be due to the effect of *B. bassiana*on the availability of nutrients in plants(Dara *et al.*,2017). According to Surendra*et al.*, (2017) used *B. bassiana* to promotes cabbage growth and had a positive influence on survival, growth, health, length, and dry weight. A few studies have shown positive effects on plant growth following the conidial application of entomopathogenic endophytes including higher stand count, root and shoot growth (Ownley *et al*., 2004, 2008; Griffin *et al*., 2005; Kabaluk and Ericsson 2007). Also, *B. bassiana* promotes plant growth of cassava (*Manihot esculenta*), faba bean (*Vicia faba*) and cotton (*Gossypium hirsutum*) (Lopezand Sword, 2015; Greenfield *et al*., 2016; Jaber and Enkerli, 2016 a and b).In cotton plants, *B. bassiana* treatments could induce the length and weight of fresh stem (Mazen *et. al.*, 2020).

Table 2: Effect of *Beauvaria bassiana* applications on vegetative growth characters of sweet potato season 2018 and 2019.

Treatments	2018 season				2019 season			
	Plant length (cm)	No of branches/ plant	Fresh weight of plant (Kg)	D, M% of vines	Plant length (cm)	No of branches/ plant	Fresh weight of plant (Kg)	D, M% of vines
Control	135.7	15.3	1.203	13.66	137.9	15.9	1.312	13.82
One Soil addition	143.2	15.7	1.306	14.24	144.2	16.3	1.365	14.36
Two Soil addition	149.2	16.2	1.361	14.67	156.7	16.7	1.422	14.54
One Foliar application	150.6	16.7	1.432	13.92	157.1	17.3	1.434	14.86
Two Foliar application	153.7	17.3	1.489	14.33	164.7	18.1	1.587	15.37
Foliar + Soil	142.3	16.3	1.321	14.55	145.3	17.2	1.477	14.64
LSD at 0.05	2.2	NS	0.105	NS	2.3	1.7	0.122	0.36

Root Yield and Its Components:

In both seasons the results presented in Table (3) show the salary that applications with *B.bassiana* significantly affected on yield and quality of root parameters in both seasons. The application of.*Bassiana*in the soil twice give the highest values of storage roots yield, marketable yield, marketable roots, average weight, diameter and percentage of dry matter of storage roots in both seasons. Adding treatment 2, T3, T4, T5, and T6 increased roots yield by 15.2, 19.3, 9.1, 12.1, and 12.7%, respectively in the first season as well as 16.4, 19.2, 5.5, 12.9 and 13.9%, repectevely in the second season while the control (the plants weren't received treatments by *B.bassiana)* recorded the lowest results of all yield and its components of sweet potato in this study, they attributed these results to the effects of *B. bassiana* in nutrient uptake. Fungal endophytes might affect the nutrient cycle and uptake of nutrients from the soil by plants (Saikkonem *et al.,* 2015).

Table 3: Effect of *Beauvaria bassiana* root yield and components during seasons 2018 and 2019.

Treatments	Yield of roots (Ton/fed.)	Yield of marketable (Ton/fed.)	No of roots /plant	Weight of root(g)	Root length (cm)	Root diameter (cm)	D.M of roots%
Season 2018							
Control	10.213	9.008	3.67	134.7	19.03	5.21	23.6
One Soil addition	11.762	10.575	4.93	141.2	20.93	5.71	25.2
Two Soil addition	12.187	10.933	5.37	153.3	22.17	6.77	26.9
One Foliar application	11.137	9.987	3.73	137.7	20.71	5.53	24.3
Two Foliar application	11.447	10.106	3.83	143.6	21.03	5.81	25.9
Foliar + Soil	11.513	10.331	3.97	140.3	21.27	5.93	26.3
LSD at 0.05	0.213	0.116	1.12	2.4	1.41	1.13	1.4
Season 2019							
Control	10.931	9.507	4.13	139.7	20.07	4.91	23.9
One Soil addition	12.721	11.503	4.28	153.3	23.31	6.13	25.9
Two Soil addition	13.031	12.773	5.63	163.9	24.62	6.45	26.8
One Foliar application	11.534	10.317	4.16	145.3	22.45	5.31	25.3
Two Foliar application	12.337	11.121	4.55	148.1	23.57	5.89	25.9
Foliar + Soil	12.451	11.917	4.25	144.3	23.49	6.23	25.7
LSD at 0.05	0.231	0.212	NS	2.5	1.81	1.22	1.2

Organic and Chemical Composition:

Date in Table (4) cleared that protein and starch percentage in the root of sweet potato plants were positively responded to the studied treatment, however, the highest values of protein and starch were recorded by soil application *B. bassiana* at twice in both seasons while starch percentage in roots insignificant effect in the first season. Data in the same table conceding the effect of *B. bassiana* on N, P, and K concentration in storage roots of sweet potato plants. The nitrogen, phosphorus and Potassium percentage in storage roots of sweet potato increasing by application of twice to the soil compared together treatments in both seasons. While the lowest values of these characters were obtained when the plants weren't treated by *B. bassiana*in in both seasons. Protein accumulation may be due to plant defense proteins when injecting the conidia of *B. bassiana* into date palm leaves (Gómez-Vidal *et al.,* 2009).

Table 4: Effect of *Beauvaria bassiana*on chemical composition in storage roots of sweet potato during seasons 2018 and 2019.

Treatments	N%	P%	K%	Protein %	Starch%
Season 2018					
Control	1.53	0.231	2.73	9.56	14.03
One Soil addition	1.61	0.263	2.81	10.06	15.19
Two Soil addition	1.69	0.296	2.97	10.56	15.81
One Foliar application	1.58	0.251	2.73	9.88	14.53
Two Foliar application	1.53	0.262	2.79	9.56	14.77
Foliar + Soil	1.67	0.268	2.85	9.79	14.85
LSD at 0.05	0.11	0.043	NS	0.69	NS
Season 2919					
Control	1.58	0.227	2.79	9.88	15.91
One Soil addition	1.73	0.261	2.91	10.81	16.33
Two Soil addition	1.79	0.299	3.03	11.19	17.03
One Foliar application	1.61	0.251	2.85	10.06	16.11
Two Foliar application	1.71	0.267	2.93	10.69	16.65
Foliar + Soil	1.65	0.253	2.90	10.31	16.13
LSD at 0.05	0.14	0.034	0.22	0.89	0.33

Population Dynamic of Whitefly of Sweet Potato Treated With Endophytic *B. bassiana* and Control in Sohag governorate:

The graphically plotted data in Fig. (1)shows the weekly whitefly census on 25 leaves of sweet potato plants untreated with *B. bassiana* fungus, as well as weekly data for different treatments with *B. bassiana* fungus. The drawing indicates the escalation of the whitefly population on the leaves of non-treated sweet potato plants until reached their peak on the 10th Aug. with an average population of 197 individuals/25 plant. The timing of adding the fungus treatments to the plants is indicated in Fig. (1), and the results of using endophytic *B. bassiana* is clear in the graph, where the fungus kept the infection rate of whitefly low throughout the season compared to untreated plants in 2018 season.

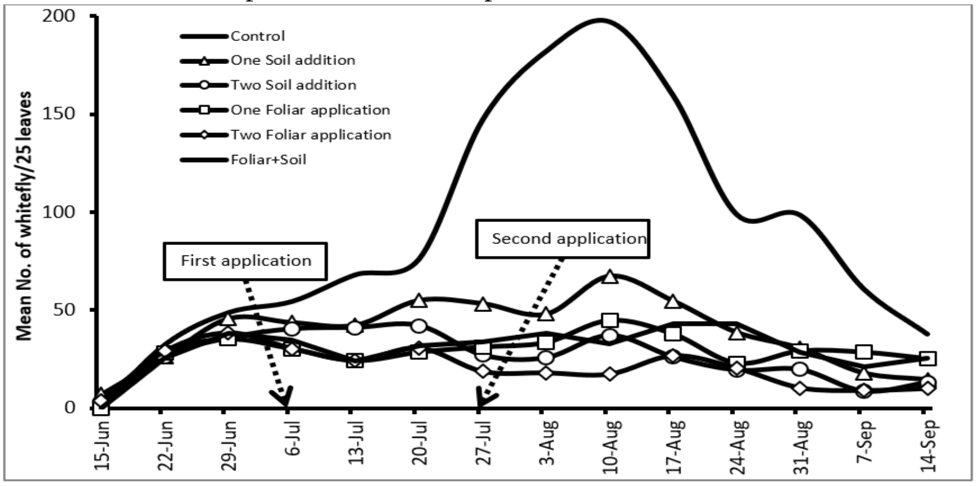

Fig. 1: Population dynamic of whitefly/25 leaves of sweet potato treated with five treatments of endophytic *B. bassiana* and control in Sohag governorate during 2018 season.

The weekly white fly census was shown on 25 leaves of untreated sweet potato plants and those treated with *B. bassiana* in fig. (2). The graph shows the fluctuation of whitefly infestation throughout the season, as it formed two activity peaks on the 24th Jul and 14th Aug with an average population of 73.67 and 87.33 respectively. While treated plants with *B. bassiana* (addition time show in Fig. 2) were kept their mean populations less than untreated plants. Using endophytic *B. bassiana* twice foliar treatment was achieved the best results, as the lowest average number of whitefly was recorded 10 individuals/25 leaves of sweet potato on 7th Aug.

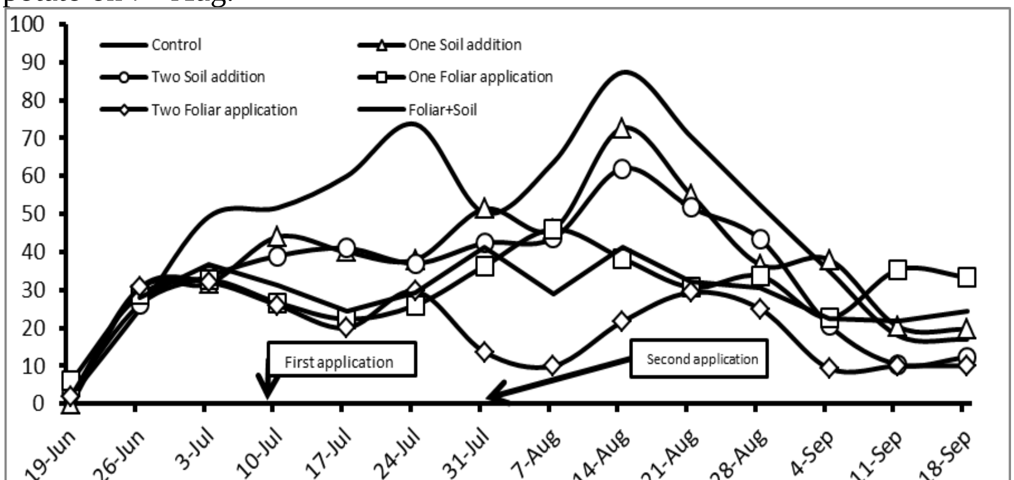

Fig. 2: population dynamic of whitefly/25 leaves of sweet potato treated with five treatments of endophytic *B. bassiana* and control in Sohag governorate during 2019 season.

Damage of Whitefly of Sweet Potato Treated with Endophytic *B. bassiana* and Control in Sohag Governorate:

Data in Table (5) show the effect of fungus treatment, soil addition (once and twice), foliar application (once and twice), Foliar+Soil application on whitefly, leaf defoliators, root defoliators and control (untreated) in two successive seasons. Data indicated the significant effect of fungus on studied pest infestations.

Twice foliar application treatment was recorded the lowest number of whitefly by 32.94 individuals/ 25 leaves with significant differences with untreated and other treatments in 2018 and 2019 seasons with LSD= 4.82 and 4.9 respectively. One foliar and foliar+soil treatment were come in the second significant group after twice foliar application, without significant differences with each other in two successive seasons.

The Kasopers (1965)formula was used to calculate the percentage of damage in the leaves and roots of the sweet potato. The damage in the leaves was calculated before the week of harvest and the root damage was calculated immediately after harvest. The results showed that the use of *B. bassiana* in all treatments had a positive effect on infection rates for leaves and tuber roots compared to untreated sweet potato plants. The minimum damage percentages in leaves and tuber roots were observed in two foliar treatments (0.28%) and in two soil addition treatments (0.21%) respectively for 2018 season. The same trend was counted in the second season, by 0.28% and 0.26% damage of leaves and tuber roots.

Table 5: Effect of *Beauvaria bassiana*on whitefly, leaf and root defoliators in sweet potato plants during seasons 2018 and 2019.

Treatment	2018 season			2019 season		
	WF	Leaf D.	Root D.	WF	Leaf D.	Root D.
Control	98.94	0.47	0.41	86.11	0.48	0.42
One Soil addition	49.47	0.33	0.31	55.92	0.32	0.30
Two Soil addition	39.42	0.32	0.21	39.67	0.29	0.26
One Foliar application	37.25	0.32	0.35	34.53	0.31	0.35
Two Foliar application	23.86	0.28	0.34	25.12	0.28	0.33
Foliar + Soil	32.94	0.30	0.24	32.53	0.29	0.29
L:SD	**4.824**	**0.0061**	**0.0075**	**4.899**	**0.0057**	**0.0063**

These results can attempt from many authors which they studied the effect of endophytic fungi on plant and evidence insects. Fungal endophytes improve the colonized plant height, weight and other growth parameters are also influenced. Jaber and Enkerli (2017) reported an improvement in the height, fresh weight of shoots and roots of *V. faba* plants following artificial inoculation of *B. brongniartii*, *B. bassiana* and *M. brunneum.* In another study, *B. bassiana* and *P. lilacinum* also increased the growth and dry biomass of colonized cotton plants (Lopez and Sword, 2015).

Fungal endophytes can also act as insect pathogenic agents by infesting lepidopterous larvae, aphids, thrips, and other cosmopolitan insects, which are of great concern in agriculture worldwide. They are known to infect specific hosts and pose little or no risk to non-target organisms or beneficial insects (Akutse*et al.*, 2014). Existing of fungal endophytes symbiotically within the host plants acts as an indirect defense against herbivores (Powell *et al.*, 2009 and Quesada-Moraga *et al.*, 2009).Akutse *et al.*, (2013) observed that endophytic fungi reduce insect herbivore damage are numerous, some of the common measures include: reduction in the insect developmental rate.

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ARABIC SUMMARY

تأثير استخدام الفطر الداخلي للنبات والممرض للحشرات *Beauvaria bassiana* علي جودة محصول البطاطا والحشرات المصاحبة تحت ظروف محافظة سوهاج

حسن البدري[1] وحسام الجبالي[2]

1- معهد بحوث البساتين – مركز البحوث الزراعية

2- معهد بحوث وقاية النباتات – مركز البحوث الزراعية

أجريت هذه الدراسةخلال موسم ٢٠١٨ و٢٠١٩ بمحطة بحوث شندويل،سوهاج وذلك بغرض التعرف على استجابة نباتات البطاطا المعاملة بفطر بيوفاريا باسياناوذلك من خلال ٦ معاملات للإضافةوهي:

١- الاضافة الأرضية مرة واحدة ٢-الاضافة الأرضية مرتين ٣-الرش الورقيمرة واحدة ٤-الرش الورقي مرتين ٥-الاضافة الأرضية والرش الورقى معا مرة واحدة ٦-الكنترول بدون معاملة بالفطر.وكانت أهم النتائج المتحصل عليها من الدارسة ما يلي:

أظهرت المعاملات المختلفة زيادة واضحة في صفات النمو الخضريحيث أعطت المعاملة التيتم فيها رش النباتات بفطر بيوفاريا باسيانا مرتين أعلى القيم المتحصل عليها لصفات النمو الخضري خاصة طول النباتات والوزن الطازج العرش مقارنة مع المعاملات الأخرى محل الدراسة خلال موسمى الدراسة في لم يكن لاستخدام هذا الفطر تأثير معنوي على صفة عدد الأفرع لكل نباتوالنسبة المئوية للمادة الجافة للأفرع فى موسم الدراسة الأول.

من النتائج المتحصل عليها لصفات المحصول ومكوناته أظهرت المعاملة بفطر بيوفاريا باسيانا مرتين كإضافة أرضية افضل القيم للمحصول الكلى والحصول التسويقىومتوسط وزن الجذر وأيضا أعلى نسبة مادة جافة فى الجذور التخزينية لنباتات البطاطا مقارنة بالمعاملات الأخرى فى الوقت الذى أعطت معاملة الكنترول اقل القيم لكل الصفات محل الدراسة وذلك خلال كلا موسمي الدراسة.

عند دراسة تأثير اضافة فطر بيوفاريا باسيانا على المكونات الكيماوية لجذور نباتات البطاطا تباينت المعاملات المختلفة فيما بينها حيث أعطت معاملة الاضافة الأرضية مرتين زيادة معنوية لصفات محتوى الجذور من النيتروجين والفوسفور والبوتاسيوم والبروتين والنشا خلال موسمى الدراسة معدا صفة نسبة البوتاسيوم والنشا فى الموسم الأول فى ذات الوقت اعطت معاملة الكنترول (بدون استخدام الفطر) اقل القيم لهذه الصفات.

عند دراسة تأثيراستخدام الفطر بالمعاملات المختلفة على تواجد وتعداد الذبابة البيضاء، أكدت الدراسة على ان معاملة الرش الورقي مرتين كان الأفضل من حيث قلة تعداد الذبابة البيضاء.

من خلال النتائج المتحصل عليها من هذه الدراسة يمكن التوصية برش نباتات البطاطا بفطر بيوفاريا باسيانا مرتين خلال موسم النمو للحصول على أعلى وزن طازج للعروش اما فى حالة الرغبة فى الحصول على محصول عالى وذو جودة تسويقية عالية يمكن التوصية بمعاملة نباتات البطاطا بالإضافة الأرضية مرتين بفطر بيوفاريباسيانا خلال موسم النمو وذلك فى الظروف المماثلة الدراسة.