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Sensitivity of *Pisum sativum* plants agents *F. solani, F. verticilliodes, F. tricinctum* and its effect on some vegetative growth characteristics

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Abstract
Result of sensitivity of *Pisum sativum*Plants refers to Holland variety is more sensitive than French variety to *F. solani*, *F. verticilliodes* and *F. tricinctum***,** and the results indicate that the vegetative growth improved in the treatment with the three fungi, in addition to the biological control *T. harzianum* compared with the treatment with the three fungi both separately and alone, as well as the formalin sterilized soil treatment (control), as the treatments recorded good growth represented by high significant differences in the percentage of germination and a significant increase in the plant height rate and chlorophyll content, the number of leaves and leaflets, the average fresh weight of the shoot and root system and the average dry weight of the shoot and root system. The most sensitive treatments were the treatment with *F. solani* alone in the French *Pisum sativum* plants.
The results showed an increase in the number of flowers for the Holland and French *Pisum sativum* varieties, as the number of flowers in the Holland variety was 9.63 flowers and the French variety was 8.00 flowers. The statistical analysis showed that there were no significant differences between them, and the superiority of the biological control *T. harzianum* significantly over the rest of the treatments, the number of flowers was 11.25, and the least significant effect was in treatment *F. tricinctum* and it reached 5.5 flowers and also the treatment *F. solani* where it reached 6.75 flowers, where there are no significant differences between them.
Results indicates that there are significant differences between the studied treatments, but among the varieties there are no significant differences, and the number of pods in Holland variety reached 12.81 pods and in the French variety it reached 11.06 pods, and the superiority of the control *T. harzianum* Morally, the number of pods was 14.50 pods, and *F. tricinctum* in addition to biological control *T. harzianum* the least significant effect of the number of pods reached 7.80 pods.
The results show a significant difference in the number of seeds between the studied treatments, and there is no significant difference between Holland and French pea cultivars, as the number of seeds in the Holland variety reached 5.29 and in the French variety 4.67 seeds, and the superiority of biological control *T. harzianum* for the rest of the treatments, the number of seeds was 6.33.

Keywords: sensitivity, *Pisum sativum, F. solani, F. verticilliodes, F. tricinctum*

Introduction
The cause of spoilage of grains and seeds in general is attributed to two groups of fungi: field fungi and storage fungi (Suad, 2010) [34]. Field fungi invade seeds before harvest when the crop is in the field, and these fungi may affect the appearance and quality of the seeds, and damage caused by field fungi usually occurs before harvest and is detected by routine examination, most field fungi when it rains are more prevalent and higher than usual during seed packing and harvesting (Pellegrino *et al*., 2020) [27].
The most important field fungi in crops and the common ones are *Fusarium, Penicillium, Cladosporium, Aspergillus, Alternaria* (Kulik, 2020) [19]. As for storage fungi such as *Aspergillus* spp., *Fusarium* spp., *Penicillium* spp. and *Mucor*. (Al-Kadi and Al-Jali, 2020), are fungi that invade seeds during storage, small amounts of storage fungi may be present on seeds entering storage or may be present on seeds that are stuck in equipment and mechanisms of harvesting, handling and storage if storage conditions are not appropriately, this small amount of the vaccine can quickly increase, resulting in major problems. (Javaid *et al*., 2021) [16].
Climatic factors such as temperature and humidity are among the most important factors that affect the speed of the spread of fungi and thus negatively affect the quality of seeds and the decrease in germination (Fleurat-Lessard, 2017) [11]. Factors affecting the development of storage fungi in stored seeds are temperature, humidity, condition of stored seeds and length of time during which storage is carried out, as well as insects such as mites (Javaid *et al*., 2021) [16].
It also uses many chemical pesticides that have shown high efficiency in combating diseases, losses of seeds exposed to fungal contamination are estimated at 5-10%, Where these fungi secrete various toxins that cause

serious diseases to humans and animals, and the production of these toxins depends on the type of mushroom and the environmental conditions suitable for its growth, especially the food source, temperature and humidity, Many chemical and biological methods are used to combat pea diseases and biological methods such as living organisms and plant extracts are used to control agricultural pests that affect pea daughters, as these methods reduce the amount of vaccine for the pathogen and inhibit its growth and reproduction directly or indirectly without any harmful effects on the plant (Kumar *et al.*, 2008) [20].

Abdul Rahim (2013) [2] indicated that the production of the pea crop in Iraq is relatively low compared to the global production, as the cultivated area in Iraq reached 500 hectares.in2005 and a productivity of 4000 kg / hectare. While in Syria in the same year, the cultivated area reached 2710 hectares and the productivity was 8527 kg/ha (Arab Organization for Agricultural Development, 2006) [4].

The production rate of pulses reached 17-19 million tons annually, with an area of 24-26 million hectares, which represents more than a third of the total area of the world and more than 20% of the total production of pulses in the world. In the last four years, there has been a significant increase in the average consumption of about 50gm due to the increase in production due to the task of national food security. For Iraq, this production does not meet the local need of the crop, especially since peas are included in the main meals of the Iraqi consumer, and for this reason, good quantities of peas are imported from abroad annually (IIPR,2014) [15].

In a study in the United States, the harvested area of peas has increased by more than 300% over the past 25 years, although the yield has decreased by an average of 75% over this time period. Less productive regions such as Montana and Edkota. (Vandemarkand *et al.*, 2014) [40].

Materials and methods

Sensitivity of Holand and French *Pisum sativum* Plants agents *F. solani, F. verticilliodes, F. tricinctum* and biological resistance *T. harzianum*

For the purpose of testing the sensitivity of pea cultivars to the three studied fungi, the Holland and French *Pisum sativum*verities were selected based on the percentage of germination of the cultivars. Soils are perpetrated as Tortora (2004) [39].

The soil placed in the anvils was inoculated with the three studied fungi as in Saydam *et al*. (1973) [33]. This experiment was carried out in the greenhouse of the College of Sciences /University of Mosul, the results recording for four months from the date of cultivation on 12/19/2021 (Melzer *et al*., 2016) [22].

Greenhouse experiment treatments

1. *F. solani*
2. *F. Solani* + Biological control *T. harzianum*
3. *F. verticilliodes*
4. *F. verticilliodes* + Biological control *T. harzianum*
5. *F. tricinctum*
6. *F. tricinctum* + Biological control *T. harzianum*
7. Biological control *T. harzianum*
8. Soil sterilized with formalin (control treatment)

Measurement of the content of chlorophyll (%)

The relative content of chlorophyll was read in the leaves of the plants of the experimental unit and for all treatments, with an average of three readings from each replicate using a field device. Opti-sciences CCM-200 plus The reading was taken 60 days after transplantation.

Calculating the number of flowers

The number of flowers for all plants of the experimental unit was calculated using three readings, the first reading was on 22/2/2022, the second reading was on 27/2/2022, and the third reading was on 1/3/2022.

Calculating the number of horns

The number of pods for all plants of the experimental unit was calculated by counting with three readings, where the first reading was on 27/2/2022, the second reading was on 20/3/2022, and the third reading was on 3/4/2022.

Calculating the number of seeds inside the pods

The number of seeds inside each pod for all plants of the experimental unit was calculated by counting method on 4/5/2022.

Results and discussion

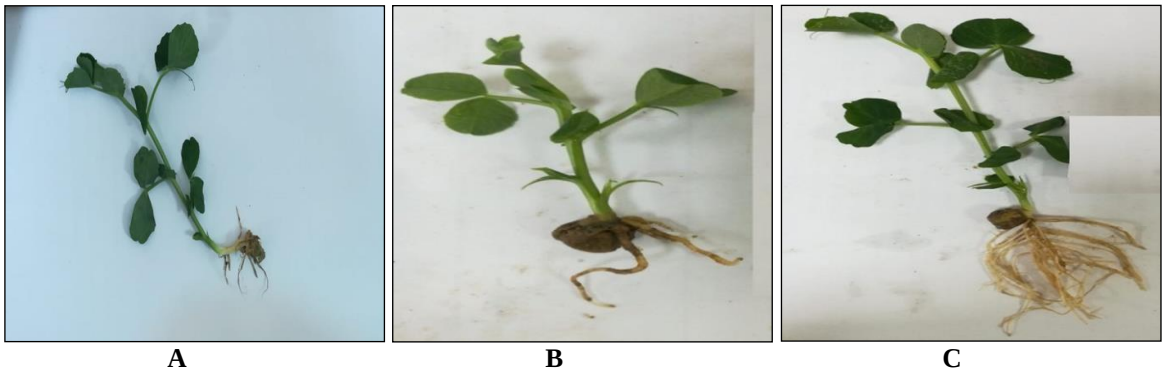
Sensitivity of Holand and French *Pisum sativum* Plants agents *F. solani, F. verticilliodes, F. tricinctum* and biological resistance *T. harzianum*

The results in Figure (1-.A) are shown the Holland variety is more sensitive than the French variety towards F. solani, F. verticilliodes and *F. tricinctum*, and the results indicate an improvement in vegetative growth in the treatment with the three fungi in addition to the biological control *T. harzianum* compared with the treatment with the three fungi, both separately and alone, as well as the formalin sterilized soil treatment, as the treatments

recorded good growth represented by high significant differences in the percentage of germination and a significant increase in the plant height rate and chlorophyll content, the number of leaves and leaflets, the average fresh weight of the shoot and root system and the average dry weight of the shoot and root system. The most sensitive treatments were the treatment with *F. solani* alone in the French *Pisum sativum*.

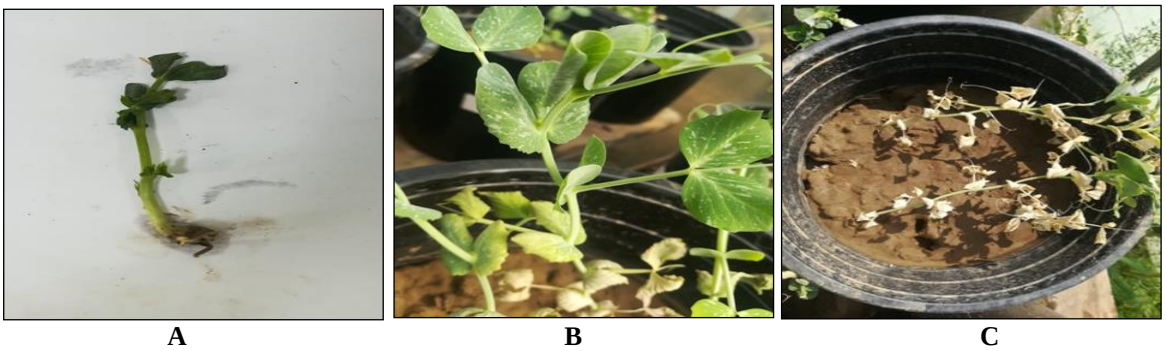
The increase in the vegetative density in the treatments in which the biological control *T. harzianum* was added. The result of the improvement of root growth, represented by the light color of the roots, in addition to the abundance of the root system, represented by the number and length of roots, while the root total appeared to suffer from weakness and blackening of the main roots and secondary roots in the treatment with the fungus alone (Figure 1-.B) compared to the treatment in which the biological control *T. harzianum* was added (Fig. C-1), as well as an increase in the ability of roots to grow and absorb nutrients and stimulate vegetative growth characteristics represented by an increase in the number of leaves and leaflets and an increase in leaf area and leaf area index.

Symptoms of vascular wilt appeared in the treatment with the three *F. solani*, *F. verticilliodes* and *F. tricinctum* represented a general wilting of the leaves and their turning inward in addition to the entire leaf blight, and the most affected treatments were the fungus treatment. *F. solani* in the French *Pisum sativum* (A, B, C- 2).



A **B** **C**

Fig 1: The sensitivity of the Holland *Pisum sativum* to: A: *F. solani*, B: *F. tricinctum*, C: *F. tricinctum* in addition of *T. harzianum*



A **B** **C**

Fig 2: sensitivity of the French *Pisum sativum* variety to, A: *F. solani*, B: Symptoms of leaf curling, slitting, and yellowing, C: Symptoms of leaf blight and plant wilt

Number of flowers

The results in Table (1) showed an increase in the number of flowers for the Holland and French pea cultivars, as the number of flowers in the Holland variety was 9.63 flowers and the French variety was 8.00 flowers. The statistical analysis showed that there were no significant differences between them, and the superiority of the biological control *T. harzianum* significantly over the rest of the treatments, the number of flowers was 11.25, and the least significant effect was in the treatment of *F. tricinctum* and it reached 5.5 flowers and also the treatment of *F. solani* where it reached 6.75 flowers, where there are no significant differences between them.

The effect of the interaction between treatments and pea cultivars indicates the existence of significant differences between treatments, as in the Holland variety it was less significant effect was in the treatment of *Pisum sativum*. *F. solani* in which the number of flowers reached 2.50 flowers, and the treatment of *F. solani* in addition to the biological control *T. harzianum* in which the number of flowers reached 13, and we note from the table that the number of flowers in F. tricinctum in addition to biological control *T. harzianum* was 5.50 flowers, and this indicates that the biological control did not affect *F. tricinctum* in the number of flowers, while in the French variety There are no significant differences between the treatments, where the number of flowers in the treatment of *F. solani* was 11 flowers, and in the treatment with biological control *T. harzianum* 8.50 flowers and in sterilized soil (control) 8.50 flowers.

Number of horns

Table (1) indicates that there are significant differences between the studied treatments, but among the varieties there are no significant differences, and the number of pods in the Holland variety reached 12.81 pods and in the French variety it reached 11.06 pods, and the superiority of the biological control *T. harzianum* significantly, the number of pods was 14.50 pods.

The effect of the interaction between treatments and *Pisum sativum* varieties in the Holland variety showed that there were no significant differences between the treatments. The number of pods in one treatment *F. solani* 9.00 pods, and in treatment with biological control *T. harzianum* 15.00 pods, also in the French variety there are no significant differences between the treatments, so the number of pods in a treatment *F. solani* 14 pods and treated with biological control *T. harzianum*14.00 Pod.

Number of seeds

The results in Table (1) show a significant difference in the number of seeds between the studied treatments, and there is no significant difference between the Holland and French *Pisum sativum* varieties, as the number of seeds in the Holland variety reached 5.29 and in the French variety 4.67 seeds, and the superiority of the biological control *T. harzianum* for the rest of the treatments, the number of seeds was 6.33, followed by the treatment *F. verticilliodes*In addition to the biological control *T. harzianum*, the number of seeds, respectively, reached 83-5, and the least significant effect was in the treatment of *F. solani* and *F. solani* in addition to biological control *T. harzianum*, where there are no significant differences between them and the number of seeds was 4.17 seeds.

The effect of the interaction between treatments and *Pisum sativum* varieties indicates that there are no significant differences between treatments in the Holand variety, as the number of seeds in treatment *F. solani* 3.67 seeds were treated with biological control *T. harzianum* 7.00 seeds, and in the French variety there were no significant differences between the treatments and the number of seeds per treatment *F. solani* 4.67 seeds and treated with biological control *T. harzianum*5.67 seeds.

The efficiency of photosynthesis increases with the plant's resistance to disease infections, bypassing harsh conditions, and preventing vitamin oxidationE and C present in chloroplasts and thus improve plant growth and development, as well as the activity of peroxidase enzyme will increase and thus strengthen the cell wall and prevent the combustion of fungal causes of plant tissues and the role of biological resistors in increasing the readiness of plant elements such as potassium Nitrogen and phosphorous will cause an increase in the vegetative density of the plant, as these elements play a major role in building chlorophyll, especially nitrogen, which is included in its composition. Potassium is one of the most important elements that are activators of many mechanisms of photosynthesis and respiration (Jensen, 2004) [17], or the reason may be the genetic difference between the two varieties, as well as the variation between species and genera and genetic variation between isolates of the species due to the difference in the amount of toxins and metabolic substances secreted by these isolates, which have a major role in the ability of pathogenic fungi such as Phenyl acetic acid. And Fusaric acid, Anhydro Fusarbin and Polpeptide toxin (Barreto *et al*., 2003) [3], or because of the different isolates in their ability to secrete cellulose-degrading enzymes and pectin at the beginning of infection and have a role in penetrating the host, including Pectinase, Cellulase, Laccase and Pectinlyase, which have an effective role in Pathogenicity of the fungus and the difference of isolates in their ability to parasitize. Trichoderma spp. Several mechanisms by which it affects plant pathogenic fungi (Chet and Chernin, 2002) [7].

Table 1: Effect of different treatments and two *Pisum sativum* varieties plants and the interaction between them on the number of flowers, pods and seeds inside the pods

The number of seeds inside the pods	Number of horns	Number of flowers	Treatments	
Transaction Effect				
1.17+4.17 And the	3.30+11.50 D r	5.32+6.75 e	*F. solani*	
1.94+4.17 And the	6.70+11.80 D r	3.74+9 c d	*F. solani* + *T. harzianum*	
1.10+5.00 Dr	1.00+12.80 c	5.96+8 D r	*F. verticilliodes*	
1.17+5.83 B	4.00+10.50 h	2.45+10 B	*F. verticilliodes*+ *T. harzianum*	
2.07+4.33 H	1.00+13.30 c	0.58+5.5 And the	*F. tricinctum*	
1.51+4.67 Dr	6.30+7.80 And the	2.65+9.5 c	*F. tricinctum* + *T. harzianum*	
1.63+6.33 A	1.00+14.50 A	3.77+11.25 a	Biological control *T. harzianum*	
2.07+5.33 C	0.8+14.00 Dad	4.12+10.5 B	Sterile Soil (control)	
Varieties Effect				
1.63+5.29 A	3.62+12.81 A	4.66+9.63 a	Holland variety	
1.71+4.67 A	4.57+11.06 A	3.18+8.00 a	French variety	
The effect of the interaction between transactions and classes				
1.15+3.67 b c	2.80+9.00 b c	2.12+2.50 h	Holland variety	*F. solani*
1.15+4.67 a b c	0.00+14.00 a b c	2.83+11.00 a b c	French type	
1.53+4.33 a b c	0.70+14.50 a b c	4.24+13.00 dad	Holland variety	*F. solani* + *T. harzianum*
2.65+4.00 a b c	0.70+13.50 a b c	2.83+8.00 A - E	French type	

0.58+6.33 Dad	0.70+13.50 Dad	4.24+7.00 b - e	Holland variety	*F. verticilliodes*
1.53+5.33 a b c	0.00+12.00 a b c	2.83+11.00 a b c	French type	
1.00+6.00 a b	0.00+14.00 Dad	2.83+140 a	Holland variety	*F. verticilliodes* + *T. harzianum*
1.15+2.67 C	0.00+7.00 C	2.65+4.00 d e	French type	
2.52+5.33 a b c	0.70+13.50 a b c	4.24+13.00 dad	Holland variety	*F. tricinctum*
2.08+5.33 a b c	1.40+13.00 a b c	3.54+9.50 Mr. Dr	French type	
1.73+5.00 a b c	7.10+7.00 a b c	0.71+5.50 JD H	Holland variety	*F. tricinctum* + *T. harzianum*
1.53+4.33 a b c	7.20+8.30 a b c	0.71+5.50 JD H	French type	
1.00+7.00 A	0.00+15.00 A	3.54+10.50 Mr. Dr	Holland variety	*T. harzianum*
2.08+5.67 a b c	1.40+14.00 a b c	2.12+8.50 Mr. Dr	French type	
1.53+4.67 a b c	0.00+16.00 a b c	2.12+11.50 a b c	Holland variety	Sterile Soil (control)
0.58+5.33 a b c	7.80+9.00 a b c	2.12+8.50 Mr. Dr	French type	

The different letters on the averages of the coefficients indicate the presence of significant differences at the level of probability (P, 0.05), according to the type of comparison, and similar or common letters on the averages of the coefficients indicate that there are no significant differences

The infection of pea seeds with storage fungi is one of the most important reasons that make the germination rate low and the seeds rot, as the change in color is one of the signs of fungal infection, and the severity of infection increases with the increase in the storage period (Comby *et al*., 2017) [9], that the fungus Trichoderma was used as a bio-resistant to control vascular wilt disease caused by Fusarium and that its use leads to a reduction in the severity of infection compared to the control treatment. This is consistent with the results obtained from the varietal sensitivity experiment with pathogenic fungi, where an increase was observed in the percentage of germination, chlorophyll content, vegetative sum and in the induction factors the number of flowers, pods, and seeds and the number of leaves and that *F. solani* is one of the pathogenic fungi that infects peas and causes root rot (Williamson-Benavides, 2020) [44, 45], and this is consistent with the results obtained in an allergy experiment where The seeds treated with *F. solani* caused a significant decrease in germination rates, shoot and root system, and chlorophyll content, and the pathogenicity of *F. solani*.

In a study by Waheed *et al*. (2010) treating soil with bio-resistance *Paecilomyces*lilacinus, where the results showed an improvement in all studied growth parameters of cucumber plants such as shoot length, root total, number of leaves and number of flowers compared to treatments inoculated with *Pyhium aphanidermatum*. Vegetative and flowering, the number of flowers, as well as early flowering and prolongation of flowering period to 24 days, compared to plants not treated with chelated calcium (Abdullatif, 2015) [1].

In a study conducted in the field, it was found that moisture stress at the level of 55 and 35% of the field capacity caused a significant decrease in the number of pods, seeds and total crops. The reason may be drought stress, which will lead to a decrease in growth parameters such as plant height, leaf area and relative water content. Moisture stress causes a decrease in effort. The fullness of cells negatively affects cell division and elongation as well as cell size. This will lead to a short pod length and a few in number, as well as the lack of water in the soil causes a decrease in the dry weight of the vegetative and root system and thus a decrease in the number of pods (Ahmed *et al*, 2018) [3] and another study showed that water stress has a negative role on the growth of wheat plant, which leads to a decrease in the number of stalks and thus a decrease in the number of spikes (Dahl and Kazem, 2017).

The moisture contents of healthy seeds are lower compared to other seeds. Infection of seeds with pathogenic fungi in the field will change the color and shape of the seeds. These results are consistent with Castillo *et al*. (2004) showed that seed biodegradation is due to seed-parasitic fungi during primitive reproduction, ripening and storage, and that seed invasion can lead to various damages such as reducing seed yield quantitatively and qualitatively, production of mycotoxins, and reducing germination and total decay.

Fusarium. *Rhizoctonia*, *Sclerotinia*does not produce spots in pea seeds (Youssef, 2018) [46], and in a study of pea and soybean seeds, the effect of 5 species of *Fusarium* on seed germination and early plant development was examined by a practical study along with the expected toxicity of certain isolates and the possibility of producing T-2 toxins on soybean and pea seeds, and in a test Germination It was observed that 33 out of 47 isolates of *F. verticilliodes* and *F. solani*. *F. chlamydosporum*. It has worked to reduce the natural number of pea seeds from *F. sporotrichiodes* and *F. sem* when pollinating plants grown in a medium Hoagland, almost all *Fusarium* isolates necroticed pea roots but did not significantly reduce root and vegetative mass of peas or vegetative dry mass of soybeans. *F. verticilliodes* is the most deadly pathogen in the seed (Ivic, 2014).

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