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Control Of Peanut Root-Rot Using Some Chemical Substances

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PEANUT (*Arachis hypogaea* L.) is an important leguminous crop in Egypt. Root rot caused by *Rhizoctonia solani* is the most common disease of peanuts. In this study, six isolates of *R. solani* were isolated from peanut roots in El-Behera governorate during 2014 and 2015 growing seasons. Humic acid (H), sulfur (S) and gypsum (G) alone or in combinations were used as a seed dressing or a soil application to control root-rot disease in two peanut cultivars (Gregory and Ismailia1). Results indicated that peanut cv. Gregory appeared to be more susceptible to the fungus than cv. Ismailia1. Under greenhouse conditions, the combination of the three substances (H+S+G) caused the highest reduction in the incidence of *R. solani* damping-off on peanut cv. Gregory. Similar results were also obtained in the field experiment during 2015 and 2016 growing seasons. Furthermore, the results also indicated that each chemical substances and their combinations improved the growth characters in terms of the root and shoot weight as well as the yield of peanut plants.

Keywords: *Rhizoctonia solani,* Peanut, Damping-off, Root rot.

Introduction

Peanut (*Arachis hypogaea* L.) is one of the most important leguminous oil and food crop. High quality seeds are used for industries, while low quality seeds and shoots of harvested plants are used for animal feeding. The cultivated area of groundnuts with shell in Egypt reached 57,321 ha and producing 183,438 tons (FAO, 2014). Most of the peanut cultivation is in infertile soil and usually infested with several plant pathogens. Plant nutrition is crucial in those soils for acceptable and exportable peanut yield. Several soil-borne diseases caused by *Fusarium* spp., *Rhizoctonia solani*, *Macrophomina phaseolina*, *Sclerotium rolfsii*, *Pythium* spp. and *Aspergillus niger* (Helal et al., 1994; Morsy, 1999; Atta-Alla et al., 2004) affect peanut.

Amendment of soil with organic or inorganic chemicals results in better uptake of nutrients by root system that improves crop yield and increases the suppression of root infecting fungi (Rafi *et al*., 2016). The use of gypsum reduced the incidence of groundnut pod rot and increased the pod yield (Walker and Csinos, 1980; Chen and Huang, 1992; Ismail and Abd-El-Momen, 2007). Humic substances have been proven to improve the soil fertility and increase the availability of nutrients and consequently increase plant growth and yield (Moraditochaee, 2012). It was used to reduce the negative effects of pathogenic fungi such as *Fusarium solani* on mandarin (El-Mohamedy and Ahmed, 2009) and *Fusarium graminearum* and *Bipolaris sorokiniana* on wheat plants (Sakr *et al*., 2010). The application of sulfur significantly increased potato tuber yield and decreased the infection rate with *Rhizoctonia solani* (klikocka *et al*., 2005).

The aim of this investigation was to study the efficacy of sulphur, gypsum and humic acid individually or in combinations for controlling *Rhizoctonia solani* root rot in peanut.

Materials and Methods

Isolation and identification of the pathogen

A survey of peanut root-rot diseases was carried

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out during the 2014 and 2015 growing seasons in different localities of El-Behera governorate (El-Bostan, El–Nobaria, South El-Tahrir and Shabeb El- Khrigine). Collected diseased peanut roots of each locality were washed thoroughly with tap water, and small pieces of the diseased parts were surface sterilized by immersing in 3% Colorox (NaOCl) solution for three minutes. After rinsing several times in sterilized distilled water, samples were dried between two sterilized filter papers, then placed on PDA medium in Petri-dishes and incubated at 22±1^{o}C for 3 to 7 days. Hyphal tip or single spore of each the developing fungi was transferred to PDA medium. Inoculum of each purified culture was transferred into PDA slants and incubated at 25 ^{o}C. The developed fungal growth was sub-cultured and identified at the Department of Mycology, Plant Pathology Research Institute, Agricultural Research Center in Egypt according to Hildebrand (1938), Gilman (1957) and Booth (1971). Stock cultures were maintained on PDA slants and kept in a refrigerator at 5 $^°$C for further studies.

Pathogenicity test

The pathogenicity of *R. solani* isolates were tested against two cultivars of peanut (Gregory and Ismailia1). Glass bottles containing autoclaved sorghum-coarse sand-water (2:1:2 v/v/v) medium were inoculated by each isolate using agar dishes taken from the periphery of its 5 days-old colony and incubated at 25 ^{o}C for 10 days. The inoculum were used by disk (3 mm diameter) at the rate of 5% w/w, to infest sterilized potted soil, mixed thoroughly with the soil, then watered and left for one week before sowing. Apparently, healthy seeds of peanut Ismailia1 or Gregory cultivars were surface disinfested by sodium hypochlorite solution (3%) for 2 min before sowing. The seeds were sown at the rate of 5 seeds/pot (30 cm diameter). Four pots were used for each particular treatment. Pots containing sterile non-infested soil were used as a control. Percentage of pre-and post-emergence damping-off were calculated after 30 and 60 days from sowing, respectively (Morsy, 1999).

Greenhouse experiment

Greenhouse experiment was conducted to evaluate the efficacy of humic acid, sulfur and gypsum, individually or in combinations, on peanut cv. Gregory pre- and post- emergence damping-off in pots during 2015 season. Sterilized potted soil was inculcated with I_6 (the most aggressive isolate of *R. solani*) in a barley grains medium at a rate of 5g/kg soil (Morsy, 1999). The soil was then moistened with water for one week before sowing. Peanut seeds cv. Gregory were surface disinfested by sodium hypochlorite solution (3%) for 2 min before sowing.

Preparation of the treatments

In the seed dressing treatment, gypsum (10 g), sulfur (5 g) and humic (2 g) were incorporated, separately or in combinations, with 1 kg seeds before sowing; while in the soil application treatment, the above-mentioned substances were added to each pot. The experiment was carried out in a randomized complete block design with four replicates for each particular treatment. Five seeds were sown in each pot, and four pots filled with non-treated seeds were serve as a control.

Disease assessment

Disease assessment was recorded as percentage of damping-off (pre- and post-emergence) after 30 days and 60 days from sowing using the following formula (Hussien et al. 2012):

$$\text{\% Pre-emergence} = \frac{\text{Number of non germinated seeds}}{\text{Number of sown seeds}} \times 100$$

$$\text{\% Post-emergence} = \frac{\text{Number of dead seedlings}}{\text{Number of sown seeds}} \times 100$$

Effect of treatments on growth characters and yield of peanut plants

Growth characters of peanut plants including fresh weight (g) were recorded in different treatments and control at harvesting time and the average pod yield/plant was calculated in each treatment.

Field experiments

Field experiments were conducted in two successive seasons (2015 and 2016) at El-Tahrir region in El-Behera governorate to determine the effect of three chemical soil amendments or treated seed as seed dressing on pre- and post-emergence damping-off (determined at 30 and 60 days after sowing by checking each plot) and yield (weight of 100 pods/treatment) of Gregory cultivar. The applied treatments were used individually or in combinations as follows:

(1) Gypsum at one ton/fed in two equal portions. The first one was at soil preparation and the second one was at the beginning of the flowering stage. Seeds were treated with gypsum as seed dressing at the rate of 5 g gypsum: 1 kg seeds.

(2) Sulfur at 500 kg/fed was added during soil preparation. Seeds were treated with sulfur at the rate of 5 g sulfur: 1 kg seeds.

(3) Humic acid at 10 kg/fed was added during sowing. Seeds were treated with humic acid at the rate of 5 g humic: 1 kg seeds.

The experiment was laid out in a factorial design (Snedecor, 1956) in four replicates for each treatment. In the main plots, the cultivar Gregory was randomly distributed, while the three soil amendments or seed dressing were sub-plotted. The control was randomly allotted in sub-plots. The area of each sub-plot was 9 m^2 (3 m × 3 m) and consisted of three rows 5m long and 0.75 m apart and hill spacing at 10 cm single seed was sown in each hill. The preceding crop was potatoes in both seasons. Seeds of peanut were sown on 25th and 26th of May 2015 and 2016, respectively. Weed control was non-treated. Irrigation was applied every three days using sprinkler irrigation system. Other agricultural practices for peanut production were applied according to the recommendations.

Statistical analysis

The collected data were statically analyzed as described by Gomez and Gomez (1984). The new least significant difference was used to compare the differences among means (SAS, 1996).

Results and Discussion

Pathogenicity test of R. solni

Six isolates of *R. solni* were collected and isolated from different localities of El-Behera Governorate. All obtained fungal isolates proved to be able to infect peanut plants causing root rot symptoms. According to the results presented in Table 1, isolate No. 6 (I_6) was the most pathogenic as incited pre-emergence damping-off 40 % and 45 % and so post-emergence damping-off 25 % and 30 % on the tested peanut cultivars Ismailia 1 and Gregory, respectively. However, isolate No. 3 (I_3) was the least pathogenic recorded 15% and 20% for pre-emergence as well as 10% and 10% for post-emergence on two cultivars, respectively. On the other hand, results in Table (1) also indicated that peanut cv. Gregory was more susceptible than Ismailia 1 was. Accordingly, isolate I_6 and Gregory cultivar were selected for further experiments. *R. solani* is considered one of the most destructive fungi to peanut plant causing pre-and post-emergence damping-off and pod necrosis. The same trend was found by Ibrahim *et al* (1977) and Morsy (1999 and 2013).

Effect of soil application or seed dressing by some chemical substances on percentage of pre- and post-emergence damping-off on peanut cv. Gregory

1. Under greenhouse condition

The ability of the three chemical substances, alone or in combinations, to control *R. solani* were evaluated under greenhouse conditions. Results in Table 2 indicated that, disease incidence was significantly reduced in all treatments in comparison with the control. The best reduction in damping-off disease incidence was noted when peanut seeds were treated with chemical substances as a combination (Humic + Sulphur + Gypsum) in case of soil application or seed dressing, as the average reduction reaches to 12.5% and 2.5% compared with 50% and 25% for the control, respectively. Furthermore, the seed dressing with chemical substances was appeared to be better than soil application for controlling the disease in all treatments.

Results in Tables 3-5 indicated that significant differences were found in the root and shoot fresh weights and number of pods/plant of peanut plants. The highest means of root and shoot fresh weights as well as number of pods/plant (16 g, 35 g and 14 pod/plant, respectively) were obtained when chemical substances (Humic + Sulphur + Gypsum) were used as a combination applied as a soil application and a seed dressing. However, sulfur alone obtained lower root weight (11.4 g/plant) and 8.5 pod/plant; while shoot weight reached to 23.65 g/plant when humic acid was used alone (Table 3). This could be due to the utilization of various chemical substances. These results are in agreement with those of Hussein *et al.* (2000) and Ismail and Abd El-Momen (2007).

2. Under field condition

The three chemical substances alone or in combinations under field condition had similar effect to that obtained under greenhouse in reducing the damping-off. Results in Table 6 indicated that all soil application or seed dressing had significantly positive effect in reducing disease incidence in growing seasons 2015 and 2016. Treatment of the combination of humic, sulfur and gypsum was the most effective to reduce damping-off reaching to 7.5% and 3.75% in case of seed dressing and soil application, respectively for 2015 season; and 7.0% and 7.0% in case of seed dressing and soil application, respectively for 2016 season. However, the mean percentage of damping-off in the control reaches to 41.0% and 28.0% as seed dressing and soil application, respectively in the 2015 season, while it reaches

TABLE 1. Pre- and post-emergence damping off incited on Ismailia1 and Gregory cultivars of peanut sown in potted soil artificially infested with *Rhizoctoniasolani* isolates.

Isolates	%Damping- off						
	Pre-emergence			Post-emergence			
	Ismailia1	Gregory	Mean	Ismailia1	Gregory	Mean	I Mean
Control	0.00±0.00	0.00± 0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00 f
I_1	25.00±4.08	30.00±4.90	27.50±4.49	10.00±1.63	20.00±3.27	15.00±2.45	21.25±3.47 c
I_2	20.00± 3.27	35.00±5.72	27.50±4.49	20.00±3.27	15.00±2.45	17.50±2.86	22.50±3.68 b
I_3	15.00± 2.45	20.00±3.27	17.50±2.86	10.00±1.63	10.00±1.63	10.00±1.63	13.75±2.25 e
I_4	25.00± 4.08	30.00±4.90	27.50±4.49	15.00±2.45	20.00±3.27	17.50±2.86	22.50±3.68 b
I_5	25.00± 4.08	20.00±3.27	22.50±3.68	10.00±1.63	20.00±3.27	15.00±2.45	18.75±3.06 d
I_6	40.00± 6.53	45.00±7.35	42.50±6.94	25.00±4.08	30.00±4.90	27.50±4.49	35.00±5.72 a
C Mean	Ismailia1	17.14±2.80 b		Gregory	21.07±3.44 a		
T mean	Pre-emergence	23.57±3.85 a	Post-emergence	14.64±2.39 b			
L.S.D (0.05)							
I				0.57			
T				0.30			
C				0.30			
I × C				0.68			
I × T				0.68			
C × T				0.36			
I × T × C				0.96			

- Values are means of four replicates in each treatment±SE.
- Means values in each column followed by the same letter are not significantly different (P ≤0.05).
- I: Isolate,T: Time, C: Cultivar.

TABLE 2. Effect of some chemical substances on damping-off of peanut cv. Gregorycaused by *R.solani* under greenhouse condition.

Treatments	Soil application			Seed dressing			
	% pre-emergence	% post emergence	Mean	%pre-emergence	%post-emergence	Mean	Tr Mean
C	50.00±2.08	30.00±1.25	40.00±7.39	50.00±2.08	30.00±1.25	40.00±7.39	40.00±7.39 a
H	40.00±1.67	30.00±1.25	35.00±5.17	20.00±0.83	15.00±0.63	17.50±2.59	26.25±1.09 b
S	30.00±1.25	25.00±1.04	27.67±4.09	15.00±0.63	10.00±0.42	12.67±1.87	20.00±0.83 d
G	35.00±1.46	25.00±1.04	30.00±4.44	25.00±1.04	15.00±0.63	20.00±2.96	25.00±1.04 c
H+S	20.00±0.83	20.00±0.83	20.00±2.96	15.00±0.63	10.00±0.42	12.50±1.85	16.25±0.68 e
H+G	30.00±1.25	15.00±0.63	22.50±3.33	10.00±0.42	5.00±0.21	7.50±1.11	15.00±0.63 f
S+G	25.00±1.04	20.00±0.83	22.50±3.33	10.00±0.42	5.00±0.21	7.50±1.11	15.00±0.63 f
H+S+G	15.00±0.63	10.00±0.42	12.50±1.85	5.00±0.21	0.00±0.00	2.50±0.37	7.50±0.31 g
T Mean	Pre-emergence	24.69±1.03 a		Post-emergence	17.54±0.73 b		
App Mean	Soil application	17.93±0.75 a		Seed dressing	10.26±0.43 b		
LSD (0.05)							
Tr				0.29			
App				0.14			
T				0.14			
App. × Tr				0.34			
APP. × T				0.17			
Tr× T				0.34			
App. × Tr× T				0.47			

- Values are means of four replicates in each treatment ± SE.
- Means values in columns followed by the same letter are not significantly different (P ≤ 0.05).
- C: Control, H: Humic acid, S: Sulphur, G: Gypsum, H+S: Humic acid+Sulphur, H+G: Humic acid+Gypsum, S+G:Sulphur+Gypsum, H+S+G: Humic acid+Sulphur+Gypsum, Tr: Treatment, T: Time, App: Application.

TABLE 3. Effect of some chemical substances on root weight (g/plant) of peanut cv. Gregoryunder greenhouse conditions.

Treatments	Root weight(g/plant)		
	Soil application	Seed dressing	Mean
C	9.30 ±0.12	9.30±0.12	9.30±0.12 g
H	10.60± 0.13	12.80±0.16	11.70±0.15 e
S	11.30±0.14	11.50±0.15	11.40±0.14 f
G	12.80±0.16	14.50±0.18	13.65±0.17 c
H+S	15.20±0.19	13.70±0.17	14.45±0.18 b
H+G	12.80±0.16	13.60±0.17	13.20±0.17 d
S+G	14.00±0.18	15.30±0.19	14.65±0.19 b
H+S+G	16.10±0.20	15.90±0.20	16.00±0.20 a
App Mean	**12.76±0.16 b**	**13.33±0.17 a**	
L.S.D (0.05)			
Tr		**0.23**	
App		**0.12**	
Tr × App		**0.29**	

-Means values in columns followed by the same letter are not significantly different ($P \leq 0.05$).
-C: Control, H: Humic acid, S: Sulphur, G: Gypsum, H+S: Humic acid+Sulphur, H+G: Humic acid+Gypsum, S+G: Sulphur+Gypsum, H+S+G: Humic acid+Sulphur+Gypsum, App: Application, Tr: Treatment..

TABLE 4. Effect of some chemical substances on shoot weight (g/plant) of peanut cv. Gregoryunder greenhouse conditions.

Treatments	Shoot weight (g/plant)		
	Soil application	Seed dressing	Mean
C	18.90±0.63	18.90±0.63	18.90±0.63 h
H	23.70±0.79	23.60±0.79	23.65±0.79 g
S	21.00±0.70	28.30±0.94	24.65±0.82 f
G	25.20±0.84	26.80±0.89	26.00±0.87 e
H+S	26.40±0.88	28.20±0.94	27.30±0.91 d
H+G	30.80±1.03	29.80±0.99	30.30±1.01 b
S+G	28.60±0.95	27.10±0.90	27.85±0.93 c
H+S+G	33.30±1.11	36.70±1.22	35.00±1.17 a
App Mean	**25.99±0.87 b**	**27.43±0.91 a**	
L.S.D (0.05)			
Tr		**0.38**	
App		**0.23**	
Tr × App		**0.47**	

-Means values in columns followed by the same letter are not significantly different ($P \leq 0.05$).
-C: Control, H: Humic acid, S: Sulphur, G: Gypsum, H+S: Humic acid+Sulphur, H+G: Humic acid+Gypsum, S+G: Sulphur+Gypsum, H+S+G: Humic acid+Sulphur+Gypsum, App: Application, Tr: Treatment.

TABLE 5. Effect of some chemical substances on number of pods/plant of peanut cv. Gregoryunder greenhouse conditions.

Treatments	Number of pods/plant		
	Soil application	Seed dressing	Mean
C	8.00±0.32	8.00±0.32	8.00±0.32 e
H	10.00±0.40	12.00±0.48	11.00±0.44 c
S	9.00±0.36	8.00±0.32	8.50±0.34 e
G	10.00±0.40	13.00±0.52	11.50±0.46 c
H+S	11.00±0.44	11.00±0.44	11.00±0.44 c
H+G	10.00±0.40	14.00±0.56	12.00±0.48 b
S+G	10.00±0.40	12.00±0.48	11.00±0.44 c
H+S+G	13.00±0.52	15.00±0.60	14.00±0.56 a
App. mean	**10.13±0.41 b**	**11.63±0.47 a**	
L.S.D (0.05)			
Tr		**0.41**	
App		**0.21**	
Tr × App		**0.51**	

-Means values in columns followed by the same letter are not significantly different ($P \leq 0.05$).
-C: Control, H: Humic acid, S: Sulphur, G: Gypsum, H+S: Humic acid+Sulphur, H+G: Humic acid+Gypsum, S+G: Sulphur+Gypsum, H+S+G: Humic acid+Sulphur+Gypsum, App: Application, Tr: Treatment.

TABLE 6. Effect of some chemical substances on damping-off of peanut cv. Gregory under field conditions.

Treatment	Seed dressing				Soil application				Tr. Mean
	2015		2016		2015		2016		
	%Pre-emergence	%Post-emergence	%Pre-emergence	%Post-emergence	%Pre-emergence	%Post-emergence	%Pre-emergence	%Post-emergence	
C	40.00±2.01	35.00±1.76	42.00±2.11	30.00±1.51	40.00±2.01	35.00±1.76	42.00±2.11	30.00±1.51	36.75±1.85 a
H	27.00±1.36	20.00±1.01	28.50±1.43	9.50±0.48	12.50±0.63	7.25±0.36	19.00±0.96	10.00±0.50	16.72±0.84 c
S	18.00±0.91	10.00±0.50	17.00±0.86	7.00±0.35	8.50±0.43	3.50±0.18	12.00±0.60	10.00±0.50	10.75±0.54 e
G	30.00±1.51	14.00±0.70	26.50±1.33	17.50±0.88	15.50±0.78	6.50±0.33	22.50±1.13	15.50±0.78	18.50±0.93 b
H+S	13.00±0.65	6.00±0.30	16.00±0.81	6.00±0.30	7.00±0.35	4.00±0.20	13.00±0.65	7.00±0.35	9.00±0.45 f
H+G	20.00±1.01	8.50±0.43	19.00±0.96	7.00±0.35	8.50±0.43	5.00±0.25	16.50±0.83	8.50±0.43	11.63±0.59 d
S+G	18.50±0.93	6.50±0.33	17.50±0.88	6.50±0.33	8.00±0.40	4.00±0.20	19.00±0.96	12.00±0.60	11.50±0.58 d
H+S+G	10.00±0.50	5.00±0.25	10.50±0.53	4.00±0.20	4.00±0.20	3.50±0.18	10.50±0.53	3.50±0.18	6.38±0.32 g
App Mean	**Seed dressing**	**17.11±0.86 a**		**Soil application**	**13.24±0.67 b**				
S Mean	**2015 season**	**14.22±0.72 b**		**2016 season**	**16.14±0.81 a**				
T Mean	**Pre-emergence**	**19.15±0.96 a**		**Post-emergence**	**11.18±0.56 b**				
LSD (0.05)									
Tr					**0.22**				
App					**0.11**				
S					**0.11**				
T					**0.11**				
Tr×App					**0.16**				
Tr×S					**0.16**				
Tr×T					**0.16**				
App ×S					**0.06**				
App ×T					**0.06**				
S ×T					**0.06**				
Tr×app ×S					**0.23**				
Tr×app ×T					**0.23**				
App ×S ×T					**0.11**				
Tr×App ×S ×T					**0.32**				

-Values are means of four replicates in each treatment ± SE.
-Means values in columns followed by the same letter are not significantly different ($P \leq 0.05$).
-C: Control, H: Humic acid, S: Sulphur, G: Gypsum, H+S: Humic acid+Sulphur, H+G: Humic acid+Gypsum, S+G: Sulphur+Gypsum, H+S+G: Humic acid+Sulphur+Gypsum, Tr: Treatment, App: Application, S: Season, T: Time.

36.0% and 33.0% for seed dressing and soil application, respectively in 2016 growing season.

Significant differences were found for the weight of 100 pods/treatment (kg) in both growing seasons 2015 and 2016 (Table 7). The combination of humic, sulfur and gypsum exhibited the highest weight of 100 pods with values of 0.403 kg and 0.403 kg for soil amended and seed dressing, respectively followed by humic and gypsum with 0.388 and 0.379 kg, respectively. Contrarily, the non-treated control gave the lowest values for the weight of 100 pods exhibiting 0.285 and 0.293 kg for soil amended and seed dressing, respectively. These results are in accordance to those obtained by Chitkala and Reddy (1991), Ahmed and Osman (2003) and Kalaiyarasan *et al.* (2003).

Humic substances are mixtures of high-molecular organic compounds. They are created by natural processes in soil organic matter. The formation of defined humic substances depends on chemical soil properties that are determined by a parent material character, the soil forming process, direction, and climate. Humic substances have specific chemical structure and contain various functional groups that determine the role of the humus in the environment (Tolpa *et al.,* 1976). Thus, humic substances also influence the growth of plants including their germination and nourishment on the presence of microorganisms especially the phytopathogenic ones (Tolpa *et al.,* 1976; Abdel-Monaim *et al.,* 2011 and Abdel-Kader *et al.,* 2012).

Sulfur is a constituent of amino acids, such as cysteine and methionine. Thiamine, biotin, ferredoxines and coenzyme A are examples of S compounds. Protein also contains N and S. Therefore, S deficiency in plants results in lower contents of essential proteins and carbohydrate.

TABLE 7. Effect of some chemical substances on yield of peanut cv. Gregory under field conditions.

Treatments	100-pods weight (kg)						Tr Mean
	Soil application			Seed dressing			
	2015	2016	Mean	2015	2016	Mean	
C	0.2850±0.0011	0.3000±0.0012	0.293±0.066	0.2850±0.0011	0.3000±0.0012	0.293±0.066	0.293±0.066 g
H	0.3500±0.0014	0.3450±0.0014	0.348±0.055	0.3300±0.0013	0.3350±0.0013	0.333±0.058	0.3400±0.0014 e
S	0.3100±0.0012	0.3050±0.0012	0.308±0.062	0.3050±0.0012	0.3000±0.0012	0.303±0.063	0.3050±0.0012 f
G	0.3800±0.0015	0.3700±0.0015	0.375±0.051	0.3750±0.0015	0.3700±0.0015	0.373±0.052	0.3738±0.0015 c
H+S	0.3620±0.0014	0.3400±0.0014	0.351±0.055	0.3510±0.0014	0.3250±0.0013	0.338±0.057	0.3445±0.0014 e
H+G	0.3950±0.0016	0.3800±0.0015	0.388±0.050	0.3880±0.0016	0.3700±0.0015	0.379±0.05	0.3833±0.0015 b
S+G	0.3750±0.0015	0.3650±0.0015	0.370±0.052	0.3700±0.0015	0.3600±0.0014	0.365±0.053	0.3675±0.0015 d
H+S+G	0.4100±0.0016	0.3950±0.0016	0.403±0.048	0.4030±0.0016	0.4020±0.0016	0.403±0.048	0.4025±0.0016 a
S Mean	2015 Season	0.3546±0.0014 a	2016 Season	0.3546±0.0014 b			
App Mean	Soil application	0.3542±0.0014 a	Seed dressing	0.3525±0.0014 b			
L.S.D (0.05)							
Tr				0.0030			
S				0.0020			
App				0.0020			
Tr×S				0.0110			
Tr×App				0.0133			
S ×App				0.0067			
Tr×S ×App				0.0188			

-Values are means of four replicates in each treatment ± SE.
-Means values in columns followed by the same letter are not significantly different ($P \leq 0.05$).
-C: Control, H: Humic acid, S: Sulphur, G: Gypsum, H+S: Humic acid+Sulphur, H+G: Humic acid+Gypsum, S+G: Sulphur+Gypsum, H+S+G: Humic acid+Sulphur+Gypsum, Tr: Treatment, App: Application, S: Season.

Sulfur mainly comes from organic sources and acts as natural biocide as well as increases resistance of plants against pathogens. However, sulfur application significantly influenced the growth, yield attributing characters, yield and oil content over control regardless of the sources and levels of sulfur (Rao *et al.,* 2013).

In addition, results of the current study could be attributed to the role of calcium in building the cell walls of the plant tissues through the formation of calcium pectate, which is more resistant to pectic enzymes, which play an important role in pathogenesis. This finding is consistent with that of Chen and Huang (1992), who reported that the addition of gypsum reduced pod rots and improved the appearance and quality of peanut pods and thus its commercial value. Ismail and Abd El-Momen (2007) also obtained similar results.

Conclusions

Using the chemical substances (humic, sulfur and gypsum) as a combination in the form of a seed dressing or a soil application gave the highest reduction of *R. solani* incidence, damping-off on peanut cv. Gregory. Furthermore, seed dressing with these chemical substances was better form than the soil application in all treatments. Our results also indicated that these chemical substances was reflected in improving the growth characters in terms of the root and shoot weight as well increasing the pod yield as the number of pods/plant.

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