Efficacy of several chemical fungicides and biofungicides for controlling damping-off and root rot diseases in common bean under field conditions

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ABSTRACT

Fusarium solani, *Rhizoctonia solani*, *Pythium ultimum* and *Sclerotium rolfsii* cause different bean diseases under field conditions. This study aims to evaluate the efficacy of four chemical fungicides and three biofungicides against damping-off and root rot diseases in common bean. The four fungicides included Tendro 40% FS (carboxin+thiram), Maxim XL 3.5% FS (fludioxonil+metalaxyl-M), Hattric 6% FS (tebuconazole) and Rizolex-T 50% WP (tolclofos-methyl+thiram). While the used biofungicides included Rhizo-N [(30 million cell g^{-1}) (*Bacillus subtilis*)], Biocontrol T 34 12% WP (*Trichoderma asperellum*), and Plant Guard [(30 million cell ml^{-1}) (*Trichoderma harzianum*)]. Each kind if fungicide or biofungicides was used under two application rates. The results indicated that, chemical fungicides were more effective than the biofungicides, and all the tested compound particularly Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS that were significantly lower at pre- and post-emergence damping-off, rotted roots, increased survival plants and subsequently increase biological, seed and straw yields in comparison with the untreated control. All chemical fungicides particularly Hattric 6% FS reduced nodules number per plant. In contrast, the tested biofungicides increased nodules number per plant. In connection with the tested rates, all the tested compounds gave better results at their high application rates but accompanied with reduced the nodules number in case of chemical fungicides and increased nodules number in case of biofungicides.

Keywords: Common Bean, Damping-Off, Root Rot, Chemical Fungicides, Biofungicides.

INTRODUCTION

Bean (*Phaseolus vulgaris* L.) represents an important vegetable crop worldwide including Egypt and can be consumed as green pods or dry bean seeds (Ragab, *et al*., 2015). Common bean is one of the most important food legumes for direct human consumption. Such crop represents about 50% of the consumed legumes worldwide (Broughton *et al*. 2003; Graham *et al*., 2003). Bean plays an important role in human nutrition as a cheap source for protein, carbohydrates, unsaturated fatty acids, vitamins and minerals (Nassar *et al*. 2011; Beebe *et al*. 2013; Yunsheng *et al*. 2015; Ganesan and Xu 2017). The nutritional attributes of common bean make it a potential crop for improving the nutritional security of poor communities (Kator *et al*. 2016). In addition, bean is important in providing fodder for feeding livestock and it contributes to soil fertility improvement through atmospheric nitrogen fixation (Asfaw 2011; Ambachew *et al*. 2015; Abebe and Mekonnen 2019). In Egypt, common bean is one of the most important leguminous crops cultivated for local consumption and exportation. The total cultivated area of common bean in Egypt in 2018 reached 120729 feddans that yielded 122870 tons (Anonymous, 2018). Also, bean is known by many other names such as common bean (Abeysinghe, 2007; Mahamune and Kakde, 2011; Shehata, 2015 and Hussein *et al*., 2018), bean (Kataria *et al*., 2002; Sallam *et al*. 2008; El-Fiki *et al*. 2014; Ragab, *et al*. 2015), dry bean (Abd-El-Khair *et al*. 2019; Jacobs *et al*. 2019), French bean, Rajma (Hindi), haricot bean, snap bean, navy bean (Mahamune and Kakde, 2011; Yunsheng *et al*., 2015 and Mahmoud *et al*., 2018a), kidney bean (Mahamune and Kakde 2011; Abd El-Hai and Ali, 2018) and finally bean which commonly known in Egypt as Phasolia is a member of family Fabaceae (Nassar *et al*. 2011; Yunsheng *et al*. 2015).

Bean plants are exposed under greenhouse and field conditions to infection with several foliar and root fungal diseases at all its growth stages and these diseases can attack all plant parts *i.e.* roots, leaves, stems and pods (Graham and Ranalli, 1997; Mukankusi *et al*., 2010). Among this disease, damping-off and root rot diseases are serious and persistent problem for bean plants during growing season (Filion *et al.* 2003; Harveson *et al.* 2005; Wen *et al.* 2005; Ragab *et al.* 2015). Damping-off and root rot diseases are caused by several seed and soil-borne pathogenic fungi such as *Alternaria alternata*, *Fusarium solani*, *F. oxysporum*, *Pythium* spp., *Rhizoctonia solani* and *Sclerotium rolfsii* (El-Gamal, *et al*. 2003; Abeysinghe, 2007; El-Shami, 2008; Abd-El-Khair *et al.*, 2011; Mahmoud *et al*., 2013; Pena *et* *al*., 2013 and Abd-El-Khair *et al*., 2019). These pathogens act either individually or in a complex manner (Rusuku *et al*., 1997), and reduce seed germination, seedling emergence and final plant stand and cause great losses in yield of the affected plants (Mahmoud, 1985; Rizvi and Yang 1996; EL-Mougy 2001; Vinale *et al*. 2008; Valentin, 2010; Yaquelyn *et al.* 2010). Yield losses in several infested areas approached 50% (de Jensen *et al*. 2002).

Various methods were reported to control damping-off and root rot diseases in common bean. These methods including cultivate resistant varieties (Brisa *et al.* 2007; Obala *et al*. 2012), cultural practices (Abeysinghe 2007; Abawi and Widmer 2000; Toledo-Souza *et al*. 2012), plant extracts (Kumar and Tripathi 1991; Soliman *et al*. 2013), biological control agents (Sallam *et al*. 2008; Mahamune and Kakde 2011; El-Fiki *et al*. 2014; Riad *et al.* 2015; Hussein *et al*. 2018; Korayem *et al*. 2020) and the most effective method is chemical control (Theer 2012; Buts and Singh, 2014; Elshahawy *et al*. 2016; Kumar *et al*. 2019 and Korayem *et al*. 2020).

Therefore, the present work was conducted to evaluate the efficiency of four fungicides and three bioagents (BCAs) for controlling damping-off and root rot diseases of common bean under field conditions and their side effects on nodulation of rhizobium bacteria.

MATERIALS AND METHODS

The field experiments were performed in a private field naturally heavily infested with damping-off and root rot diseases of common bean, at Khaled Ibn El-Waleed Village, Badr Center, El-Behera Governorate, Egypt, during the two successive growing seasons of 2018 and 2019. Common bean (*Phaseolus vulgaris* L.) seeds, cv. Giza 6 were obtained from the Department of Legume Crop Research, Field Crop Research Institute, Agricultural Research Center (ARC), Ministry of Agriculture and Land Reclamation, Egypt. *Rhizobium leguminosarum* biovar *phaseoli* was obtained from Bio-fertilizer Lab, Water and Soil Research Institute, Agricultural Research Center (ARC).

Four fungicides and three biofungicides were used in this study (Table, 1).

The experiments were designed as a randomized complete block design (RCBD) with three replicates for each treatment as well as untreated control. The experimental area of each plot was 21 m^2 (4.2 × 5m). Each plot comprised of eight rows and 42 holes row^{-1}. Common bean seeds were treated with the tested fungicides at the recommended and half recommended rates (Table 1), according to the method described by Metwaly *et al*. (2006). The candidate amount of the tested fungicides was thoroughly mixed with common bean seeds in plastic bags with 3 mL of Arabic gum solution (1%) as sticker and shaked for 10 min to insure uniform coverage of seeds with the tested rates. Treated seeds were then allowed to dry at room temperature for 24h before sowing. Just before sowing, the seeds were inoculated by *Rhizobium leguminosarum* biovar *phaseoli* at the rate 10 g.kg^{-1} seed. The inoculum was added and thoroughly mixed with the seeds and during the mixing process 3mL of Arabic gum solution (1 %) was added to ensure their surfaces were uniformly coated and adhere with inoculum. Seeds treated with *Rhizobium* alone were used as control. Treated and untreated seeds were sown at the rate of 2 seeds.holes^{-1} at 10 cm apart to comprise a total of 672 seeds plot^{-1} in Sep. 9, 2018 and Sep.12, 2019 during both growing seasons, respectively. The recommended cultural practices for bean production were adopted throughout growing seasons in this district.

During the growing seasons, we recorded the different measurements, including number of pre-emergence damping-off [15 days after sowing (DAS) (Ragab *et al*., 2015)]; number of post-emergence damping-off [45 DAS (Ragab *et al*. 2015)]; number of infected plants by rotted roots [60 DAS (Soliman *et al*. 2013)]; number of survival (healthy) plants [60 DAS (Soliman *et al*. 2013)]; number of nodules per plant (at the flowering stage, five plants were uprooted from each plot and washed gently with water and the nodules on every plant root system were counted) according to Elkoca *et al*. (2010).

In both seasons, the plants were harvested after 100 days from sowing and left to dry in the field for 15 days, then, the following characters were determined:

Biological yield included (weight of all plants kg.plot^{-1}), seed yield (kg plot^{-1}), and straw yield (kg plot^{-1}).

Statistical analysis:

The obtained results were statistically analyzed by analysis of variance (ANOVA) according to Gomez and Gomes (1984), and L.S.D values were obtained at 0.01 and 0.05.

RESULTS AND DISCUSSION

Effect of seed treatments on damping-off, root rot and survival plants.

The data presented in Tables (2 and 3) showed the effect of treatments on pre- and post-emergence damping-off, rotted rots and survival plants. Generally, all treatments, at any rate of application in both seasons 2018 and 2019, significantly (*P= 0.05*) reduced the number of pre- and post-emergence damping-off, rotted rots and increased survival plants in comparison with the untreated control. The chemical treatments were significantly better than the biological treatments in both seasons. Among the tested fungicides, Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS were the most effective in reducing the number of pre- and post-emergence damping-off, rotted roots and consequently increasing survival (healthy) plants. On the other hand, Plant guard was the least effective in this respect, while other fungicides showed an intermediate effect, and the results were similar in both seasons. For example, when Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS were applied at recommended rate (3g, 3.5 cm^3 and 1 cm^3 kg^{-1} seeds, respectively) the number of pre-emergence damping-off recorded 23.67, 24.67 and 32.00 plants $plot^{-1}$ in the first season and 19.67, 22.33 and 34.00 plants $plot^{-1}$ in the second season, respectively, while the corresponding values with the Plant guard at the highest rate of application (2.5 cm^3 kg^{-1} seeds) were 110.00 and 104.33 plants $plot^{-1}$ comparing with those in the control (201.67 and 193.33, plants $plot^{-1}$, respectively). Hattric 6% FS, Rhizo-N and Biocontrol T 34 12% WP at recommended rate (1 cm^3, 4g and 2g kg^{-1} seeds, respectively) gave 50.67, 66.33 and 83.33 plants $plot^{-1}$ in the first season and 46.00, 62.67 and79.33 plants $plot^{-1}$ in the second season, respectively, indicating that these fungicides have an intermediate effect. For the number of post-emergence damping-off, the same trend was observed in both seasons as that Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS at recommended rate (3g, 3.5 cm^3 and 1 cm^3 kg^{-1} seeds, respectively), recorded values of 19.33, 22.00 and 27.67 plants $plot^{-1}$ in the first season and 14.67, 17.67 and 23.33 plants $plot^{-1}$ in the second season, respectively, compared with those in the control (141.67 and 135.67), while Plant guard gave 97.67 and 93.00 plants $plot^{-1}$ in both seasons, respectively. In the case of the number of rotted roots, results indicated that Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS at recommended rate (3g, 3.5 cm^3 and 1 cm^3 kg^{-1} seeds, respectively) recorded 7.67, 9.33 and 16.00 plants $plot^{-1}$ in the first season and 4.33, 5.67 and 13.00 plants $plot^{-1}$ in the second season, respectively, in comparison with those in the control which gave 102.00 and 97.00 plants $plot^{-1}$ during both seasons, respectively. Concerning the number of survival plants, results showed that Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS were the most effective fungicides. These fungicides at recommended rate (3 g, 3.5 cm^3 and 1 cm^3 kg^{-1} seeds, respectively) increased the survival plants to 621.33, 616.00 and 596.33 plants $plot^{-1}$ in the first season and 633.33, 627.33 and 601.67 plants $plot^{-1}$ in the second season comparing to those of control (226.67 and 246.00 plants $plot^{-1}$), respectively.

Generally, the recommended rates of treatments significantly (*P= 0.05*) decreased the number of pre- and post-emergence damping-off, rotted roots and subsequently increased the number of survival plants in comparison with half rate. However, certain exceptions were recorded. For example, no significant differences were observed between the effects of half recommended and the recommended rates (1.75 and 3.5 cm^3 kg^{-1} seeds) of Tendro 40% FS against pre-emergence damping-off, which recorded 25.33 and 22.33 plants $plot^{-1}$ in the second season (Table, 3) and Rizolex-T 50% WP at the same rates of application (1.5 and 3 g kg^{-1} seeds) in case of pre- and post-emergence damping-off, rotted roots and survival plants during both seasons (Tables 2 and 3).

The high efficacy of Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS in reducing pre-emergence, post emergence damping-off and root rot diseases may be due to the high activity of these fungicides on fungal pathogens of the seed and root rot diseases including genera of *Fusarium*, *Sclerotium*, *Pythium* and *Rhizoctonia*. Efficiency of tested fungicides for controlling damping-off and root rot diseases in the present study are consistent with those described by several authors. Kataria *et al*. (2002) found that treatment of bean seeds with tebuconazole and tolclofos-methyl resulted in maximum protection to bean seedlings against pre- and post-emergence damping-off and yielded healthy seedling stands up to > 90 %. Theer (2012) recorded that pre- and post-emergence damping-off caused by *Rhizoctonia solani* and *Fusarium oxysporum* significantly decreased by using seed dressing fungicides (Rhizolex-T, Topsin-M and Basten). Mahmoud *et al*. (2018 b) found that Rizolex-T and Moncut were the most effective fungicides in reducing the percentages of pre- and post-emergence damping-off caused by *F. solani* and *R. solani* in faba bean.

On the other hand, several mechanisms were suggested to explain the role of biocontrol agent as antagonistic organisms in suppression phytopathogenic fungi and controlling diseases. Their action could be occurred through mycoparasitism (Haran *et al.,* 1996; Viterbo *et al*. 2002; Pierre *et al*., 2016) competition for nutrients and space (Inbar *et al.* 1994), production of antibiotics, stimulate plants for producing chemical defenses compounds, induced systemic resistance in plants (Ghisalberti and Rowland, 1993; Howell *et al.* 2000; Morsy *et al.* 2005) and produced extracellular enzymes such as proteases, chitinases, glucanases,b-1-3-glucanase, protease and lipase (Chet and Inbar 1994; Harman 2006; Fernando *et al.* 2007). The obtained results are in agreement with those obtained by several researchers. El-Fiki *et al*. (2014) reported that treatment of bean seeds with *Trichoderma harzianum*, *T. viride, Bacillus subtilis* and *Pseudomonas fluorescens* at the different rates of 2, 4 and 8 g kg^{-1} seeds reduced the incidence of pre- and post-emergence damping off and increased crop parameters under greenhouse conditions in comparison to the control. Sowing coated bean seeds with *Bacillus megaterium, B. subtilis, Pseudomonas fluorescens*, *Serratia marcescens, Trichoderma album, T. harzianum, T. lignorum* and *T. viride* significantly reduced the incidence of pre- and post-emergence damping- off with significant increase in the fresh and dry weight of roots and shoots compared with control treatment (Ahmed 2016). Also, Abd-El-Khair *et al.* (2019) found that *T. harzianum, T. viride,* and *T. virens* significantly reduced the incidence of damping-off, root rot, wilt diseases and increased the percentage of survival bean plants under greenhouse and field conditions.

Side effect of seed treatments on nodulation number of rhizobium bacteria in common bean.

Data illustrated in Table (4) clearly indicated that, all the tested chemical fungicides, particularly Hattric 6% FS significantly (*P=0.05*) reduced the number of nodules per plant compared with the untreated control, except for Maxim XL 3.5% FS (at both rate of application) in the first season and at half recommended rate in the second season. Also, insignificant reduction in nodules number $plant^{-1}$ in both seasons was found when Rizolex-T 50% WP was used at half recommended rate. On the contrary, biofungicides significantly (*P= 0.05*) increased the number of nodules per plant compared with the untreated control, with the exception of Plant guard which exhibited insignificant effect at half recommended rate in the first season and at both rates in the second season. These results were similar in the two consecutive growing seasons 2018 and 2019. For example, Hattric 6% FS at recommended rate (1cm^3 kg^{-1} seeds) reduced the number of nodules per plant to 2.80 and 4.00 during both seasons respectively, while Rhizo-N at recommended rate (4g kg^{-1} seeds) increased the number of nodules per plant to 28.03 and 30.40 during both seasons, comparing with those of the control (20.73 and 22.93), respectively.

Results indicated that, recommended rate of chemical fungicides significantly (*P= 0.05*) reduced the number of nodules per plant compared with the half recommended rate, with the exception of Maxim XL 3.5% FS at half recommended and recommended rates, that was insignificant during the two tested seasons. For example, significant differences were observed between the effects of the half recommended and recommended rates (1.75 and 3.5 cm^3 kg^{-1} seeds) of Tendro 40% FS on number of nodules per plant, which recorded 15.83 and 13.80 in the first season and 18.70 and 15.73 in the second season, respectively. In contrast, all biofungicides at recommended rate significantly (*P= 0.05*) increased the number of nodules per plant, except for Plant guard at half recommended and recommended rates resulted insignificant differences in the second season.

The harmful effect of chemical fungicides on rhizobium bacteria may be due to these fungicides disrupt the signaling between plants and rhizobia by blocking the communication between plant derived phytochemicals and *Rhizobium* Nod D receptors that plays an important role in initiating nodulation leading to a successful N_2 fixation (Fox *et al*. 2007). Also, fungicides reducing the inoculation viability, death of rhizobium cells, altering the root exudate composition and consequently acts on the molecular signals to the bacteria and alters the bacterial morphology and physiology (Andrés *et al*. 1998 and Dunfield *et al*. 2000). On the other hand, the nodulation on the roots of bean plants treated with biocontrol agents were increased may be due to stimulate the growth of *Rhizobium phaseoli* (Smith, 1996; Baraka *et al*. 1998). Biocontrol agents such as *Trichoderma* spp. and *Bacillus* spp. increased number of nodules (Ragab, *et al*. 2015; Baraka *et al*. 1998; El-Dabaa *et al*. 2019).

The negative effects of fungicides on nodulation were observed by (Ahmed, 1997) who cited that Rizolex T at rates 3 kg seeds^{-1} reduced the number of nodules in groundnut. Zilli *et al*. (2009) found that carbendazim + thiram and carboxin + thiram reduced soybean nodulation. Kintschev *et al*. (2014) reported that carbendazim + thiram (Product A), carbendazim + thiram (Product B), carboxin + thiram, fludioxonil + metalaxyl-M and fludioxonil + metalaxyl-M + thiabendazole led to a reduction in the nodulation of bean plants, especially for nodular mass.

Effect of seed treatments on some agronomic traits of common bean.

The data in Tables (5 and 6) indicated the effect of chemical and biological seed treatments on biological yield, seed yield and straw yield during the two tested seasons (2018 and 2019). These results showed that all treatments, at any rate of applications, were significantly (*P*= *0.05*) increased biological yield, seed yield and straw yield in comparison with the untreated control during both seasons. As stated previously with other evaluation parameters, Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS were the most effective fungicides in this respect whereas Plant guard was the lowest effective one. For example, the application of Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS at recommended rate (3g, 3.5 cm^3 and 1 cm^3 kg^{-1} seeds, respectively) resulted in biological yield values 11.15, 10.97 and 10.43 kg plot^{-1} in the first season and 11.75, 11.55 and 10.87 kg plot-^{1} in the second season, respectively, whereas the corresponding biological yield values of Plant guard were 6.15 and 6.53 kg plot^{-1}. On the other hand, the corresponding seed yield values of the same fungicides at the same application rate were 5.70, 5.62 and 5.43 kg plot-^{1} in the first season and 6.05, 6.00 and 5.62 kg plot^{-1} in the second season, respectively, while those of Plant guard were 3.35 and 3.48 kg plot^{-1}.

Regarding the examined rates of fungicides, and as expected, recommended rate significantly (*P* = *0.05*) increment biological yield, seed yield and straw yield compared with half rate. For example, Hattric 6% FS at 0. 5 and 1 cm^3 kg^{-1} seeds significantly increased biological yield values from 8.42 to 9.40 kg plot^{-1} in the first season and from 8.70 to 9.70 kg plot^{-1} in the second season, respectively, while seed yield values were 4.42 and 4.95 kg plot^{-1} in the first season and 4.50 and 5 kg plot^{-1} in the second season, respectively. In addition, the same fungicide at the same rates of application significantly increased straw yield values from 4.00 to 4.45 kg plot^{-1} in the first season and from 4.20 to 4.70 kg plot^{-1} in the second season, respectively. Generally, chemical fungicides gave biological yield, seed yield and straw yield better than the bioagents and this may be resulted from the efficacy of these compounds in controlling damping-off and root rot diseases than bioagent compounds. Also, these results suggested that, most fungicides were more effective than bioagents (BCAs). These results are in agreement with those obtained by several authors. Shehata (2015) found that treatment common bean seeds with Rhizolex-T reduced percentage of pre- and post-emergence damping-off, increased the percentage of healthy survival plants and significantly increased number of pods/plant and seed yield compared with untreated control. Under field conditions highest reduction in the diseases incidences and increases in the percentages of bean yield (number and weight of pods plant^{-1} and dry weight of 100 seeds) were induced by *T. harzianum,* followed by *T. viride* when used as seed treatment (El-Fiki *et al*. 2014). Also, Abd-El-Khair *et al.* (2019) reported that *T. harzianum, T. viride* and *T. virens* increased yield components of the survival dry bean plants.

Conclusion

In conclusion, the fungicides (Rizolex-T 50% WP, Tendro 40% FS and Maxim XL 3.5% FS) were significantly reduced pre- and post-emergence damping-off, rotted roots, increased survival plants and subsequently increase biological, seed and straw yields. Regardless the examined fungicide, and as expected, the higher rate of application were more effective than the law rate in controlling damping-off and root rot diseases in common bean and recorded higher seed yield. Also, chemical fungicides were more effective than biofungicides. Regarding the effect of seed treatments on nodulation number of rhizobium bacteria in common bean, all chemical fungicides particularly Hattric 6% FS reduced nodules number per plant. In contrast, the tested biofungicides increased nodules number per plant.

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Table 1. The tested chemical fungicides and biofungicides.

Item Trade names	Common names	Rate of application (g. or cm^3 kg^{-1} seeds	Sources
Fungicides			
Tendro 40% FS	Carboxin+thiram	1.75 and 3.5 cm^3	Shoura Chemicals Company
Maxim XL 3.5% FS	Fludioxonil+metalaxyl-M	0.5 and 1 cm^3	Syngenta Company
Hattric 6% FS	Tebuconazole	0.5 and 1 cm^3	Starchem Company
Rizolex-T 50% WP	Tolclofos-methyl+thiram	1.5 and 3 g.	Kafr El-Zayat for Pesticides and Chemicals Company
Biofungicides			
Rhizo- N (30×10^6 cell / g) powder	*Bacillus subtilis*	2 and 4 g.	Biotech Company for Fertilizers and Biocides.
Biocontrol T 34 12% WP (1×10^9 spores / g)	*Trichoderma asperellum*	1 and 2 g	Shoura Chemicals Company
Plant guard (30×10^6 spores / mL) liquid	*Trichoderma harzianum*	1.25 and 2.5 cm^3	Biotech Company for Fertilizers and Biocides.

Table 2. Effect of treatments on pre- and post- emergence damping-off, rotted roots and survival plants of common bean under field conditions during season (2018).

Treatments	Rates of application (g or cm³ kg⁻¹ seeds)	Damping-off				Rotted roots***		Survival plants****	
		Pre*		Post **					
		Mean	Reduction %	Mean	Reduction %	Mean	Reduction %	Mean	Increase %
Carboxin+thiram (Tendro 40% FS)	1.75 cm³	33.67	83.30	23.67	83.29	12.33	87.91	602.33	62.37
	3.50 cm³	24.67	87.77	22.00	84.47	9.33	90.85	616.00	63.20
Fludioxonil+metalaxyl-M (Maxim XL 3.5% FS)	0.50 cm³	45.67	77.35	38.33	72.94	21.00	79.41	567.00	60.02
	1.00 cm³	32.00	84.13	27.67	80.47	16.00	84.31	596.33	61.99
Tebuconazole (Hattric 6% FS)	0.50 cm³	76.33	62.15	68.67	51.53	41.33	59.48	485.67	53.33
	1.00 cm³	50.67	74.87	46.67	67.06	33.33	67.32	541.33	58.13
Tolclofos-methyl+thiram (Rizolex-T 50% WP)	1.50 g	25.33	87.44	21.67	84.70	10.33	89.87	614.67	63.12
	3.00 g	23.67	88.26	19.33	86.36	7.67	92.48	621.33	63.52
Bacillus subtilis (Rhizo-N)	2.00 g	95.00	52.89	88.00	37.88	62.67	38.56	426.33	46.83
	4.00 g	66.33	67.11	63.33	55.30	56.33	44.77	486.00	53.36
Trichoderma asperellum (Biocontrol T 34 12% WP)	1.00 g	115.00	42.98	104.67	26.12	72.33	29.09	380.00	40.35
	2.00 g	83.33	58.68	74.33	47.53	68.00	33.33	446.33	49.22
Trichoderma harzianum (Plant guard)	1.25 cm³	139.00	31.08	121.00	14.59	90.67	11.11	321.33	29.46
	2.50 cm³	110.00	45.46	97.67	31.06	85.33	16.34	379.00	40.20
Control	--------	201.67	--------	141.67	--------	102.00	0.00	226.66	--------

*Mean number of pre-emergence damping-off 15 days after sowing (DAS).,**Mean number of post-emergence damping-off 45 DAS.,***Mean number of infected plants by rotted roots 60 DAS.,****Mean number of survival (healthy) plants 60 DAS

	Pre		Post		Rotted roots		Survival plants	
L.S.D. at =	1%	5%	1%	5%	1%	5%	1%	5%
Treatments (T.) =	12.48	9.29	20.35	15.14	6.68	4.97	24.46	18.19
Rates (R.) =	6.24	4.64	10.18	7.57	3.34	2.48	12.23	9.10
T. × R. =	17.66	13.13	28.78	21.41	9.45	7.03	34.59	25.73

Table 3. Effect of treatments on pre- and post- emergence damping-off, rotted roots and survival plants of common bean under field conditions during season (2019).

Treatments	Rates of application (g or cm³ kg⁻¹ seeds)	Damping-off Pre* Mean	Pre* Reduction %	Post** Mean	Post** Reduction %	Rotted roots*** Mean	Rotted roots*** Reduction %	Survival plants**** Mean	Survival plants**** Increase %
Carboxin+thiram	1.75 cm³	25.33	86.90	20.00	85.26	9.00	90.72	617.67	151.09
(Tendro 40% FS)	3.50 cm³	22.33	88.45	17.67	86.98	5.67	94.15	627.33	155.01
Fludioxonil+metalaxyl-M	0.50 cm³	42.67	77.93	34.00	74.94	18.00	81.44	577.33	134.69
(Maxim XL 3.5% FS)	1.00 cm³	34.00	82.41	23.33	82.80	13.00	86.60	601.67	144.58
Tebuconazole	0.50 cm³	71.00	63.28	65.00	52.09	36.00	62.89	500.00	103.25
(Hattric 6% FS)	1.00 cm³	46.00	76.21	50.00	63.15	29.00	70.10	547.00	122.36
Tolclofos-methyl+thiram	1.50 g	22.00	88.62	16.67	87.71	6.33	93.47	627.00	154.88
(Rizolex-T 50% WP)	3.00 g	19.67	89.83	14.67	89.19	4.33	95.54	633.33	157.45
Bacillus subtilis	2.00 g	89.00	53.96	83.33	38.58	59.00	39.18	440.67	79.13
(Rhizo-N)	4.00 g	62.67	67.58	58.00	57.25	52.00	46.39	499.33	102.98
Trichoderma asperellum	1.00 g	108.33	43.97	108.00	20.40	69.00	28.87	386.67	57.18
(Biocontrol T 34 12% WP)	2.00 g	79.33	58.97	76.00	43.98	64.33	33.68	452.33	83.87
Trichoderma harzianum	1.25 cm³	129.67	32.93	117.33	13.52	85.33	12.03	339.67	38.08
(Plant guard)	2.50 cm³	104.33	46.04	93.00	31.45	81.67	15.80	393.00	59.76
Control	--------	193.33	--------	135.67	--------	97.00	--------	246.00	--------

*Mean number of pre-emergence damping-off 15 days after sowing (DAS).
**Mean number of post-emergence damping-off 45 DAS.
***Mean number of infected plants by rotted roots 60 DAS.
****Mean number of survival (healthy) plants 60 DAS.

	pre 1%	pre 5%	Post 1%	Post 5%	Rotted roots 1%	Rotted roots 5%	Survival plants 1%	Survival plants 5%
L.S.D. at =								
Treatments (T.) =	9.57	7.12	19.83	14.75	6.22	4.63	16.92	12.58
Rates (R.) =	4.78	3.56	9.91	7.37	3.11	2.32	8.46	6.35
T. × R. =	13.53	10.06	28.04	20.86	8.80	6.55	23.92	17.79

Table 4. Effect of treatments on numbers of nodules per plant of common bean under field conditions during seasons 2018 and 2019.

Treatments	Rates of application (g or cm^3 kg^{-1} seeds)	seasons 2018	seasons 2019
		*nodules number $plant^{-1}$	nodules number $plant^{-1}$
Carboxin+thiram	1.75 cm^3	15.83	18.70
(Tendro 40% FS)	3.50 cm^3	13.80	15.73
Fludioxonil+metalaxyl-M	0.50 cm^3	20.23	21.00
(Maxim XL 3.5% FS)	1.00 cm^3	19.83	20.07
Tebuconazole	0.50 cm^3	5.47	6.03
(Hattric 6% FS)	1.00 cm^3	2.80	4.00
Tolclofos-methyl+thiram	1.50 g	18.73	20.70
(Rizolex-T 50% WP)	3.00 g	15.87	18.67
Bacillus subtilis	2.00 g	24.33	26.77
(Rhizo-N)	4.00 g	28.03	30.40
Trichoderma asperellum	1.00 g	23.20	25.53
(Biocontrol T 34 12% WP)	2.00 g	25.00	28.37
Trichoderma harzianum	1.25 cm^3	21.83	23.67
(Plant guard)	2.50 cm^3	23.10	24.07
Control	--------	20.73	22.93

L.S.D. at =	1%	5%	1%	5%
Treatments (T.) =	2.91	2.16	3.46	2.58
Rates (R.) =	1.45	1.08	1.73	1.29
T. × R. =	4.11	3.06	4.90	3.64

*Nodules number $plant^{-1}$ resulted from 5 plants collected randomly from each replicate at the flowering stage.

Table 5. Effect of treatments on biological yield, seed yield and straw yield of common bean under field conditions during season (2018).

Treatments	Rates of application (g or cm^3 kg^{-1} seeds)	Biological yield ($kg\ plot^{-1}$)		Seed yield ($kg\ plot^{-1}$)		Straw yield ($kg\ plot^{-1}$)	
		Mean	YOC %	Mean	YOC %	Mean	YOC %
Carboxin+thiram (Tendro 40% FS)	1.75 cm^3	10.63	65.66	5.48	62.59	5.15	68.93
	3.50 cm^3	10.97	66.73	5.62	63.52	5.35	70.09
Fludioxonil+metalaxyl-M (Maxim XL 3.5% FS)	0.50 cm^3	9.65	62.18	5.17	60.35	4.48	64.29
	1.00 cm^3	10.43	65.00	5.43	62.25	5.00	68.00
Tebuconazole (Hattric 6% FS)	0.50 cm^3	8.42	56.65	4.42	53.62	4.00	60.00
	1.00 cm^3	9.40	61.17	4.95	58.59	4.45	64.04
Tolclofos-methyl+thiram (Rizolex-T 50% WP)	1.50 g	10.83	66.30	5.58	63.26	5.25	69.52
	3.00 g	11.15	67.26	5.70	64.04	5.45	70.64
Bacillus subtilis (Rhizo-N)	2.00 g	7.23	49.52	3.88	47.16	3.35	52.24
	4.00 g	8.30	56.02	4.35	52.87	3.95	59.49
Trichoderma asperellum (Biocontrol T 34 12% WP)	1.00 g	6.47	43.59	3.47	40.92	3.00	46.67
	2.00 g	7.65	52.29	4.05	49.38	3.60	55.56
Trichoderma harzianum (Plant guard)	1.25 cm^3	4.85	24.74	2.85	28.07	2.00	20.00
	2.50 cm^3	6.15	40.65	3.35	38.81	2.80	42.86
Control	--------	3.65	--------	2.05	--------	1.60	--------

Biological yield = weight of all plants in each plot ($kg\ polt^{-1}$)
Seed yield = weight of seeds in each plot ($kg\ polt^{-1}$)
Straw yield = weight of straw in each plot ($kg\ polt^{-1}$)
YOC % = yield over control (treatment – control / treatment $\times$100)

	Biological yield		Seed yield		Straw yield	
L.S.D. at =	1%	5%	1%	5%	1%	5%
Treatments (T.) =	0.66	0.49	0.31	0.23	0.39	0.29
Rates (R.) =	0.33	0.25	0.16	0.12	0.20	0.15
T. × R. =	0.93	0.69	0.44	0.33	0.55	0.41

Table 6. Effect of treatments on biological yield, seed yield and straw yield of common bean under field conditions during season (2019).

Treatments	Rates of application (g or cm^3 kg^{-1} seeds)	Biological yield ($kg\ plot^{-1}$)		Seed yield ($kg\ plot^{-1}$)		Straw yield ($kg\ plot^{-1}$)	
		Mean	YOC %	Mean	YOC %	Mean	YOC %
Carboxin+thiram (Tendro 40% FS)	1.75 cm^3	11.07	63.87	5.72	62.41	5.35	65.42
	3.50 cm^3	11.55	65.37	6.00	64.17	5.55	66.67
Fludioxonil+metalaxyl-M (Maxim XL 3.5% FS)	0.50 cm^3	10.05	60.20	5.35	59.81	4.70	60.64
	1.00 cm^3	10.87	63.20	5.62	61.74	5.25	64.76
Tebuconazole (Hattric 6% FS)	0.50 cm^3	8.70	54.02	4.50	52.22	4.20	55.95
	1.00 cm^3	9.70	58.76	5.00	57.00	4.70	60.64
Tolclofos-methyl+thiram (Rizolex-T 50% WP)	1.50 g	11.40	64.91	5.90	63.56	5.50	66.36
	3.00 g	11.75	65.96	6.05	64.46	5.70	67.54
Bacillus subtilis (Rhizo-N)	2.00 g	7.53	46.88	3.98	45.98	3.55	47.89
	4.00 g	8.58	53.38	4.43	51.47	4.15	55.42
Trichoderma asperellum (Biocontrol T 34 12% WP)	1.00 g	6.75	40.74	3.55	39.44	3.20	42.19
	2.00 g	7.87	49.17	4.12	47.82	3.75	50.67
Trichoderma harzianum (Plant guard)	1.25 cm^3	5.15	22.33	2.93	26.62	2.22	16.67
	2.50 cm^3	6.53	38.74	3.48	38.22	3.05	39.34
Control	--------	4.00	--------	2.15	--------	1.85	--------

Biological yield = weight of all plants in each plot (kg $polt^{-1}$)
Seed yield = weight of seeds in each plot (kg $polt^{-1}$)
Straw yield = weight of straw in each plot (kg $polt^{-1}$)
YOC % = yield over control (treatment – control / treatment

		Biological yield		Seed yield		Straw yield	
L.S.D. at	=	1%	5%	1%	5%	1%	5%
Treatments (T.)	=	0.35	0.26	0.23	0.17	0.22	0.16
Rates (R.)	=	0.17	0.13	0.11	0.09	0.11	0.08
T. × R.	=	0.49	0.36	0.32	0.24	0.31	0.23

فاعلية بعض مبيدات الفطريات الكيماوية والحيوية فى مكافحة مرضى موت البادرات وعفن الجذور فى الفاصوليا تحت ظروف الحقل

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الملخص العربى

أجريت التجارب الحقلية فى قرية خالد بن الوليد، مدينة بدر، محافظة البحيرة وذلك لتقييم فاعلية أربعة من مبيدات الفطريات الكيماوية وثلاثة من المركبات الحيوية لمكافحة مرضى موت البادرات وعفن الجذور فى الفاصوليا والتى تسببها فطريات الفيوزاريوم سولانى، الريزوكتونيا سولانى، البثيوم التيمم والأسكليروشيوم رولفساى فى الحقل وذلك خلال موسمي 2018 و2019 .كانت مبيدات الفطريات المستخدمة هى هاتريك 6% FS وماكسيم اكس ال 3,5% FS وريزولكس تى 50%WP وتندرو 40% FS والمركبات الحيوية هى بيوكنترول تى 34 وبلانت جارد وريزو ان. وتم إجراء كل معاملة سواء للمبيدات الكيماوية أو المركبات الحيوية باستخدام معدلين للتطبيق. أوضحت النتائج أن المبيدات الكيماوية كانت فعالة أكثر من المبيدات الحيوية وكانت جميع المبيدات المستخدمة وبصفة خاصة الريزولكس تى والتندرو والماكسيم اكس ال كانت معنوية فى خفض موت البادرات قبل وبعد الإنبثاق وكذلك عدد النباتات المصابة بأعفان الجذور وزادت عدد النباتات السليمة. ونتج عن هذة المكافحة زيادة المحصول البيولوجى ومحصول البذور ومحصول القش مقارنتة بالكنترول الغير معامل. وعموماً أوضحت النتائج أن جميع المبيدات الكيماوية وخصوصاً مبيد هاتريك قد سبب خفض فى عدد العقد البكتيرية، وعلى النقيض من ذلك فإن جميع المبيدات الحيوية قد زادت من عدد العقد البكتيرية. كما أوضحت النتائج ايضاً أن جميع المبيدات المختبرة أعطت نتائج فى المكافحة أفضل فى المعدلات العالية عن المعدلات الأقل وعموما كانت مبيدات الفطريات الكيماوية أحسن من المبيدات الحيوية فى مكافحة مرضى موت البادرات وعفن الجذور على الفاصوليا. وبناء عليه يمكن استخلاص أن .....

الكلمات الاسترشادية: الفاصوليا، موت البادرات، عفن الجذور، مبيدات الفطريات، والمركبات الحيوية.