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ORIGINAL PAPER

Performance of Safe Treatments in Controlling Some Soil Diseases of Peanut

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ABSTRACT

Effect of Parnof (*Pluchea dioscoridis*) and Zyzafon (*Tilia cordata*) water extracts, potassium chloride and salicylic acid, on inhibiting damping-off, root and pod-rot diseases on peanut plants in greenhouse and field was evaluated as seed treatment followed by foliar spraying 35 days after planting. Under greenhouse and field conditions, all treatments reduced target diseases and increased peanut pod yield. Salicylic acid at 5 mM showed the superior effect on all plant parameters in two growing seasons. While, the rest of other treatments alternated between each other in terms of increase and decrease in the efficiency of preventing the diseases under study. Furthermore, in treated plants, all treatments increased accumulation of phenolic compounds and activity levels of oxidative enzymes (catalase, peroxidase, and polyphenoloxidase) compared to untreated plants. Also, new protein bands, may including pathogenesis-related proteins were found in treated peanut plants with electrophoretic analysis. Therefore, our research offers valuable insights into the potential of the inducers, antioxidants, and plant extracts in reducing peanut diseases and presents features that show promise for a strategy of disease control in peanut production.

Keywords: Damping-off, Parnof, peanut, pod-rot, potassium chloride, root-rot, salicylic acid and Zyzafon.

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1- INTRODUCTION

Oil crops play a pivotal role in the Egyptian agricultural landscape, holding significant importance in the country's economy. However, these crops face numerous challenges that have led to a decline in their overall production. Peanut areas are affected in some years because of some difficulties such as deficiency of peanut cultivated areas as well as diseases

that affect production in quantity and quality. Peanut is good for cultivation in sandy and light yellow soils, which may not be suitable for cultivation with other field crops. Average peanut area in Egypt during the last ten years (2012-2022) was about 160000 feddans (Anonymous 2022). Damping-off, root and pod-rot are common diseases worldwide. These diseases affect peanut plants with considerable severity due to the activity of numerous soil-borne pathogens, including *Macrophomina phaseolina, Sclerotium* spp., *Rhizoctonia solani* and *Fusarium* spp.

Parnof (*Pluchea dioscoridis* L.) DC. formerly known as *Conyza dioscoridis* L. Desf. id a member of Asteraceae . It is widely of geographical distribution, whcih primarily inhabiting regions within the Middle East and various African countries. In addition, antifungal activities were demonstrated by Metwally *et al*., 2022. Ethanolic leaf extract exhibiting notable antifungal properties against *Aspergillus niger* and *Fusarium solani* induced root-rot in cantaloupe plants.

Zyzafon (*Tilia cordata* Mill.), a member of the Tiliaceae (Malvaceae) family, has a history of traditional use in folk medicine. According to literature data, many papers mentioned the antifungal effects of *T.cordata* against plant pathogenic fungi and bacteria such as *Alternaria* sp, *Candida albicans, Escherichia coli, Bacillus subtillis* and *Staphylococcus aureus* (Suskalo *et al*., 2018 and Tambur, 2018).

Numerous studies have focused on harnessing abiotic factors, such as salicylic acid and potassium salts, to bolster plant resistance against various diseases. Salicylic acid has emerged as a prominent chemical agent for inducing plant resistance, garnering considerable attention in a multitude of research endeavors. For instance, application of salicylic acid led to a significant reduction in the density of peanut leaf blight disease, concurrently boosting pod yield in greenhouse conditions and percentage of onion white rot under field studies (Saleh *et al*., 2013 and Amin *et al.,* 2016).

Potassium salts has been demonstrated to effectively inhibit several fungal pathogens that infect various vegetables and crops. Application of potassium significantly reduced the incidence of peanut plant leaf spot caused by *Cercospora archidicola,* inducing systemic protection against powdery mildew (*Sphaerotheca fuliginea*) in

cucumber and tomato plants (Sharma *et al*., 2021).

In this study, our primary objective was to explore the efficacy of Parnof and Zyzafon water extracts, salicylic acid and potassium chloride to evaluate their effectiveness in mitigating peanut damping-off, root and pod-rot diseases. Furthermore, we examined the impact of these treatments on the activity of different enzymes, protein pattern and finally peanut pod yield was also taken into consideration.

2- MATERIALS AND METHODS

2.1 The pathogens:

Isolates of *Fusarium solani*, *Macrophomina phaseolina, Rhizoctonia solani* and *Sclerotium rolfsii*, which used throughout this study were kindly provided by Onion, Garlic and Oil Crops Disease Dept., Plant Pathol. Res. Inst., ARC.

Seven days old colonies of each pathogen were used to inoculate bottles of sterilized sorghum-coarse sand medium (sorghum, sand and water in proportions of 2:2:1 w/w/v) then incubated at 25±2^{0}C for ten days to use as inoculum.

2.2 Plant extracts:

Both of Parnof (Pa) and Zyzafon (Zy) used in this investigation were collected from open field and used as water extracts. One hundred gram of each plant were frozen for 24 h and blended in 100 ml distilled water to achieve 1:1 w/v concentration. Water extract were used at the rate of 50 and 25% for Parnof and 20 and 10% for Zyzafon as described by Tapwal *et al*. (2011).

2.3 Chemical inducers:

In this study, potassium chloride (PC) and salicylic acid (SA) were used to study their effect on pre and post-emergence damping-off, pod and root-rot of peanut plants at the rate of 5 and 10 mM. PC (KCl), ionic compound whose molecules consist of one potassium atom and one chlorine atom and SA (C7H6O3) is a monohydroxybenzoic acid, a type of phenolic acid and a beta hydroxy acid were manufactured by El Nasr Pharmaceutical Chemicals Co. Abu Zaabal, Egypt.

2.4 Peanut seeds:

Peanut seeds Giza 6 were procured from Oil Crops Res. Dept., Field Crops Res. Inst., ARC. Seeds of approximately similar size were surface sterilized in 5%

sodium hypochlorite (Clorox) for 2 min then thoroughly washed in sterilized distilled water and left to air dried under aseptic conditions.

Sterilized seeds were soaked for 30 min in solutions of the above mentioned concentrations of Parnof, Zyzafone, PC and SA just before sowing under greenhouse and open field conditions.

2.5 Greenhouse experiment:

Pot experiments were carried out during 2022 season to evaluate the effect of Zyzafon (25 and 50%), Parnof (10 and 20%) as well as PC and SA at 5 and 10 mM on controlling pre, post-emergence damping-off, root and pod-rot incidence in peanut. Plastic pots 40 cm in diameter were filled with sterilized clay soil, and then infested with mixture of the previously prepared fungal inocula at the rate of 2% w/w, 7 days before seed sowing. Four pots were used as replicates for each treatment and control (infested pots free treatment). Ten seeds were used for each pot in June 1st and irrigated when needed till harvest in September. After 35 days, all treatments were repeated as foliar spraying with 5%Tween 80 as spreading substance.

Field experiments:

Field experiments were carried out at Meet-Khalaf Experimental Station, Shebin El-Kom, Egypt, during 2022 and 2023 summer growing seasons under clay soil conditions. The selected field is known to have a history of natural infestation with root and pod-rot pathogens. The same treatments carried out under greenhouse were applied under the open field. Experiment was designed as complete randomized blocks. Five plots as replicates for each treatment and control (free treatment plots) was adopted. Each plot was 15 m^2 (5x3), 8 rows and 10 cm apart between hills. Three seeds were sown for each hill and thinned 25 days after sowing to one plant. Seed sowing was in 25th May in 2022 and 2023, growing seasons. All agricultural routine practices were applied according to the recommendations till harvest in September.

2.6 Disease and yield assessment:

Under greenhouse and open field conditions, pre and post emergence damping-off were recorded after 15 and 25 days, respectively from seed sowing using the following formulas according to Almaghasla *et al*, (2023). While, percentage of root- rot was recorded at 65 days from sowing date, while, pod-rot

and peanut pod yield were calculated at harvest.

$$\text{Pre-emergence damping-off \%} = \frac{\text{Number of Pre-emergence dead seeds}}{\text{Number of planted seeds}} \times 100$$

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

$$\text{Root-rot \%} = \frac{\text{Number of infected plants}}{\text{Number of examined plants}} \times 100$$

$$\text{Pod-rot \%} = \frac{\text{Number of infected pods}}{\text{Number of examined pods}} \times 100$$

$$\text{Efficacy \%} = \frac{\text{Control} - \text{treatment}}{\text{Control}} \times 100$$

2.7 Chemical assay:

In this investigation, we carried out a study aimed to determine some specific biochemical changes that could be associated with induced resistance resulting from the application of different plant extracts and chemical inducers. Root samples were taken after 15 days from seed sowing during 2022 growing season under greenhouse conditions to determine changes of total phenols, catalase(CAT), peroxidase (POD) and polyphenol oxidase (PPO) using spectrophotometer (model UV-Vis spectronic 601).

Total phenols were determined according to Snell and Snell (1953). While, according to Aluko and Ogbadu, (1986), 1 g of peanut root samples were extracted and stored at 2-5° C for enzymatic activities. Catalase, peroxidase and polyphenol oxidase were determined as explained by Maxwell and Bateman (1967), Allam and Hollis (1972) and Matta and Dimond (1963), respectively.

2.9. Protein electrophoresis:

Samples were taken from peanut pod seeds in 2022 growing season under greenhouse conditions. One g freeze-dried sample was grounded in a mortar and pestle in liquid nitrogen under cryogenic conditions. The crushed samples were transferred to 1.5 ml Eppendorf tube, 200-µl extraction buffer was added then centrifuged at 18,000 rpm for 30-minute. Protein content in the supernatant was estimated according to Bradford (1976).

The crude protein solution was subjected to denaturation by heating at 100°C for 5 minutes. Subsequently, equal volumes of this denatured protein solution were carefully loaded into each well of the stacking gel. The electrophoresis procedure was conducted using a vertical

slab mold, specifically the Hoefer Scientific Instruments model LKB 2001 from San Francisco, CA, USA, which had dimensions of (16 x 18 x 1.5 cm). Electrophoresis was executed for 3 hours at a constant current of 30 milli-Amperes and 10°C.

The visualization of protein bands was achieved through the silver staining method, following the protocol outlined by Sammons *et al.* (1981). Subsequently, gel documentation was carried out using a one-dimensional software system provided by Advanced American Biotechnology and Imaging, located in Fullerton, CA 92831, USA.

2.10. Statistical analysis:

The collected data were statistically analyzed using the "F" test and treatments were compared by LSD values at 5% according to Gomez and Gomez (1984).

3. Results

Results in Table (1) show that all treatments except Parnof water extract at 10 % and PC at 5% showed a significant effect in reducing damping-off and peanut root-rot compared to control. In this respect, Zyzafon 50% and salicylic acid at 5mM were the most effective in reducing pre and post-emergence damping-off, with 7.5 and 5.0% damping-off for both. However, it was noted that potassium chloride treatment at both concentrations gave the lowest effect in reducing pre and post-emergence damping-off. The same trend was also reported for root-rot incidence.

Results in Table (2) show the effect of pre and post-emergence damping-off of peanut plants as well as root and pod-rot under field conditions during 2022 and 2023 growing seasons. All treatments significantly reduced the percentage of infection in all stages. Efficacy in reduction ranged between 22.2- 61.2 for pre-emergence, 45.8 - 65.7 for post-emergence, 50.0 - 71.8 for root- rot and 21.2 - 48.3 for pod-rot in 2022, while for 2023 were 33.4 - 83.4, 38-100, 57.4-74.1 and 26.8-63.8, respectively. In 2022 growing season, Parnof water extract 20% and salicylic acid 5mM gave the best results in reducing the percentage of studied diseases without significant differences.

Table 1. Effect of Parnof and Zyzafon water extracts, potassium chloride (PC) and salicylic acid (SA) treatments* on peanut damping-off and root-rot during 2022 growing season under greenhouse conditions.

Treatment	Concentration	Unit	2022 growing season					
			Damping-off (%)**				Root-rot**	
			Pre-emergence	Efficacy	Post-emergence	Efficacy	(%)	Efficacy
Parnof	20	%	12.5	44.4	7.5	54.6	22.5	40.0
	10		17.5	22.2	7.5	54.6	24.0	36.0
Zyzafon	50		7.5	66.7	5.0	70.4	19.5	48.0
	25		12.5	44.4	7.5	56.3	22.0	41.3
PC	10	mM	12.5	44.4	10.0	40.5	23.3	38.0
	5		15.0	33.3	12.5	37.0	25.0	33.3
SA	10		12.5	44.4	5.0	72.0	20.3	46.0
	5		7.5	66.7	5.0	72.0	20.0	46.7
Control			22.5	-	17.5	-	37.5	-
LSD at 5 %			8.7	-	8.5	-	13.7	-

* Seeds were soaked for 30 min just before sowing, and treatments were repeated as foliar spraying after 35 days

** At 15, 25 and 65 days from seed sowing for pre-, post-emergence damping-off and Root-rot.

While in 2023, only salicylic acid treatment was the best treatment in terms of reducing the percentage of diseases recorded from seed sowing to harvest. The rest of treatments alternated between each other in terms of increase and decrease in the efficiency of preventing the severity of the diseases under study during the two growing seasons without a fixed pattern.

Data presented in Table (3) illustrate the effect of Zyzafon, Parnof water extracts, potassium chloride and salicylic acid on peanut pod yield in 2022 and 2023 growing seasons. All treatments

increased peanut pod yield production compared to control. Positive relationship was found between concentrations of the tested treatments and their effect on increased pod yield production. Increasing efficacy ranged between 10-40 and 22.2-55.6% for 2022 and 2023, respectively. SA at the rate 5mM was the best treatment in the two seasons followed by Parnof 20% and Zyzafon 50% for the first and second season, respectively.

Tabulated data (Table, 4) clearly show that the two extracts and antioxidants caused increase in the activity of catalase, peroxidase, and polyphenol oxidase, as well as the content of phenolic compounds of peanut primordial pods compared to the control treatment. It is also noted that the highest phenol contents, catalase, peroxidase, and polyphenol oxidase activity were induced by salicylic acid at 5 mM and Zyzafon extract at 50% followed by Parnof extract at 20%.

Data presented in Table (5) and illustrated in Figure (1) reveal noteworthy findings regarding the treatment of peanut plants with various treatments, including Zyzafon, Paranof water extracts, salicylic acid, and potassium chloride. These treatments led to the emergence of novel proteins that were absent in the control plants. Specifically, new proteins were consistently observed in plants subjected to all treatments but were conspicuously absent in the control group at 25 kDa marker. Also, Zyzafon and Parnof treatments yielded new proteins at 37, 40, 45, 48 and 60 KDa except Zyzafon at 50% with 60 KD.

Table 2. Effect of Parnof and Zyzafon water extracts, potassium chloride (PC) and salicylic acid (SA) treatments* on damping-off, root and pod-rot of peanut plants during 2022 and 2023 growing seasons under field conditions at Meet-Khalaf Experimental Station, Shebin El-Kom.

Treatment	Concentration	Unit	2022 growing season							
			Damping-off (%) **				Root rot**		Pod rot**	
			Pre-emergence	Efficacy	Post-emergence	Efficacy	(%)	Efficacy	(%)	Efficacy
Parnof	20	%	6.3	61.2	4.3	62.9	4.3	71.8	16.8	43.2
	10		8.7	47.0	6.3	45.8	5.3	65.2	19.8	33.1
Zyzafon	50		8.3	49.0	4.7	60.1	5.3	65.2	18.5	37.3
	25		9.0	44.9	6.0	48.6	6.0	60.9	23.3	21.2
PC	10	mM	11.3	30.6	5.0	57.2	5.7	63.0	17.3	41.5
	5		12.7	22.5	4.3	62.9	7.7	50.0	17.8	39.8
SA	10		7.3	55.1	5.7	51.5	7.3	52.2	18.0	39.0
	5		7.0	57.1	4.0	65.7	4.7	69.5	15.3	48.3
Control			16.3	-	11.7	-	15.3	-	29.5	-
LSD at 5 %			2.6	-	4.2	-	4.6	-	4.6	-
			2023 growing season							
Parnof	20	%	10.0	50.0	6.7	60.0	4.7	74.1	14.8	53.5
	10		11.3	43.4	10.3	38.0	6.0	66.7	20.5	35.4
Zyzafon	50		6.7	66.7	6.7	60.0	5.0	72.2	17.3	45.7
	25		6.7	66.7	10.0	40.0	6.3	64.8	21.5	32.3
PC	10	mM	10.0	50.0	0.0	100.0	7.0	61.1	18.0	43.3
	5		13.3	33.4	6.3	62.0	7.7	57.4	23.3	26.8
SA	10		10.0	50.0	3.3	80.0	6.0	66.7	15.0	52.8
	5		3.3	83.4	0.0	100.0	4.7	74.1	11.5	63.8
Control			20.0	-	16.7	-	18.0	-	31.8	-
LSD at 5 %			5.63	-	3.49	-	3.03	-	5.3	-

* Seeds were soaked for 30 min just before sowing, and treatments were repeated as foliar spraying after 35 days

** At 15, 25 and 65 days from seed sowing for pre-, post-emergence damping-off and Root-rot.

Table 3. Effect of Parnof and Zyzafon water extracts, potassium chloride (PC) and salicylic acid (SA) treatments* on peanut pod yield during 2022 and 2023growing seasons under field conditions at Meet-Khalaf Experimental Station, Shebin El-Kom.

Treatment	Concentration	Unit	2022		2023	
			Yield (ton/ fed.)	Efficacy	Yield (ton/ fed.)	Efficacy
Parnof	20	%	1.4	40.0	1.2	33.3
	10		1.2	20.0	1.2	33.3
Zyzafon	50		1.3	30.0	1.3	44.4
	25		1.1	10.0	1.1	22.2
PC	10	mM	1.3	30.0	1.2	33.3
	5		1.1	10.0	1.1	22.2
SA	10		1.3	30.0	1.2	33.3
	5		1.4	40.0	1.4	55.6
Control			1.0	-	0.9	-
LSD at 5 %			0.2	-	0.1	-

Table 4. Effect of Parnof and Zyzafon water extracts, potassium chloride (PC) and salicylic acid (SA) treatments* as seed soaking on total phenols content, activity of catalase (CA), peroxidase (PO) and polyphenol oxidase (PPO) in peanut plants grown* during 2022 under greenhouse conditions.

Treatments	Concentration	Unit	Total phenols (mg/g freshweight)	Activity of		
				CA	PO	PPO
Zyzafon	50	%	16.55	1.57	1.10	0.95
	25		14.25	1.10	1.06	0.72
Parnof	20		15.86	1.55	1.13	0.81
	10		14.15	1.00	0.85	0.63
PC	10	mM	12.95	1.12	0.93	0.78
	5		11.42	0.95	0.85	0.52
SA	10		16.48	1.25	0.96	0.79
	5		18.43	1.61	1.22	0.97
Control		-	11.11	0.99	0.56	0.31

* Seeds were soaked for 30 min just before sowing, and samples were taken after 15 days from seed sowing.

Table 5. Effect of Parnof, Zyzafon water extracts, potassium chloride (PC) and salicylic acid (SA) treatments* on protein bands in peanut plants growing during 2022 under greenhouse conditions.

Marker (MW)	control	Protein bands							
		Zayzafon (%)		Parnof (%)		SA (mM)		PC (mM)	
		50	25	20	10	10	5	10	5
75	-	-	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-
60	-	-	+	+	+	-	-	-	-
48	-	+	+	+	+	-	-	-	-
45	-	+	+	+	+	-	-	-	-
40	-	+	+	+	+	-	-	-	-
37	-	+	+	+	+	-	-	-	-
35	+	+	+	+	+	+	+	+	+
32	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-
25	-	+	+	+	+	+	+	+	+
23	+	+	+	+	+	+	-	-	+
19	+	+	+	+	+	+	+	-	+
11	+	+	+	+	+	+	+	-	+
5	+	+	+	+	+	+	+	+	+
Total observed bands	5	10	11	11	11	6	5	3	6

* Seeds were soaked for 30 min just before sowing, and treatments were repeated as foliar spraying after 35 days. Samples were taken from peanut pod seeds.

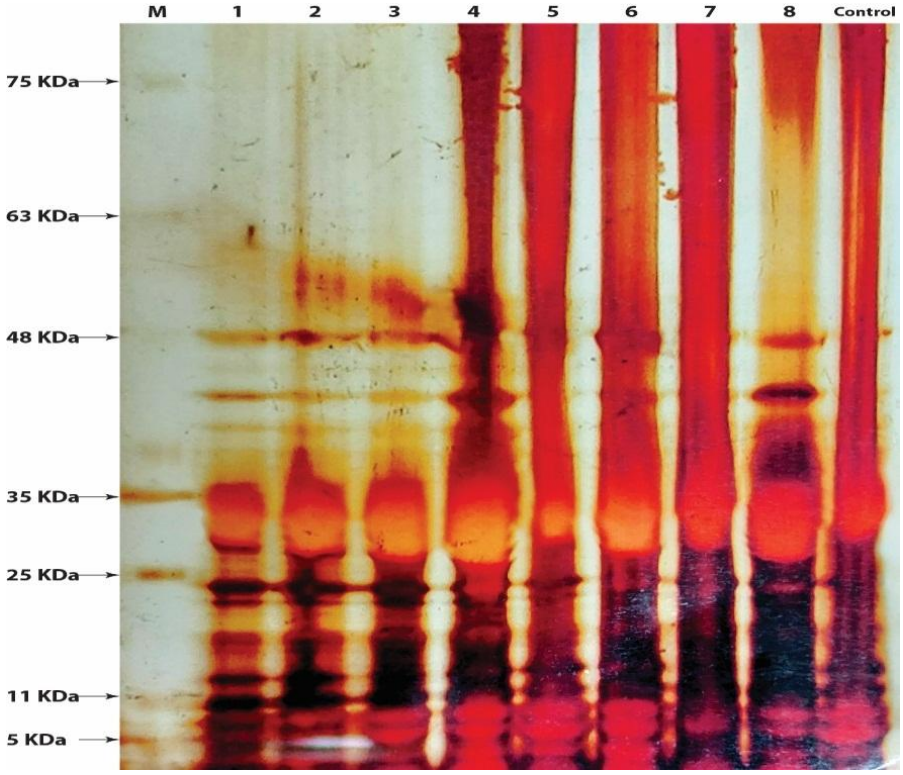

Fig. (1). Separated protein bands from peanut plants treated by Parnof, Zyzafon water extracts, potassium chloride and salicylic acid under greenhouse conditions during 2023.

Lane (1) plant treated with Zyzafon at 50% Lane (2) plant treated with Zyzafon at 25%

Lane (3) plant treated with Parnof at 20% Lane(4) plant treated with Parnof at 10%

Lane (5) plant treated with SA at 10mM Lane(6) plant treated with SA at 5mM

Lane (7) plant treated with PC at 10mM Lane(8) plant treated with PC at 5mM

Lane (9) control treatment.

4. Discussion

Many researchers discussed the effect of plant extracts on plant diseases. Abdel-Kader *et al.* (2013) recorded that essential oils from lemon grass, thyme, and rose can reduce peanut crown rot at pre and post-emergence stages, while Mahmoud *et al.* (2013) concluded that plant extracts like cumin, thyme, garlic, and cardamom have inhibitory effects against peanut pre- and post-emergence damping-off.

Parnof and Zyzafon extracts compounds, derived from medicinal plants are considered non-phytotoxic and potentially effective against various plant pathogenic fungi and pests, as suggested

by Saleh *et al*. (2013) and Abdel-Monaim *et al*. (2017).Some researchers have attributed the inhibitory effect of these plant extracts to the presence of phenolics, flavonoids, terpenoids, and alkaloids (Metwally *et al.,* 2021).

Results of the current study showed that treating peanut seeds with *P. dioscoridis* water extract significantly reduced the incidence of peanut root and pod-rot and increased the yield of healthy pods in both greenhouse and field experiments. These results are highly promising and aligned with the findings of Adel *et al*. (2020), who reported that *P. dioscoridis* leaf extract exhibited antifungal activity against *Fusarium solani* and *Rhizoctonia solani* the causative agents of cantaloupe root-rot fungi. Similarly, El-Zalabani *et al.* (2013) demonstrated the antifungal and antibacterial activity of *P. dioscoridis* leaf extract against various pathogens. Likewise, the aqueous extract of *T. cordata* plants effectively reduced the incidence of peanut damping-off, root-rot, and pod-rot. These results corroborate previous research by Farid *et al.* (2017), who observed similar effects against various bacteria and *Candida albicans*. The reduction in peanut diseases can be attributed to natural antioxidants present in *T. cordata* extract, such as flavonoids and essential oils, known for their protective role against oxidative damage.

Gallic and tannic acids were found in both *P. dioscoridis* and *T. cordata* extracts, which are known for their biological influence against bacterial species due to their hydroxyl (-OH) groups ability to disrupt bacterial cell metabolism (Allan *et al.,* 1999). Gallic acid has also demonstrated antifungal activity against various pathogens (Nguyen *et al.,* 2013; Metwally *et al.,* 2021). Moreover, the extracts induced biochemical changes in peanut plants, including enzymatic activities of catalase, peroxidase, polyphenol oxidase, and total soluble phenolics, ultimately contributing to increased pod yield. These findings align with El-Nagar (2020) results, where gallic acid and its derivatives effectively suppressed tomato early blight caused by *Alternaria solani*.

In terms of induced resistance, the application of salicylic acid (SA) and potassium chloride reduced the percentage of peanut pod-rot infection. Potassium treatments have been shown to reduce the incidence of various diseases in different crops, supporting our results (Umar *et al.*, 1997; Harris, 1997; Sharma *et al*., 2021). The relationship between available soil potassium and disease severity is documented (Huber and Arny, 1985). Potassium ions can disrupt hyphal

walls and inhibit sporangial production of pathogens like *Phytophthora* spp. (El-Mohamedy *et al*., 2013). Potassium's quick assimilation and mobility within plant tissues, along with its nutritional value, likely contribute to disease control.

In our study, soaking peanut seeds in salicylic acid at concentrations of 5 and 10 mM effectively reduced the incidence of root and pod-rot diseases. These findings are consistent with previous research by Sallam *et al*. (2017), who reported that 8 mM SA reduced mycelial growth of *Fusarium* species causing peanut diseases. However, higher SA concentrations were associated with increased disease incidence, likely due to inhibitory effects on plant physiological processes. High SA concentrations can interfere with nutrient uptake, mitochondrial function, and stomatal behavior (Macri *et al*. 1986). Our field trials further demonstrated the effectiveness of SA treatment, leading to reduced disease severity and increased phenolic compound accumulation and oxidative enzyme activity, consistent with other studies on different crops (Soliman and El-Mohamedy, 2017).

Finally, our electrophoretic analysis revealed the induction of new proteins that could be pathogenesis-related proteins in peanut plants treated with various inducers. These proteins play a vital role in plant defense due to their antifungal and antibacterial activities, supporting the notion that balanced use of inducers can reduce root-rot incidence in peanuts (Abd-Elbaky *et al.*, 2013). In summary, our study provides considerable insights into the potential of plant extracts, antioxidants, and inducers in reducing peanut diseases and offering promising elements for disease management strategy in peanut production.

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