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Effectiveness of some biorationals in controlling damping-off diseases and promoting growth and yield of wheat crop

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Abstract

This study aimed to evaluate the effectiveness of treating wheat seeds with some indigenous medicinal plants powder on the germination rate, growth and yield of wheat, as well as, a commercial fungicide (Tebuconazole) and a bio growth promoter Bacillus subtilis bacteria+ amino acid were applied for the same purpose. The results of this study indicated that seed coated with Chamomile flower powder (T1) suppressed damping-off by 89.22% compared with 0% in control and gave a significantly higher number of tillers (6.583 ± 0.617) compared to T0 and other treatments. Meanwhile, the T1 gave the highest plant heights, straw, and total shoot dry mass (94.0± 1.684, 9.096 ± 1.154, and 10.192 ± 1.216), respectively. in the meantime, T1 significantly provided the uppermost number of spikes, spike length, and yield (6.083 ± 0.594 spike/plant, and 3.380±0.017 ton.ha^{-1}), respectively. On the other hand, T4 treatment performed a significantly higher weight of spikes and grains per spike (1.521 ± 0.092 and 1.065 ± 0.068), respectively. Furthermore, T4 conferred a higher number of grains per spike (33.431 ± 1.915) than other treatments. The yield in all the treatments was significantly higher than in the control (p-value ≤ 0.05), and the highest yield was recorded in the T1 (mean =3.380±0.017).

Keywords: *Triticum aestivum L.*, Biorationals, Sustainable Agriculture, Plant Promotor, Pest Control

Introduction

Sustainable agriculture means food production abundantly without depleting the earth's resources or polluting its environment [1]. Doubling global food demand projected for the next half-century poses enormous challenges for the sustainability of food production, earth ecosystems and their services to society [2]. At present, Intensive high-yield agriculture is dependent on massive amounts of chemical fertilizers and pesticides [3, 4]. One of the essential crops that play an important role in sustainable agriculture is the wheat crop which is one of the worldwide staple crops produced on a large scale and widely cultivated with more than 221.53 million hectares planted annually under wide ranges of climatic conditions and many geographic regions. It is one of the most important crops for global food security [5]. Likewise in the Kurdistan region of Iraq (KRI), it is the most important crop and the staple food of the people, which dominated the landscape of the KRI [6]. According to a previous report [7], about 826,000 hectares were cultivated with wheat crops in 2018 and its production was estimated at 2,427,000 tonnes with an estimated average yield of 2.938 tons. ha-1, in the KRI.[6].

Wheat plants are vulnerable to numerous pathogens that infect their root and shoot system causing serious damage to productivity worldwide [8, 9]. Damping-off is one of the important diseases that cause seed decaying, root rotting, and lesioning of hypocotyls. The responsible fungi include species of *Pythium, Phytophthora, Fusarium, and Corticium* [10]. *Rhizoctonia, Sclerotinia, Sclerotium, Botrytis*, and others [11, 12] under different soil temperatures, moisture, and pH levels [13]. Its control needs massive amounts of chemical fungicides which cause big damage to the environment and a big threat to human health, as well as increasing production costs [14]. To mitigate the environmental pollution due to chemical applications, there are efforts through subtitling them with biopesticides since plant parts are naturally rich in active fungicide components [15].

Chamomile and Liquorice are among the important medicinal plants that several pharmacological actions have been documented based on in vitro and animal studies, including antibacterial, antifungal, anti-inflammatory, antispasmodic, anti-ulcer, antiviral, and sedative effects [16].In the Kurdish tradition, for itsantibiotical effectiveness, Liquorice (Scientific name: *Glycyrrhiza glabra* - Family: Fabaceae), which is locally called Belek in the Kurdish language, its roots are mainly decocted as a tea or powdered and orally used for treating some illnesses (such as; Gastric ulcer, cough, rheumatism, oral herpes, liver cirrhosis, abdominal injury, as well as, Chamomile (Scientific name: *Matricaria chamomilla* – Family: Compositae), which is called Beibûn (/ˈbeɪbuːn/) in the local Kurdish language, that its flowers are decocted as a tea and orally used for treating some illnesses (such as; hypertension, stomach inflammation, blood circulation, kidney stones, intestinal worms, cough, anxiety, diuretic, headache, abdominal pain, hair loss, and sore throat), by the traditional healers in the Kurdistan region [17, 18].

The main objective of this experiment was to determine the effects of two indigenous locally available and commonly used medicinal plants (namely; Chamomile and Liquorice) on suppressing damping-off and root rot of wheat seeds, as well as their effects on the growth and yield of wheat crops in comparison to the treated seeds with a commercial fungicide, a commercial biofertilizer, and untreated wheat seeds.

Materials and Methods

Site Description

This study was conducted in an experimental research field belonging to the College of Agricultural Engineering Sciences, the University of Sulaimani, which is located in the Bakrajo district, Sulaymaniyah city, Kurdistan Region of Iraq.

Medicinal plant collection and preparation

The Liquorice (*Glycyrrhiza glabra*) root and Chamomile (*Matricaria chamomilla, L.*) flowers were identified by the college of agricultural sciences-University of Sulaimani and collected around the college of agricultural sciences in Bakrajo. The collected Liquorice root samples were hung and air dried for 5 weeks, and Chamomile flowers were air dried for 7 days. The dried samples were ground with an electric spice grinder and kept in zippered plastic bags at room temperature.

Experimental design

The research was laid out in Completely Randomized Block Design CRBD within three replicants for each treatment. The treatments were carried out to test the effects of some indigenous medicinal plants (Liquorice (*Glycyrrhiza glabra*) root and Chamomile (*Matricaria chamomilla, L.*) flowers), chemical pesticide (Tebuconazole (Raxil)), and a commercial biopromotor (*Bacillus subtilis* + *Psedumonas Putida* bacteria, etc (Fulzyme)) on the growth, yield, and suppress of damping off diseases caused by several different fungi and fungus-like organisms [18] on wheat crops grown in an open field without infesting the soil. The wheat variety used was a local variety named 'Aras' which is a commercial wheat cultivar commonly cultivated in the Kurdistan Region of Iraq [19]. The wheat seeds were coated with the selected powders for each treatment. Each 1 kg of wheat seeds was slightly sprayed with deionized water and coated with 10g [1 % (wt./wt.)] of each powder and mixed until whole seed grains' color turned to the powder's color [20]. The treatments were included; T0= Control (untreated), T1= Chamomile (*Matricaria chamomilla, L.*) flower powder, T2= Liquorice (*Glycyrrhiza glabra*) root powder only, T3= Raxil (as instructed on the productbox100g/100kg) (which is the most commonly used commercial fungicide in Kurdistan region and Iraq which is produced by Bayar company/Germany, the active ingredient is Tebuconazole), and T4= Fulzyme powder(as instructed on the product box2kg/1000kg) (which is a commercial biofertilizer produced by JH Biotech company, that content: *Bacillus subtilis* and *Pseudomonas putida* bacteria; Protease, Amylase, Chitinase and lipase enzymes; and gibberellin and cytokinin hormones).

Wheat seed was sown in an open field, that non-infested soil, on 24-12-2019 when the total amount of rainfall was reached (185.3 mm) in Bakrajo district, which was less than half of rainfall amount (408.7 mm) compared to the previous year (2018) until then [21, 22]. Additionally, the rainfall amount was (663.1mm) until 6-5-2020 while it was (1134.1mm) in the previous growing season by the end of Spring 2019 [21, 22]. No fertilizers were applied during the growing season .

Table (1) shows the physicochemical properties of the soil samples collected from the experimental site and analysed according to [23] standard methods.

Table (1): The Physicochemical properties of the study site's soil

Parameters	Unit	Soil Test Values
Bulk Density	$mg.cm^{3\ -1}$	1.3
Particle Density	$mg.cm^{3\ -1}$	2.5
Organic Matter	$g.\ kg^{-1}$	22.3
$CaCO_3$	$g.\ kg^{-1}$	270
pH	-	7.3
Soil Texture	-	Silty Clay

Parameters and Sample Analyses

A survey was conducted for the fungus that may cause damping-off disease in the experimental soil and the plant residues on the soil before sowing. The fungi from the experimental soil and plant residues were isolated and identified according to [24], and morphological characteristics of the fungi (type of hyphae, and asexual reproductive structure) were observed and recorded according to [25, 26]. The identification of soil fungi was conducted depending on their taxonomic keys [27, 28, 29, 30].
The percentage of damping-off and survival seedlings were recorded in the field after 45 days from planting date, then the suppress percentage was calculated with the following equation:

$$\boldsymbol{S}\,\% = \frac{\mathbf{A - B}}{\mathbf{A}} \times \mathbf{100}$$

Where:
S = Damping-off Suppression
A = Number of seedlings showing damping-off disease in control
B = Number of seedlings showing damping-off disease in each treatment

The collected samples from wheat plant foliage, spike and grains were measured regarding the physical parameters and yield with a measure tape and ruler for measuring length, and scale for weighing.

Data Analysis

The collected data regarding the suppression, growth and yield of wheat crops were analyzed using XLSTAT, and the means were compared by ANOVA (Fishier LSD) at the significance levels of 99% and 95% ($p < 0.05$ and $p<0.01$).

Results and Discussion

Table (2) shows the fungal genera isolated from the experimental soil and plant residues. Fifteen fungal genera were found in the soil and plant residues that mostly can cause seed decay, root rot, and lesions on hypocotyls such as *Botrytis sp.*,*Fusarium*, *Pythium*, *Phytophthora*, *Rhizoctonia* [9, 11, 10]. Though each of the found fungal genera may emerge under different soil temperature, moisture, and pH levels [31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43] the damping-off disease caused by *Pythium infatum* [44], that optimal condition is high soil moisture, pH more than 5.8, low temperatures (12 °C) [33, 34, 35], can be counted as a major problem of the wheat crop production in the KRI where wheat is cultivated in the winter under rain-fed. Though Fusarium is considered a major cause of damping-off in wheat, namely, *Fusarium nivale*, *F. graminearum*, *F. tricinctum* [45, 46, 47, 48, 49, 50] *F. avenaceum* [51, 52] *F. calmorum* [52, 53] *F. pseudograminerarum*[54, 55], only *Fusarium oxysporum* and *Fusarium solani* were found in the experimental soil.

Table (2): The isolated and identified fungal genera from the experimental soil and plant residues

no.	Fungal genera
1.	*Acremonium sp.*
2.	*Aspergillus niger*
3.	*Aspergillus fumigatus*
4.	*Aspergillus flavus*
5.	*Alternaria solani*
6.	*Botrytis sp.*
7.	*Fusarium oxysporum*
8.	*Fusarium solani*
9.	*Mucor sp.*
10.	*Penicillium sp.*
11.	*Pythium infatum*

12.	*Phytophthora sp.*
13.	*Rhizoctonia solani*
14.	*Rhizopus sp.*
15.	*Verticillium sp.*

Figure (1) illustrates that the seed coated with Chamomile flower powder (T1) recorded the significantly highest percentage of damping-off suppression (89.22%) compared to other treatments. Similarly [56] found that the application of chamomile gives significant results in controlling Pythium pathogen of beans with an effect up to 30-81.6% radial growth reduction. Additionally, the results come in agreement with chamomile extract in some other reported studies [57,58]. Likewise, a couple of previous studies considered German Chamomile as an alternative to antifungal activity for its containing of Polyphenolic compounds.[60 ,59]

Liquorice root powder (T2) also recorded 72.71% damping-off suppression which was a better result than the commercial fungicide (Raxil - Tebuconazole) 60.61%. As similarly, the antifungal effectiveness of liquorice was recorded against *Penicillium expansum* in apples [51]. The seed-coating with the biocontrol agent Fulzyme (T4) was not effective in controlling damping-off with 19.05%.

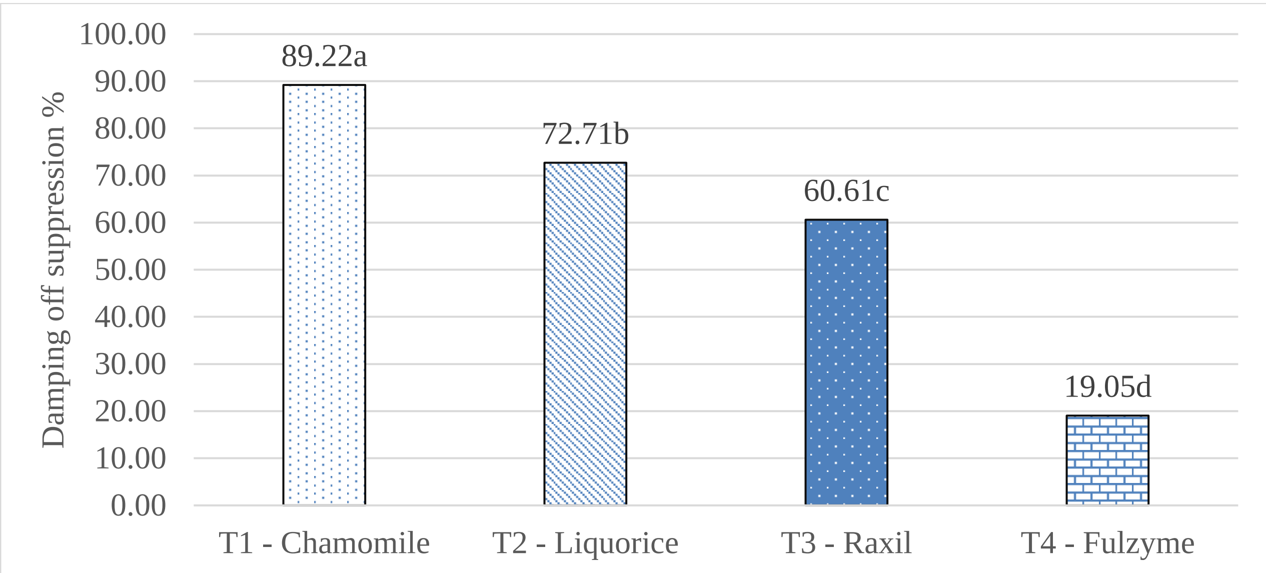

Figure (1): Damping-off suppression percentage for the treated seeds

The results in Table (3) show the effects of seed-coating treatments on the growth of wheat plants. The germination percentage in the field was significantly affected by the seed treatments in comparison to the control (55.739±0.04%), which was close to the germination percentages for Aras wheat recorded by [19]. The significantly superb germination percentage was recorded for T1 (95.229±0.230%) then T2 came in second (87.921±0.020%). The T1 (Chamomile flower powder) gave a significantly higher number of tillers (6.583±0.617) compared to T0 (Control) and other treatments. The other growth parameters did not give any significant differences. Meanwhile, the T1 gave the highest plant height (94.0±1.684 cm), straw, and total shoot dry mass (9.096±1.154 and 10.192±1.216 g. plant-1), respectively.

Table (3): Wheat plant growth traits

Treatments	Germination %	No. of Tillers	Plant height (cm)	Straw dry mass (g. plant^{-1})	Total shoot dry mass (g. plant^{-1})
T0	55.74±0.04e	3.44±0.71b	88.11±1.95a	4.43±1.33a	5.50±1.41a
T1	95.23±0.23a	6.58±0.62 a	94.00±1.68a	9.10±1.15a	10.19±1.22a
T2	87.92±0.02b	5.33±0.71 ab	92.00±1.95a	7.29±1.33a	8.57±1.41a
T3	82.57±0.07c	5.42±0.62 ab	90.58±1.68a	7.82±1.15a	9.05±1.22a
T4	64.17±0.17d	5.00±0.62 ab	89.83±1.68a	6.64±1.15a	8.14±1.22a
Pr> F	0.000**	0.034*	0.203	0.127	0.166

* Significance Level (p-value ≤ 0.05)
** Significance Level (p-value ≤ 0.01)

Table (4) illustrates that though T1 (Chamomile flower powder) gave the significantly uppermost number of spikes (6.083±0.594 spike. plant-1), and yield, and (3.380±0.017 ton. ha-1), T4 (Fulzyme) recorded a significantly higher weight of spikes (1.521±0.092 g) and weight of grains per spike (1.065±0.068 g). Meantime, T4 gave insignificantly the highest number of grains per spike (33.431±1.915). The yield in all the treatments was significantly higher than control (p-value≤0.05), and the maximum yield was recorded in the T1 (mean =3.380±0.017 ton. ha-1).

Table (4): Wheat spike, grain and yield traits

Treatments	No. of Spikes	Spike Length (cm)	Weight of spikes (g)	No. of grains per spike	Weight of grains per spike (g)	Yield (ton. ha^{-1})
T0	3.11±0.69b	9.09±0.36a	1.03±0.13b	26.04±2.58a	0.67±0.09b	0.89±0.021e
T1	6.08±0.59a	9.16±0.22a	1.17±0.08b	29.75±1.60a	0.77±0.06b	3.38±0.02a
T2	4.67±0.69ab	8.66±0.29a	1.30±0.10ab	30.55±2.11a	0.87±0.08ab	2.66±0.071b
T3	4.83±0.59ab	8.70±0.25a	1.26±0.09ab	31.78±1.80a	0.83±0.06ab	2.51±0.015c
T4	4.25±0.59ab	8.88±0.26a	1.52±0.09a	33.43±1.92a	1.07±0.07a	2.07±0.03d
Pr> F	0.034*	$0.565^{n.s}$	0.013*	$0.202^{n.s}$	0.003**	0.000**

* Significance Level (p-value ≤ 0.05)
** Significance Level (p-value ≤ 0.01)

Application of biorationals can be considered as a potential alternative to the presently used synthetic chemicals with better results for a sustainable food production system. From the results of this study, the usage of chamomile powder can be considered an important natural source that significantly contributesto the suppression of some fungal diseases, as well as promoting the performance of growth and yield of wheat crops. Further studies are recommended to conduct on the use of these biorationals or others for their phytotoxicity and growth promotion potential in order to obtain a better understanding of their mode of action and step toward more sustainable farming practices through the limitation of the chemical practices.

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