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Research Paper

Seed biopriming with endophytic fungi enhances germination, growth, yield and fruit quality of fennel under salinity stress

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ABSTRACT: *Salt stress is one of the major abiotic stresses limiting crop growth and productivity. The aim of this study was to assess whether seed biopriming with Trichoderma atroviride MUCL 45632 could improve germination, seedling establishment, yield and fruit quality of fennel (Foeniculum vulgare Mill.) under Salinity Stress. Fresh seeds of fennel cultivar were subjected to osmopriming treatment with Trichoderma atroviride and treated with different concentrations of NaCl: 0, 40 and 80 mM. To characterize salt tolerance germination, plant growth and biochemical parameters were studied. In germination test, Trichoderma atroviride improved germination percentage, and index and reducing Mean Germination Time and the time to get 50% germination (T_{50}) under salinity stress. Treated seed germinated consistently faster and more uniformly than untreated seeds. Plant growth, fruit yield and components were significantly reduced with the severity of saline treatment. However, seed priming mitigated the effects of salinity for all of these parameters. Regarding biochemical parameters, total phenolic and essential oil contents increased gradually and significantly by the increase in irrigation water salinity and all the more with Trichoderma atroviride treatment. Therefore, fennel seed biopriming with the biostimulant Trichoderma atroviride MUCL 45632 could be a complementary approach to overcoming the inhibitory efects of salinity stress and promoting seed germination, seedling growth and fruit quality.*

KEYWORDS: *Salinity, Seed biopriming, Trichoderma atroviride, Foeniculum vulgare.*

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I. INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.; Apiaceae), a medicinal plant that is native to the Mediterranean areas, has a long history of herbal use [1]. Different parts of this plant can be used for several pharmaceutical, cosmetic, and food goals [2]. Fennel is widely cultivated, both in its native range and elsewhere for its uses, and is influenced by environmental stresses.

Salinity is one of the major factors that affect plant growth in Tunisia, where there is a wide variety of saline-sodic soils in depression and in the main sebkhas and chotts [3]. Moreover, in irrigated areas, the low quality of irrigation water charged with dissolved salts has resulted unfortunately in soil secondary salinization responsible for decline in productivity [3,4]

Seed germination is one of the most important phases in the life cycle of plants. It is the sum of all physiologic processes inside the seed, when water is taken up for respiration, protein synthesis and other metabolic activities [5]. However, under unfavorable growth conditions, such as salinity, the seed viability will be affected by osmotic potential outside and obstructing of water absorption, or Na^+ and Cl^- toxicity effects [6], which results in osmotic stress and generation of reactive oxygen species (ROS) [7].

Salt stress has been shown to decrease the germination percentage and germination rate of some crops. Soil salinity may influence the germination of seeds either by creating an osmotic potential external to the seed

preventing water uptake, or the toxic effects of Na^+ and Cl^- ions on germinating seed. Salt and osmotic stresses are responsible for both inhibition or delayed seed germination and seedling establishment [8,9].

Under salinity stress, plant growth is reduced due to the accumulation of toxic levels of sodium and chloride, reducing the osmotic potential of water and decreasing nutrient uptake [10]. Salinity also damages the stomata, reduces photosynthetic pigments and photosynthesis and thus reduces leaf growth rate [11].

Plants grow in dynamic environments where they can be exposed to stressful conditions and are able to further fortify their defense systems. Therefore, some management strategies have been developed to improve plant performance under unfavorable conditions to guarantee better rate of germination and plant development [12,13]. Thus, some strategies employed to increase salt tolerance of vegetable crops and mitigate the negative effects of salinity focus on the exogenous application of plant growth regulators (gibberellins, auxins, and cytokinins) [14,15], or the inoculation of the rhizosphere with root colonizing bacteria, which produce phytohormones [16,17].

Plant beneficial microbes (PBMs) are considered to be a natural alternative path to ease the pressure on the environment resulting from conventional farming. These microbes can help plants maintain or increase productivity while reducing the input of agrochemicals, restoring soil fertility, and/or overcoming problems caused by abiotic and biotic stresses [18,19].

Trichoderma spp. have been drawing the interest of researchers and intensively investigated. The great economic and industrial interest in *Trichoderma* spp. has resulted in formulations of regulated and commercialized products for agricultural use [20].

Seed treatment with *Trichoderma* spp. is a promising approach, as an integral component of agricultural practice in seed–plant–soil system that can replace chemical seeds treatments, in order to establish seed bio-priming through making beneficial microorganisms [21] accessible to the roots of crops [22], and capable of colonizing the rhizosphere at the critical "early germination" stage and therefore facilitating early, healthy and rapid development with improving nutrient uptake and tolerance to stresses [23].

Studies have shown that treatment seeds with PBM can assist crops in improving seedling establishment and germination or achieving high yields and food quality, under reduced chemical fertilization [24].

Trichoderma spp. are endophytic plant symbionts that are widely used as seed treatments to control diseases and to enhance plant growth and yield. Although some recent work has been published on their abilities to alleviate abiotic stresses, specific knowledge of mechanisms, abilities to control multiple plant stress factors, their effects on seed and seedlings is lacking. Therefore, the present study aimed to investigate the efficiency of *Trichoderma* spp. application on the alleviation of the adverse effect of salinity as natural and safe compound for humans and environment.

II. MATERIAL AND METHODS

1. Plant material

Fully ripened fennel seeds "local cultivar" used in this work were collected from cultivated plants from the experimental station of the Higher Agronomic Institute of Chott Mariem, Sousse, Tunisia.

2. Seed biopriming

Trichoderma atroviride MUCL 45632 strain was kindly provided by "Department of Agriculture and Forest Sciences, University of Tuscia, Viterbo, Italy". Seeds of fennel (*Foeniculum vulgare* Mill) were surface sterilized with 70% ethanol for 2 min, followed by 5% sodium hypochlorite for 10 min. Thereafter, the product was applied after dissolution of 1 g powder of *Trichoderma atroviride* in 1 ml distilled water at a rate of 1.5 g Kg^{-1} of fennel seeds.

3. Germination test

For germination, seeds were soaked for 2 h in distilled water or two NaCl concentrations 40 and 80 mM. The seeds were then placed in Petri dishes with double-layer filter paper initially moistened with a solution of the respective salt concentration. The Petri dishes were incubated for 4 days in the dark at room temperature (25 ± 2C). Each treatment consisted of 50 seeds per Petri dish and was replicated three times. Seeds with emerged radicle were counted daily.

Germination rate (GR) or final germination percentage was calculated as 100 X number of germinated seeds divided by number of sown seeds.

$$Germination\ rate\ (\%) = \frac{Seed\ germinated}{Total\ number\ of\ seeds} * 100$$

The time to get 50% germination (T_{50}) was calculated according to the following formulae of Coolbear et al. [25] modified by Farooq et al. [26]:

$$T50 = ti + \frac{\left(\frac{N}{2} - ni\right)(tj - ti)}{(nj - ni)}$$

Where N is the final number of germination and ni, nj cumulative number of seeds germinated by adjacent counts at times ti and tj when ni < N/2 < nj.

Mean germination time (MGT) was calculated according to the equation of Ellis and Roberts [27]:

$$MGT = \frac{\Sigma Dn}{\Sigma n}$$

Where n is the number of seeds, which were germinated on day D, and D is the number of days counted from the beginning of germination.

Germination index (GI) was calculated as described in the Association of Official Seed Analysts [28] as the following formulae:

$$Gi = \frac{(No.of\ germinated\ sseds)}{Days\ od\ first\ count} + \text{------} + \frac{No.of\ germinated\ seeds}{Days\ of\ final\ count}$$

Energy of germination was recorded 4th day after sowing. It is the percentage of germinating seeds 4 days after planting relative to the total number of seeds tested [29].

To evaluate the effect of each treatment in fennel seedlings, the seedling vigor index (SVI) was calculated:

$$SVI = GR(\%) * Root\ mean\ length\ (cm)$$

Where GR was calculated as 100 x number of germinated seeds divided by number of sown seeds [30].

4. Seedling growth and salt stress treatment

Priming and no priming seeds were sown in plastic pots containing peat and irrigated with Hoagland's nutrient solution. Three fennel seeds were planted in each pot. The treatments studied were three levels of salinity, (0 mM NaCl, 40 mM NaCl, or 80 mM NaCl) in combination with thwo biostimulant applications (treated and untreated with *Trichoderma atroviride*). The treatments were arranged into a 2 × 3 factorial in a completely randomized design with three replications, giving a total of 6 treatment combinations and 18 experimental units each consisting of 15 plants. At stage of two leaves, seedlings were separated in six groups with different NaCl concentrations. To avoid osmotic shock, salt concentrations increased stepwise daily with 20 mM NaCl for the two concentrations (40 and 80 mM NaCl).

5. Data recorded

5.1. Plant growth parameters

The morphological characters such as plant height, leaf number, stem diameter, fresh and dry weights of vegetative growth were estimated at flowering stage. The number of umbels/plant and fruits weight/plant was estimated after maturity.

5.2. Biochemical parameters

Determination of essential oil percentage

About 100 g of dried fennel seed powder was exposed to hydrodistillation in 1 L of deionized water using a clevenger apparatus for up to 4 hr [31]. Essential oil percentage was determined in the fruits using water distillation methods according to British Pharmacopoeia, 1963.

Determination of total phenolic contents

The total phenolic content of the tomato leaf extracts was determined using Folin-Ciocalteu reagent, according to Falleh et al. [32]. Absorbance was determined against a blank at 760 nm using UV-visible spectroscopy. The content of total phenolic compound in each extract was expressed as mg of gallic acid equivalents per g fresh weight (mg GAE g^{-1} FW) from a calibration curve with gallic acid. All determinations were carried out in triplicate. Gallic acid was used as the reference standard for plotting the calibration curve.

6. Statistical analysis

Data were subjected to an analysis of variance (ANOVA), and means and standard errors were calculated. All parameters were subjected to a one-way-analysis ($P < 0.001$) and compared using Tukey's test at 5% of probability. The statistical analyses were performed using Statistical Package for the Social Sciences software (SPSS; version 20).

III. RESULT

Germination test

The results showed that fennel germination parameters significantly declined with the increase in NaCl concentrations, as shown in Table 1; compared to the control, the germination energy (GE), Germination index

(GI) and germination percentage (GP) of fennel seeds were significantly decreased under salt stress; at 80 mM NaCl, the GP decreased by 92.98%, the GE decreased by 96.33 % and the GI decreased by 95.54%.

Table 1: Effect of seed priming treatment on fennel seed germination under salt stress conditions.

	Untreated seeds			Treated seeds		
	0 mM	**40 mM**	**80mM**	**0 mM**	**40 mM**	**80mM**
Radicule lenght (cm)	5.06 ±0.49^{b}	4.56±0.63^{b}	4.36±0.40^{b}	7.56±0.81^{a}	6.16±1.15^{ab}	5.26±0.25^{b}
T_{50}	1.61±0.01^{bc}	1.69±0.17^{bc}	2.75±0.66^{a}	1.42±0.08^{c}	1.99±0.45^{abc}	2.38±0.07^{ab}
GI	44.21±7.23^{b}	15.66±9.72^{cd}	1.97±0.66^{d}	68.70±5.95^{a}	23.60±5.30^{c}	7.17±2.02^{d}
MGT	4.11±0.05^{c}	4.12±0.09^{c}	4.76±0.22^{a}	3.88±0.09^{c}	4.22±0.11^{bc}	4.54±0.23^{ab}
EG	72.66±14.04^{a}	26±15.87^{bc}	2.66±1.15^{c}	84±19.28^{a}	37.33±4.16^{b}	12.66±4.16^{bc}

Under no-stress condition, seed priming with *Trichoderma* slightly increased the germination and seedling vigor of fennel seeds in the present investigation. Compared with the control, the seed priming resulted in lower T_{50} and MGT and, higher GP, GI, GE, radicule lenght and SVI (Table 1). Maximum germination percentage (98.66%) was achieved in seeds treated with *Trichoderma*. Its effect is significant especially at 80mM, where we measured maximum germination percentage (17.33%). Minimum germination percentage (5.33%) and maximum reduction percentage of germination (92.98%) were observed in untreated seeds with *Trichoderma* at all salt stress levels (Figure 1).

Under no-stress condition (0 mM), *Trichoderma* generally had little effect on germination. However, under stress, treated seeds germinated consistently faster and more uniformly than untreated seeds.

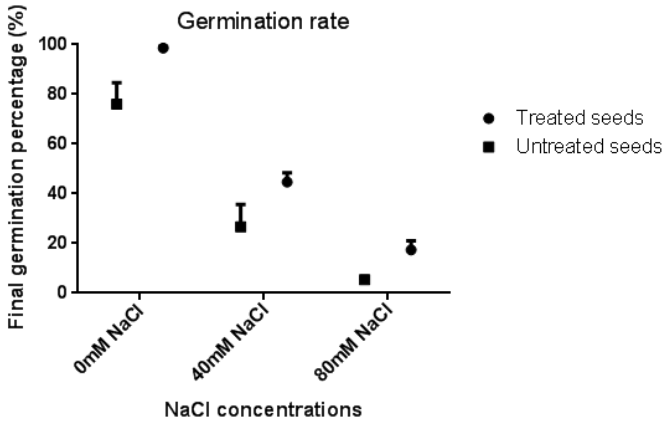

Figure 1: Effect of seed priming treatment on germination rate of fennel seeds under salt stress conditions.

Analysis of variance showed a significant effect of salinity on seedling vigor index (Figure 2). Maximum of seedling vigor index (381.4) was observed at control level of salinity and minimum of them (23.53) were obtained at highest level of salinity (80 mM). However, seed Priming with *Trichoderma* significantly enhanced it across salinity levels. The seedling vigor index increased to almost more than 70% from 381.4 in untreated seeds to 746.2 in treated seeds at 0 Mm and from 25.53 in untreated seeds to 92.33 at 80mM in treated seeds.

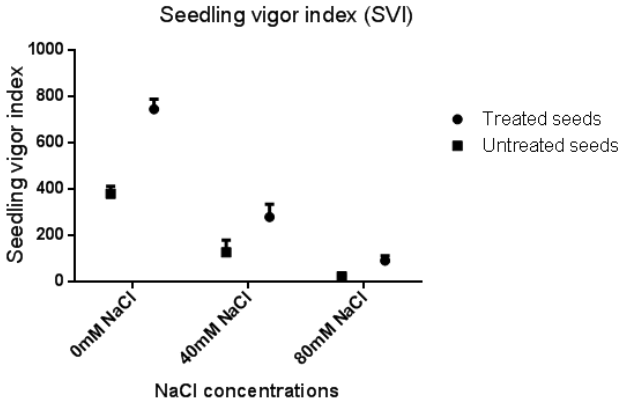

Figure 2: Effect of seed priming treatment on Seedling Vigor Index of fennel *Foeniculum vulgarae* Mill under salt stress conditions.

Vegetative growth

Table 2 show the effect of salinity and biostimulant application on the growth variables. As shown in Table 2, Salinity negatively affected vegetative growth of fennel plants. The negative impact of salinity on vegetative parameters such as plant height, leaf number, stem diameter, umbel number and umbell diameter increased as salinity of irrigation water went up to the highest level (80 mM).

Maximum fresh weight (31.93 g plant-1) was obtained from the control treatment (0 Mm Nacl). Tukey's test results indicated that the treatments including control and 40 mM Nacl irrigation water salinity were in the same group but the severe salt treatment (80mM) was statistically different.

As shown in Table 2, increasing salinity levels caused a marked inhibitory effect on fruit yield per plant of fennel. Fruit yield per plant was greatest for the control treatment (9.64 g plant-1); at 80 mM Nacl treatment, the seed yield was significantly reduced (6.47g plant^{-1}).

Results showed that the application of *Trichoderma* increased significantly the growth parameters of fennel plants compared to control. Plant height, leaf number, umbell number, fresh weight as well as fruit weight increased significantly in *Trichoderma* Treated fennel plants subjected to 0, 40 and 80 mM NaCl treatments as compared to those plants that were not treated with *Trichoderma atroviride*.

Table 2: Effect of seed priming treatment on vegetative growth of fennel (*Foeniculum vulgarae* Mill) under salt stress conditions.

	Untreated **seeds**			Treated **seeds**		
	0 mM	**40 mM**	**80mM**	**0 mM**	**40 mM**	**80mM**
Plant height (cm)	59.76±1.93^{ab}	49.94±2.01^{c}	45.45±0.58^{c}	64.33±2.84^{a}	62.45±2.99^{a}	56.24±0.6^{b}
Leaf number	10 ±0.02^{bc}	9.33±0.57^{bc}	7.33±0.57^{d}	12.33±0.57^{a}	10.67±0.57^{b}	8.67±0.58^{cd}
No. of umbels	4.33±0.57^{ab}	2.66±0.57^{bc}	2±0.1^{c}	6±1^{a}	5±0.0^{a}	4.33±0.57^{ab}
Fresh weight (g)	31.93±1.45^{bc}	29.1±4.81^{bc}	21.1±6.65^{c}	64.7±12.47^{a}	48.23±7.73^{ab}	37.9±5.22^{bc}
Dry weight (g)	3.83±0.47^{a}	4.03±0.61^{a}	3.06±1.10^{a}	7.2±2.25^{a}	6.5±1.68^{a}	7.4±2.51^{a}
Fruit's weight(g)	9.64±0.36^{b}	8.93±0.29^{c}	6.47±0.36^{d}	10.75±0.03^{a}	10.33±0.15^{ab}	9.82±0.15^{b}
Weight of 1000 fruits	4.95±0.24^{b}	4.82±0.31^{bc}	3.92±0.22^{c}	6.12±0.69^{a}	5.58±0.07^{ab}	5.26±0.26^{ab}
Stem diameter (mm)	9.38±0.90^{a}	8.51±0.96^{abc}	7.66±0.94^{abc}	8.85±0.18^{ab}	7.31±0.27^{bc}	6.69±0.62^{c}
Umbell diameter(cm)	13.66±1.25^{a}	10.83±2.51^{a}	9.83±1.25^{a}	13.3±2.45^{a}	12.46±0.05^{a}	13.06±2.72^{a}

Total phenolic content

Under salt treatment, total phenol content increased proportionally with the increase in salt concentration (Table 2). Treatment with *Trichoderma* at all concentration enhances significantly the total phenolic content in fennel plants cultivated under different growth conditions (0,40 and 80 mM of NaCl). The highest levels of total phenolic were detected in plants treated with *Trichoderma* (6 mg GAE g^{-1}) at non-saline conditions followed by plants treated with *Trichoderma* (5.83 mg GAE g^{-1}) under 80 mM of NaCl.

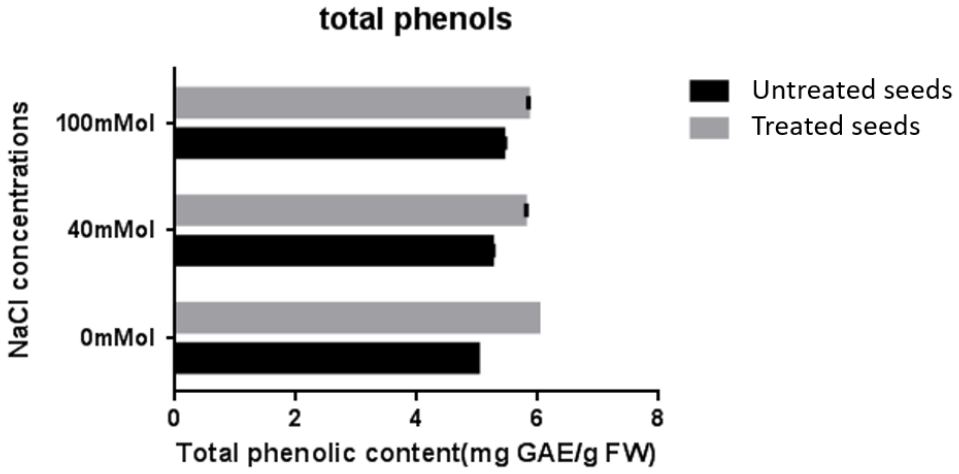

Figure 2: Effect of seed priming with *Trichoderma atroviride* and salinity concentrations on total phenolic content of fennel fruits.

Essential oil yield

As shown in Figure 3, in the control fruits, essential oil yield was 2.02%, based on their dry weight and was significantly affected by the salt treatment. The application of increasing NaCl concentrations (40 and 80 mM) resulted in essential oil yield of 3.06% and 3.63%, respectively. Thus, NaCl enhances Essential oil production of fennel.

Biostimulant application significantly enhanced the essential oil yield at different salinity levels with the highest under *Trichoderma atroviride* application at 80 mM NaCl (3.97%).

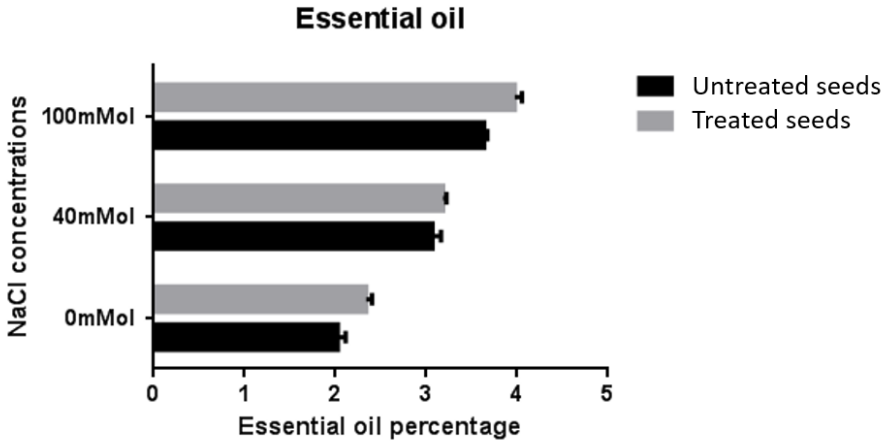

Figure 3: Effect of seed priming with *Trichoderma atroviride* and salinity concentrations on essential oil yield of fennel fruits.

IV. DISCUSSION

Soil salinity is an increasingly serious global problem, as salt hampers plant growth and development and reduces crop yield. Seed germination and early seedling growth are critical stages in plant establishment and production and are very sensitive to salt stress. The harmful effects of NaCl on seed germination and seedling emergence are caused by the decrease in water use efficiency and nutrient supplement ability when sodium accumulates in soil and the toxic effects of sodium and chloride ions on plants occur [33,34,35]. It seems also that salinity stress affects seed germination via the limitation of seed water absorption [36], excessive use of nutrient pool [37] and creation of disorders in protein synthesis.

This study indicated that 80 mM NaCl solution had an obvious salt stress effect on the seed germination and seedling growth of fennel.

The germination energy (GE) and germination percentage (GP) of the seeds under salt stress conditions are reduced compared with the control. Therefore, it is of great practical significance for agricultural production

to study the technical methods of improving seed vigor under salt stress in order to alleviate the adverse effects of salt stress on seed germination and seedling emergence.

The objective of this study was to investigate the effects of seed biopriming with *Trichoderma* on the seed germination and seedling growth of fennel under salt stress. Related reports have shown that some microorganisms could improve the growth performance of plants under a stress environment by providing plant hormones, soluble phosphate, fixed nitrogen, and other substances [38,39]. Some researchers began to pay attention to the application of microorganisms in seed pre-sowing treatment because of the ability of beneficial microorganisms to inhibit diseases and improve crop germination ability and vitality.

In the present study, salt stress caused significant decrease in germination and seedling growth of fennel in untreated plants. These results are in agreement with those obtained by other authors, showing that in some medicinal plants, germination is significantly decreased by salinity [40,41,42].

From the present investigation of the germination test, it is quite clear that earlier and synchronized germination and emergence was observed in the treated seeds compared with that of control as depicted by lower T_{50} and MGT, and higher GI, GE, EP, radicule lenght and SVI in treated seeds compared with untreated ones (Tables 1).

Higher radicle length as observed in treated seeds might be the result of earlier germination and emergence (Tables 1).

It is well documented that seed biopriming with *Trichoderma* improves seed performance and helps seeds to germinate even under adverse soil conditions. *Trichoderma* releases a variety of compounds that induce resistance response to biotic and abiotic stresses [43]. The results related to germination percentage can be related to earlier findings in which it was reported that seed treatment with *Trichoderma* increases the germination percentage and rate of germination [44].

Results of the present study showed that all parameters related yield and growth were affected adversely by increasing salinity in irrigation water. These results are confirmed by earlier findings of Mangal et al. [45] on coriander and fennel; Singh et al. [46]; Ahmad [47]; Abou El-Magd et al. [48] and Zaki et al., [49] on sweet fennel. The above negative effects of salinity on the vegetative parameters of sweet fennel can be explained based on the findings of Abel and Mackenzie [50] who explained that the possible harmful effects of specific ions such as Na, Cl, Ca and $NaSO_4$ which inhibited the synthesis of chlorophyll and carotene in leaves, and/or high sodium concentration that induced calcium and magnesium nutritional deficiencies and influenced the respiratory pathways in roots. Physiological draught stress due to long exposure to salinity can reduce water and nutrient uptake resulting in those negative effects [51]. Furthermore, those specific ion effect may result in direct toxic effect due to imbalances of mineral nutrition [52]. Osmotic effect can also result in reduction in stomata conductance and limitations to CO2 uptake leading to minimized photosynthesis [53].

Fresh and dry weight of fennel plants were adversely affected by salinity increases in irrigation water. These results were similar to those of plant height and leaf numbers. Fresh and dry

weights are the summation of the vegetative growth, transpiration and photosynthetic activity. So that, fresh and dry weight were decreased by the decrease in those parameters. This adverse effect might be due to the harmful effect of salinity on the vegetative growth, photosynthetic activity reflecting decreases in the carbohydrates accumulation. Decreased biomass under salt stress is due to the integrated adverse effects of ion toxicity and nutritional disorders in soil solution [54].

The depressive effect of salt on fruit yield has been reported earlier in several aromatic and medicinal plants including *Foeniculum vulgare* [55] and *Trachyspermum ammoli* [56]. One cause of this yield reduction under saline constraint is an inadequate photosynthesis owing to stomatal closure limiting carbon dioxide uptake [57]. Concomitant with the decrease in fruit yield, the number of umbels per plant, the 1000 fruit weight as well diminished significantly with the increasing concentration of NaCl (Table 2). A decrease in fruit yield might arise from a reduction of flower production and/or a decrease of their fertility

Results suggested that, the application of "*Trichoderma* »to the fennel plants mitigates salt-related consequences in plants, which results in considerable increases in growth and biomass production. It was observed that salinity caused a substantial reduction in growth and biomass of those plants without *Trichoderma* treatment.

Trichoderma is an endophytic symbiont, as its inoculation has antagonistic properties and therefore enhances the systemic tolerance to salt stress in plants [43]. The increase in growth and biomass production with a *Trichoderma* application may be due to its ability to produce phytohormones like cytokine and gibberellins, which could be beneficial for biological enhancements of crop fertility and may not only promote the plant growth but also increase some degree of tolerance in a saline environment [58,44,59].

Trichoderma spp. were suggested as a plant growth promoting fungi due to their ability to produce siderophores and phosphates-solubilizing enzymes[60]. This can be realized through several mechanism involved like mycoparasitism, antibiosis, degradation of toxins, inactivation of pathogenic enzymatic pathways, resistance to pathogens, enhanced nutrient uptake leading to overall development [60,61].

Salinity led to biochemical disorders and can change plant behaviour regarding the biosynthesis of primary and secondary metabolites. Among all the secondary metabolites synthesized by plants, phenolic and essential oil compounds are some of the most widespread.

Regarding the data acquired in our experiment, it can be highlighted that total phenolic content was remarkably increased as a result of increasing the level of salinity. Polyphenols represent a large family of plant secondary metabolites. The synthesis of these compounds is induced in response to biotic and abiotic stimuli and may act as antioxidants to protect the plant against oxidative stress [62]. Increase in total phenolic content by application of biostimulant in fennel plants can be explained by enzyme activation.

It is well known that Essential oil yield is influenced by intrinsic parameters (such as growth stages) and extrinsic ones (such as pedoclimatic conditions and salinity). Significant changes of Essential oil yield as calculated on the basis of dry weight, were observed among the different salt doses. The fennel essential oil yield increased significantly with the constraint severity and reached 3.97% for 80 mM NaCl in treated plants with *Trichoderma atroviride* (Figure 1). Such increase of essential oil yield by salinity has been reported earlier in leaves of other plant species, such as Salvia officinalis [63], Coriandrum sativum at low (25 mM) and moderate (50 mM) NaCl concentrations [64] and Nigella sativa [65]. The stimulation of essential oil production under salinity could be due to a higher oil gland density and an increase in the absolute number of glands produced [66].

V. CONCLUSION

Our results confirmed that priming of fennel seeds in *Trichoderma atroviride* increases the germination percentage, growth as wel as essential oil and phenolic contents of salinity stressed seedlings. The present research, thus, offers a new approach to alleviate salinity stress in fennel through seed biopriming with *Trichoderma atroviride* strain. It could be concluded that seed biopriming with the biostimulant *Trichoderma* increased the ability of crops to grow successfully under saline conditions. Consequently, study should continue to isolate other strains of *Trichoderma atroviride* that could be used in alleviation of salinity and determine the efficiency of these strains under natural field condition.

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