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*(Original Article)*

# Predicting the Severity of Alfalfa Root *rot* Disease Under Salinity Conditions

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## Abstract

Alfalfa roots are infected with several fungal pathogens under salinity conditions. The effect of two salts of NaCl and $CaCO_3$ at three concentrations was studied *in vitro.* Mycelial growth and disease severity (DS%) were estimated to determine the relationship between (DS%) and water salinity. The highest effect on mycelial growth was detected at the electrical conductivity ($EC_W$ value) of 18.75 ds/$m^2$ which ranged from 8.80 and 9.44% with NaCl and $CaCO_3$, respectively. Furthermore, *Exserohilum* sp. was the most affected by water salinity. With the different levels of water salinity, the DS% of alfalfa root rot increased gradually with the increased water salinity level. The highest level of water salinity with NaCl and $CaCO_3$ $EC_W$ value at 18.75 ds/$m^2$ ranged (42.76 and 43.53% severity for NaCl) and (44.04 and 44.42% severity for $CaCO_3$, respectively). Moreover, with water salinity NaCl and $CaCO_3$, *Fusarium* sp. was the highest (DS%) with NaCl. Alfalfa root rot prediction model based on information gathered from the interaction of pathogen, water salinity, disease severity, and root and shoot length. It was found the relation between DS% with fungi, salt type, salt concentration, root and shoot length in the multiple regression model ($r^2$ =88.83%).

***Keywords:*** *Alfalfa, Root rots, Water salinity, Prediction models*

## Introduction

Alfalfa (*Medicago sativa* L.), is a perennial herb native to Iran and Central Asia (Bingham *et al*., 1975; Harrison *et al*., 2002). Alfalfa is widely regarded as a superior feed for dairy and beef cattle (*Bos* spp.) because it is easily digested, has a high protein content and a high concentration of cell solutes. (Conrad and Klopfenstein, 1988).

The total area under cultivation in Egypt throw 2018/2019 was 73469 feddans and the total production was 3156757 tons, while in New Valley Governorate, the total cultivated area in 2018/2019 was 41612 feddans and the total production was 2307613 tons (CAPMAS, 2023).

Several biotic agents and abiotic agents highly stress effect on alfalfa yield. Root rot is one of the most damaging fungal diseases. Root rot pathogens are

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responsible for some of the most serious plant diseases in the world, affecting a variety of crops. (Nzungize *et al*., 2011). Symptoms of root rot are a serious threat because the damage occurs below the ground. Root rot can be caused by different groups of pathogens as fungi (Cui *et al*., 2015).

Pythium species and Phytophthora species belong to the family Pythiaceae, both attack several crops. Symptoms include wilting, yellowing of the foliage and cause stem or root rots in numerous legumes crop, including alfalfa (Zhang and Franken, 2014). Also, alfalfa is frequently affected by *Rhizoctonia* sp. which causes root rot disease (Zhang *et al*., 2021). *Fusarium* spp. can attack a wide range of crops. Among the symptoms, brown lesions, then become dark black lesions on below-ground roots and stems. that results in stunting and death (Subrahmanyam *et al*., 1992).

In arid and semi-arid areas, salts frequently build up as a result of inadequate soil drainage and poor-quality irrigation water. Saline soils affect several physiological processes in plants, which reduce growth and production. While salinity stress can cause significant changes in plant physiology and morphology, little is known about how such changes may affect plant susceptibility to pathogenic organisms. The threat of increasing salinity in many irrigated areas around the world, as well as field observations, prompted some research into possible interaction between salinity stress and disease development. (Besri, 1993). Water salinity increases the population of *Fusarium oxysporum* in the soil, the spores of fungus in plant vessels, the formation of chlamydospores, and, finally, the development of disease even in very hot conditions. Furthermore, high salinity can break the resistance of Fusarium resistant cultivars. (Besri, 1981). Disease risk assessments have been developed and used for some soil-borne plant diseases such as *F. oxysporum* f. sp. *lycopersici* on tomato (Stirling *et al*., 2004), *A. cochlioides* on sugar beet (Almquist *et al*., 2016) and root rot disease of cereals (Poole *et al*., 2015). The aims of this study were to study the relationship between disease severity and water salinity with pathogen, salt concentration, shoot and root length.

## Materials and Methods

### 1-Pathogenic fungi caused Alfalfa root rots

Twelve pathogenic fungal, viz, five isolates of *Fusarium* spp., two isolates of *Rhizoctonia solani*, one isolate of *Ceratobasidium* sp., one isolate of *Alternaria* sp., two isolates of *Curvularia* spp. and one isolate of *Exserohilum* sp. were obtained from the Department of Plant Pathology, Faculty of Agriculture, New Valley University, Egypt.

### 2-Pathogenicity tests

Pathogenicity tests of all fungi were carried out on alfalfa plants (Wadi1 cultivar) under greenhouse conditions in Plant Pathology Dep., Fac. of Agric., New Valley Univ. According to (Cao *et al.*, 2020) pots (25 cm in diameter) were sterilized by immersing them in 5% formalin solution for 20 minutes and left to dry before use. After that, the pots were filled with autoclaved sandy loam soil.

Alfalfa seeds were surface sterilized by dipping them in a 0.1 percent sodium hypochlorite solution for 2 minutes, then washed with sterilized water and seeded. The inoculum was grown in Erlenmeyer flasks (500 ml) with 100 ml of liquid Richard's medium in each. (McCauley *et al*., 2005). All fungi were incubated for 10 days at 28°C before being centrifuged for 10 minutes at 3000 r.p.m. Propagules fungi were re-suspended in sterile water to give propagules concentration of 4 x $10^5$ C.F.U. /ml, after one month from alfalfa seeded, fifty ml of each mycelial suspension were added to each pot. Pots with uninfected plants were used as control. Three replicates were performed for each tested isolate. After 2–months, plants were carefully uprooted and disease severity was recorded as the disease severity index (DSI) of root rots from sowing data using the arbitrary scale of 0 to 4 used by (Alejandro Rojas *et al*., 2017).

**3-Effect of saline on mycelial linear growth of pathogenic fungal in vitro**

The effect of salts (NaCl or CaCO3) on the mycelial linear growth was investigated by growing the isolates in a PDA medium at three concentrations of NaCl or CaCO3 (6.25 ds/m2, 12.50 ds/m2 and 18.75 ds/m2); Control medium without added with salts. In order to test mycelial growth inhibition, a plug (5 mm) from an actively growing culture (7-10 days) was placed in the center of a PDA agar plate of 90 mm Petri dishes. Cultures were incubated at 27°C for 7-14 days, with three replications for each treatment. Colony diameters were measured at 10-15 days, as a reduction of mycelial growth (Boumaaza *et al.*, 2015).The reduction of mycelial growth percentage that occurred in each pathogenic fungus was determined at the end of the experiment using formula according to Thangavelu *et al.* (2004).

**4-Effect of water salinity concentrations on Alfalfa root rots severity under greenhouse conditions**

This experiment was conducted under greenhouse conditions in Plant Pathology Dep., Fac. of Agric., New Valley Univ. Inoculation methods and preparation of all fungi utilized as mentioned above. Salinity treatments tested with two salts (NaCl and CaCO3), with 3 concentrations for each salt and three replicates for each concentration. Irrigation of seedlings with 100 mL of NaCl or CaCO3 at concentrations 6.25 ds/m2, 12.50 ds/m2 and 18.75 ds/m2 (Rauf *et al.*, 2014). The control plants received SDW only. After 2–months, plants were carefully uprooted, and DS% was recorded as mentioned above.

**5-The relationship between DS% with fungi, salt, root and shoot length**

Depending on the experiment in greenhouse to assess the DS% of alfalfa root rots diseases under salinity conditions we studied the relationship between DS% and salinity conditions while:

DS% = dependent variable (Y)

Fungi, salt, root and shoot length = independent variable (X)

## Statistical Analysis

The results of the experiments were analyzed using the software CoStat version 6.303–CoHort Software. Duncan's multiple range test was used to compare the means of all treatments at a 5% level of probability. (Gary, 2010). The STATGRAPHICS–Version 19–Stat Point, Inc. was used to prediction models. A linear model and the regression model test were used to analyze the obtained data in order to determine statistically significant differences (p = 0.05). Pearson's coefficient of correlation (r) was used to test the correlations between disease severity with fungi, salt, root and shoot length.

## Results and Discussion

### 1-Pathogenicity tests

Data in Table (1) show that all the tested fungal isolates are significant to infect alfalfa plants (Wadi1 cv.). The tested isolates caused root rots diseases and they differed in their virulence. *Fusarium verticillioides* (F19), F. *solani* (F 39) and F. *brachygibbosum* (F23) were given the highest DS% (43.33, 45.83 and 40.00%, respectively) also recorded the highest loss of root length (58.78, 58.83 and 55.27%, respectively) and shoot length (62.77, 62.66 and 55.39%, respectively). While the lowest DS% was (24.17%) for *Exserohilum rostratum* (F10) also recorded the lowest loss of root and shoot length (21.36 and 21.38%, respectively). These results indicate that the major root rot causing agents are *Fusarium* spp. as mentioned by (Peterson *et al*., 2018)

**Table 1. Pathogenicity tests for pathogenic fungi causing alfalfa root rots diseases.**

| Fungi | Code | DS (%) | loss of root length % | loss of shoot length % |
|---|---|---|---|---|
| *Exserohilum rostratum* | F10 | 24.17±0.83 $^{h*}$ | 21.36±8.86 $^{l}$ | 21.38±0.66$^{l}$ |
| *A. alternata* | F20 | 27.50±1.44 $^{gh}$ | 25.07±0.39$^{k}$ | 25.22±0.30$^{k}$ |
| *C. spicifera* | F25 | 28.33±0.83 $^{gh}$ | 28.87±0.77$^{j}$ | 28.89±0.72$^{j}$ |
| *C. spicifera* | F38 | 30.83±2.20 $^{fg}$ | 32.77±0.60$^{i}$ | 32.95±0.67$^{i}$ |
| *Ceratobasidium* sp. | F7 | 39.17±0.83 $^{bcd}$ | 51.37±1.03$^{d}$ | 51.21±1.02$^{d}$ |
| *Rhizoctonia solani* | F26 | 33.33±0.83$^{defg}$ | 39.98±0.35$^{g}$ | 39.83±0.37$^{g}$ |
| *R. solani* | F27 | 32.50±2.89 $^{efg}$ | 36.38±0.41$^{h}$ | 36.28±0.40$^{h}$ |
| *F. verticillioides* | F1 | 38.33±2.20$^{bcde}$ | 47.77±0.20$^{e}$ | 47.6±10.27$^{e}$ |
| *F. solani* | F19 | 43.33±3.63$^{ab}$ | 58.78±1.46$^{b}$ | 58.83±1.42$^{b}$ |
| *F. brachygibbosum* | F23 | 40.00±1.44$^{abc}$ | 55.27±0.13$^{c}$ | 55.39±0.05$^{c}$ |
| *F. proliferatum* | F30 | 35.83±1.67$^{cdef}$ | 43.94±2.18$^{f}$ | 43.70±2.12$^{f}$ |
| *F. solani* | F39 | 45.83±3.00$^{a}$ | 62.77±0.40$^{a}$ | 62.66±0.44$^{a}$ |
| Noninfected plant (Control) | | 0.00 $^{i}$ | 0.00 $^{m}$ | 0.00 $^{m}$ |
| Mean | | 32.24 | 38.79 | 38.77 |

* Means followed by the same letter(s) are not significantly different (p < 0.05) according to Duncan's multiple range test.

### 2- Effect of salinity on mycelial growth *in vitro*

Table (2) illustrate that the highest significant effect of salts was detected at the Electrical Conductivity (EC value) 18.75 ds/m$^2$ which ranged (8.80 and 9.44% with NaCl and $CaCO_3$ reduction growth, respectively), followed by EC value 12.5 ds/m$^2$ ranged (1.13 and 0.99% reduction growth, respectively) and EC value 6.25

ds/m$^2$ (0.21 and 0.10% reduction growth, respectively). On the other hand, *Exserohilum* sp. (F10) and *A. alternata* (F20) were recorded the most affected by salinity (7.38 and 6.01% reduction, respectively). While *F. solani* (F39) was the latest affected by salinity (0.51% reduction). The other isolates were moderate significant to salinity. These results are in line with several workers (Rauf *et al*., 2014)

**Table 2. Effect of saline on mycelial growth of fungal pathogen *in vitro* causing alfalfa root rots diseases.**

| Fungi | code | Reduction of mycelial growth (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Salinity $EC_W$ (ds/m$^2$) | | | | | | | |
| | | NaCl | | | | $CaCo_3$ | | | Mean |
| | | 0.00 | (6.25) | (12.5) | (18.75) | (6.25) | (12.5) | (18.75) | |
| ***Ex. rostratum*** | F10 | 0.00 | 0.96±0.49* | 2.59±1.62 | 19.70±3.48 | 0.74±0.74 | 3.19±1.52 | 24.44±1.28 | 7.38±3.85$^{a}$ |
| ***A. alternata*** | F20 | 0.00 | 0.89±6.46 | 2.37±0.70 | 18.30±3.62 | 0.52±0.52 | 1.70±0.32 | 18.30±2.01 | 6.01±3.18$^{b}$ |
| ***C. spicifera*** | F25 | 0.00 | 0.67±0.67 | 2.22±1.28 | 13.19±1.55 | 0.00 | 1.48±0.08 | 14.07±2.14 | 4.52±2.37$^{c}$ |
| ***C. spicifera*** | F38 | 0.00 | 0.00 | 1.56±0.13 | 9.11±1.02 | 0.00 | 1.48±0.74 | 10.44±2.84 | 3.23±1.72$^{d}$ |
| ***Ceratobasidium* sp.** | F7 | 0.00 | 0.00 | 0.52±0.32 | 4.81±0.98 | 0.00 | 0.22±0.22 | 5.33±1.58 | 1.56±0.91$^{fg}$ |
| ***R.solani*** | F26 | 0.00 | 0.00 | 1.26±0.20 | 8.67±3.02 | 0.00 | 1.04±0.52 | 8.59±1.28 | 2.79±1.52$^{de}$ |
| ***R. solani*** | F27 | 0.00 | 0.00 | 1.33±0.67 | 9.04±1.84 | 0.00 | 1.11±0.59 | 8.89±1.28 | 2.91±1.58$^{de}$ |
| ***F. verticillioides*** | F1 | 0.00 | 0.00 | 0.59±0.59 | 5.56±1.05 | 0.00 | 0.67±0.67 | 5.70±0.85 | 1.79±1.00$^{ef}$ |
| ***F. solani*** | F19 | 0.00 | 0.00 | 0.00 | 4.15±0.45 | 0.00 | 0.00 | 4.30±1.16 | 1.21±0.78$^{fg}$ |
| ***F. brachygibbosum*** | F23 | 0.00 | 0.00 | 0.00 | 4.22±1.10 | 0.00 | 0.00 | 5.19±0.74 | 1.34±0.87$^{fg}$ |
| ***F. proliferatum*** | F30 | 0.00 | 0.00 | 1.11±0.34 | 7.41±1.96 | 0.00 | 0.96±0.19 | 5.93±0.74 | 2.20±1.18$^{def}$ |
| ***F. solani*** | F39 | 0.00 | 0.00 | 0.00 | 1.41±0.45 | 0.00 | 0.00 | 2.15±0.07 | 0.51±0.34$^{g}$ |
| **Mean** | | 0.00 $^{d}$ | 0.21±0.11$^{cd}$ | 1.13±0.27$^{b}$ | 8.80±1.64$^{a}$ | 0.10±0.07$^{d}$ | 0.99±0.27$^{bc}$ | 9.44±1.88$^{a}$ | 2.95±0.55 |

* Means followed by the same letter(s) are not significantly different ($p < 0.05$) according to Duncan's multiple range test.

## 3- Prediction disease severity % Models

## Relationship between disease severity with fungi, salt, root and shoot length:

## Relationship between disease severity with fungi (Model 1)

Table (3) illustrate the linear model had the lowest percentage of correctly predicting the disease severity % expected with fungi. (r2 = 57.69%) and (r2 adjusted for d.f.= 57.49%). In the linear model (Fig. 1). The fitted linear model's equation is:

Disease severity % Average = 22.6179 + 2.64394*Fungi

The variables' relationship is moderately strong, according to the correlation coefficient of 0.273247. Figure 2, the square root-X model had the highest accuracy in predicting the DS% expected with fungi (r2 = 76.02%) and (r2 adjusted for d.f.= 75.90%). The square root-X model's fitted equation is:

Disease severity % Average = 12.0987 + 11.7261*sqrt (Fungi). (1)

The variables have a moderately strong relationship, as indicated by the correlation coefficient of 0.87188.

**Table 3. Relationship between disease severity with fungi**

| No. | Model | Equation | Output | Correlation Coefficient | $R^2$ % | $R^2$ (adjusted for d.f.) % | Standard Error of Est | Mean absolute error | Durbin-Watson statistic | Lag 1 residual autocorrelation | Model No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Linear | Y = a + b*X | DS% Average = 22.6179 + 2.64394*Fungi | 0.759544 | 57.6907 | 57.4853 | 8.51294 | 6.21154 | 0.632082 (P=0.0000) | 0.666492 | - |
| | Square root X | Y = a + b*sqrt(X) | DS% Average = 12.0987 + 11.7261*sqrt (Fungi) | 0.87188 | 76.0174 | 75.901 | 6.40928 | 5.19719 | 1.07714 (P=0.0000) | 0.451433 | 1 |

**Table 4. Relationship between disease severity with salt**

| No. | Model | Equation | Output | Correlation Coefficient | $R^2$ % | $R^2$ (adjusted for d.f.) % | Standard Error of Est | Mean absolute error | Durbin-Watson statistic | Lag 1 residual autocorrelation | Model No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Linear | Y = a + b*X | DS% Average = 22.0076 + 11.8979*Salt | 0.570867 | 32.5889 | 32.2617 | 10.7455 | 8.57525 | 0.504342 (P=0.0000) | 0.734772 | - |
| | Double square root | Y = (a + b*sqrt(X)) ^2 | DS% Average = (1.59116 + 3.90117*sqrt (Salt))^2 | 0.82214 | 67.5912 | 67.4339 | 1.02668 | 0.87263 | 0.5346 (P=0.0000) | 0.726351 | 2 |

**Table 5. Relationship between disease severity with shoot length**

| No. | Model | Equation | Output | Correlation Coefficient | $R^2$ % | $R^2$ (adjusted for d.f.) % | Standard Error of Est | Mean absolute error | Durbin-Watson statistic | Lag 1 residual autocorrelation | Model No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | Linear | Y = a + b*X | DS% Average = 70.341 - 2.13589*Shoot average | -0.90052 | 81.0935 | 81.0017 | 5.69072 | 3.74049 | 0.425483 (P=0.0000) | 0.781135 | - |
| | Squared-Y | Y = sqrt (a + b*X) | DS% Average = sqrt (-3931.95 + 76219.8/Shoot average) | -0.97485 | 95.0336 | 95.0095 | 166.393 | 110.739 | 1.41919 (P=0.0000) | 0.279997 | 3 |

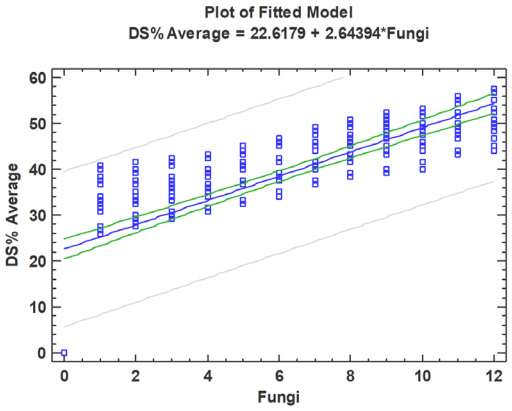


**Figure 1. Relationship between disease severity with fungi**

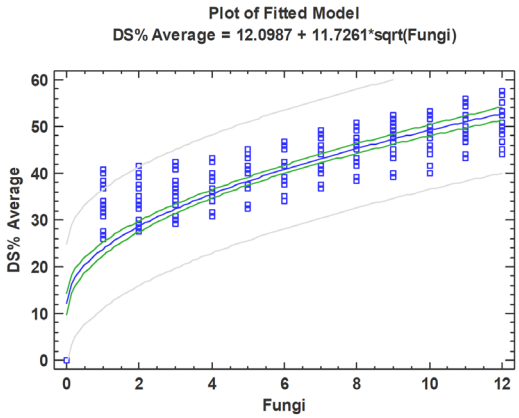


**Figure 2. Relationship between disease severity with fungi (model 1)**

## Relationship between disease severity with salt (Model 2)

Table (4) shows that the linear model had the lowest percentage of correctly predicting the disease severity % expected with salt (r2 = 23.59%) and (r2 adjusted for d.f.= 32.26%). In the linear model (Fig.3). The fitted linear model's equation is:

Disease severity % Average = 22.0076 + 11.8979*Salt

The variables' relationship is moderately strong, according to the correlation coefficient of 0.570867. On the other hand, the Double square root model had the highest accuracy in predicting the DS% expected with salt (r2 = 67.59%) and (r2 adjusted for d.f.= 67.43%) Figure 4 shown that the Double square root model's fitted equation is:

Disease severity % Average = (1.59116 + 3.90117*sqrt (Salt)) ^2. (2)

The variables have a moderately strong relationship, as indicated by the correlation coefficient which equals 0.822139.

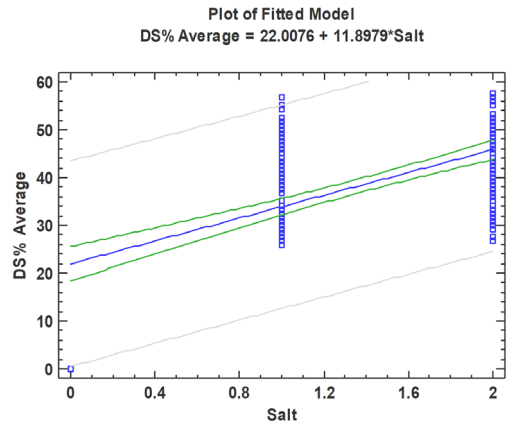


**Figure 3. Relationship between disease severity with salt**

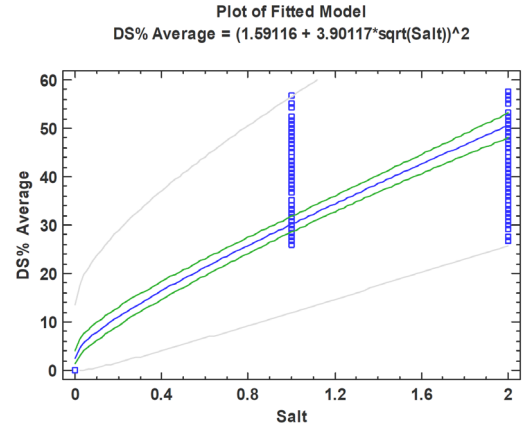


**Figure 4. Relationship between disease severity with salt (model 2)**

**Table 6. Relationship between disease severity with root length**

| No. | Model | Equation | Output | Correlation Coefficient | $R^2$ % | $R^2$ (adjusted for d.f.) % | Standard Error of Est | Mean absolute error | Durbin-Watson statistic | Lag 1 residual autocorrelation | Model No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | Linear | Y = a + b*X | DS% Average = 70.1888 - 3.6381*Root average | -0.90111 | 81.1992 | 81.108 | 5.67478 | 3.71555 | 0.432562 (P=0.0000) | 0.7781 | - |
| | Squared-Y | Y = sqrt (a + b*ln(X)) | DS% Average = sqrt (3606.7 - 224.458*Root average) | -0.9745 | 94.9657 | 94.9412 | 167.527 | 111.475 | 1.44207 (P=0.0000) | 0.267615 | 4 |

**Table 7. Relationship between disease severity with fungi, salt, shoot and root length**

| No. | Model | Equation | Output | $R^2$ % | $R^2$ (adjusted for d.f.) % | Standard Error of Est | Mean absolute error | Durbin-Watson statistic | Lag 1 residual autocorrelation | Model No. |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | Multiple | $Y = a + b*X_1 + b*X_2 + b*X_3 + b*X_4$ | DS% Average = 60.9148 - 0.206622*Fungi + 5.86298*Salt - 17.5978*Root average + 8.31705*Shoot average | 88.5443 | 88.3186 | 4.46228 | 3.24596 | 0.712138 (P=0.0000) | 0.641502 | 5 |
| | Multiple | $Y = a + b*X_1 + b*X_2 + b*X_3$ | DS% Average = 61.4189 - 0.207509*Fungi + 5.95686*Salt - 3.43535*Root average | 88.4624 | 88.2928 | 4.46722 | 3.28288 | 0.659866 (P=0.0000) | 0.666724 | - |

## Relationship between disease severity with shoot length (Model 3)

Data in Table (5) shows that the linear model had the lowest percentage of correctly predicting the disease severity % expected with shoot length (r2 = 81.09%) and (r2 adjusted for d.f.= 81.00%). in the linear model (Fig. 5). The fitted linear model's equation is:

Disease severity % Average = 70.341 - 2.13589*Shoot average

The variables' relationship is a relatively strong, according to the correlation coefficient of -0.900519. On the other hand, the the Squared-Y model had the highest accuracy in predicting the DS% expected with shoot length (r2 = 67.59%) and (r2 adjusted for d.f.= 67.43%). Figure 6 shown that the Squared-Y model's fitted equation is:

Disease severity % Average = sqrt (3618.08 - 131.91*shoot Average). (3)

The variables have a relatively strong relationship, as indicated by the correlation coefficient which equals -0.974852.

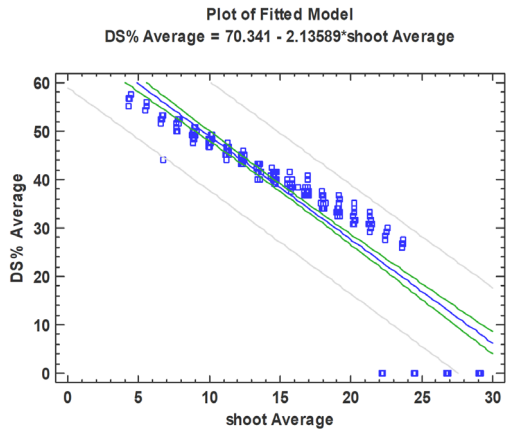


**Figure 5. Relationship between disease severity with shoot length**

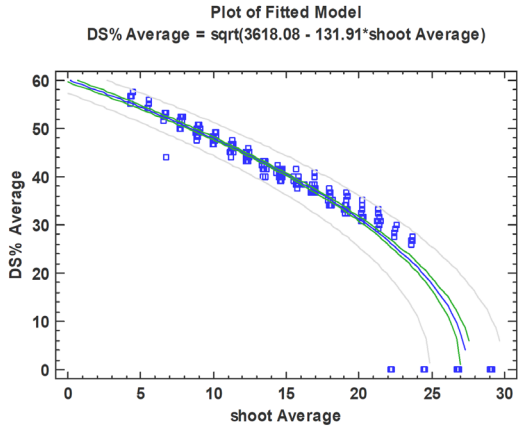


**Figure 6. Relationship between disease severity with shoot length (model 3)**

## Relationship between disease severity with root length (Model 4)

Results in Table (6) shows that the linear model had the lowest percentage of correctly predicting the disease severity % expected with shoot length (r2 = 81.20%) and (r2 adjusted for d.f.= 81.11%). In the linear model (Fig. 7). The fitted linear model's equation is:

Disease severity % Average = 70.1888 - 3.6381*Root average

The variables' relationship is a relatively strong, according to the correlation coefficient of -0.901106. On the other hand, the the Squared-Y model had the highest accuracy in predicting the DS% expected with root length (r2 = 67.59%) and (r2 adjusted for d.f.= 67.43%). Figure 8 shown that the Squared-Y model's fitted equation is:

Disease severity % Average = sqrt (3606.7 - 224.458*Root average). (4)

The variables have a relatively strong relationship, as indicated by the correlation coefficient which equals -0.974503.

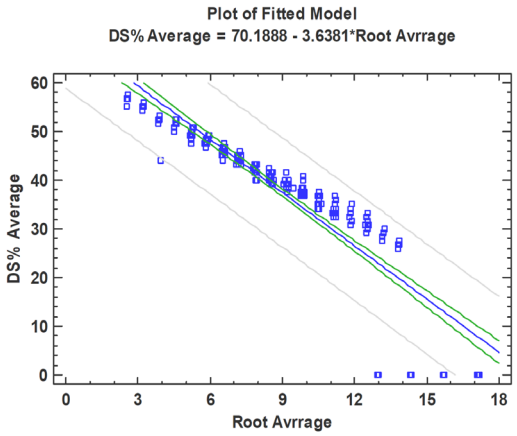


**Figure 7. Relationship between disease severity with root length**

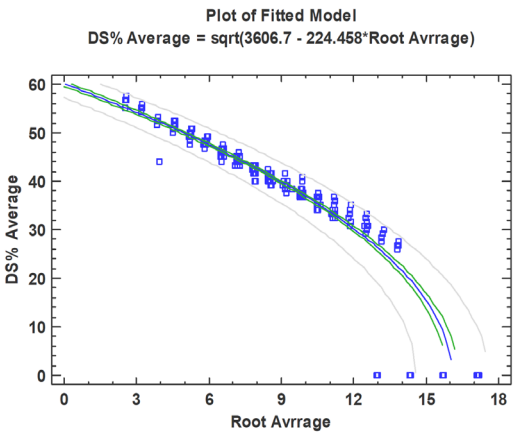


**Figure 8. Relationship between disease severity with root length (model 4)**

## Relationship between disease severity with fungi, salt, shoot and root length (Models 5)

Table (7) shows that the multiple regression model had the percentage of correctly predicting the disease severity % expected with fungi, salt, shoot and root length (r2 88.54%) and (r2 adjusted for d.f.= 88.32%). In the multiple regression model (Fig. 9). The fitted multiple regression model's equation is:

Disease severity % Average = 60.9148 - 0.206622*Fungi + 5.86298*Salt - 17.5978*Root average + 8.31705*Shoot average

According to the R-Squared statistic, the fitted model accounts for 88.5443% of the variation in the DS% Average. The adjusted R-squared statistic is 88.3186%, so it is more suitable for comparing models with various numbers of independent variables.

When considering if the model can be improved keep in mind that the shoot average has the highest P-value on the independent variables at 0.2297. Because the P-value is greater than or equal to 0.05, the term is not statistically significant at the 95.0% confidence level or higher. As a result, you should think about removing shoot average from the model.

According to the result of the obtained out puts from previous model and multiple regression model had the percentage of correctly predicting the disease severity % expected with fungi, salt and root length (r2 88.4624%) and (r2 adjusted for d.f.= 88.2928 %). In multiple regression (Fig. 10). The fitted multiple regression model's equation is:

Disease severity % Average = 61.4189 - 0.207509*Fungi + 5.95686*Salt - 3.43535*Root average

According to the R-Squared statistic, the fitted model accounts for 88.4624% of the variation in the DS% Average. The adjusted R-squared statistic is 88.2928%, so it is more suitable for comparing models with various numbers of independent variables.

When considering if the model can be improved keep in mind that the shoot average has the highest P-value on the independent variables at 0.2073. Because the P-value is greater than or equal to 0.05, the term is not statistically significant at the 95.0% confidence level or higher. As a result, you should think about removing fungi from the model. These results above are consistent with those reported by other researchers. (Stirling *et al*., 2004; Poole *et al*., 2015; Almquist *et al*., 2016; Arafat *et al*., 2021).

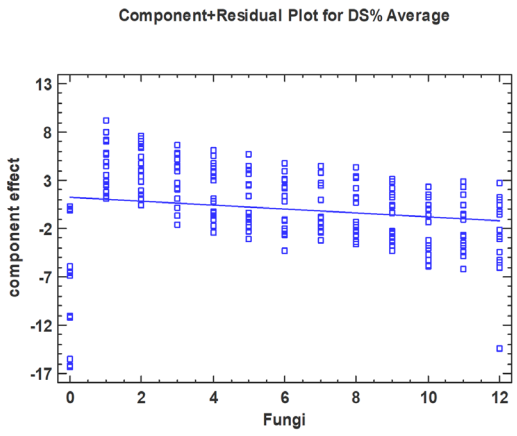


**Figure 9: Relationship between disease severity with fungi, salt, shoot and root length (model 5)**

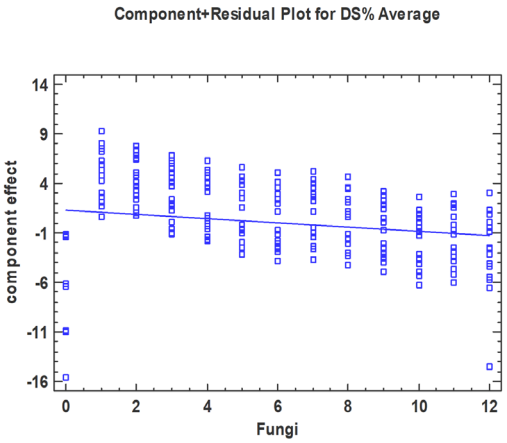


**Figure 10: Relationship between disease severity with fungi, salt and root length**

## Conclusion

Based on the study's previous results, it is concluded that using the prediction model to Prediction disease severity for alfalfa root rot. Where it helps to predict of disease severity expected if alfalfa is cultivated in an area based on soil microbial analysis and analysis of water salinity.

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# التنبؤ بشدة الإصابة بأمراض أعفان جذور البرسيم الحجازي تحت الظروف الملحية

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**الملخص**

تصاب جذور البرسيم الحجازى بالعديد من مسببات الامراض الفطرية تحت الظروف الملحية. تم دراسة تأثير ثلاث تركيزات من ملحين مختلفين هما كلوريد الصوديوم وكربونات الكالسيوم على نمو الفطريات المسببة لاعفان جذور البرسيم الحجازى في المعمل وكذلك تأثير هذه الاملاح على شدة الإصابة على النباتات في الصوبة لايجاد العلاقة بين شدة الإصابة بالفطريات الممرضة وملوحة مياه الرى. معمليا: وجد ان أعلى تأثير على نمو الميسليوم الفطرى تم الحصول عليه عند تركيز 18.75 ديسيسيمنز/م2 حيث تراوح من (8.80 و9,44 % مع كلوريد الصوديوم وكربونات الكالسيوم على التوالي. علاوة على ذلك فطر *Exserohilum* sp. كان اعلى الفطريات تأثرا ملوحة المياه. مع المستويات المختلفة. وجد ان شدة الإصابة بأعفان الجذور تزداد بزيادة التركيزات المختلفة من الملوحة. وأدى التركيز الأعلى للملوحة (18.75 ديسيسيمنز/م2) لكلا الملحين الى زيادة شدة الإصابة حيث تراوحت من (42.76، 43.53% بالنسبة لكلوريد الصوديوم و44.04، 44.42 % بالنسبة لكربونات الكالسيوم). ومن ناحية اخرى مع التركيزات المختلفة لكلا الملحين حصل الفطر *Fusarium* sp. على اعلى متوسط لشدة الإصابة وبذلك بالاعتماد على النتائج التي تم الحصول عليها أمكن تصميم نموذج تنبؤ لتوضيح العلاقة بين الملوحة وشدة الإصابة وطول الجذر والساق، حيث وجد أن معامل ارتباط العلاقة بين النسبة المئوية لشدة الإصابة بالفطريات ونوع وتركيز الملح وطول الجذر والساق في نموذج الانحدار المتعدد هي 88.83% . تهدف هذه الدراسة الى ايجاد العلاقة بين قيم شدة الإصابة وتركيزات الملوحة للتنبؤ المبكر بشدة الإصابة المرضية باعقان الجذور.